Joint EIFAAC/ICES WGEEL Report 2012

ICES Advisory Committee

ICES CM 2012/ACOM:18

Ref. ACOM, WGRECORDS, SGEF & EIFAAC

Report of the Joint EIFAAC/ICES Working Group on Eels (WGEEL)

3–9 September 2012

Copenhagen, Denmark

ICES International Council for the Exploration of the Sea
CIEM Conseil International pour l'Exploration de la Mer

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Recommended format for purposes of citation:

ICES. 2012. Report of the Joint EIFAAC/ICES Working Group on Eels (WGEEL), 3–9 September 2012, Copenhagen, Denmark. ICES CM 2012/ACOM:18. 824224 pp.

Report of the 2012 Session of the Joint EIFAAC/ICES Working Group on Eels

Copenhagen, Denmark, 3–9 September 2012

The 2012 report of the WGEEL should be read as an interim report (especially Section B) in a two year Term of Reference. Therefore, the WGEEL will be taking note of the Technical Review (Annex 11) and incorporating as appropriate in the 2013 WGEEL Report.

European Inland Fisheries and Aquaculture Advisory Commission
Food and Agriculture Organization of the United Nations
Rome

International Council for the Exploration of the Sea
Copenhagen

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

Rome, 2012

INTERNATIONAL COUNCIL FOR THE EXPLORATION OF THE SEA

Copenhagen, 2012

ISBN *tbc.*

Executive Summary

The Joint EIFAAC/ICES WGEEL met in 2012 in ICES HQ, Copenhagen, Denmark. The group was chaired by Russell Poole (IE) and Cédric Briand (FR), and there were thirty-six participants present at the meeting from sixteen countries. Additional inputs to the WGEEL were made by Henrik Sparholt, Poul Degnbol, Neil Holdsworth, Mark Dickey-Collas and Helle Gjeding Jørgensen from ICES.

ICES has provided advice on eel since 1999. Following long-term declines in recruits (e.g. glass eel since 1980, yellow eel since 1960s) and landings (since 1960s), the urgent compilation of a management plan was recommended, aiming at a recovery of the stock. Suggested eel-specific management targets were based on precautionary reasoning and general considerations. In 2007, the EU adopted the Eel Regulation, which led to the development of Eel Management Plans by 2009. Implementation of these plans has generated much more data, and further research studies have been executed. Reporting to the EU in 2012 by Member States on their post-evaluation of the implementation of the first three years of the Regulation will enable the first compilation of the implemented management actions and the stock indicators. This should facilitate the planned post-evaluation by ICES of the international eel stock. The Terms of Reference for the 2012 WGEEL was framed with this approach in mind.

The WGEEL meeting was organized on a general agreed agenda and task based meetings with discussion plenary sessions.

The report comprises six main chapters in two sections, the first section addresses data, trends and information for current advice in four chapters, the second section addresses International Stock Assessment, the planning for the review of reported local stock assessments and stock indicators, delivered by EU Member States, including a preliminary assessment of the information currently available to the WGEEL. A final third section in the report summaries other areas of WGEEL activity.

(Chapter 4) Indications are that the eel stock has continued to decline in 2012. The WGEEL recruitment index (five year average) is currently at its lowest historical level, less than 1% for the North Sea and 5% elsewhere in the distribution area with respect to 1960–1979. In the 2011/12 season, recruitment for the series outside the North Sea ('Elsewhere Europe') returned to 2007–2008 levels. This change is within the range of normal variation within the series, and recruitment levels remain at a low level. The recruitment of young yellow eel has been declining continuously since the 1950s. Reported data on landings show that they have declined to about 4000 t, a level which has not changed in the recent years. Since the entry into force of the eel regulation, stocking has started to increase. Different sizes (and ages) of stocking material are being applied and an attempt was made to express those in a common unit of "glass eel equivalents".

(Chapter 5) In 2012 the best estimate of the total catch of glass eel was 45.4 t representing a 6.4% increase on 2011. Of the 45.4 t caught, 36.5 t could be accounted for through exports, internal usage in the donor country and from seizures; a loss rate of ~20%. Some of this loss may be explained by mortality and weight loss post-capture, some through underreporting of exports and through illegal activities. Of the 2012 catch, 16% went to stocking, 22% went to aquaculture and the destiny of 62% remains unknown. Some of the glass eel currently classified as going to aquaculture will be stocked in future.

A comparison between data presented by the various countries and that obtained from the EuroStat database shows consistency between the two. Between 2011 and 2012 stocking of glass eel was undertaken in nine countries. The price of glass eels remains high ranging from € 300–492 per kg over the last five years.

(Chapter 6) Parameters developed for estimating the condition of escaping silver eels have the potential to be used to calculate the reproductive potential of individual female silver eels leaving their catchment, and this quantitative approach in estimating eel quality can be integrated into the stock assessments. This has the potential for important applications for stock management, although the development of this methodology is hampered by the lack of field verified 'dose effect' threshold information and a lack of monitoring data.

In some countries, a considerable proportion (38%) of eels (n = 986 eels from 314 sites in eight countries) exceeded the new maximum levels for non-dioxin like PCBs in food (new EU Dioxin Regulation Com Reg EU No 1259/2011, into force since 1 Jan 2012), and more eel fisheries have been closed due to high PCB contamination (e.g. in France and Italy).

(Chapter 7) A review of the models used to calculate Natural Mortality, and their use by each European country in their National Stock Assessment, allows their comparison and recommendations on their use. The choice of the appropriate model is crucial because it potentially brings about enormous differences in the estimations of natural mortality rates.

The age based methods show an increasing trend in natural mortality from North to South, as does the method of Bevacqua. In the case of European eel, the specific Bevacqua *et al*. (2011) model seems to be the most complete approach, since it involves the main processes affecting mortality (body mass, temperature and population density), and it provides results in accordance with the empirical estimated value of Dekker (2000). On the other hand the age based methods require less information and are easier to apply.

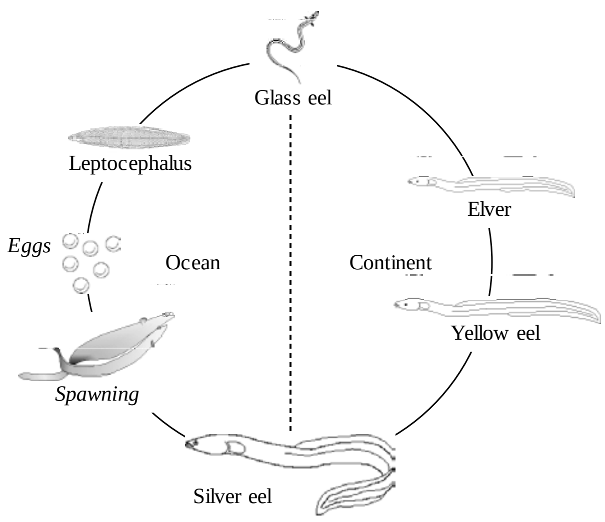
(Chapter 8) Standardized data collection and analytical procedures that are routinely applied in ICES are not always applicable to eel due to the high variation in data, processes and methods with over 70 independent assessments. Options for quality control ranging from full check to pragmatic acceptance with some creative solutions in between, such as a data score card and assessment method scenario checking are discussed.

(Chapter 9) WGEEL, using the available new data, reconsidered the basis for applying reference limits to eel, following where possible the lines of standard ICES advice procedures. In particular, the dependence of glass eel recruitment from the Ocean on the biomass of the escaping silver eel was reconsidered, and new, appropriate indicators are suggested in the report. Indications are that the stock–recruitment relation for eel might be depensatory, as indicated by recruitment falling faster than stock abundance. If true, this would change the view on the status of the stock and appropriate reference points considerably and reinforce the urgency and gravity of the advice. However, current views are based on preliminary information, compiled in relation to the 2012 post-evaluation of the EU Eel Regulation. ICES has planned a full update of its international assessment and advice in 2013, using the new information. Pending completion, no new advice on reference points is provided in this report.

Glossary

Eels are quite unlike other fish. Consequently, eel fisheries and eel biology come with a specialized jargon. This section provides a quick introduction for outside readers. It is by no means intended to be exhaustive.

There are two species of eel in the North Atlantic, the European eel (*Anguilla anguilla*) and the American eel (*A. rostrata*).



The life cycle of the European eel. The names of the major life stages are indicated; spawning and eggs have never been observed in the wild and are therefore only tentatively included. **(Diagram: Willem Dekker).**

The European eel *Anguilla anguilla* (L.) is found and exploited in fresh, brackish and coastal waters in almost all of Europe and along the Mediterranean coasts of Africa and Asia. The life cycle has not been fully elucidated but current evidence supports the view that recruiting eel to European continental waters originate in a single spawning stock in the Atlantic Ocean, presumably in the Sargasso Sea area, where the smallest larvae have been found. Larvae (*Leptocephali*) of progressively larger size are found between the Sargasso Sea and European continental shelf waters. While approaching the continent, the laterally flattened *Leptocephalus* transforms into a rounded glass eel, which has the same shape as an adult eel, but is unpigmented. Glass eel migrate into coastal waters and estuaries mostly between October and March/April, before migrating, as pigmented elvers, on into rivers and eventually into lakes and streams between May and September. Following immigration into continental waters, the prolonged yellow eel stage (known as yellow eel) begins, which lasts for up to 20 or more years. During this stage, the eels may occupy freshwater or inshore marine and estuarine areas, where they grow, feeding on a wide range of insects, worms, molluscs, crustaceans and fish. Sexual differentiation occurs when the eels are partly grown, though the mechanism is not fully understood and probably depends on local stock density. At the end of the continental growing period, the eels mature and return from the coast to the Atlantic Ocean; this stage is known as the silver eel. Female silver eels are twice as large and may be twice as old as males.

Glossary of terms

Glass eel	Young, unpigmented eel, recruiting from the sea into continental waters.
Elver	Young eel, in its first year following recruitment from the ocean. The elver stage is sometimes considered to exclude the glass eel stage, but not by everyone. Thus, it is a confusing term.
Bootlace, fingerling	Intermediate sized eels, approx. 10–25 cm in length. These terms are most often used in relation to stocking. The exact size of the eels may vary considerably. Thus, it is a confusing term.
Yellow eel (Brown eel)	Life-stage resident in continental waters. Often defined as a sedentary phase, but migration within and between rivers, and to and from coastal waters occurs. This phase encompasses the elver and bootlace stages.
Silver eel	Migratory phase following the yellow eel phase. Eel characterized by darkened back, silvery belly with a clearly contrasting black lateral line, enlarged eyes. Downstream migration towards the sea, and subsequently westwards. This phase mainly occurs in the second half of calendar years, though some are observed throughout winter and following spring.
Eel River Basin or Eel Management Unit	"Member States shall identify and define the individual river basins lying within their national territory that constitute natural habitats for the European eel (eel river basins) which may include maritime waters. If appropriate justification is provided, a Member State may designate the whole of its national territory or an existing regional administrative unit as one eel river basin. In defining eel river basins, Member States shall have the maximum possible regard for the administrative arrangements referred to in Article 3 of Directive 2000/60/EC [i.e. River Basin Districts of the Water Framework Directive]." EC No. 1100/2007.
River Basin District	The area of land and sea, made up of one or more neighbouring river basins together with their associated surface and groundwaters, transitional and coastal waters, which is identified under Article 3(1) of the Water Framework Directive as the main unit for management of river basins. The term is used in relation to the EU Water Framework Directive.
Stocking	Stocking is the practice of adding fish [eels] to a waterbody from another source, to supplement existing populations or to create a population where none exists.

Eel reference points/population dynamic	
Anthropogenic mortality after management (A_{post})	Estimate of anthropogenic mortality after management actions are implemented
Anthropogenic mortality before management (A_{pre})	Estimate of anthropogenic mortality before management actions are implemented
Spawner escapement biomass after management (B_{post})	Estimate of spawner escapement biomass after management actions are implemented
Spawner escapement biomass before management (B_{pre})	Estimate of spawner escapement biomass before management actions are implemented
Best achievable biomass (B_{best})	Spawning biomass corresponding to recent natural recruitment that would have survived if there was only natural mortality and no stocking
Interim Target for biomass ($B_{interim}$)	Pragmatic intermediate goals for spawner escapement biomass set by managers.
Interim Target for mortality ($A_{interim}$)	Pragmatic intermediate anthropogenic mortality goal set by managers.
Limit anthropogenic mortality (A_{lim})	Anthropogenic mortality, above which the capacity of self-renewal of the stock is considered to be endangered and conservation measures are requested (Cadima, 2003).
Limit spawner escapement biomass (B_{lim})	Spawner escapement biomass, below which the capacity of self-renewal of the stock is considered to be endangered and conservation measures are requested (Cadima, 2003).
Precautionary anthropogenic mortality (A_{pa})	Anthropogenic mortality, above which the capacity of self-renewal of the stock is considered to be endangered, taking into consideration the uncertainty in the estimate of the current stock status.
Precautionary spawner escapement biomass (B_{pa})	The spawner escapement biomass, below which the capacity of self-renewal of the stock is considered to be endangered, taking into consideration the uncertainty in the estimate of the current stock status.
$B_{MSY-trigger}$	Value of spawning–stock biomass (SSB) which triggers a specific management action, in particular: triggering a lower limit for mortality to achieve recovery of the stock.
Pristine biomass (B_o)	Spawner escapement biomass in absence of any anthropogenic impacts.
Spawner per recruitment (SPR)	Estimate of spawner production per recruiting individual.
%SPR	Ratio of SPR as currently observed to SPR of the pristine stock, expressed in percentage. %SPR is also known as Spawner Potential Ratio.
B_{stop}	Biomass of the spawning stock, at which recruitment is severely impaired, and the next generation is (on average) expected to produce an equally low spawning-stock biomass as the current.
B_{stoppa}	Biomass of the spawning stock at which recruitment is severely impaired, and the next generation has a 5% chance to produce an equally low spawning-stock biomass as the current.

Contents

1 Opening of the meeting

The Joint EIFAAC/ICES WGEEL met in 2012 in ICES HQ, Copenhagen, Denmark. There were thirty-six participants present at the meeting from sixteen countries. The list of attendees is given in Annex 1. The meeting was preceded by a Task Leaders coordination meeting on Sunday 2nd September and the full meeting was opened at 09.30 on Monday 3rd September 2012.

Parts of the WGEEL meeting were also attended by Poul Degnbol, Henrik Sparholt, Neil Holdsworth, Mark Dickey-Collas and Helle Gjeding Jørgensen from ICES.

2 Adoption of the agenda

The ToRs, a draft agenda and a list of Tasks to address the ToR had been circulated prior to the meeting. Each country provides a Country Report in advance of the meeting on the status of the eel stock and fishery, including updates on any time-series data.

The Chair went through the agenda and Tasks in detail and the Task Leaders gave preliminary presentations on the proposed work plan for the week. Following that, each Country Report leader gave a short summary presentation of the highlights within their report.

The agenda and timetable was agreed by the meeting and this was updated on a daily basis (Annex 2).

2010/2/ACOM18 The **Joint EIFAAC/ICES Working Group on Eels** (WGEEL), chaired by Russell Poole, Ireland and Cedric Briand, France, will meet at ICES HQ, Copenhagen, Denmark, 3rd–9th September 2012, to:

a) assess the trends in recruitment, stock and fisheries indicative of the status of the European stock, and of the impact of exploitation and other anthropogenic factors; analyse the impact of the implementation of the eel recovery plan on time-series data (i.e. data discontinuities). Establish an international database for data on eel stock and fisheries, as well as habitat and eel quality (update EEQD) related data – seek advice from ICES Data Centre for this task; review and make recommendations on data quality issues;

b) In conjunction with WGBEC (Biological Effects of Contaminants) and MCWG (Marine Chemistry Working Group), review and develop approaches to quantifying the effects of eel quality on stock dynamics and integrating these into stock assessments;

c) respond to specific requests in support of the eel stock recovery Regulation, as necessary;

d) plan for an evaluation of the EU Regulation for recovery of the eel stock (EC No. 1100/2007), its target (40% SSB escapement compared to historic production) and its consistency with the precautionary approach, including planning for data exchange, quality control, methodology for stock-wide assessment;

e) assess state of current and historic data (including outputs from WKBALTEEL and GFCMEEL) and undertake an analysis of the possible stock–recruitment relationships, incorporating spatial differences (e.g. age at maturation, sex ratio), that could lead to establishing precautionary reference limits;

f) make recommendations on how WGEEL 2013 should undertake the post-evaluation and assessment using the 2012 reported data, taking note of previous WGEEL and SGIPEE reports.

3 Introduction

This report is a further step in the ongoing process of documenting the status of the European eel stock and fisheries and compiling management advice. As such, it does not present a comprehensive overview, but should be read in conjunction with previous WGEEL reports (ICES, 1998 to 2011) and with the SGIPEE reports (ICES 2010 and 2011).

In addition to documenting the status of the stock and fisheries and compiling management advice, in previous years the Working Group also provided scientific advice in support of the establishment of a recovery plan for the stock of European Eel by the EU. In 2007, the EU published the Regulation establishing measures for the recovery of the eel stock (EC 1100/2007). This introduced new challenges for the Working Group, requiring development of new methodologies for local and regional stock assessments and evaluation of the status of the stock at the international level. Implementation of the Eel Management Plans has now introduced discontinuities to data trends and the shift from fisheries-based to scientific survey-based assessments is now needed.

In its Forward Focus (2011), WGEEL mapped out a process for post-evaluation of the EU Regulation, based on 2012 reporting to the EU by Member States, including an international assessment of the status of the stock and the levels of anthropogenic mortalities.

ICES understand the evaluation of the 2012 reports will be undertaken by the EU Commission. Post-evaluation of the reported biomass and anthropogenic mortality data and the impact of the implemented management actions on the stock will require a process that collates local data and aggregates to the national and international levels. A system of quality control of the input data, the assessment methods and the output stock indicators will be required for ICES to provide advice on the stock.

The 2012 meeting of WGEEL is the first step in this post-evaluation process. A further two meetings are envisaged, with some homework in advance, in order to complete the post-evaluation. Countries must be committed to this process in order for it to succeed and it must be internationally coordinated.

The structure of this report does not strictly follow the order of the Terms of Reference for the meeting. The meeting, and consequently the report, was organized in six Tasks using the Agenda in Annex 2, under the headings of "Data and trends", "Stocking Time-series", "Glass Eel Trade", "Assessment of eel quality", "Natural Mortality", "International Stock Assessment – data and assessment quality" and " Objectives, targets and reference values".

Section A: Data, trends and information for current advice

4 Data and trends

Chapter 4 addresses the following Terms of Reference:

a) assess the trends in recruitment, stock and fisheries indicative of the status of the European stock, and of the impact of exploitation and other anthropogenic factors; analyse the impact of the implementation of the eel recovery plan on time-series data (i.e. data discontinuities). Establish an international database for data on eel stock and fisheries, as well as habitat and eel quality (update EEQD) related data – seek advice from ICES Data Centre for this task; review and make recommendations on data quality issues;

4.1 Recruitment

4.1.1 Update on the status of data

The information on recruitment is provided by a number of datasets, relative to various stages, (glass eel and elver, yellow eel), recruiting to continental habitats (Dekker, 2002). The recruitment time-series data in European rivers and a description of the dataseries are presented in Annex 6 - Tables 4-1.

The time-series used for recruitment analysis are coming from 49 series out of which 45 have data in the period (1979-1994), which is then used as a scaling for all the series (Figure 4-1). For glass eel[1], 18 series were updated to 2012. The number of available series rises back in time to reach a peak of 31 series in 1994.

For recruitment at the yellow eel stage, 9 series were updated to the last year available (2011) out of a maximum of 11 which were available in 1997 (Figure 4-2).

Some countries are reporting data on shorter series and these have so far not been added to the ICES dataset but they are available in national reports.

[1] In this chapter on recruitment series, glass eel correspond to pure glass eel in some series and a mixture of glass eel and young yellow eel stage in others.

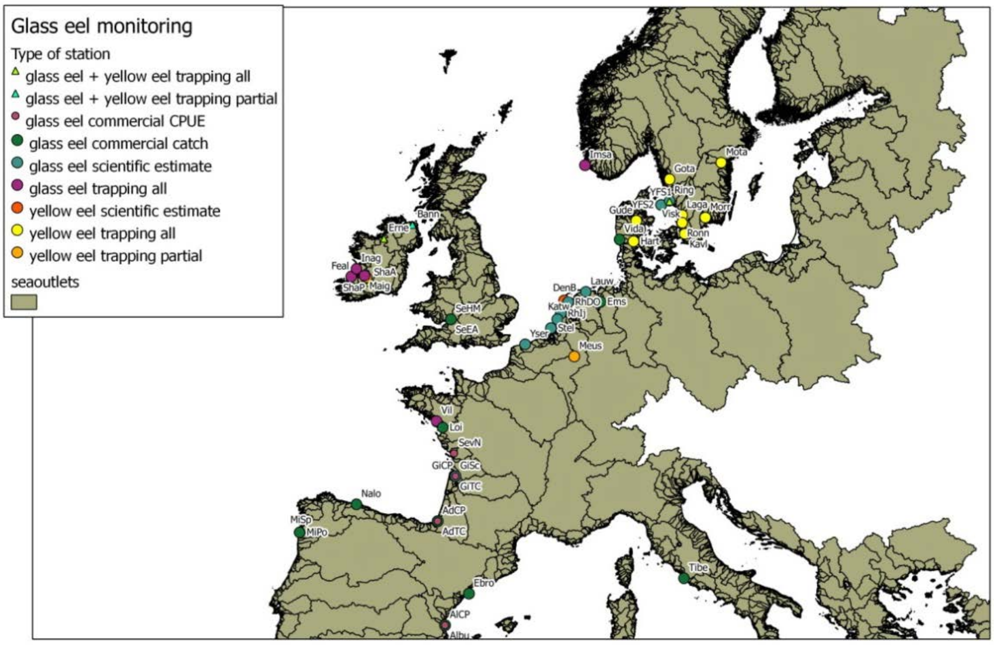


Figure 4-1. Location of the recruitment monitoring sites in Europe. The code of the stations and their short description is given in Annex 6, Table 4.1.

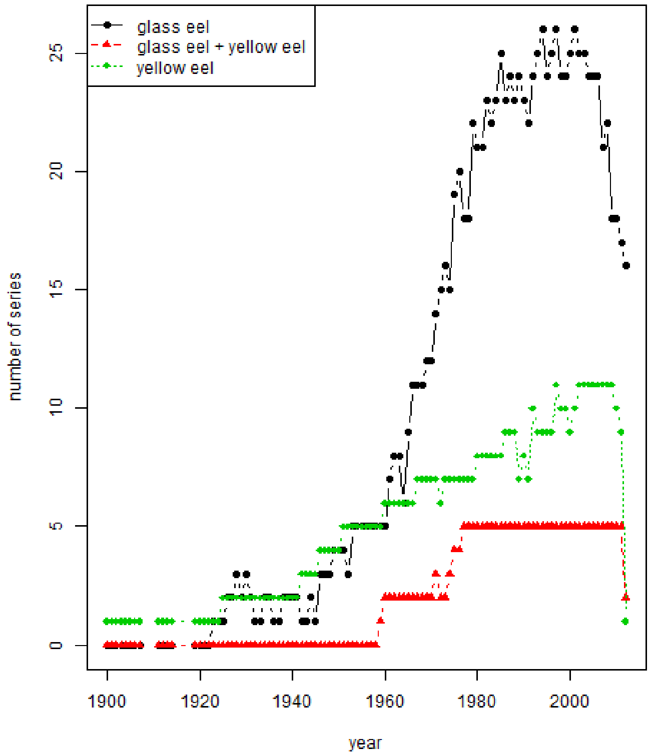


Figure 4-2. Trend in number of available dataseries per life stage, updated to 2012.

4.1.2 Series modified

Some series have been updated also for past time values, namely:

- the Young fish survey in the North Sea which was completely recalculated and the first year of the series discarded.
- the Imsa, where the total number of recruits ascending the ladder was re-evaluated.
- the Erne (Ballyshannon) which was revisited for slight changes.
- the Severn for which new cpue data were provided for the last five years.
- All Dutch scientific series to which effort data have been added, Lauwersoog, IJmuiden, DenOever, Katwijk, Stellendam. For the two latter, data points have been removed for years where the number of hauls was judged insufficient (<5). In the case of Stellendam, the number of hauls will have to be collected and filled in to the database from 1973 to 1987. These points are retained in the series, as internal checking within the WGEEL indicated that those data exist somewhere. Information on effort (number of hauls or day of fishing) needs to be gathered, particularly for the Ijzer series, as the effort could be used as a weighting factor in future regressions.

4.1.3 Series lost

Some of the series have been stopped, as the consequence of a lack of recruits in the case of the fishery based surveys (Ems, Germany 2001; Vidaa, Denmark 1990) or as a consequence of a lack of financial support (the Tiber, Italy 2006). There should be a programme next year to resume two series in Italy (Tiber and the Marta which is a shorter experimental fishing series), and this is welcomed as increasing the number of series in the Mediterranean was a recommendation from last year. Noting this development, the WGEEL encourages the development of other new recruitment monitoring time-series in the GFCM area.

Last year, four out of the six French series were discontinued as the catch statistics no longer reported the precise location of the catch, only the EMU. In 2012, the Vilaine series can also be considered as stopped, as the quota system has diminished the fishing period, and only the Gironde scientific series remains as a reliable indicator of the trend in recruitment in the place where most glass eel arrive.

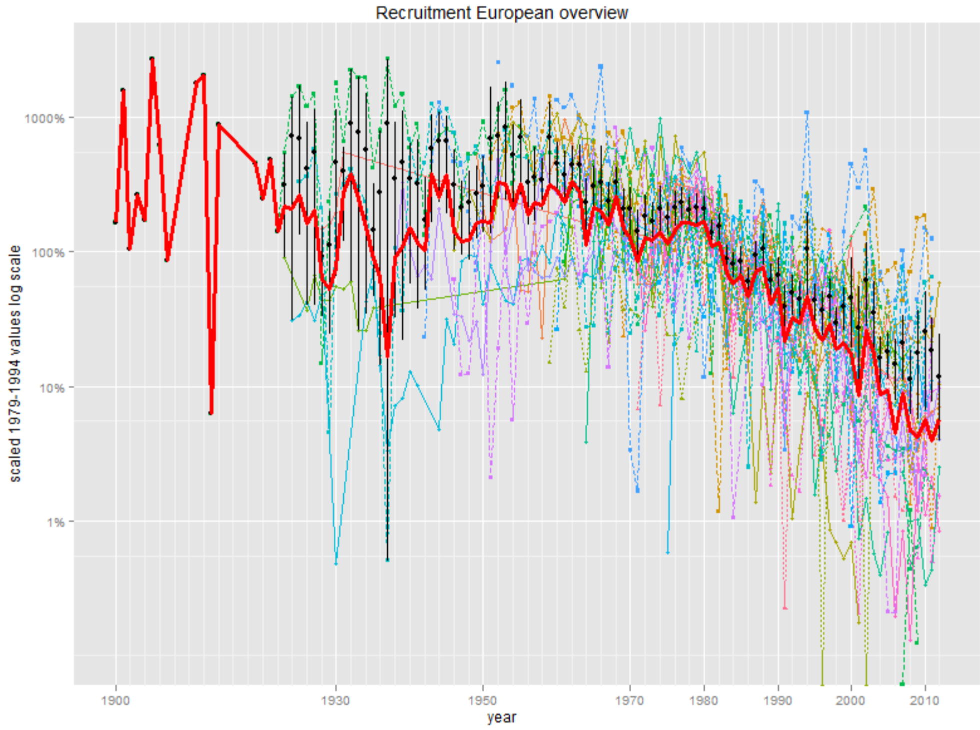


Figure 4-3. Time-series of glass eel and yellow eel recruitment in European rivers with dataseries >35 years (45 rivers) updated to 2012. Each series has been scaled to its 1979–1994 average. Note the <u>logarithmic scale</u> on the y-axis. The mean values and their bootstrap confidence interval (95%) are represented as black dots and bars. Note: for practical reasons, not all series are presented in this graph. Geometric means are presented in red.

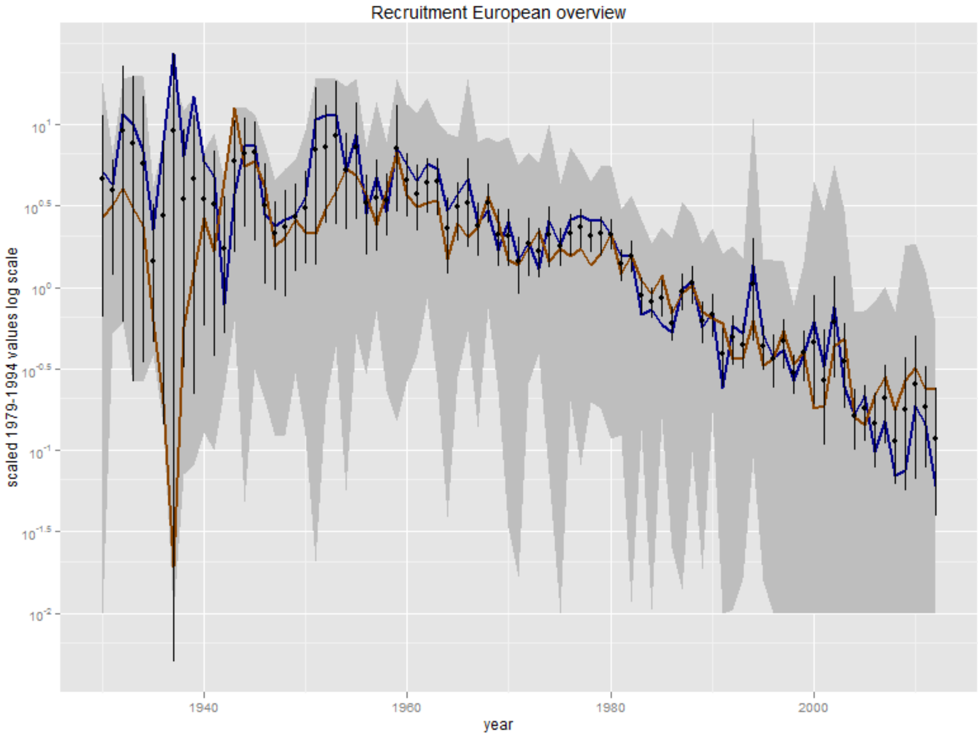


Figure 4-4. Time-series of glass eel and yellow eel recruitment in European rivers with dataseries >35 years (45 rivers) updated to 2012. Each series has been scaled to its 1979–1994 average. Note the logarithmic scale on the y-axis. The mean values of combined yellow and glass eel series and their bootstrap confidence interval (95%) are represented as black dots and bars. The brown line represents the mean value for yellow eel, the blue line represents the mean value for glass eel series. The range of the series is indicated by a grey shade. Note that individual series from Figure 4.3 were removed for clarity.

4.1.4 Trends in recruitment

The recruitment time-series data are derived from fishery-dependent sources (i.e. catch records) and also from fishery-independent surveys across much of the geographic range of European eel. The series cover varying time intervals and only those series covering >35 years were selected for a final analysis of the trend. Some series date back as far as 1920 (glass eel, Loire France) and even to the beginning of 20th century (yellow eel, Göta Älv, Sweden).

The glass eel recruitment-series have also been classified according to two areas: North Sea and Elsewhere Europe, as it cannot be ruled out that the two places have different trends (ICES 2010); see also Section 4.1.5. The Baltic area does not contain any pure glass eel series. The yellow eel recruitment-series are comprised of either a mixture of glass eel and young yellow eel, or as in the Baltic, are only of young yellow eel.

The WGEEL recruitment index is a reconstructed prediction using a simple GLM (Generalised Linear Model): *glass eel~year:area+site*, where glass eel is the number in each series, site is the site monitored for recruitment and area is either the North Sea or Elsewhere Europe. In the case of yellow eel series, only one estimate is provided: *yellow eel~year +site*. The trend is reconstructed using the predictions for the whole time range for all series.

For graphical presentation, the series are scaled to 1979–1994 as it is not possible to set an appropriate reference earlier than 1980 for most of the series. But, the reconstructed values when using the GLM analysis are given in reference to the mean reconstructed estimate of the 1960–1979 period. Declining trends are evident over the last three decades for all time-series. After high levels in the late 1970s, there has been a rapid decrease that continues to the present time (Figures 4.3–4.6; note the logarithmic scales).

The WGEEL recruitment index (five year average) is currently at its lowest historical level, less than 1% for the North Sea and 5% elsewhere in the distribution area with respect to 1960–1979 (Table 4-4). An increase in recruitment has been observed in 2012 for the series outside the North Sea, returning recruitment to the level observed in 2007–2008 (Table 4-2, Figure 4-5, Annex 6, Table 4.3).

The glass eel landings data in 2010 and 2011 were higher than in 2009. This upward trend might have continued in France in 2012, but in the 2011/2012 fishing season the quota was reached in most estuaries capping the amount of glass eel caught by the French glass eel fishery. The drop in estimated landings of the French marine commercial fishery between 2007/2008 (71.4 t) and 2011/2012 (30.5 t) is about 60%, and this value is consistent with the drop in daily fishing effort (daily fishing) estimated as 56% (WGEEL French country report). The catch from the UK was stable from last year 3.7 t to that in 2012 (3.8 t) with no real variation in effort. The catch increased in Spain from 3.1 t to 6.2 t.

This raw analysis of glass eel catch and effort is also indicating that recruitment levels might have risen back to values slightly higher than 2008 levels.

The series for yellow eel recruitment show a continuous decrease to a low level around 10% of their mean of 1960–1979 levels (Figure 4-6, Table 4-2 and 4-4, Annex 6, Table 4-3).

According to SGIPEE (ICES 2011) the probability of having observed a change in the trend is not significant (p=0.563).

Table 4-2. Working group on eel series on recruitment, GLM N=area:year+site estimated values from 2001 to 2012 for glass eel and yellow eel recruitment. See Annex 6, Table 4.3 for full results.

	Glass eel		*Yellow eel*
	Elsewhere Europe	North Sea	
2001	0.097	0.010	0.168
2002	0.146	0.029	0.365
2003	0.119	0.023	0.186
2004	0.079	0.007	0.235
2005	0.099	0.014	0.066
2006	0.073	0.005	0.121
2007	0.070	0.014	0.194
2008	0.057	0.007	0.080
2009	0.037	0.012	0.072
2010	0.045	0.007	0.126
2011	0.043	0.005	0.130
2012	0.065	0.008	0.021

Table 4-4. Working group on eel series on recruitment, GLM N=area:year+site. Five year averages. See Annex 6, Table 4.3 for full results.

	Glass eel		*Yellow eel*
	Elsewhere Europe	North Sea	
1950	0.53	0.81	2.42
1955	0.53	1.21	2.05
1960	1.29	1.56	1.37
1965	0.93	0.90	1.20
1970	0.71	0.79	0.78
1975	1.07	0.75	0.65
1980	0.83	0.42	0.49
1985	0.53	0.09	0.47
1990	0.28	0.08	0.31
1995	0.28	0.05	0.15
2000	0.13	0.02	0.22
2005	0.067	0.010	0.11
2010-12	0.051*	0.007**	0.092 ***

*** average 2008–2012 = 0.049 ** 0.008. *** 0.086**

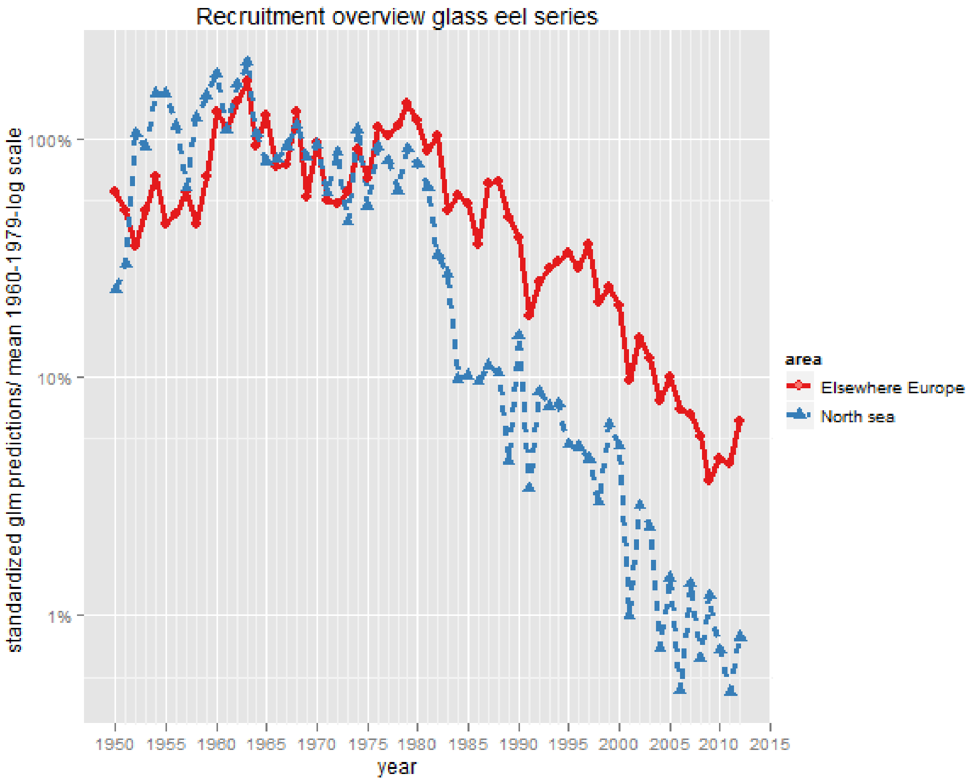


Figure 4-5. WGEEL recruitment index: mean of estimated (GLM) glass eel recruitment for the North Sea and elsewhere in Europe updated to 2012. The GLM (recruit=area:year+site) was fitted on 34 series glass eel series comprising either pure glass eel or a mixture of glass eels and yellow eels and scaled to the 1960–1979 average. No series for glass eel are available in the Baltic area. Note <u>logarithmic scale on the y-axis</u>.

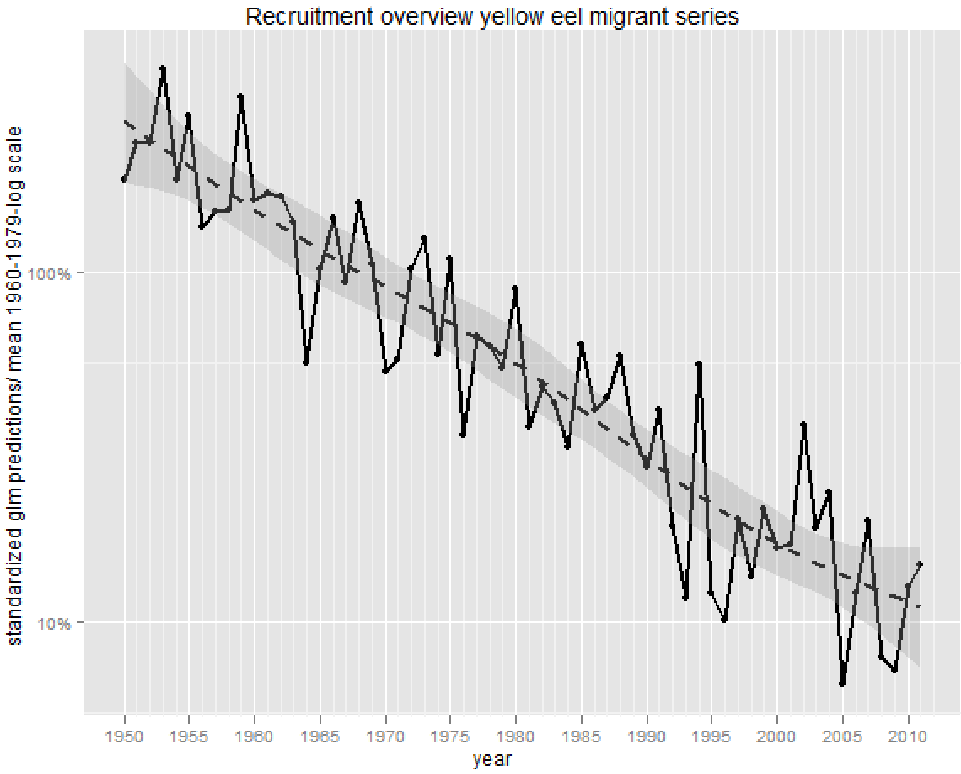


Figure 4-6. Mean of estimated (GLM) yellow eel recruitment and smoothed trends for Europe updated to 2011. The GLM (recruit= year+site) was fitted to 10 yellow eel series and scaled to the 1960–1979 average. Note logarithmic scale on the y-axis. Bands show 95% point-wise confidence interval of the smoothed trend.

4.1.5 Justification for separating the North Sea series and elsewhere

A spatial analysis was carried out two years ago to assess if there was a spatial pattern in glass eel recruitment (ICES, 2010). While the analysis (PCA, hierarchical clustering, Multidimensional Scaling and k-means) demonstrated that no such pattern was apparent in the data, a further analysis of the slope of the decrease showed that most of the North Sea series were dropping faster than the other, and for this reason, it was decided to separate North Sea from the other series. However a careful examination of the trends shows that the major drop in most North Sea series occurred between 1980 and 1985 and that after that period the trend of the two series was about the same as before (Figures 4-5).

The reason why the North Sea series has dropped more rapidly than the others is not clear. Two of the series (Vidaa and Ems) are commercial series which were stopped, and there is a concern that for those series, the drop observed might have been the consequence of the change in fishing effort.

A careful analysis of the deviation from a common trend was analysed over two consecutive periods of time, i.e. 1970–1990 and 1990–2012. For the first period, ten out of the 12 most rapidly diminishing trends are located in the North Sea. Most importantly, some of the series showing this sharper decrease are scientific series. For the second period the trends are less contrasted, and show that North Sea series are diminishing more rapidly than Atlantic ones. As a consequence, the working group decided to keep the two series separate even if the reasons to this different trend remain unexplained (Figures 4-7, 4-8; Annex 6, Table 4-5).

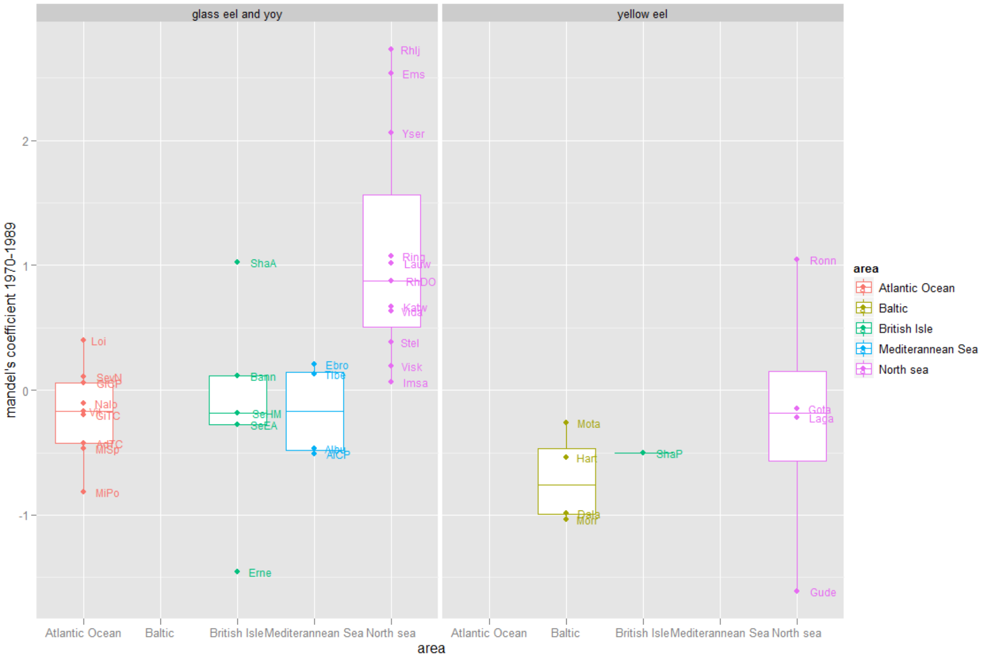


Figure 4-7. Mandel's bundle of straight line, the coefficient shows the deviation from a common trend in the series, analysis from 1970 to 1989 inclusive.

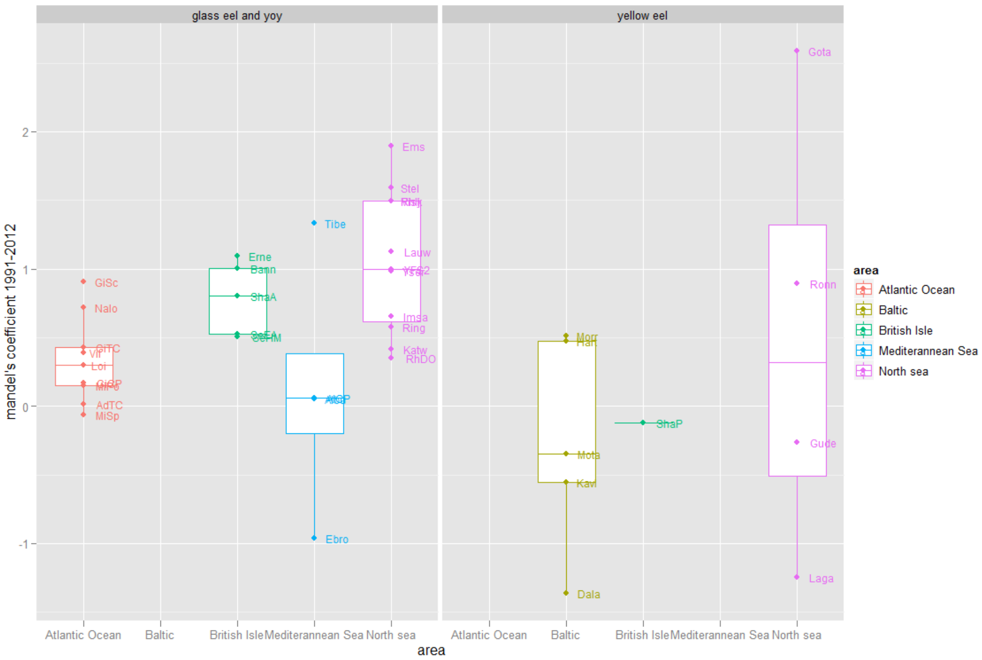


Figure 4-8. Mandel's bundle of straight line, results for 1990 to 2012 inclusive.

4.2 Time-series of yellow and silver eel

4.2.1 Yellow eel

Several Country Reports present information on long-term monitoring of yellow eel abundance in various habitats, and these values have been updated in the WGEEL database. Methodologies vary from electrofishing and traps in rivers to beach-seines, fykenets and trawls in larger waterbodies. In some cases, detailed information on catches and effort in commercial fisheries are combined to give estimates on local abundance.

Coastal habitats in southern Norway were monitored with beach-seine nets since 1925 (Skagerrak). No trend in eel abundance occurred until a sharp decrease started in the early 2000s. Cpue in fishery-independent fykenet surveys on the Swedish west coast were on a stable level, or increased, since the late 1970s, but tend to decrease in recent years. A similar development was observed in Irish fykenet surveys, compared to the late 1960s. In this case a change in sex ratio towards female dominance was observed, and an increase in mean weight compensated for a decrease in abundance. Fykenet catches at Den Burg, Texel, dropped to close to zero in the 1980s and decreasing abundance along with increasing size was observed in Dutch estuaries in the last decade. In Lake IJsselmeer and in Belgian lower Scheldt estuary, yellow eel densities decreased significantly in recent decades. In the same time increasing abundance was observed upstream in the same estuary in Belgium (Figure 4-9).

Commercial yellow eel cpue did not change in Norwegian and Swedish coastal fisheries since the 1970s. In the Garonne estuary, France, eelpot cpue did not change significantly since 1987. Concerns over bias due to changes in fishing gear and fishing operations was raised in two of the cases.

Available information on long time changes in yellow eel abundance show that the decrease in recruitment post 1980 is not necessarily reflected in a subsequent decrease in yellow biomass for some of the series. A decrease in number may be compensated for by an increase in the share of females growing to a larger size. In areas already dominated by females a decrease in recruitment may result in reduced opportunities for the eel to colonize distant/marginal habitats of that area. These factors, as well as bias introduced by biotic or abiotic circumstances, have to be taken into consideration in future design and interpretation of data from a variety of different survey methods.

Information on long-term changes in yellow eel abundance in many cases is the only way to assess the status of eel production in the absence of a significant fishery. A development towards standardized methods is thus suggested by WKESDCF to be included in the DCMAP framework in 2014–2020.

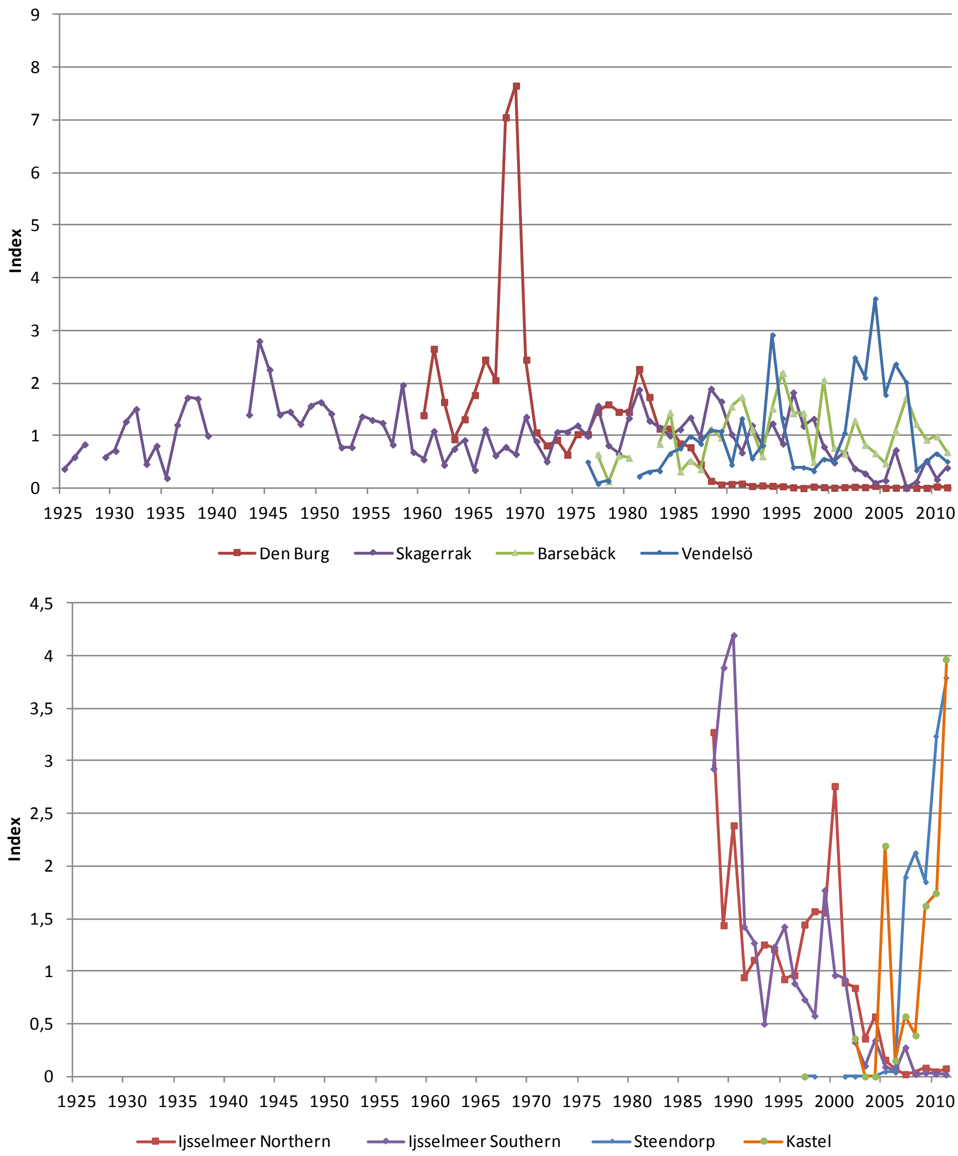


Figure 4-9. Trends in yellow eel abundance from fishery-independent surveys. Upper panel, data from coastal surveys in the North Sea area; lower panel, data from freshwater (Ijsselmeer) in the Netherlands and from upstream the Scheldt estuary in Belgium. Data were normalized as annual fractions of the long-term mean in each series, and updated to 2012.

4.2.2 Silver eel

Country Reports in 2012 presented fishery-independent data on silver eel escapement from one river in Norway, one river in Ireland and from three riverine sites in Scotland. A 50% reduction in numbers of escaping silver eel was recorded in Burrishoole, Ireland (1971–2011), in River Imsa, Norway (1975–2011) and in Girnock Burn Scotland when the period 1966–1981 is compared to the period 2003–2011. In Burrishoole, biomass did not change since 1971, as the decrease in abundance was compensated for by an increase in average weight (contributed to by a change in sex ratio and increasing size of female eels; see Country Report for Ireland) (Figure 4-10).

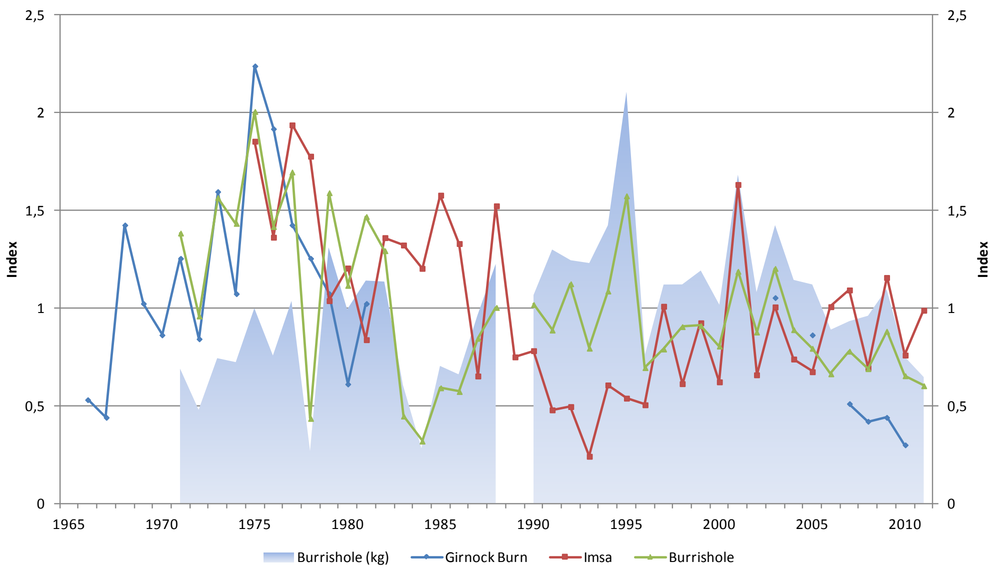


Figure 4-10. Trends in silver eel abundance and/or biomass from river traps in Burrishoole, Ireland, Girnock Burn, Scotland and Imsa, Norway. Normalized trends were based on kg/ha (Girnock Burn) and counts in numbers and weight (Burrishoole) and counts in numbers (Imsa).

In Sweden cpue based on detailed landing statistics from selected poundnets in specific sites were used to estimate silver eel escapement from the Baltic Sea coastal fishery since the late 1950s (Andersson *et al*., 2012). Escapement by numbers decreased in all but one of four investigated areas, the major decrease (50%) taking place in the late 1960s and in the early 1970s. The decrease in numbers was compensated for by a 70–100% increase in average body weight. A reduction in fishing mortality and increasing seawater temperature are suggested to explain a lack of correlation between Baltic recruitment indices and escapement.

4.3 Data on landings

In WGEEL 2010, data on total eel landings obtained from Country Reports were presented, without data on official eel landings from FAO sources which differed from Country Report data.

At the present 2012 status, dataseries from the Country Reports continue to be unreliable but are improving. A review of the catches and landing reports in the CR showed a great heterogeneity in landings data reports, with countries making reference to an official system, some of which report total landings, others report landings by Management Unit or Region, and some countries haven't any centralized system. Furthermore, some countries have revised their dataseries, with extrapolations to the whole time-series, for the necessities of the Eel Management Plan compilation (Poland, Portugal).

Since landings data were incomplete, with some years missing for some of the countries, an estimate of the missing values is provided by simple GLM extrapolation (after Dekker, 2003), with year and countries as the explanatory factors (Figure 4-11).

The EU Eel Regulation requires that Member States implement a full catch registration system, along with the Data Collection Framework. This was expected to improve the coverage of the fishery, i.e. reduce underreporting markedly.

However, the CITES database, which has full harvest information gathered from Member States, differs from some WGEEL Country Report data. According to the Country Reports, the total eel landings in 2011 amounted to 3201 tonnes, compared to CITES data; 2635 tonnes, some 18% lower. The main reasons for such differences were that, some countries for CITES provided only glass eel data (for example, France) while other countries provided data from only a few regions of their country (for example: Netherlands, Spain) (Figure 4-12).

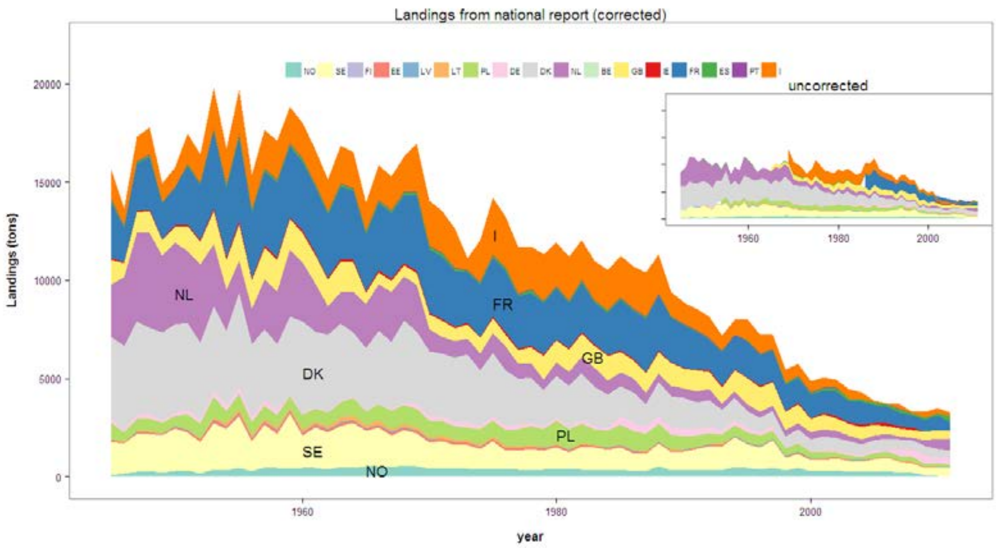


Figure 4-11. Total landings (all life stages) from 2012 Country Reports (not all countries reported); the corrected trend has missing data filled by GLM.

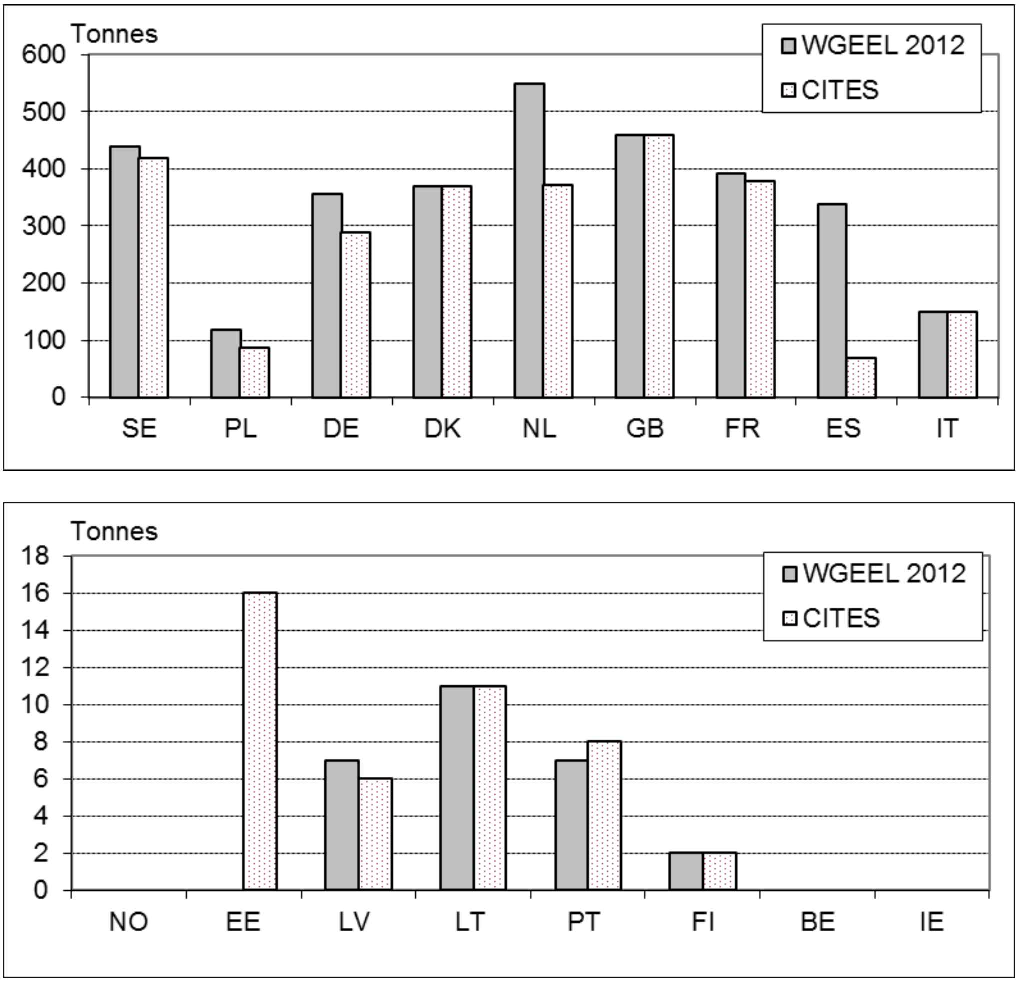


Figure 4-12. Comparison between total landings reported in 2011 in CR and CITES database. Note different y-axis scales.

4.3.1 Collection of landings statistics by country (from CRs)

Landings data are presented in Annex 6, Table 4.6.

Norway: Provided official landing statistics (Fisheries Directorate) calculated according to the number of licences. Fishing for eel has been banned in Norway since January 1st 2010.

Sweden: Data on eel landings in coastal areas are based on sales notes sent to the appropriate agency and in recent years also from a logbook system. There is a considerable discrepancy between the two methods used. This makes comparisons over time difficult and confusing. Landings data from freshwaters come from a system with monthly or yearly journals. Fishing for eels in private waters was not reported before 2005. Data from logbooks and journals are stored at the Swedish Agency for Marine and Water Management.

Finland: The statistical data are collected by the FGFRI. Data from professional fishers collected by logbooks, recreational questionnaires. For 2011 only marine landing data provided.

Lithuania: Fisheries companies provide information according to their logbooks about catch on a monthly basis to the authority issuing permits: a Regional environmental protection department under the Ministry of Environment of the Republic of

Lithuania if a company is engaged in inland fisheries (including the Curonian Lagoon), or the Fisheries Service of the Ministry of Agriculture of the Republic of Lithuania if a company is engaged in maritime fisheries. Data on recreational fishery collected using questionnaires.

Estonia: The catch statistics are based on logbooks from inland and coastal fisheries. No data available for 2011.

Latvia: Logbooks from coastal and inland fisheries were collected by local Boards of Marine and Inland Waters Administration and transmitted to Institute of Food Safety, Animal Health and Environment for data summarization and storing. All logbooks data were verified by Institute of Food Safety, Animal Health and Environment. National sea and coastal fisheries database (ICIS) are administrated by Department of Fisheries Ministry of Agriculture. Inland fisheries data maintained by Institute of Food Safety, Animal Health and Environment and at once in quarter handed to State Board of Statistics (SBS). ICIS and SBS data are used as official country data.

Poland: The data on inland catches were obtained by surveying selected fisheries facilities, and then extrapolating the results for the entire river basin. These data are thus approximate. The data from the lagoons and coastal waters were drawn from official catch statistics (logbooks).

Germany: Eel landings statistics from coastal fishery is based on logbooks. The obligation to deliver the inland catch statistics separate for both stages has only recently been established in most of the States. Fishers have to deliver the information at least on a monthly basis to the authorities. Data are missing for the States Niedersachsen, Hamburg and Rheinland-Pfalz for inland landings in 2011.

Denmark: The yellow and silver eel catches are reported by commercial fishers.

Netherlands: For Lake IJsselmeer, statistics from the auctions around Lake IJsselmeer are now kept by the Fish Board. For the inland areas outside Lake IJsselmeer, no detailed records of catches and landings were available until 2010. In January 2010 the Ministry of Economic Affairs, Agriculture and Innovation introduced an obligatory catch recording system for inland eel fishers. Catches and landings in marine waters are registered in EU logbooks.

Belgium: There are no commercial eel fishing in Belgium.

United Kingdom: In England and Wales, the Environment Agency licence commercial eel fishing. It is a legal requirement that all eel fishers submit a catch return, giving details of the number of days fished, the location and type of water fished, and the total weight of eel caught and retained, or a statement that no eel have been caught. Annual eel and elver net licence sales and catches are summarized by gear type and Environment Agency region (soon to be RBDs) and reported in their "Salmonid and Freshwater Fisheries Statistics for England and Wales" series (www.environment-agency.gov.uk/research/library/publications/33945.aspx). In Northern Ireland, overall policy responsibility for the supervision and protection of eel fisheries, and for the establishment and development of those fisheries rests with the Department of Culture, Arts and Leisure (DCAL). Catch returns from the one remaining fishery are collated at a single point of collection and marketing and reported to DCAL.

Ireland: Until 2008 eel landing statistics in Ireland were collected from voluntary declarations. From 2005 to 2008 this was improved by issuing catch declaration forms with the licence and from 2009 commercial fishing of eel has been closed.

France: The marine professional fisheries in Atlantic coastal areas, estuaries and tidal part of rivers in France has been monitored by the "Direction des Pêches Maritimes et de l'Aquaculture" (DPMA) of the Ministry of Agriculture and fisheries through the Centre National de Traitement Statistiques (CNTS, ex-CRTS) from 1993 to 2008 and is now by France-Agrimer. This system is evolving and is supposed to include marine professional fishers from Mediterranean lagoons. In this system, glass eels are distinguished from subadult eel, but yellow and silver eels cannot be separated until recently. The professional and amateur fishers in rivers above marine estuaries (and in lakes) have been monitored since 1999 by the ONEMA (Office National de l'Eau et des Milieux Aquatiques, ex-CSP). These two monitoring systems are based on mandatory reports of captures and effort (logbooks) using similar fishing forms collected monthly (or daily for glass eel) with the help of some local data collectors.

Spain: Data on eel landings in the Country Report are mostly collected from fishers' guild reports and fish markets (auctions). The precision of the information of the catches and landings differs greatly among Autonomies. No data available for marine fishery.

Portugal: The eel fishery is managed by DGPA (General Directorate of Fisheries and Aquaculture) with responsibility in coastal waters, and AFN (National Forestry Authority) with responsibility in inland waters. Fisheries managed by DGPA have obligatory landing reports, while in inland waters, landing reports are obligatory in some fishing areas but in other areas only if requested by the Authorities.

Italy: The management framework for DCF is the same as has been set up for the eel management under Regulation 1100/2007. In the eleven Regions that preferred to delegate eel management to central government (Directorate-General for Sea Fishing and Aquaculture of the Ministry of Agricultural, Food and Forestry Policy) where commercial eel fishing has been stopped completely since the year 2009, no data collection is carried out. In the remaining nine regions, where eel fisheries are ongoing, eel fishery data are collected with a standard methodology, as foreseen by the Italian National Plan for the Data Collection Framework. Detailed data on catches and landings (by life stage, by type of fishing gear, by EMU, commercial and recreational, etc.) are available from 2009.

4.4 Recreational and non-commercial fisheries

Data for recreational catch and non-commercial landings for 2011 became more available compared with previous WGEEL reports. Almost all countries provided some estimates based on various methods. For the purpose of compilation, two sources of data were used; Country Reports and the CITES database, which substantially supplemented information gathered from WG participants.

In total, a catch of 660 tons of eels by recreational and non-commercial fishers was estimated in 2011. Taking into account lack of French and Portuguese data, this estimate might be higher.

The legal framework for collection of recreational fisheries data by EU Member States is given by the EU Data Collection Framework (Council Regulation (EC) No 199/2008 and Council Decision 2008/949/EC). The species for which recreational fishery data are to be collected in each area are:

- Baltic (ICES Subdivisions 22–32): Salmon, cod and eel.
- North Sea (ICES Division IV & VIId) and Eastern Arctic (ICES Division I & II): cod and eel.
- North Atlantic (ICES Division V–XIV): Salmon, sea bass and eel.
- Mediterranean and Black Sea: bluefin tuna and eel

For the period 2014–2020 the new DCF will be introduced. The EC (DG-MARE) has indicated some general principles in DC-MAP which are relevant to diadromous species, including improvement the quality of data and coverage of recreational fisheries. The last workshop about eel and salmon data collection (WKESDCF 2012) recommends the collection of data on all recreational and commercial eel and salmon fisheries regardless of how they are undertaken; however it should be noted that the distinction between recreational and commercial fisheries is not always clear, and it may be difficult to define precise métier because of the varied and specialised methods used to exploit these species (Table 4-7).

Table 4-7. Status and catch volume (if available; in t) of recreational and non-commercial eel fishing in 2011; 'Prohibited' (by law), 'Active' (permitted under regional angling licence), 'n/a' (not applicable due to non-occurrence in the region). Data source: CR & CITES database. 'Prohibited' may also include catch & release.

Country	Glass eel	Yellow eel	Silver eel	Not specified	Total
Norway	Prohibited	Prohibited	Prohibited		
Sweden	Prohibited	Prohibited	Prohibited		
Finland	n/a	no catches	no catches		
Estonia	n/a	Active	Active/1		1
Latvia	n/a	Active/1	Active	1	1
Lithuania	n/a	Active	Active	3	3
Poland	n/a	Active	Active	40	40
Germany	Prohibited	Active/154	Active/7	69	230
Denmark	n/a	Active	Active	80	80
Netherlands	Prohibited	Active	Active	230	230
Belgium	Prohibited	30/Prohibited****	No catches/Prohibited****		30
UK	Prohibited	Prohibited	Prohibited		
Ireland	Prohibited	Prohibited	Prohibited		
France	Prohibited	Active	Prohibited		
Spain	Active*/1	Active	Active/4**		4
Portugal	Prohibited	Prohibited***/Active	n/a		
Italy	Prohibited	Active/64	Active/13		77

*** Estimates for Basque inner basins RBD and Cantabria**

**** Estimation available for the Albufera Lagoon**

***** Prohibited in Minho River**

****** Data from Flanders/Wallonia**

4.5 Eel stocking

4.5.1 Trends in stocking

Data on stocking were obtained from a number of countries, separated for glass eels and for young yellow eels.

An overview of data available up to 2011 (partly 2012) is compiled in Annex 6, Tables 4-8 and 4-9. Note that various countries use different size and weight classes of young yellow eels for stocking purposes.

Stocking with glass eel has decreased strongly since the early 1990s and appears now to be growing again, due to EMP`s implementation (Figure 4-13). This decline has partly been compensated for by an increasing number of young yellow eels stocked since the late 1980s. During the 1990s stocking of young eel showed an increase but dropped again in the late 1990s (Figure 4-14). During recent years, another increase in stocking young yellow eels was observed.

In 2012, stocking of glass eels was the highest since 1995.

4.5.2 Stocking review notes

Sweden: Until the 1990s, the transport of eels from the west coast to the east coast (bootlace, sättål) has dominated the stocking programmes; recently, quarantined glass eel (elver, yngel) stocking is the only action left. Trollhättan eel (from Göta Älv) has always been a small quantity, and this transport has ended completely in 2005. In 2012, glass eels (elvers) were again imported from River Severn (UK) after a few years with French glass eels. According to the Swedish EMP about 2.5 million glass eels (in practice ongrown cultured eels) will be stocked annually. All stocked eel have been chemically marked since 2009.

Finland: In 1989 it was decided to carry on restockings only with glass eels reared in a careful quarantine. Since then, glass eels originating in River Severn in the UK have been imported through a Swedish quarantine and restocked in almost one hundred lakes in Southern Finland and in the Baltic along the south coast of Finland. All stocked eel have been chemically marked since 2009.

Lithuania: Stocking of Lithuanian inland waterbodies with glass eel originating in France or Great Britain began in 1956. During 1956–2007, a total of 148 lakes and reservoirs covering an area of 95 618 ha was stocked. About 50 million glass and juvenile eels were stocked in total. Stocking activities started again in 2011. 134 000 ongrown individuals were released in 2011, 444 000 individuals in 2012 to the inland waters.

Estonia: An historical database is available on stocking of glass eel/young yellow eel in Estonia, with records back to1950. During the period 2011–2014 the stocking of eel into L. Peipsi basin will supported by EFF up to 255 000 EUR (co-financing up to $^{0}/_{3}$ of total annual financing). In 2011, 680 000 glass eels were stocked (UK glass eels).

Latvia: Data on stocking from 1945–1992 obtained from archives of USSR institution Balribvod responsible on fish stocking and fisheries control in former USSR. Since 1992 every stocking of fish in natural waterbodies in Latvia must be reported to BIOR by special documents. In 2011, Latvia started stocking again. Glass eel were imported from Glass Eel UK by a supplier from Czech Republic. All stocking of any species in natural waterbodies must be reported by special protocol to the Ministry of Agriculture. Generally, few people ("commission") representing the local municipality and the fish supplier actually participate in stocking to certify the fact.

Poland: Eel stocking was initiated in regions within current Polish borders as early as at the beginning of the 20th. This was done mainly in rivers in the Vistula River basin and in the Vistula Lagoon. The stocking material of the day originated from the coasts of Great Britain (glass eel), although the Vistula Lagoon was also stocked with eel inhabiting the River Elbe 20–30 cm total length. In 2011 Poland started stocking within EMP framework. Because of ice coverage in the glass eel fishing season, about 6 tons of fingerlings (average of 5 grammes) were restocked in August in various waterbodies. Data on stocking by private stakeholders comes from eel importers. All eels are foreign source, glass eels-France, England, yellow eels-ongrown cultured-Denmark, Germany, Sweden.

Germany: There is no central database on stocking, but some data are available. The quantity of young yellow eels stocked to the waterbodies is significant.

Denmark: Stocking has taken place for decades by fishers in inland waters, in places where recruitment of young eel was limited or absent, because of migration barriers or distance to the ocean. Glass eels are imported mostly from France and are grown to a weight of 2–5 gramme in heated culture before they are stocked. Stocking is done as a management measure. In 2012 a total of 1284 million eels of size 2–5 gramme were stocked in lakes and rivers as a management measure and 0.25 million was stocked in marine waters.

Netherlands*:* Glass eel and young yellow eel are used for stocking inland waters since time immemorial, mostly by local action of stakeholders. Future stocking of 1–1.6 t of glass eel is foreseen. All young yellow eel stocked in 2012 originated from glass eel caught in France in 2011 and 2012. Overall all stocked of glass eel is sourced outside the Netherlands. The main stocking material is glass eels in the Netherlands.

Belgium: Glass eel stocking in Belgium, both in Flanders and in Wallonia, has been carried out from 1964 onwards, with glass eel from the catching station at Nieuwpoort (River Yser). However, due to the low catches after 1980 and the shortage of glass eel, together with regionalisation of the fisheries, this stocking was stopped in Wallonia. In Flanders, stocking was continued after 1980 with foreign glass eel imported mostly from UK or France. Also yellow eels were restocked, mostly from The Netherlands, but this was ceased after 2000 as yellow eels used for stocking contained high levels of contaminants. In Wallonia, glass eel stocking was again initiated in 2011, in the framework of the Belgian EMP. Quantities of glass eel stocked amount 40 and 50 kg for Wallonia in 2011 and 2012 respectively, in Flanders 120 and 156 kg.

UK: There is no stocking of ongrown eel anywhere in UK. Glass eel from the England and Wales fishery are stocked into river systems of England and Wales: 53.6 kg in 2010, 50.1 kg in 2011 and 20.5 kg in 2012. No eel stocking takes place in Scotland. In Northern Ireland, recruitment of glass eel and elver to Lough Neagh has been supplemented by stocking of purchased glass eel since 1984 (Table 5), and these eel have been sourced from the glass eel fishery in England and Wales. However, in 2010 the 996 kg of glass eel purchased from "UK Glass Eel Ltd" originated from fisheries in San Sebastian, Spain and the west coast of France: no glass eels from UK waters were purchased. In 2011 and 2012, glass eel from UK and French sources were stocked into Lough Neagh though all were purchased from "UK Glass Eels Ltd". Glass eel are not routinely quarantined before stocking into Lough Neagh, but arrive from "UK Glass Eels Ltd" with a Veterinary Health certificate.

Ireland: Purchase of glass eel for stocking from outside the state does not currently take place. Assisted migration of upstream migrating pigmented elvers takes place in the Shannon (Ardnacrusha) and Erne (Cathaleen's Fall) and of pigmented young eel (bootlace) on the Shannon (Parteen Regulating Weir). Prior to 2009, small amounts of glass eel and elver were taken in the Shannon estuary and in neighbouring catchments and these were stocked into the Shannon above Ardnacrusha and Parteen HPSs.

France: The first nationally organized stocking action started in 2010 in the Loire River. 209 kg (glass eel mean weight 0,233 g and thus 900 000 glass eels) were stocked in the Loire River in July 2010. However, the glass eel came from a CITES seizure. In 2011, eleven projects have been selected for a total amount of 4024 kg., but of this only 733 kg was really stocked, partly because of late selection process and partly because of supply. In 2012, eleven projects have been selected for a total amount of 3475 kg., of which 3086 kg were ultimately stocked.

Spain: No stocking on a national level. Each autonomy has its own rules and experience concerning stocking. In Asturias, the Head Office of Fishery purchased 6 kg and 8 kg of glass eel that were released in Sella and Nalón rivers in 2010 and 2011 respectively. In Cantabria, a 40% of the total landings of the 2010–2011 season recreational fisheries have been used for stocking. The corresponding amounts of glass eel have been obtained daily from the fishers, and kept alive in tanks by the Consejería de Medio Ambiente. In the Basque Country, a new pilot study started in the Oria River in 2011. During 2012, and within the same project, 2.8 kg of glass eels from the fishery were stocked directly in the Oria river and another amount was kept for fattening in an eel farm; 1.7 kg of ongrown glass eel were stocked after.

Portugal*:* No stocking on a national level.

Italy: The new glass eel regulation foresees that glass eel fisheries can continue on a local scale, provided that 60% is used for stocking in national inland waters open to the sea, and provided that fishers compile specific and detailed logbooks of catches and sales. Up to 2010, the new regulation was not in force, its definite approval being achieved in 2011. From 2011, the new regulation being in force, fishing has started again and catches are declared to the Ministry on a weekly basis. In the 2011–2012 season, 248.49 kg of glass eels from national fisheries have been used for stocking, amounting to 82.9% of the total glass eel catch in Italy in this season (299.48 kg). The remainder (51 kg, 17.2%) was used for aquaculture, either intensive or extensive (vallicoltura).

Morocco: No stocking carried out.

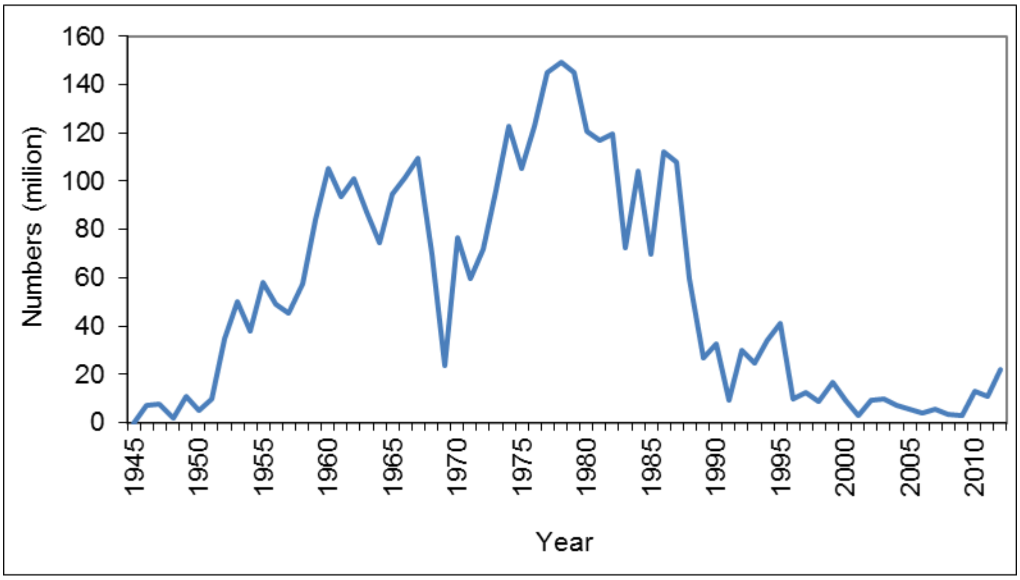


Figure 4-13. Stocking of glass eel in Europe (Sweden, Finland, Estonia, Latvia, Lithuania, Poland, Germany, the Netherlands, Belgium, Northern Ireland, France and Spain) in millions stocked. 2011–2012 data not fully available.

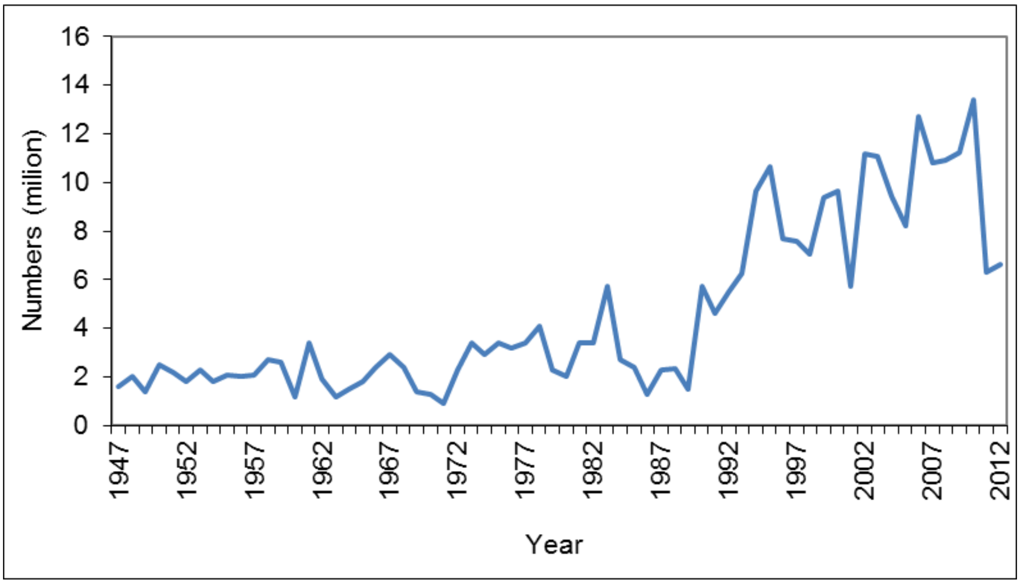


Figure 4-14. Stocking of young yellow eel in Europe (Sweden, Finland, Estonia, Latvia, Lithuania, Poland, Germany, Denmark, the Netherlands, Belgium, and Spain), in millions stocked. 2011–2012 data not fully available.

4.6 Categorizing of the different sizes and origins in stocked eels

This section examines the data from countries performing stocking, compiled and grouped according to their origin (local or foreign source) and to their size class (glass eel with or without quarantine, bootlace eel from the wild, ongrown eel from culture units). The aim was to update figures showing the development of stocking activities given in previous years (Section 4.5 of this report) and to distinguish between local and foreign origin of eels stocked. For this, data given in Country Reports were used. Portugal, Morocco and Norway state they do not stock at all.

Harmonization procedures were restricted to cases, where data did not correspond to size classes given in the template or when just biomass of stocked eels were available and had to be converted into numbers. The results (Table 4-10; Figure 4-15) indicate that stocking of larger eels, either pre-grown in farms or bootlace eel from the wild, prevails today, while in previous times most eels were stocked as glass eel.

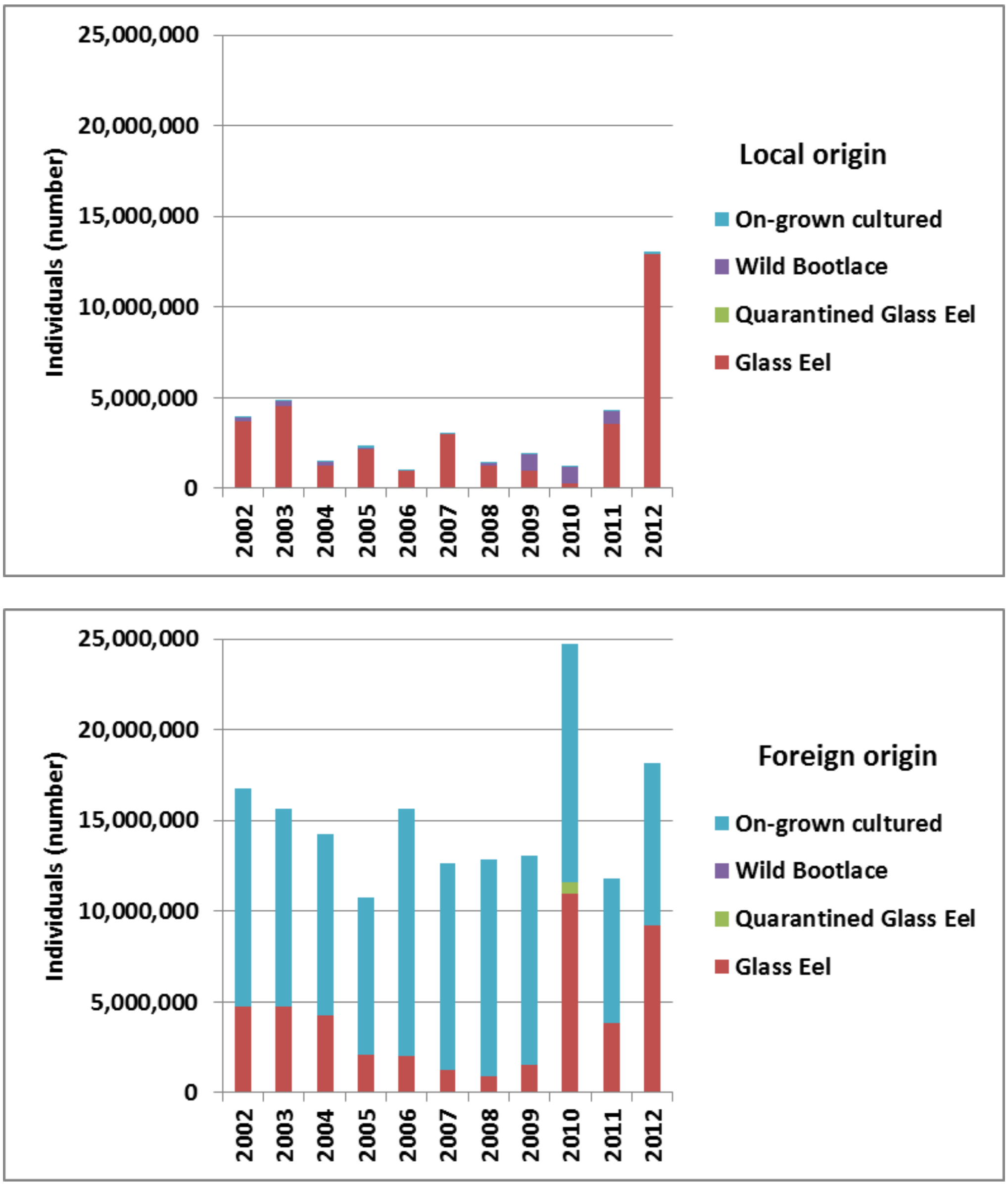


Figure 4-15. Stocked eels (individuals) classified according to origin (local origin upper figure, foreign origin lower figure) and size groups.

Table 4-10. Numbers of glass eels, bootlace and on-grown cultured eels stocked in Sweden, Finland, Estonia.

	SWEDEN							
	Local				Foreign			
YEAR	Glass Eel	Quarantined Glass Eel	Wild Bootlace *	On-grown cultured	Glass Eel	Quarantined Glass Eel	Wild Bootlace *	Ongrown cultured
2002	0	0	210 234	0	0	0	0	1 516 372
2003	0	0	278 598	0	0	0	0	701 866
2004	0	0	204 692	0	0	0	0	1 312 493
2005	0	0	66 158	0	0	0	0	1 037 331
2006	0	0	2 850	0	0	0	0	1 313 978
2007	0	0	27 067	0	0	0	0	971 507
2008	0	0	117 168	0	0	0	0	1 379 946
2009	0	0	16 478	0	0	0	0	763 214
2010	0	0	0	0	0	0	0	1 936 510
2011	0	0	0	0	0	0	0	2 625 984
2012	0	0	0	0	0	0	0	2 561 774
	FINLAND							
	Local				Foreign			
Year	Glass Eel	Quarantined Glass Eel	Wild Bootlace *	On-grown cultured	Glass Eel	Quarantined Glass Eel	Wild Bootlace *	Ongrown cultured
2002	0	0	0	0	0	0	0	55 000
2003	0	0	0	0	0	0	0	0
2004	0	0	0	0	0	0	0	63 500
2005	0	0	0	0	0	0	0	64 000
2006	0	0	0	0	0	0	0	55 000
2007	0	0	0	0	0	0	0	107 000
2008	0	0	0	0	0	0	0	206 000
2009	0	0	0	0	0	0	0	117 500
2010	0	0	0	0	0	0	0	153 000
2011	0	0	0	0	0	0	0	306 000
2012	0	0	0	0	0	0	0	177 000

Year	ESTONIA							
	Local				Foreign			
	Glass Eel	Quarantined Glass Eel	Wild Bootlace *	On-grown cultured	Glass Eel	Quarantined Glass Eel	Wild Bootlace *	Ongrown cultured
2002	0	0	0	0	0	0	0	360 000
2003	0	0	0	0	0	0	0	540 000
2004	0	0	0	0	0	0	0	440 000
2005	0	0	0	0	0	0	0	370 000
2006	0	0	0	0	0	0	0	380 000
2007	0	0	0	0	0	0	0	330 000
2008	0	0	0	0	0	0	0	190 000
2009	0	0	0	0	0	0	0	420 000
2010	0	0	0	0	0	0	0	210 000
2011	0	0	0	0	680 000	0	0	200 000
2012	0	0	0	0	910 000	0	0	100 000

Table 4-10. (continued). Numbers of glass eels, bootlace and on-grown cultured eels stocked in Latvia, Lithuania, Poland.

Year	LATVIA							
	Local				Foreign			
	Glass Eel	Quarantined Glass Eel	Wild Bootlace *	On-grown cultured	Glass Eel	Quarantined Glass Eel	Wild Bootlace *	Ongrown cultured
2002	0	0	0	0	230 000	0	0	200 000
2003	0	0	0	0	0	0	0	0
2004	0	0	0	0	0	0	0	0
2005	0	0	0	0	120 000	0	0	0
2006	0	0	0	0	6 000	0	0	0
2007	0	0	0	0	18 000	0	0	0
2008	0	0	0	0	0	0	0	3 000
2009	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	7 700
2011	0	0	0	0	386 000	0	0	3 600
2012	0	0	0	0	1 030 000	0	0	0

Year	LITHUANIA							
	Local				Foreign			
	Glass Eel	Quarantined Glass Eel	Wild Bootlace *	Ongrown cultured	Glass Eel	Quarantined Glass Eel	Wild Bootlace *	Ongrown cultured
2002	0	0	0	0	0	0	0	0
2003	0	0	0	0	353 000	0	0	0
2004	0	0	0	0	0	0	0	71 000
2005	0	0	0	0	0	0	0	2 000
2006	0	0	0	0	0	0	0	0
2007	0	0	0	0	0	0	0	5 000
2008	0	0	0	0	0	0	0	5 000
2009	0	0	0	0	0	0	0	10 000
2010	0	0	0	0	0	0	0	2 000
2011	0	0	0	0	0	0	0	134 000
2012	0	0	0	0	0	0	0	444 000

Year	POLAND							
	Local				Foreign			
	Glass Eel	Quarantined Glass Eel	Wild Bootlace *	Ongrown cultured	Glass Eel	Quarantined Glass Eel	Wild Bootlace*	Ongrown cultured
2002	0	0	0	0	0 000	0	0	600 000
2003	0	0	0	0	500 000	0	0	500 000
2004	0	0	0	0	2 300 000	0	0	500 000
2005	0	0	0	0	0	0	0	700 000
2006	0	0	0	0	0	0	0	1 100 000
2007	0	0	0	0	0	0	0	900 000
2008	0	0	0	0	0	0	0	1 000 000
2009	0	0	0	0	0	0	0	1 400 000
2010	0	0	0	0	0	0	0	1 400 000
2011	0	0	0	0	0	0	0	2 700 000
2012	0	0	0	0	0	0	0	3 900 000

Table 4-10. (continued). Numbers of glass eels, bootlace and on-grown cultured eels stocked in Germany, the Netherlands, Belgium.

	GERMANY							
	Local				Foreign			
YEAR	Glass Eel	Quarantined Glass Eel	Wild Bootlace*	Ongrown cultured	Glass Eel	Quarantined Glass Eel	Wild Bootlace*	Ongrown cultured
2002	0	0	0	0	2 905 514	0	0	7 173 966
2003	0	0	0	0	1 992 455	0	0	7 353 251
2004	0	0	0	0	1 641 157	0	0	7 287 534
2005	0	0	0	0	1 867 015	0	0	6 622 402
2006	0	0	0	0	1 081 956	0	0	9 632 642
2007	0	0	0	0	1 012 270	0	0	8 704 726
2008	0	0	0	0	501 200	0	0	8 575 113
2009	0	0	0	0	755 128	0	0	8 282 973
2010	0	0	0	0	4 813 464	0	0	8 190 661
2011	0	0	0	0	NA	0	0	NA
2012	0	0	0	0	NA	0	0	NA

	THE NETHERLANDS							
	Local				Foreign			
Year	Glass Eel	Quarantined Glass Eel	Wild Bootlace*	Ongrown cultured	Glass Eel	Quarantined Glass Eel	Wild Bootlace*	Ongrown cultured
2002	0	0	0	0	1 600 000	0	0	100 000
2003	0	0	0	0	1 600 000	0	0	100 000
2004	0	0	0	0	300 000	0	0	100 000
2005	0	0	0	0	100 000	0	0	0
2006	0	0	0	0	582 000	0	0	0
2007	0	0	0	0	216 000	0	0	0
2008	0	0	0	0	0	0	0	230 000
2009	0	0	0	0	300 000	0	0	300 000
2010	0	0	0	0	2 714 400	0	0	62 000
2011	0	0	0	0	798 630	0	0	996 293
2012	0	0	0	0	2 374 600	0	0	499 500

Year	BELGIUM							
	Local				Foreign			
	Glass Eel	Quarantined Glass Eel	Wild Bootlace*	Ongrown cultured	Glass Eel	Quarantined Glass Eel	Wild Bootlace*	Ongrown cultured
2002	0	0	0	0	0	0	0	0
2003	0	0	0	0	324 000	0	0	0
2004	0	0	0	0	0	0	0	0
2005	0	0	0	0	0	0	0	0
2006	0	0	0	0	330 000	0	0	0
2007	0	0	0	0	0	0	0	0
2008	0	0	0	0	375 000	0	0	0
2009	0	0	0	0	456 000	0	0	0
2010	0	0	0	0	429 000	0	0	0
2011	0	0	0	0	480 000	0	0	0
2012	0	0	0	0	618 000	0	0	0

Table 4-10. (continued). Numbers of glass eels, bootlace and on-grown cultured eels stocked in Ireland, United Kingdom, France.

Year	IRELAND							
	Local				Foreign			
	Glass Eel	Quarantined Glass Eel	Wild Bootlace *	Ongrown cultured	Glass Eel	Quarantined Glass Eel	Wild Bootlace *	Ongrown cultured
2002	711 000	0	0	0	0	0	0	0
2003	431 100	0	0	0	0	0	0	0
2004	0	0	0	0	0	0	0	0
2005	3 000	0	0	0	0	0	0	0
2006	6 600	0	0	0	0	0	0	0
2007	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0

Year	UNITED KINGDOM							
	Local				Foreign			
	Glass Eel	Quarantined Glass Eel	Wild Bootlace*	Ongrown cultured	Glass Eel	Quarantined Glass Eel	Wild Bootlace *	Ongrown cultured
2002	3 021 000	0	0	0	0	0	0	0
2003	4 104 090	0	0	0	0	0	0	0
2004	1 281 270	0	0	0	0	0	0	0
2005	2 156 010	0	0	0	0	0	0	0
2006	990 000	0	0	0	0	0	0	0
2007	3 000 000	0	0	0	0	0	0	0
2008	1 284 000	0	0	0	0	0	0	0
2009	645 000	0	0	0	0	0	0	0
2010	160 800	0	0	0	2 988 000	0	0	0
2011	1 113 300	0	0	0	2 142 000	0	0	0
2012	2 761 500	0	0	0	1 200 000	0	0	0
Year	FRANCE							
	Local				Foreign			
	Glass Eel	Quarantined Glass Eel	Wild Bootlace *	Ongrown cultured	Glass Eel	Quarantined Glass Eel	Wild Bootlace *	Ongrown cultured
2002	0	0	0	0	0	0	0	0
2003	0	0	0	0	0	0	0	0
2004	0	0	0	0	0	0	0	0
2005	0	0	0	0	0	0	0	0
2006	0	0	0	0	0	0	0	0
2007	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	627 000	0	0
2011	2 242 500	0	0	0	0	0	0	0
2012	9 258 000	0	0	0	0	0	0	0

Table 4-10. (continued). Numbers of glass eels, bootlace and ongrown cultured eels stocked in Spain and Italy and Denmark.

	SPAIN							
	Local				Foreign			
Year	Glass Eel	Quarantined Glass Eel	Wild Bootlace*	Ongrown cultured	Glass Eel	Quarantined Glass Eel	Wild Bootlace*	Ongrown cultured
2002	0	0	0	43 038	0	0	0	0
2003	0	0	0	64 373	0	0	0	0
2004	0	0	0	64 923	0	0	0	0
2005	0	0	0	119 647	0	0	0	0
2006	0	0	0	1 760	0	0	0	0
2007	0	0	0	20 804	0	0	0	0
2008	0	0	0	43 352	0	0	0	0
2009	0	0	0	19 843	0	0	0	0
2010	0	0	0	4 577	0	0	0	0
2011	2 900	0	0	19 294	0	0	0	0
2012	139 590	0	0	160 039	0	0	0	0

	DENMARK							
Year	Local				Foreign			
	Glass Eel	Quarantined Glass Eel	Wild Bootlace*	Ongrown cultured	Glass Eel	Quarantined Glass Eel	Wild Bootlace*	Ongrown cultured
2002	0	0	0	0	0	0	0	2 430 000
2003	0	0	0	0	0	0	0	2 240 000
2004	0	0	0	0	0	0	0	750 000
2005	0	0	0	0	0	0	0	300 000
2006	0	0	0	0	0	0	0	1 600 000
2007	0	0	0	0	0	0	0	830 000
2008	0	0	0	0	0	0	0	750 000
2009	0	0	0	0	0	0	0	810 000
2010	0	0	0	0	0	0	0	1 550 000
2011	0	0	0	0	0	0	0	1 560 000
2012	0	0	0	0	0	0	0	1 530 000

Year	ITALY							
	Local				Foreign			
	Glass Eel	Quarantined Glass Eel	Wild Bootlace*	Ongrown cultured	Glass Eel	Quarantined Glass Eel	Wild Bootlace*	Ongrown cultured
2002	0	0	0	0	0	0	0	0
2003	0	0	0	0	0	0	0	0
2004	0	0	0	0	0	0	0	0
2005	0	0	0	0	0	0	0	0
2006	0	0	0	0	0	0	0	0
2007	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0
2009	300 000	0	950 200	0	0	0	0	0
2010	133 500	0	894 000	0	0	0	0	0
2011	195 000	0	685 700	0	0	0	0	0
2012	745 500	0	0	0	4 030 000	0	0	0

Where stocking with eel from local sources takes place, mainly glass eel are stocked. Wild bootlace eel are playing a minor role; ongrown cultured eel are not in use.

When eels from foreign origin are stocked, ongrown cultured eel dominate by far. Only in the last three years, the proportion of glass eel increased. Wild bootlace eel with foreign origin are not being stocked.

In total, eel of foreign origin dominated stocking. The proportion of local sourced eel went down from >20% to <10% until 2010. Only in the last two years has the value increased again to >40%. This is partially attributed to the fact that data for Germany for these years are missing. Because in Germany a large amount of ongrown cultured eels have been stocked every year, the absence of current data is of great impact on the ratio shown in Figure 4-16.

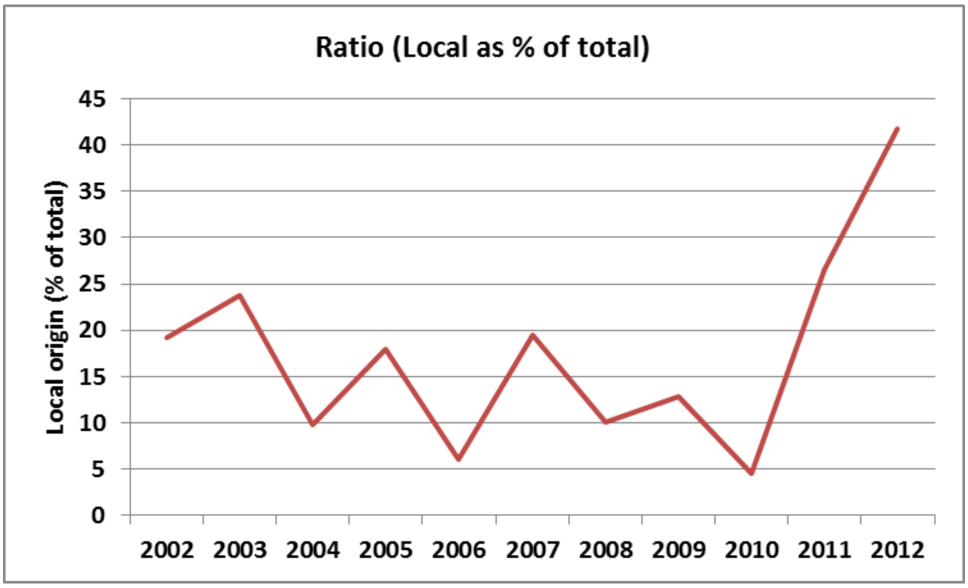


Figure 4-16. Percentage of eel with local origin used for stocking as compared to the total amount of eel stocked.

4.6.1 Methods when transferring stocked eel into "glass eel equivalents"

Due to the fact that stocked eel differ in size, an assessment of stock dynamics requires a synchronization of stocked eel with respect to size and time. Therefore, in a second step stocked eel of different individual size were transformed into "glass eel equivalents" and shifted to the respective year. Such glass eel equivalents are the number of true glass eels that would be required under natural circumstances to produce the same number of eels of the size actually restocked. The conversion is based on the average size and age of the restocked eels, and the expected number of eels that would have died between the glass eel stage and the stocking event. That means an ongrown eel of a certain size stocked in year x corresponds to a certain larger number of individuals of glass eel stocked in year x–y considering appropriate growth and mortality rates. Such normalized "glass eel equivalents" are to be used as a potential input parameter for following stock modelling and to clearly illustrate the total amounts of stocked eels if they would all have been stocked as glass eel.

For transformation of weight into length classes, the following equation was used for all datasets based on biomass values:

> Total length [cm]=9.604*Body mass [g] ^0.3033 (according to Simon, unpublished).

After this, numbers of individuals in length groups were transformed into equivalents of glass eel 7 cm in length. For countries operating VPA-models for stock analysis (e.g. Germany), mortality and growth rates from these models were applied. For all other countries, natural mortality was set on M = 0,138 (Dekker, 2000). An example of the total transformation from weight to glass eel equivalents is given in Table 4-12.

In terms of growth rates, data from literature and approximations were applied as in Table 4-11.

Table 4-11. Annual increment used to transform yellow eel into glass eel equivalent.

Country	*Annual length increment [cm]*	
Sweden		4.5
Finland		4.5
Estonia		4.5
Latvia		4.5
Lithuania		4.5
Poland		5.0
Germany	na	
Denmark		4.5
the Netherlands		5.0
Belgium	na	
Ireland	na	
United Kingdom	na	
France	na	
Spain		6.0
Italy		7.7

Table 4-12. Example for transformation procedure to calculate virtual glass eel equivalents from eels stocked at different sizes.

Type of stocking material	Glass eel	Ongrown (small)	Ongrown (large)	Ongrown (large)
Year of stocking	2012	2012	2012	2013
Length at stocking	7	10	25	25
Number stocked	100	100	100	100
Growth (cm/year)	4	4	4	6
Age (calculated)	0	0.75	4.5	3
M (natural mortality)	0.139	0.139	0.139	0.139
Year equivalent	2012	2011	2008	2010
Number equivalent	100	111	187	152

4.6.2 Problems and consequences for interpretation

The size and origin of eels stocked has been very diverse and is not known in detail for a number of countries. In these cases assumptions were made especially with regard to average size, which may have led to the misclassifying of those eels into size groups.

The natural mortality used in back-calculation of larger eels into glass eel equivalents applies to eels in natural habitats. The French EDA model used an additional 20% survival from the glass eel to the yellow eel stage. When larger eels were raised in aquaculture facilities before stocking, they might have experienced a different mortality. In addition, transformation of larger eels into glass eel equivalents led to a time shift. For example, 15 cm long on-grown eels stocked in 2010 were transformed into glass eel equivalents stocked in 2008. For bootlace eel caught in the wild, this shift resembles reality. However, eels pre-grown in farms should have had a much faster growth rate during that time and may originate from the same age cohort as the glass eel stocked that year. Therefore, the values of calculated glass-eel equivalents are of theoretical origin only and should not be interpreted and used as the true amount of glass eel assigned to stocking in a particular year.

There are some indications, that farm-sourced eels may experience problems after being stocked into natural waters and therefore display a poorer performance concerning growth and survival compared to glass eel (e.g. Pedersen, 2000; Simon and Brämick, 2012). As a result, the factors used here to transform pre-grown eels into glass eel equivalents (e.g. 1.0 pre-grown eel of 15 cm in total length was transformed into 1.3 glass eels) may not hold true particularly in cases where farm-sourced eels were used for stocking.

When interpreting the data on glass eel equivalents it has to be kept in mind, that due to the time shift applied to ongrown and bootlace eel when being transformed into glass eel equivalents, the values of the recent years (from 2006 onwards) will be affected by stocking of eel other than glass eel in coming years. Therefore, the trend of glass eel equivalents stocked can be judged only until 2006. Nevertheless, a sharp decrease between 1992 and 2005 can be observed (Table 4-13 and Figure 4-17).

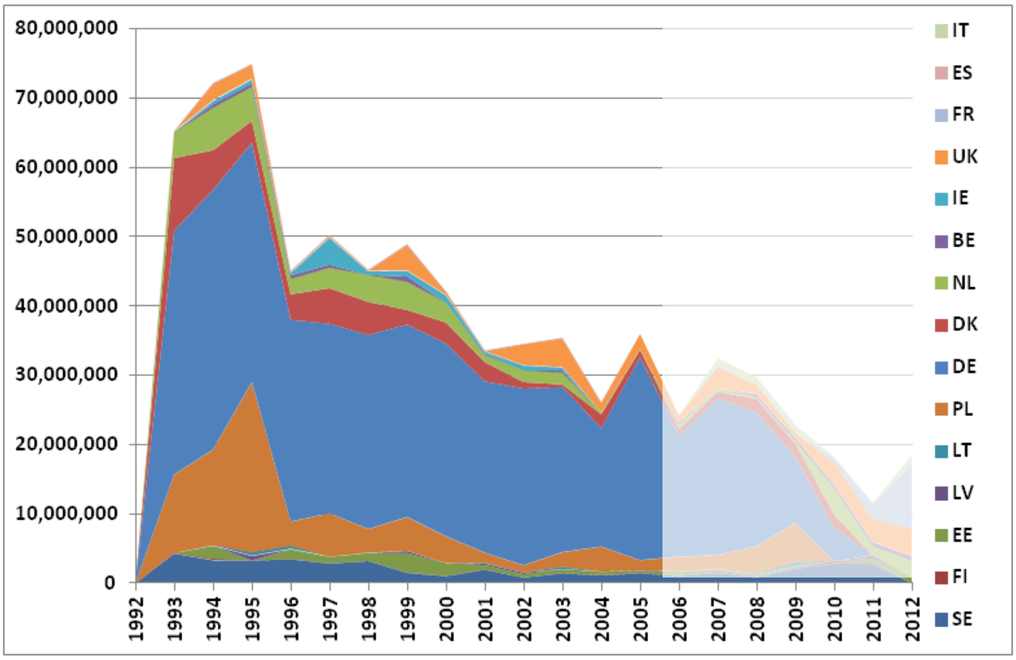


Figure 4-17. Total number of stocked eels in equivalent of glass eels stocked in Sweden (SE), Finland (FI), Estonia (EE), Latvia (LV), Lithuania (LT), Poland (PL), Germany (DE), Denmark (DK), the Netherlands (NL), Belgium (BE), Ireland (IE), United Kingdom (UK), France (FR), Spain (ES) and Italy (IT) during 1992–2012. Values from 2006 onwards are shaded because stocking with elvers and bootlace in coming years will lead to changes in this period.

Table 4-13. Numbers of stocked eels in equivalent of glass eels stocked in Sweden (SE), Finland (FI), Estonia (EE), Latvia (LV), Lithuania (LT), Poland (PL), Germany (DE), Denmark (DK), the Netherlands (NL), Belgium (BE), Ireland (IE), United Kingdom (UK), France (FR), Spain (ES) and Italy (IT).

	SE	FI	EE	LV	LT	PL	DE	DK	NL	BE	IE	UK	FR	ES	IT	Total
1992	3 688 731	113 406	2 717 090	0	0	13 800 000	27 409 773	9 180 905	3 743 130	0	0	2 357 610	0	201 447		63 212 092
1993	4 253 551	111 786	0	0	0	11 320 964	35 164 545	10 471 194	3 800 000	0	0	0	0	145 944		65 267 984
1994	3 286 333	233 941	1 900 000	0	70 897	13 786 122	37 471 324	5 707 049	6 200 000	525 000	462 000	2 315 610	0	259 299		72 217 575
1995	3 247 799	80 551	0	600 000	529 000	24 565 157	34 529 250	3 138 877	4 998 130	472 500	582 000	2 058 000	0	133 165		74 934 429
1996	3 421 263	88 781	1 400 000	0	467 713	3 520 964	29 085 001	3 697 175	2 286 261	507 000	312 000	99 570	0	238 768		45 124 496
1997	2 842 197	83 759	900 000	0	5 897	6 253 543	27 357 723	5 111 531	3 029 391	432 000	3 879 000	211 410	0	178 854		50 285 305
1998	3 167 614	67 504	1 136 798	0	77 268	3 365 157	28 000 950	4 751 739	3 958 783	0	516 000	51 810	0	167 570		45 261 193
1999	1 489 731	65 900	2 821 017	300 000	0	4 865 157	27 776 330	2 109 127	4 115 652	754 500	810 000	3 600 000	0	272 761		48 980 175
2000	1 014 868	49 143	1 881 525	0	0	3 820 964	27 819 693	3 014 811	2 921 565	0	1 044 000	450 990	0	104 265		42 121 824
2001	1 933 017	59 403	636 798	233 306	104 673	1 420 964	24 731 658	2 779 085	1 021 565	162 000	354 000	0	0	200 468		33 636 937
2002	799 579	0	535 490	230 000	2 949	1 009 350	25 502 208	930 497	1 721 565	0	711 000	3 021 000	0	99 999		34 563 637
2003	1 417 571	68 584	549 962	0	353 000	2 086 122	23 824 494	372 199	1 721 565	324 000	431 100	4 104 090	0	198 406		35 451 093
2004	1 120 379	69 124	477 599	0	7 371	3 597 736	17 101 592	1 985 061	300 000	0	0	1 281 270	0	215 476		26 155 608
2005	1 419 175	59 403	274 981	120 000	7 371	1 441 929	29 318 732	1 029 750	100 000	0	3 000	2 156 010	0	2 117		35 932 468
2006	1 049 286	115 566	607 853	6 000	14 743	2 018 700	17 498 863	930 497	582 000	330 000	6 600	990 000	0	25 028		24 175 136
2007	1 490 424	222 492	303 927	21 500	2 949	2 018 700	22 563 170	1 004 937	495 600	0	0	3 000 000	0	130 429	1 185 922	32 440 050
2008	824 317	126 907	289 454	0	197 552	3 893 208	19 320 210	1 923 027	364 696	375 000	0	1 284 000	0	36 142	1 115 780	29 750 293
2009	2 091 546	165 249	144 727	8 982	654 576	5 623 523	9 536 388	1 935 434	375 370	456 000	0	645 000	0	75 108	1 155 806	22 867 709
2010	2 836 220	330 498	0	4 200	0	0	4 813 464	1 898 214	3 925 546	429 000	0	3 148 800	627 000	107 028	133 500	18 253 470
2011	2 766 869	191 171	680 000	386 000	0	0	NA	0	1 405 848	480 000	0	3 255 300	2 242 500	27 501	195 000	11 630 189
2012	NA	NA	910 000	1 030 000	0	0	NA	0	2 374 600	618 000	0	3 961 500	9 258 000	139 590	1 148 500	19 440 190

na = not applicable.

4.7 Aquaculture production

Aquaculture production data for European eel limited to European countries from 2003 to 2011 are compiled by integrating different sources, Country Reports to WGEEL 2011 (Table 4-14), FAO (Table 4-18) and FEAP (Table 4-19). Some discrepancies exist between databases and the national reports annexed to this report, but overall the trend in aquaculture production is decreasing form 8000–9000 t in 2003 to approximately 5000–6000 t in 2010/2011 (Figure 4-18). Some of the discrepancies between FAO and the Country Reports data result from eel used for stocking not being reported to the FAO.

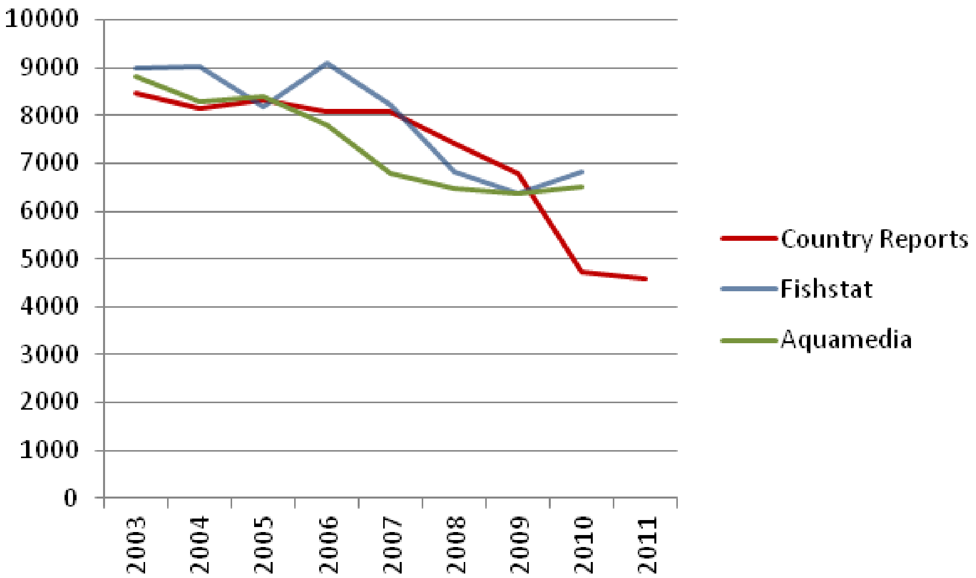


Figure 4-18. Different sources of data for aquaculture production of European eel in Europe from 2003 to 2011, in tonnes.

Table 4-14. Aquaculture production of European eel in Europe from 2003 to 2011, in tonnes as reported in the Country Reports. n.d. = no data.

	2003	2004	2005	2006	2007	2008	2009	2010	2011
Denmark	2050	1500	1700	1900	1617	1740	1707	1537	1156
Estonia	18	26	19	27	52	45	30	20	n.d.
Germany	372	328	329	567	740	749	667	681	660
Netherlands	4200	4500	4500	4200	4000	3700	3200	2000	2300
Portugal	4.7	1.5	1.4	1.1	0.5	0.4	1.1	n.d.	n.d.
Sweden	170	158	222	191	175	172	139	91	94
Poland	1	1	1	1	1	1	1	1	1
Italy	1325	1220	1131	807	1000	551	587	n.d.	n.d.
Spain	339	424	427	403	478	461	450	411	391
Total	8475	8157	8329	8096	8063	7419	6781	4741	4602

Table 4-15. Aquaculture production of European eel in Europe from 2003 to 2010, in tonnes. Source: FAO FishStat.

	2003	2004	2005	2006	2007	2008	2009	2010
Denmark	2012	1823	1673	1699	1614	895	1659	1900
Estonia	15	7	40	40	45	47	30	20
Germany	150	322	329	567	440	447	385	398
Netherlands	4200	4500	4000	5000	4000	3700	2800	3000
Portugal	5	2	1	2	1	1	1	1
Sweden	170	158	222	191	175	172	0	0
Poland								
Italy	1550	1220	1132	807	1000	551	567	647
Spain	339	424	427	403	479	534	488	423
Greece	544	557	372	385	454	489	428	430
Hungary	11	11	5	0	0	0	0	0
Total	8996	9024	8201	9094	8208	6836	6358	6819

Table 4-16. Aquaculture production of European eel in Europe from 2003 to 2008, in tonnes. Source: Aquamedia.

	2003	2004	2005	2006	2007	2008	2009	2010
Denmark	2050	1500	1610	1760	1870	1870	1500	1899
Estonia								
Germany								
Netherlands	4200	4500	4500	4200	3000	3000	3200	3000
Portugal								
Sweden	194	158	222	191	175	172	170	170
Poland								
Italy	1550	1220	1132	808	1000	550	568	568
Spain	315	390	405	440	280	390	510	446
Greece	500	500	500	385	454	489	428	428
Hungary	20	20	20	20				
Total	8829	8288	8389	7804	6779	6471	6376	6511

4.8 Conclusion on data and trends

The Working Group has identified a growing need to standardize and manage its databases. A strategy has been put in place in conjunction with the ICES database to achieve this in coming years (See Chapter 13 of this report).

Recruitment has returned to 2007–2008 level for the series outside the North Sea. This change is within the range of normal variation within the series, and recruitment levels remain at a low level. The WGEEL recruitment index (five year average) is currently at its lowest historical level, less than 1% for the North Sea and 5% elsewhere in the distribution area with respect to 1960–1979.

Commercial landings have also declined to a low level to less than 4000 t (but stable in the last 8–9 years). Aquaculture production has slowly decreased to 6000 t in 2010.

As a result of entry into force of EMPs, stocking starts to increase with about 22 million glass eels and 10 million mainly ongrown yellow eels restocked in 2012.

For most of the Country Reports, the basic indicators on the status of eel fisheries (fishing capacity, fishing effort) were missing or incomplete. The inaccuracy and poor representativeness of these indicators leads to wide uncertainties, and prevents any comparisons.

Data on catch was provided by all MS participating in the WGEEL, but some discrepancies between data sources (CR and CITES) were identified. In total, around Europe professional fishers and recreational fishers landed 3201 t and 660 t respectively, giving a total of around 4000 t of eel.

The WGEEL has continued to collect yellow and silver time-series. This work needs to be extended in order to enable an analysis of those series, permitting in future some fishery-independent trends to be included in the advice. These can also be used to ground-truth the EMU assessments and S/R relationship.

5 Glass eel landings and trade

Chapter 5 addresses the following Terms of Reference:

a) assess the trends in recruitment, stock and fisheries indicative of the status of the European stock, and of the impact of exploitation and other anthropogenic factors; analyse the impact of the implementation of the eel recovery plan on time-series data (i.e. data discontinuities). Establish an international database for data on eel stock and fisheries, as well as habitat and eel quality (update EQD) related data – seek advice from ICES Data Centre for this task; review and make recommendations on data quality issues;

and has links to:

c) respond to specific requests in support of the eel stock recovery Regulation, as necessary;

This task was organized under the following headings:

1) Assess quantities of glass eel caught and their destiny:

- caught in the commercial fishery;
- exported to Asia;
- internal trade between EU Countries;
- used in stocking;
- used in aquaculture for consumption;
- consumed direct;
- mortalities.

Assess where possible "movement through" countries and match up import/exports;

2) compare with the commitments to stocking in the EMP (use stocking data supplied in ICES review table).

5.1 Introduction

Given the decline in eel stock, information on the trade of all stages of the European eel is necessary for a complete understanding of the fishery mortality. However, a complete description of eel trade was deemed to be beyond the scope of the WGEEL at the present time and given the value and continued use of the declining resource of glass eel for consumption, aquaculture and stocking, the decision was made to begin the task of trade assessment by focusing on the glass eel trade. In addition, the Eel Regulation requires that:

- "60% for stocking is to be set out in an Eel Management Plan established in accordance with Article 2. It shall start at least at 35% in the first year of application of an Eel Management Plan and it shall increase by steps of at least 5% per year. The level of 60% shall be achieved by 31 July 2013." Article 7,2.
- "No later than 1 July 2009, Member States shall: take the measures necessary to identify the origin and ensure the traceability of all live eels imported or exported from their territory." Article 12.

Glass eel trade data incorporated into the EuroStat Database and ICES/EIFAAC WGEEL Country Reports were examined to determine the destiny of glass eel in 2012. The results were compared with those from similar analyses in 2011 (ICES, 2011).

In this task we want to be sure that we only obtain data on **stocking** that is the practice of adding fish [glass eel] to a waterbody from another source, to supplement existing populations or to create a population where none exists.

It is not where glass eel are caught and transported around an obstruction; we have termed this **assisted migration**.

5.2 Trade analysis

Three datasets were used in the trade analysis. These consisted of the CITES data (2008–2012 data provided by EU DGENV), data provided by country representatives at the WGEEL, and the EuroStat database (EU27 trade since 1988 by CN8 (DS_016890)).

The best estimate of the total catch of glass eel in 2012 was 45 392 kg (Table A.1) of which 34 957 kg were exported. Following the provision of additional data from Portugal for 2011 (1085 kg) the estimate for the 2011 glass eel harvest was adjusted to 42 649 kg (previously 41 564 kg). As such the catch of glass eel in 2012 represented an increase of 2743 kg (6.4%) which may have been influenced by the introduction of a quota in 2010 on the French glass eel fishery.

Table 5-1. The amount of glass eel caught and exported in 2012. This table is based on preliminary data; the intention is to show the technique, but specific outcomes will certainly change in future assessments.

Country	Total Catch (kg)	Total Export (kg)	Internally Stocked (kg)	Total (kg)	Loss (%)
UK	3820	2713	920	3633	4.9
France	34 256	24 004	3068	27 072	21
Spain	6209	4634#	652^	5286	42.9*
Portugal	807	807	0	807	0
Italy	300	0	300	300	0
Morocco	no data	no data			
Total 2012	45 392			36 537	19.5

 # includes illegal exports.

^ non-inclusive of 1580 kg of illegally traded glass eel seized and then stocked.

*** % loss figure calculated by including locally caught and imported eel (= 12 010 kg) and considering illegal seizures (= 2390 kg) and declared export (= 2214 kg) and assuming all seized fish originated in the declared fishery landings. If all illegally seized eel are assumed to have originated from an undeclared fishery this loss falls to 35.8%.**

5.3 Difference between catch and exports

The best estimate of catch of glass eel from the various donor countries is given in Table A1 together with the estimate of glass eel that could be accounted for through exports, internal usage in the donor country for stocking, aquaculture and/or consumption and from seizures. Of the total catch of ~45.4 t the destiny of 35 t could be accounted for, and this represents an overall loss rate of 23%. Some of this loss may be explained by mortality and loss of weight post-capture, some through underreporting of exports and through illegal activities.

For the UK glass eel are caught using handnets and this is thought to account for the lower loss rate (5%) when compared with France (21%) where most glass eel are fished using trawls.

For Spain the total export includes a seizure of 800 kg together with an export of 130 kg to Portugal in addition to those identified in Table 5-1 from the EuroStat database giving a total of 3.1 t; this represents a loss rate of ~50%. Some of this loss may be explained by mortality in the trawl fishery and also possibly from the illegal (undisclosed) export of glass eel.

For Italy, the loss rate is minimal as they operate a truck and transport system with only one or two days between capture (using fykenets) and stocking in the wild or transfer to an aquaculture facility. For Portugal no information was available.

5.4 Destination of the catch by country

The initial destination of glass eels landed in France, Portugal, Spain and the UK are reported here in two different ways, using

1) data from Country Reports or by country representatives at WGEEL (="WGEEL-CR");
2) by querying the EuroStat import/export database (Table 5-2).

The EuroStat database query was for the period September 2011–June 2012 and undertaken on 05/09/2012. The query collected export data from France (FR), Portugal (PT), Spain (ES) and the United Kingdom (UK), to BE, CZ, DE, DK, EE, EL, ES, FR, IE, IT, LT, LV, NE, PO, PT, RO, SE, SI, SK, UK, together with all 27 EU countries combined, and Morocco, Korea, Hong Kong and China. The EuroStat database has been updated in the last year, and distinction is now made by type of eel consignment, allowing live eels of <12 cm to be readily identified. However, it appears from the prices charged that some of the exports are not correctly labelled, and in such cases distinction between glass eel and yellow eel was made according to the methods in Briand *et al*. (2008). The EuroStat database has several limitations when dealing with glass eel. Sometimes the nature of the exports is not clear and must be assumed from its price, while at others some glass eels may be included in a consignment of yellow eels, and the proportion of glass eels must be estimated from price. Furthermore all data in EuroStat are rounded to the nearest 100 kg, while much trading of glass eel takes place in smaller quantities: in such cases a more precise estimate of the weight of the consignment can be made by assuming that the mean price for glass eels was paid.

The total export of glass eel according to EuroStat was 24 t for France, 3.7 t for UK, 2.2 t for Spain and 0.9 t for Portugal.

Comparison of the two datasets for the countries shows reasonably close correspondence between the two methods for Portugal (0.8 t from C.R. vs. 0.9 t from EuroStat) and for the UK (4.3 t vs. 3.7 t). In the case of Portugal the discrepancy is likely only due to the rounding error involved in the 100 kg units of EuroStat. In the case of the U.K, the EuroStat data leaves 0.6 t unaccounted for. Using the data available from glass eel dealers in the United Kingdom, it can be seen that the UK trade of eels tallies more or less perfectly, and that the source of the discrepancy using EuroStat originates from three consignments late in the season (0.34 t to Latvia, 0.4 t to Denmark and 0.09 t to Estonia in May 2012), none of which appear in EuroStat, and indeed, no exports from the UK appear in EuroStat for May and June 2012. This suggests that the data had not been entered into the database at the time it was queried (05/09/2012). Thus the data are likely to be up to date only until the end of April 2012 (four months previously). This apparent delay is not likely to have affected the data for glass eel exports from France and Spain, since the trade in glass eel from these countries is complete by February or March.

By contrast to the close correspondence between C.R. data and EuroStat data for the UK, there are large differences between the two reported datasets for Spain (no data from C.R. vs. 2.4 t from EuroStat) and France (9 t from C.R. vs. 24 t from EuroStat). This latter discrepancy is because France C.R. was only able to report on the destination of glass eels used specifically for stocking.

Accordingly it appears that EuroStat can well describe glass eel exports in Europe (although perhaps not fully until later in the reporting year than September), and at present appear to be more reliable than the reporting systems of the main exporting countries (with the possible exceptions of the UK and Portugal), which are not currently adequate for assessing even the initial exports of glass eels. EuroStat itself is not useful for tracing any subsequent reexports of glass eel consignments. The spatial distribution and quantities of exported eels from the main donor countries are presented in Figures 5-1, 5-2 and 5-3.

Table 5-2. The direct destination and quantity of glass eel landed in France, Portugal, Spain and the UK in the 2011–2012 fishing season, recorded from two different sources: Country Reports (C.R) to WGEEL and EuroStat. This table is based on preliminary data; the intention is to show the technique, but specific outcomes will certainly change in future assessments.

Destination	Quantity exported (kg)							
	UK		France		Spain		Portugal	
	C.R.	EuroStat	C.R.*	EuroStat	C.R.	EuroStat	C.R.	EuroStat
Belgium	0	0	160	26	no data	0	0	0
Czech Rep.	76	100	520	500	no data	0	0	0
Denmark	1350	1000	2750	4700	no data	0	0	0
Estonia	90	0	0	0	no data	0	0	0
France	0	0	n/a	n/a	no data	100	0	0
Germany	544	800	1761	4913	no data	0	0	0
Greece	450	400	0	700	no data	600	0	0
Italy	0	0	0	73	no data	100	0	0
Latvia	343	0	0	0	no data	0	0	0
Netherlands	100	100	2086	6000	no data	1400	0	0
Poland	120	100	90	100	no data	0	0	0
Portugal	0	0	0	n/a	no data	0	n/a	n/a
Slovakia	0	15	0	0	no data	0	0	0
Spain	n/a	n/a	352	4992	n/a	n/a	807	900
Sweden	1200	1200	0	0	no data	0	0	0
UK	0	n/a	400	2000	no data	14	0	0
Total	4273	3715	8119	24 004	0	2214	807	900

***data only available for eels destined for stocking.**

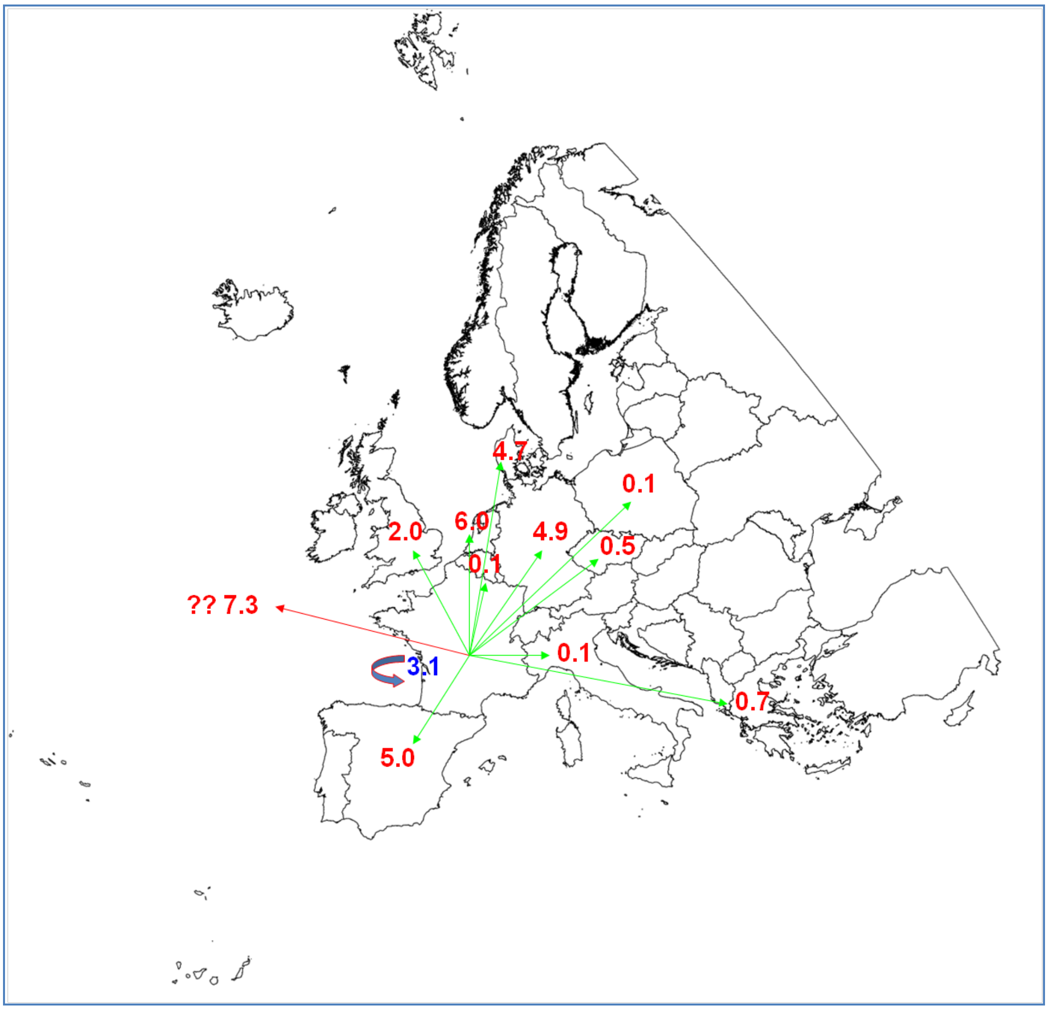


Figure 5-1. Destination and quantity of glass eels landed in France for the 2011–2012 fishing season, (data from EuroStat, values in tonnes). The total recorded export was 24.0 t. Together with 3.1 t sold for use within France (data from Country Report) this leaves a total of 7.2 t unaccounted for when compared with the reported landings of 34.3 t. These 'lost' eels may be accounted for by a combination of post-fishing mortality and/or underreporting and illegal trade (see Section 6.2). This map is based on preliminary data; the intention is to show the technique, but specific outcomes will certainly change in future assessments.

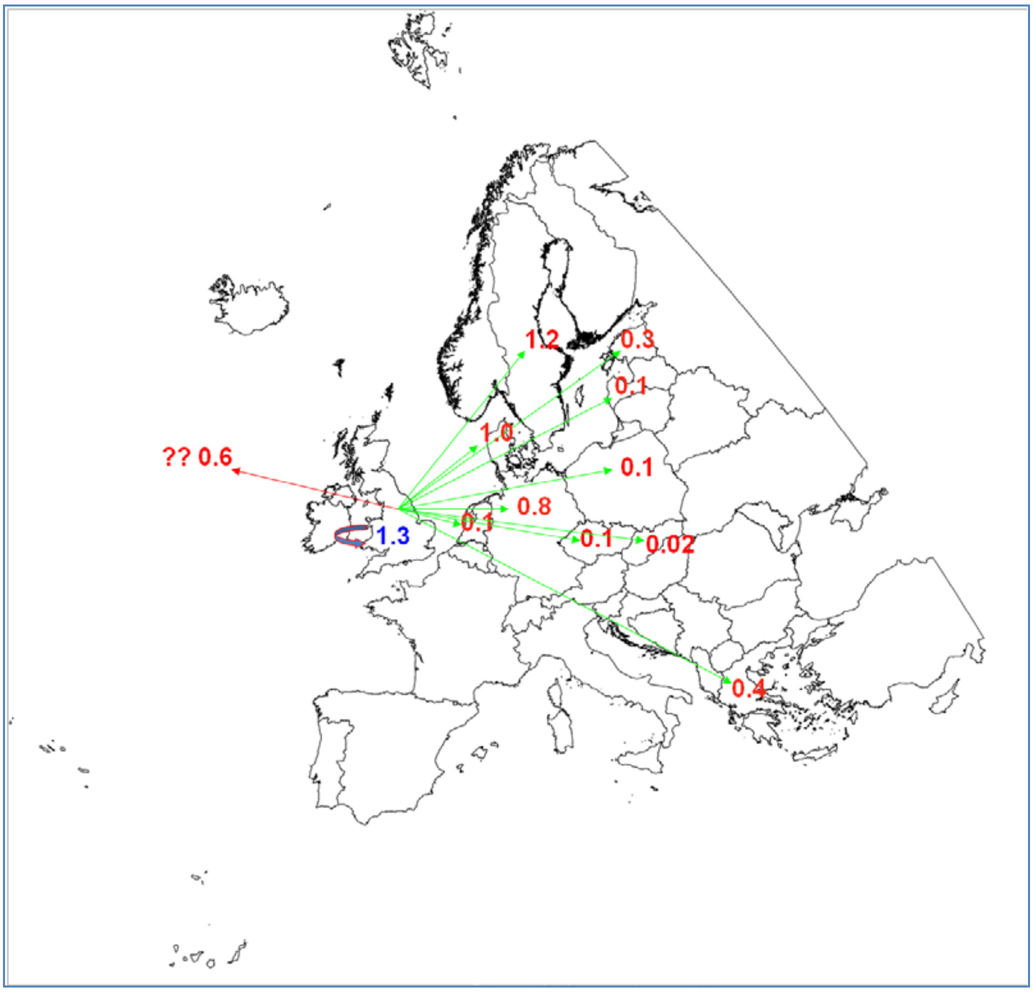


Figure 5-2. Destination and quantity of glass eels landed in the UK for the 2011–2012 fishing season, data from EuroStat (values in tonnes). A total of 3.7 t were exported, and 1.3 t were used within the UK (from Country Report). When compared with the reported landings, and adding the 2.0 t imported from France (EuroStat data) gives a total of 0.6 t unaccounted for. These are thought to be the result of EuroStat data not being complete for May and June 2012 (as of September 2012). This map is based on preliminary data; the intention is to show the technique, but specific outcomes will certainly change in future assessments.

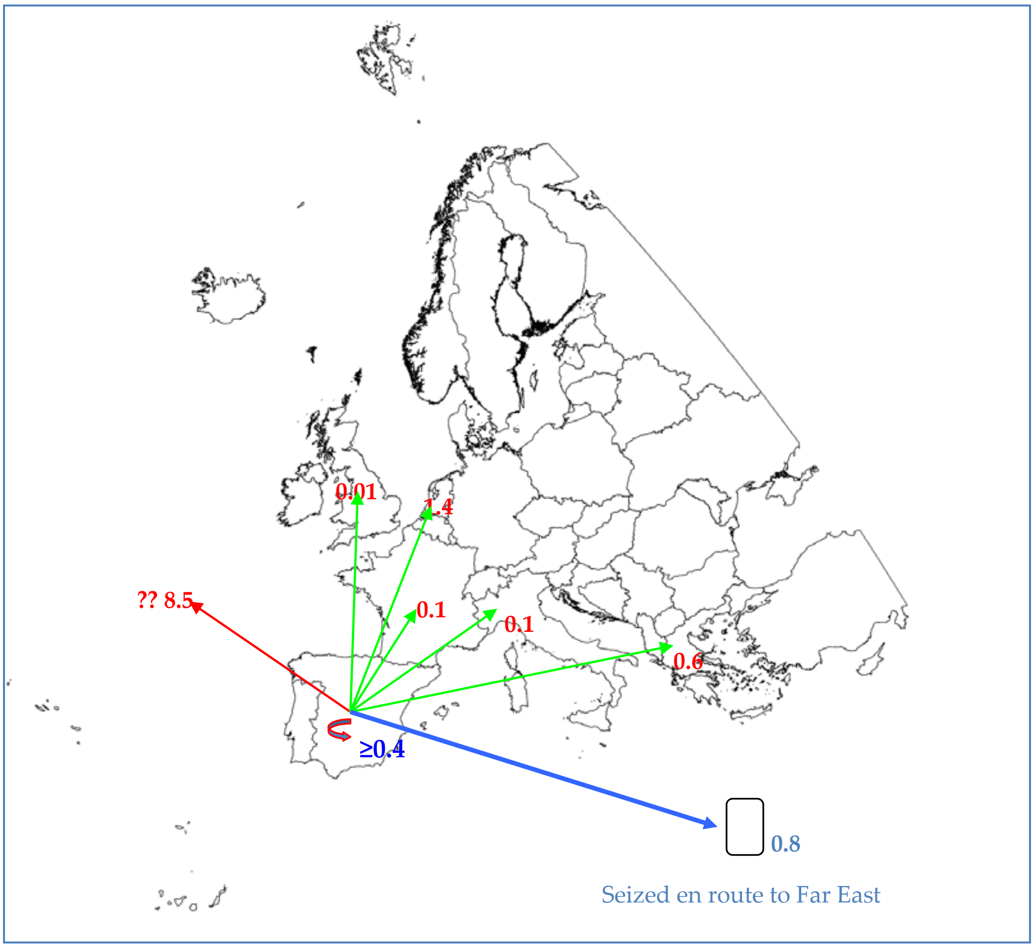


Figure 5-3. Destination and quantity of glass eels landed in Spain for the 2011–2012 fishing season (data from EuroStat), values in tonnes). At total of 2.2 t were exported, and an unknown amount (but at least 0.35 t according to French Country Report) was stocked internally. A further 0.8 t of glass eels were seized en route to China and the Philippines (data from CITES). Compared with the reported landings of 6.2 t (data from CITES), and including 5.0 t imported from France and 0.9 t imported from Portugal (EuroStat data), this leaves a total of 8.5 t unaccounted for. These 'lost' eels are likely the consequence of post-fishing mortality and/or the result of underreporting and/or illegal trade (see Section 5.2). This map is based on preliminary data; the intention is to show the technique, but specific outcomes will certainly change in future assessments.

5.5 Data audit and anomalies

In order to assess the reliability of the traceability system among countries regarding glass eel trade, a comparison has been made of import and export declarations data for the year 2012, as reported by donor countries (UK, France, Spain, Portugal, Italy and Morocco) and by recipient countries (all) and as derived by the EuroStat database query (see 5.2.2). Country data, both donor and recipient, has been derived by the Country Reports and by the specific questionnaires submitted to delegates.

Data presented in the Country Reports and in the questionnaires in most cases concern only glass eels used for stocking, because these data had been collected to meet the requirements of the EMPs with regards to stocking. Only some countries include glass eel quantities destined to aquaculture. By contrast the EuroStat data should include glass eels destined for both stocking and aquaculture.

Results are reported in Figure 5-4, where glass eel quantities as declared by the different sources (donor country, recipient country and EuroStat system) have been plotted separately for the three main donor countries (UK., France and Spain). It is evident that there are discrepancies in most cases.

For some countries, it was not possible to trace the destination of glass eel catch, amounting to ~16 t, even if in the WGEEL-CR it is stated that no use for stocking, aquaculture or direct consumption occurs within the country. Portuguese glass eel catch occurring in the Minho is exported to Spain (807 kg declared to be exported to Spain in 2012).

A further element of confusion originates from the fact that some countries buy glass eels on tender by companies that have purchased them from abroad, and therefore the original donor country is not identifiable. Such is the case for Latvia, which has imported glass eels via a dealer from the Czech Republic, but it has been ascertained that they came direct from the UK. Similarly Finland has stocked ongrown eels bought from Sweden that were quarantined and ongrown glass eels originating in the UK.

Another source of anomaly may arise from illegal trade, which traceability systems will not solve, but will highlight. For example, in the period from November 2011 to February 2012, four incidents of illegal export were recorded in CITES database, amounting to 858 kg of glass eel. These all originated from Spain and were intercepted en route to China and the Philippines. A further 1580 kg were seized in March in Bulgaria having originated in Spain again en route to the Far East (data from WGEEL-CR). This latter seizure was subsequently stocked into Spanish rivers though their quality following their illegal trading must be dubious. A further 356 kg of illegally landed glass eel were intercepted in Portugal.

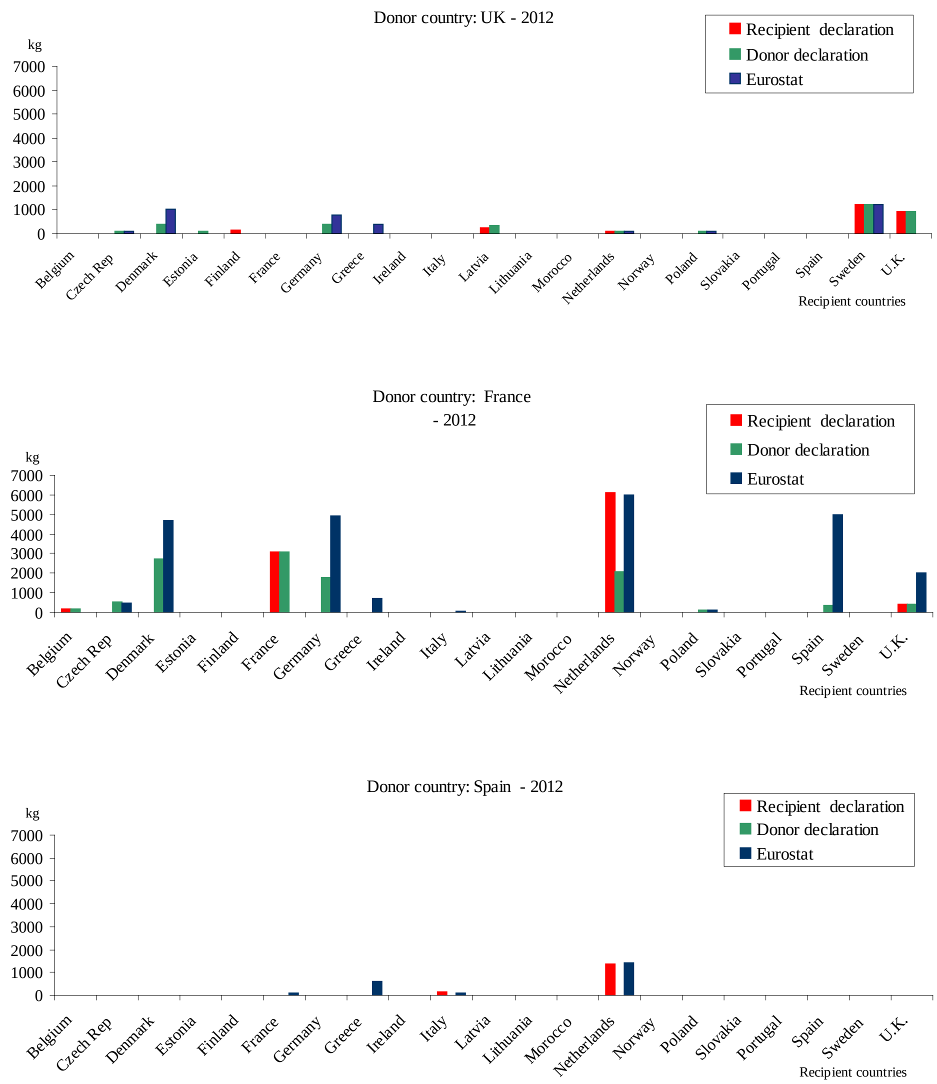


Figure 5-4. Comparison of the quantity of glass eel received by a country as identified from the EuroStat database and recipient and donor country WGEEL Country Reports. Data split by export country (United Kingdom (UK), France and Spain).

5.6 Quantity of glass eel identified being used for stocking and aquaculture

Following the provision of additional data for 2011 the amount of glass eel that was stocked, used for aquaculture or consumed, together with the proportion where the destiny could not be identified was recalculated and is shown in Table 5-4. From the original analysis of trade data in 2011 (ICES, 2011), at least 12% was used for stocking, 30% was used in aquaculture, while it was not possible to identify the destiny of the remaining 58% (Figure 5-5, top left). However retrospective calculations using data provided by Germany and Denmark for 2011 (Table 5-4) which allocated approximately 8 t of “unaccountable” glass eels to aquaculture changed these data significantly with the outcome that 12% were used in stocking, 50% in aquaculture and the destiny of 38% remaining unknown (Figure 5-5, bottom left).

Similar analysis of the 2012 data (Table 5-5) found that of the 45.4 t caught in 2012 16% went to stocking, 22% went to aquaculture whilst the final destiny of 62% remained unknown (Figure 5-5, top right). However if a speculative calculation is made based on a similar usage of glass eel by Germany and Denmark (to be reported at a later date) the figures relating to the destiny of glass eel change with 16% going to stocking, 42% to aquaculture and 42% remaining unknown (Figure 5-5, bottom right).

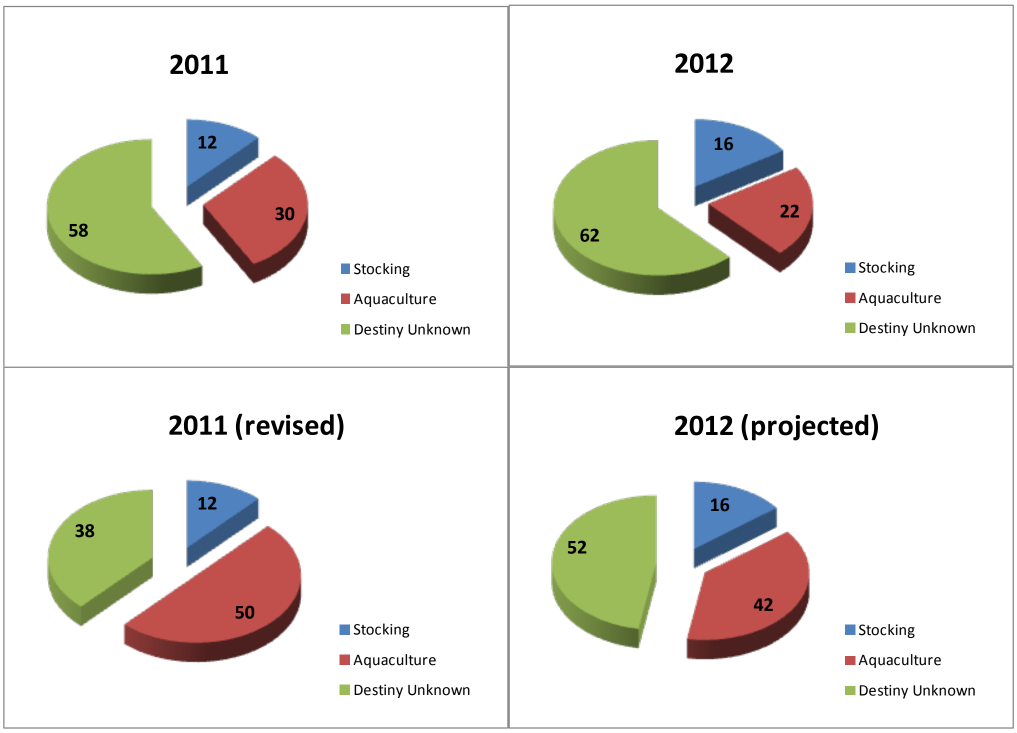


Figure 5-5. Figures showing the proportion of glass eel that was identified by WGEEL as being stocked, used for aquaculture and whose destiny was unknown. The top left shows the data for 2011 (WGEEL 2011) and the bottom left shows the updated figures. The top right shows the WGEELs best estimate for 2012, and the bottom right gives a possible outcome by applying a similar correction to the figures as applied to the 2011 data.

Table 5-3. The destiny of glass eel by country in 2011 (revised figures).

Country	Quantity (kg)			
	Total	Stocked	Aquaculture	Unknown
Austria				
Belgium	160	160	0	0
Bulgaria				
Cyprus				
Czech Rep	30	30	0	0
Denmark	7002	614	6388	0
Estonia	306	208	98	0
France	733	733	0	0
Germany	6061	661	5400	0
Greece	2323	0	1723	600
Finland	250	250	0	0
Hungary				
Ireland				
Italy				
Latvia	100	100	0	0
Lithuania				
Luxembourg				
Malta				
Morocco	390	0	390	0
Netherlands	6093	213	5880	0
Norway				
Poland	80	80	0	0
Portugal				
Romania				
Slovakia	79	79.	0	0
Slovenia				
Spain	1085	0	0	1085
Sweden	950	798	152	0
UK	1046	1046	0	0
Hong Kong	1204	0	1204	0
Unknown	14 755	0	0	14 795

Table 5-4. The destiny of glass eel by country in 2012. Table is based on preliminary data.

	Quantity (kg)			
Country	Total	Stocked	Aquaculture	Unknown
Austria				
Belgium	206	206	0	0
Bulgaria				
Cyprus				
Czech Rep	596	0	0	596
Denmark	6050	0	1350	4700
Estonia	90	0	0	90
France	3086	3086	0	0
Germany	5297	0	0	5297
Greece	450	0	450	0
Finland	159	159	0	0
Hungary				
Ireland				
Italy	729	248	352	129
Latvia	343	343	0	0
Lithuania				
Luxembourg				
Malta				
Morocco				
Netherlands	7541	766	6775	0
Norway				
Poland	210	210	0	0
Portugal				
Romania				
Slovakia				
Slovenia				
Spain	5799	652	0	5147
Sweden	1200	348	852	0
UK	1320	1320	0	0
Hong Kong				
Unknown	1880	0	0	1880

5.7 Trend in the price of glass eel

The glass eel prices since 1961 show an exponential rise from around 5 € in the 1960s to more than €500 per kg in 2005 (Figure 5-6 and Table 5-5). The high price in 1969 corresponds to the onset of Japanese buying on the French market. The prices are corrected for inflation using price index in France.

The 2012 data from EuroStat show that prices have increased from €344 in 2011 to €492 in 2012. This increasing trend was also reflected in the cost of purchased glass eel reported by country during the WGEEL meeting. The cost of glass eel in 2011 was reported at €662 range (€353–€1923) and in 2012 the price was €757 range €400–€1730.

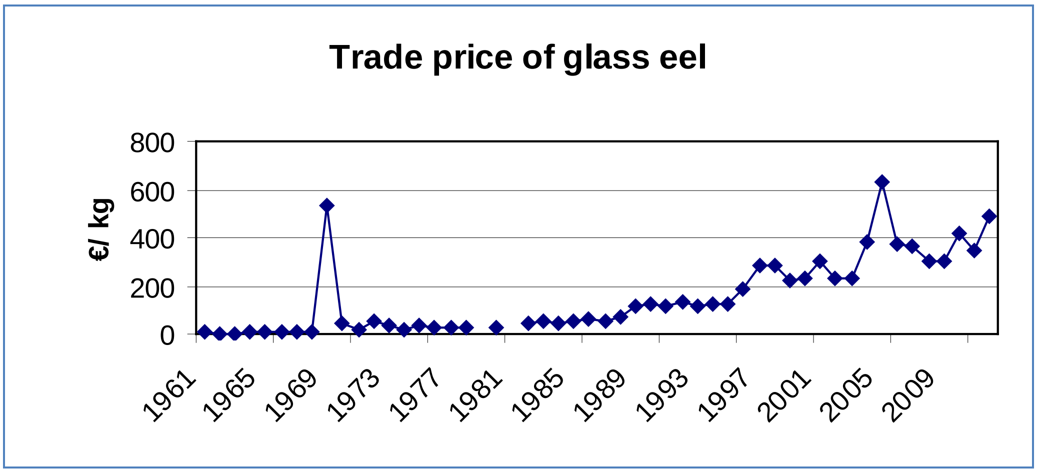


Figure 5-6. Trend in the price of glass eel 1961 to 2012.

5.8 The amount of glass eel stocked by country and in relation to EMP target

In 2008, twelve countries proposed the use of stocking in their management plans to enhance eel populations (ICES, 2008), Between 2011 and 2012 stocking of glass eel was undertaken in nine countries (Table 5-6). Of the various countries which stocked glass eel six (Denmark, France, Latvia, Netherlands, Poland and Sweden) achieved their target in 2012. Although technically Sweden achieved the EMP stocking target, there is potentially additional stocking with larger numbers that could be applied. The most common reason for a country being unable to achieve its stocking target was the high price of glass eels which over the last five years has ranged from €300–492 per kg (Table 5.5), with the trend in prices continuing to rise despite the loss of the Asian market (Figure 5.5). (See also Sections 4.5 and 4.6 on stocking).

ICES identified ~40t.yr^{-1} of glass eels were needed to meet EMP requirements, which approximates to the best estimate of the total annual European catch in both 2011 and 2012 (Table 5.6). However, if the assumption in Section 5.2 of an approximate 23% loss from mortality and/or other factors is correct then only ~35 t are available. If there is a requirement of ~20 t for aquaculture (2011 data) then ~16.5 t are available per year for stock enhancement. It is important to note that an unknown proportion of those fish currently identified as destined for aquaculture may subsequently be stocked.

From the original analysis of trade data in 2011 (ICES, 2011), at least 12% was used for stocking, 30% was used in aquaculture, whilst it was not possible to identify the destiny of the remaining 58%. However, retrospective calculations using data provided by Germany and Denmark for 2011 (Table 5-3) which allocated approximately 8 t of previously "unaccountable" glass eels to aquaculture changed these data significantly with the outcome that 12% were used in stocking, 50% in aquaculture and the destiny of 38% remaining unknown (but much of this could be mortalities as discussed in 5.2.1).

Similar analysis of these data in 2012 (Table 5-4) found that of the 45.4 t caught in 2012 16% went to stocking, 22% went to aquaculture whilst the destiny of 62% remained unknown. However, incorporating a provisional similar usage of glass eel by Germany and Denmark to that in 2011, the figures relating to the destiny of glass eel in 2012 are 18% going to stocking, 40% to aquaculture and 42% remaining unknown.

Table 5-5. Trends in glass eel trade price (€) 1961–2012 computed from various sources. The prices are corrected for inflation using price index in France.

Year	*French custom*	*French trader*	*Asturian (Spain) Market*	*EuroStat France*	*EuroStat Spain*	*EuroStat UK*	*Average price*
1961		7					7
1962		4					4
1963		3					3
1964		10					10
1965		7					7
1966		9					9
1967		12					12
1968		8					8
1969	1055	13					534
1970	68	13					41
1971		21					21
1972	77	25					51
1973		33					33
1974		20					20
1975	42	22					32
1976	45	14					30
1977	41	19					30
1978	42	19					31
1979							
1980	24						24
1981							
1982	43						43
1983	51	43	57				50
1984	33	29	59				40
1985	50	37	70				52
1986		49	82				65
1987	63		43				53
1988	59	54	91				68
1989	108	110	128				115
1990	109	120	135				121
1991	94	109	136				113
1992	162		111				136
1993	156	86	97				113
1994	177	109	96				127
1995	135	94	90		163		120
1996	202	199	148	206	186	193	189
1997	246	366	224	260	247	344	281
1998	297	267	251	295	313	295	286
1999	213	270	174	208	214	267	224
2000	226	207	227	216	254	254	231
2001	331	358	261	267	306	304	304

Year	*French custom*	*French trader*	*Asturian (Spain) Market*	*EuroStat France*	*EuroStat Spain*	*EuroStat UK*	*Average price*
2002	247	252	231	220	230	202	231
2003	235	254	216	236	199	226	228
2004	496	452	432	423	282	230	386
2005	856	872	563	648	308	530	630
2006	432		374	370	297	404	375
2007				499	343	265	369
2008				316	282		299
2009				344	146	408	299
2010				588	325	341	418
2011				373	228	431	344
2012				406	508	563	492

5.9 Conclusions

In terms of the overall catch of glass eel in 2012 and the perceived requirement of approximately 40 t to fulfil the EU stocking requirements our findings are similar to those of 2011 in that declared catch is practically equivalent to need. Taking into account losses upon first export, the amount available is less than that required. Additionally, in the years 2011 and 2012 we were only able to identify that 12–16% of glass eels caught were destined for direct stocking; though we believe the true figure may be higher given that some glass eel listed as being in aquaculture are there to be ongrown prior to stocking. These findings have implications for the fulfilment of Article 7.2 of the Regulation.

For France and UK it is possible, given the data made accessible to the WGEEL, to identify the proportion of the glass eel catch that is being stocked to assess compliance with the Regulation.

The close correspondence between the UK trade data and that held by EuroStat suggests that the EuroStat database provides an accurate measure of the quantity of glass eel across Europe. It is suggested that this analysis be extended to cover both yellow and silver eel and consideration be given to an external body to be contracted to undertake the analysis as this requirement of the Regulation would also benefit to stock assessment.

It is recommended that all countries put in place a system which will; 1) permit cross-checking of imports and exports between countries for each batch of glass eel exported and, 2) be able to identify the quantity of glass eel which are classified as going to aquaculture that are subsequently stocked.

Table 5-6. The quantity of glass eel purchased with EMP target in brackets, the % of the EMP target reached, the % of the glass eel purchased used for stocking and the quantity of glass eel harvested from the years 2011–2012, by country. This table is based on preliminary data and the intention is to update this in future.

Country	Purchased (kg) (EMP Target)		Target achieved (%)		% used for stocking		glass eel harvest (kg)	
	2011	2012	2011	2012	2011	2012	2011	2012
Austria	no data	no data	no data	no data	no data	no data	no data	no data
Belgium	160 (500)	206 (1200)	32	17.2	100	100	0	0
Bulgaria	no data	no data	no data	no data	no data	no data	0	0
Cyprus	no data	no data	no data	no data	no data	no data	0	0
Czech Rep	no data	no data	no data	no data	no data	no data	0	0
Denmark	7002 (384)	no data	100	no data	8.7	no data	0	0
Estonia	750	no data	27.8	no data		no data	0	0
France	733 (2570)	3086 (2570)	Not achieved	100	100	100	34 433	34 256
Germany	5400$ (7000)	no data	no data	no data	no data	no data	0	0
Greece	no data	no data	no data	no data	no data	no data	0	0
Finland*	275 (500)	159 (1000)	55	15.9	100	100	0	0
Hungary	no data	no data	no data	no data	no data	no data	0	0
Ireland	n/a	n/a	n/a	n/a	n/a	n/a	0	0
Italy	no data	730 (6753)	no data	3.7#	no data	34	no data	299.5
Latvia	100 (100)	334 (334)	100	100	100	100	0	0
Lithuania	no data	no data	no data	no data	no data	no data	0	0
Luxembourg	no data	no data	no data	no data	no data	no data	0	0
Malta	no data	no data	no data	no data	no data	no data	0	0

Table 5-7 cont. The quantity of glass eel purchased with EMP target in brackets, the % of the EMP target reached, the % of the glass eel purchased used for stocking and the quantity of glass eel harvested from the years 2011–2012, by country. This table is based on preliminary data and the intention is to update this in future.

Country	Purchased (kg) (EMP Target)		Target achieved (%)		% used for stocking		glass eel harvest (kg)	
	2011	2012	2011	2012	2011	2012	2011	2012
Morocco	n/a	no data	n/a	no data	n/a	no data	390	no data
Netherlands	6994 (550)	7541 (550)	49	100	3.5	10	0	0
Norway	n/a	n/a	n/a	n/a	n/a	n/a	0	0
Poland*	80 (4000)	80 (4000)	100	100	100	100	0	0
Portugal	no data	no data	no data	no data	no data	no data	1085	807
Romania	no data	no data	no data	no data	no data	no data	no data	0
Slovakia	no data	no data	no data	no data	no data	no data	no data	0
Spain	no data	no data	no data	no data	no data	no data	3059	6209
Sweden	1200 (833)	1200 (833)	100	100	84	71	0	0
UK	1046 (2054)	1321 (2054)	50.9	64.3	99.6	100	3682	3820
Total							42 649	45 392

6 Assessment of the quality of eel stocks

Chapter 6 discusses the importance of the inclusion of spawner quality parameters in stock management advice and updates information on the European Eel Quality Database (EEQD). The chapter addresses the following Terms of reference:

Establish an international database for data on eel stock and fisheries, as well as habitat and eel quality (update EEQD) related data – seek advice from ICES Data Centre for this task; review and make recommendations on data quality issues;

In conjunction with WGBEC (Biological Effects of Contaminants) and MCWG (Marine Chemistry Working Group), review and develop approaches to quantifying the effects of eel quality on stock dynamics and integrating these into stock assessments.

6.1 Introduction

In recent years WGEEL has discussed the risks of reduced biological quality of (silver) eels. The reduction of the fitness of potential spawners, as a consequence of (specific) contaminants and diseases, and the potential mobilization of high loads of repro-toxic chemicals during migration, might be key factors that decrease the probability of successful migration and reproduction. An increasing amount of evidence indicates that eel quality might be an important issue in understanding the reasons for the decline of the species. Previous WG reports have presented an overview and summaries of a variety of reports and data on eel quality. Hence, this chapter should be read in conjunction with the 'eel quality' chapters in previous reports (2006–2011).

During the WGEEL 2012 meeting, several countries provided data on contaminants and diseases for inclusion in the Eel Quality Database EQD (previously European Eel Quality Database, EEQD). We summarized scientific advances regarding the better understanding of the status and effects of contamination and diseases in the European eel, in order to facilitate future local assessments of the stock (yellow eels, silver eel and SSB). During this session, we further updated the list of areas where fisheries restrictions were issued because contaminant levels in eel were above human consumption safety limits. We made progress in developing a framework for integrating quality of eel factors in local stock assessments.

6.2 Information on eel quality provided by countries and update of database on eel quality related data: the Eel Quality Database (EQD)

6.2.1 Information on eel quality provided by countries

During the 2012 session of the WGEEL, information on eel quality provided in the country reports has been summarized (Annex 8).

6.2.2 The Eel Quality Database

Belgium (Flanders) coordinates the Eel Quality Database, for which a new application is currently under development. The database is a compilation of eel quality data over the world, including contaminants and diseases. The new application will be a more efficient system (from Excel worksheets to an Access database) and will include opportunities to include more data fields and validation mechanisms. The database expands now to include all anguillid species and hence will be renamed (from EEQD (European Eel Quality Database) to EQD (Eel Quality Database)). Further development of the database which will include a test phase and migration of all available data (including data validation) is foreseen in 2013.

During the intersession, several member states provided data on contaminants and diseases for inclusion in the EQD, which is described in the following sections:

6.2.2.1 Contaminants

Norway provided two datasets of contaminants measured in eel. One dataset includes POPs from 122 eels collected in seawater (Arne Duinker, by correspondence), while the other data were from 14 pooled analyses of POPs and metals in eels from freshwater and brackish water systems.

France has new data on contaminant analysis available at a public database http://www.pollutions.eaufrance.fr/pcb/resultats-xls.html

Belgium provided new POP analyses of ca. 50 sites from Belgium (Flanders).

Germany provided a dataset of contaminants (PCDD/F & PCB TEQ) measured in eel samples from twelve locations of North Rhine Westphalian rivers.

Italy (Lorenzo Zane, by correspondence) provided contaminant analyses from 35 eels sampled on River Tiber and Bolsena. Nine heavy metals, 36 PCB congeners, ten PBDEs and some pesticides were analysed.

Poland provided data on lipid content and contaminants (heavy metals, pesticides, PCBs) in eel from seven Polish waters.

6.2.2.2 Diseases

United Kingdom provided information on surveys of *Anguillicoloides crassus* in River Erne and Lough Neigh yellow and silver eels during 2011 and 2012. Prevalence and intensity of infection was higher in silver eels compared to yellow eels.

France (François Lefebvre, by correspondence) provided an extensive summary of published French surveys on *A. crassus*. Information on ca. 50 French sites is given, including prevalences and intensity of infection. Samples were taken in the period between 1985 and 2009.

Italy provided recent information on *A. crassus* infestation in Tevere, Caprolace, Fogliano, Lesina and Bolsena. Prevalences varied between 0 and 76%.

Swedish data of eels from eight samples collected in the Baltic Sea (2012) had *A. crassus* prevalences between 9 and 64% dependent of the site. Another Swedish dataset included data from *A. crassus* in several lakes (Hjälmaren, Mälaren, Ringssjön and Vänern). Prevalences varied between 53 and 90%.

Denmark provided information on *A. crassus* surveyed in three sites (one lake and three brackish fjords) in 2011. Prevalences were between 43 and 68%.

Information on the infestation by *A. crassus* in *A. rostrata* was provided by Kari Fenske (Fenske *et al*., 2010) including the results of surveys in six river sites in Chesapeake Bay, Maryland sampled in 2007. Prevalences varied between 18 and 43%.

Results of another study on *A. crassus* in *A. rostrata* in River Hudson were provided by Wendy Morrison (Morrison and Secor, 2003). In this study eels collected at six sites in 1998 had a prevalence of 60%.

Poland provided data on *A. crassus* from seven Polish waters.

6.2.3 New information on eel quality provided in international publications

In the following paragraphs, information on eel quality provided in new international publications is summarized.

6.2.3.1 Contaminants

The concentration of Cd, Cu, Pb and Zn in the liver of the European eel was determined to evaluate the contamination burden in Portuguese brackish water systems (Aveiro lagoon, Obidos lagoon, Tagus estuary, Santo Andre lagoon and Mira estuary) and relate it to anthropogenic pressures within those ecosystems (Neto *et al*., 2011).

Nagel *et al*., 2012 report the impact of silvering on PAH metabolite concentrations in eel bile and present suitable normalization procedures to overcome silvering related accumulation.

Forty-nine wild eels caught in the Albufera Lake (Spain), were examined for metals (Cd, Co, Cr, Cu, Fe, Hg, Mn, Pb, Se and Zn), condition (CI and HSI indices), as well as for diseases (*A. crassus* infestation; bacterial infections). Total metal load significantly increased in eel liver tissue in parallel with total length and body weight, while silvering females (BW > 200 g; L≥500 mm) exhibited the highest amounts of Co, Cu, Hg, Se and Zn (Esteve *et al*., 2012).

De Boer *et al.* (2012) carried out a frying and cooking experiment, which has shown that the concentrations of PCBs and organochlorine pesticides increase in eel after frying. The effect of boiling is negligible. This shows that preparation methods for eel as food product do not help in bringing PCB and OCP concentrations down to safe values.

6.2.3.2 Parasites and diseases

A 21 year study of *A. crassus* took place in Upper Lake Constance, Germany. *A. crassus* was first recorded in 1989. Prevalence reached 60% in 1992, remained at this level until 2007 but decreased to 48% in 2008. Infection intensity peaked in 1993 (mean 16 adult parasites per fish). Heavy swimbladder lesions were seen in 10% of eels ready to migrate to their spawning habitat (Bernies *et al*., 2011).

Popielarczyk *et al*. (2012) found that *A. crassus* was present in the swimbladder of 114 of 154 (74%) European eel sampled from eleven sites in Poland.

A genetic method is developed to study the presence and spreading of *A. crassus* without having to kill the eel (Espen Lund and Unn Refseth, NIVA, personal communication). DNA barcoding data and PCR techniques were applied to find fish paratenic hosts and crustacean secondary hosts of *A. crassus* in southern Norway, and also to find the parasite in its primary host (European eel). Samples of internal organs of several freshwater fish species and eel faeces were positive, while the crustacean samples were negative. Hence, the method was able to indicate parasite DNA in both fish organs and eel faeces, although it did not give information of the parasite viability. The parasite seemed non-specific when infecting fish paratenic hosts.

In the Chesapeake Bay, US, *A. crassus* presence and swimbladder damage was not found to be associated with age or growth rate in American eel *A. rostrata*. Prevalence of parasitized eels ranged from 18% to 72% (Fenske *et al*., 2010).

Larrat *et al*., 2012 studies efficacy of emamectin benzoate to treat *Anguillicoloides crassus* infections in American eels, *A. rostrata*. A single administration of emamectin benzoate was able to kill *A. crassus* occupying the swimbladder of eels, but the protocol was only partially effective, as 60% of the nematodes were still alive 14 days post-treatment.

6.2.4 New research initiatives

A number of research projects have recently been started, and are listed below (Table 6.1). Three types of projects are distinguished, according to research themes: reproductive physiology, impact of contaminants on reproduction and on growth and larval production (alimentation). The project EELIAD is a multidisciplinary project covering eel migrations and quality aspects.

This overview shows that some scientific surveys including eel quality aspects are in progress. However, essential issues to assess the importance of eel quality for reproductive success, such as to evaluate the effect of specific contaminants on the ability for eel to migrate and to reproduce are currently not included.

Further information on the objectives of these new research projects and on ongoing work is presented in Annex 9.

Table 6-1. Overview of relevant research initiatives in the EU.

Project	Date	Coordinator	Funding	Subjects
PRO-EEL	2010–2014	J. Tomkiewicz (DK)	FP7 Framework program	reproductive physiology, development of gametes and larval feeding
PUBERTEEL	2009–2011	S. Dufour (FR)	ANR Blanche	neuroendocrine control of puberty in eel
EELSCOPE	2008–2010	J. Schafer (FR)	ANR	physiological and behavioural response to exposure to pollutants
EELIAD	2008–2012	D. Righton (UK)	FP7 Framework program	ecology of eels during their spawning migration
MICANG	2010–2013	M. Baudrimont (FR)	Interrégional Aquit/Midi Pyr. + Québec	developed micro of ADN to define the health status of eel
ISOGIRE	2012–2014	J. Petit (BE)	Marie Curie FP7-IEF-2011	investigating heavy stable Cu, Zn and Ag isotope
IMMORTEEL	2011–2013	M. Baudrimont (FR)	International - ANR	metallic and organic contamination impacts in European and American eel
Integrated study of the impacts of pollutants on the nervous system of the European eel	2012	J-F Rees, P Kestemont (BE)	FNRS–FRFC, Belgium	*in vitro* and *in vivo* effects of sublethal concentrations of pollutants on the nervous system of the European eel

6.3 Current monitoring of eel quality in different countries

Most of the literature and data on contaminants and diseases in eels are based on local initiatives, or as part of scientific projects. This raises the question about current national routine monitoring programmes that focus on contaminants or diseases in fish covering eel. A questionnaire was filled in by delegates at the meeting, providing information on monitoring programmes in each country.

Table 6-2. Routine monitoring programmes on contamination of eel in selected countries.

Country	EMP	WFD	Other (i.e. consumer protection)
France	yes	-	yes
Belgium	no	no	yes – Wallonia no - Flanders
Germany	no	yes	yes
Denmark	no	no	no
Spain	no	no	no
Finland	no	no	no
Ireland	no	yes	no
Italy	no	no	no
Lithuania	no	no	no
Latvia	no	no	no
Netherlands	no	no	yes
Norway	-	no	no
Poland	no	?	yes
Portugal	no	no	no
Sweden	no	no	no
Great Britain	no	no	no

Regular investigations on eel contamination are undertaken in five of the 16 countries covered by this examination (Poland, Germany, Netherlands, Ireland, France; Table 6-2). Eels are analysed for various contaminants (i.e. Dioxins, PCBs, heavy metals, and pesticides). Investigations focus on both yellow and silver eels and are mostly motivated for Consumer Protection, while only one EMP addresses contamination issues (silver eels transported to the sea in Mediterranean lagoons in France are routinely checked for contaminants; PCB, OCs, heavy metals). In two countries, contamination of eels is checked under the implementation of the WFD (monitoring of hazardous substances in Ireland, and regular measurements at a few survey locations in Germany).

Table 6-3. Routine monitoring programmes of eel diseases in selected countries.

Country	EMP	WFD	Other
France	yes	yes	yes
Belgium	no	no	no
Germany	yes	no	yes
Denmark	no	no	yes
Spain	no	no	no
Finland	no	no	no
Ireland	yes	yes	no
Italy	no	no	no
Lithuania	no	no	no
Latvia	no	no	no
Netherlands	no	?	yes
Norway	-	no	no
Poland	no	no	no
Portugal	no	no	no
Sweden	yes	no	yes
Great Britain	no	no	yes

On eel diseases, regular examinations are undertaken in seven of the 16 responding countries (Sweden, Germany, Denmark, Netherland, Ireland, Great Britain, France; Table 6-3). Few of the surveys are carried out in the framework of the EMPs, mostly focusing on routine checks of glass or farmed eels prior to stocking. From 2009, parasite monitoring on *A. crassus* was started in Ireland. In France, the silver eels transported to the sea are checked for diseases (*A. crassus*, Evex). Independent from the EMPs, some countries do regular checks on *A. crassus* infestation (Sweden, Germany, Denmark, Netherlands, Great Britain, France), but these monitoring surveys are usually not designed to give a country wide overview. In France, some eels caught during WFD electrofishing are screened for diseases (external check, subsamples for *A. crassus*).

6.4 Assessment of the quality of local eel stocks

During WGEEL 2010 and 2011 progress was made in the assessment of important eel quality parameters such as general condition indices, diseases and contaminants. During this session it was agreed that it was useful to develop distinctive eel quality indices for these three categories.

6.4.1 Eel quality and reproductive potential

This section explores a way forward in developing approaches to quantifying the effects of eel quality on reproductive potential and integrating these into stock assessments.

There are indications that poor condition of the silver eels migrating to the oceanic spawning grounds might be a factor in explaining the stock decline. Several authors have proposed that the lipid content of silver eels is crucial to their successful migration and reproduction. Minimum energy requirements (in lipid weight % of muscle weight) of silver eels leaving European waters (eels have ceased eating at this stage) have been proposed for the completion of their migration and successful reproduction (Boëtius, 1980: 20%; van den Thillart *et al.*, 2007: 20.7%). Where lipid content is below these thresholds, silver eels may not contribute to the overall spawning and recruitment of the European stock. Here we develop and discuss approaches to quantifying the effects of eel condition on reproductive potential, and how such information could be integrated into stock assessments.

The reproduction potential of a female silver eel (RP) is dependent of several parameters. Apart from other condition parameters (such as physiological state, occurrence of parasites, etc.), RP will be a function of body size, muscle lipid content, and the migration distance to the Sargasso Sea (DSS) (Figure 6-1).

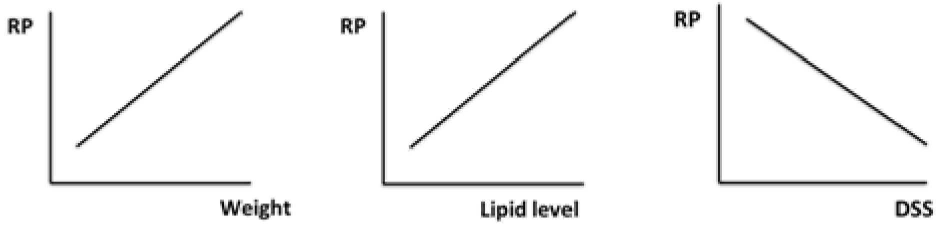


Figure 6-1. Predicted impact of body weight, muscle lipid levels of female silver eels leaving a catchment and distance from the Sargasso Sea on their reproductive potential.

The net energy of silver eels starting their migration can be roughly estimated using a simplified model (net fat content was calculated assuming all fat is muscle fat, assumptions see Belpaire *et al.*, 2009).

Net fat content at start of migration = Weight * % Lipids/100

The energy requirements (cost of transport, COT) for a silver eel to reach its spawning ground increases with the distance to the Sargasso Sea (DSS). Energy expenditure of female silver eels during swimming has been estimated through experiments in swimming tunnels, and is also related to their size (relative energy expenditure decreases with increasing body size, see e.g. Clevestam *et al.*, 2011). Measurements of COT, derived from swim tunnel experiments, indicated costs of between 0.42 and 0.62 kJ.km.kg, using two different analytical methods (oxygen consumption and bomb-calorimetry) (van Ginneken *et al.*, 2005). If we use the mean value of both methods (0.51 kJ/km.kg), an eel weighing 860 g would metabolize 66.6 g fat during a 6000 km journey to the spawning ground, or 11.1 mg fat/km (deduced from van Ginneken *et al.*, 2005 for 73 cm long eels). In this analysis a fixed value for COT was taken regardless of the length of the eel. But as energy consumption is related to size (Clevestam *et al.*, 2011), it is essential that this size related variation is taken into account and refined in future models.

COT = 0.0111 g fat/km * DSS

DSS being the distance from the sampling site to the spawning location in the Sargasso Sea at 61°00’W and 26°30’N (i.e. the centre of the area described in van Ginneken and Maes, 2005).

From this, the energy remaining for reproduction in female eels by arrival at their spawning ground (ER_{ind}) can be deduced:

ER_{ind} = Net fat content at start of migration – COT or

ER_{ind} = (Weight * % Lipids /100) - (0.0111 g fat/km * DSS)

RP was calculated as the mass of eggs which could be produced after using all ER_{ind}, based on a conversion factor of 1.72 g eggs/g fat (as used in van Ginneken and van den Thillart, 2000):

RP_{ind} = ER_{ind} (g fat) * 1.72

If data are available from a representative sample of female silver eels from a given catchment or EMU, it should be possible to infer the reproduction potential of female silver eel escapement from the catchment or EMU (RP_{EMU}). Individuals with a negative or zero ER_{ind} will not contribute to the spawning stock as they will not have energy reserves necessary to reach the spawning ground or for egg production, respectively. From the ER_{ind}, the RP_{EMU} can be calculated using the following equation:

$RP_{EMU} = (\sum RP_{ind\ ER>0} / N_{ind\ ER>0}) * N_{EMU\ ER>0}$

$N_{EMU\ ER>0}$ = number of female silver eels with $ER_{ind} > 0$ leaving the catchment

$N_{ind\ ER>0}$ = number of female silver eels with data on lipids and weight and with a calculated $ER_{ind} > 0$.

If sufficient monitoring data on weight and lipid content of silver eels leaving continental waters were be available, this would allow an assessment of the reproduction potential of the various catchments/EMUs, and their contribution to the spawning stock.

Below, the impact on reproductive potential of the variation in size (body weight), muscle lipids content and distance from the catchment to the Sargasso Sea has been analysed, using the equations as presented above.

Despite high swimming efficiency and low energy costs for swimming (van Ginneken *et al*. (2005), the individual figures clearly illustrate the considerable impact of size (body weight) and muscle lipid content on the reproductive potential of female silver eels (Figure 6-2), whereas the position of the catchment (i.e. distance to the Sargasso Sea) seems to have less impact on the RP (Figure 6-3).

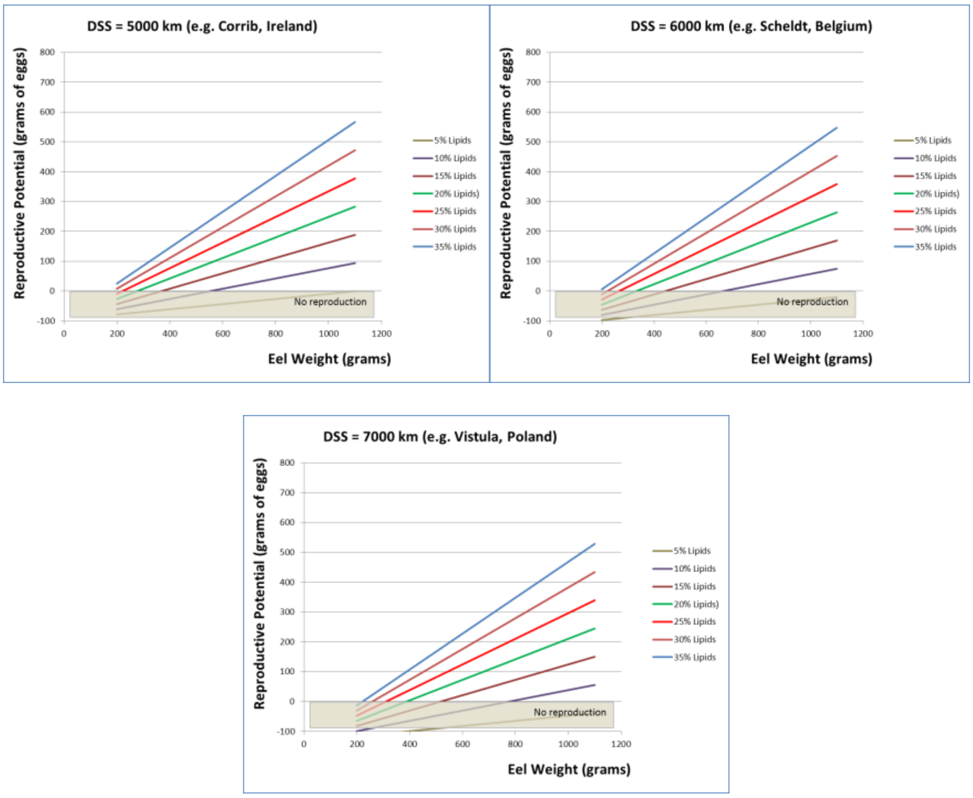


Figure 6-2. Modelled impact of body weight and different muscle lipid levels of female silver eels leaving a catchment on their reproductive potential as a function of increasing distance to the Sargasso Sea.

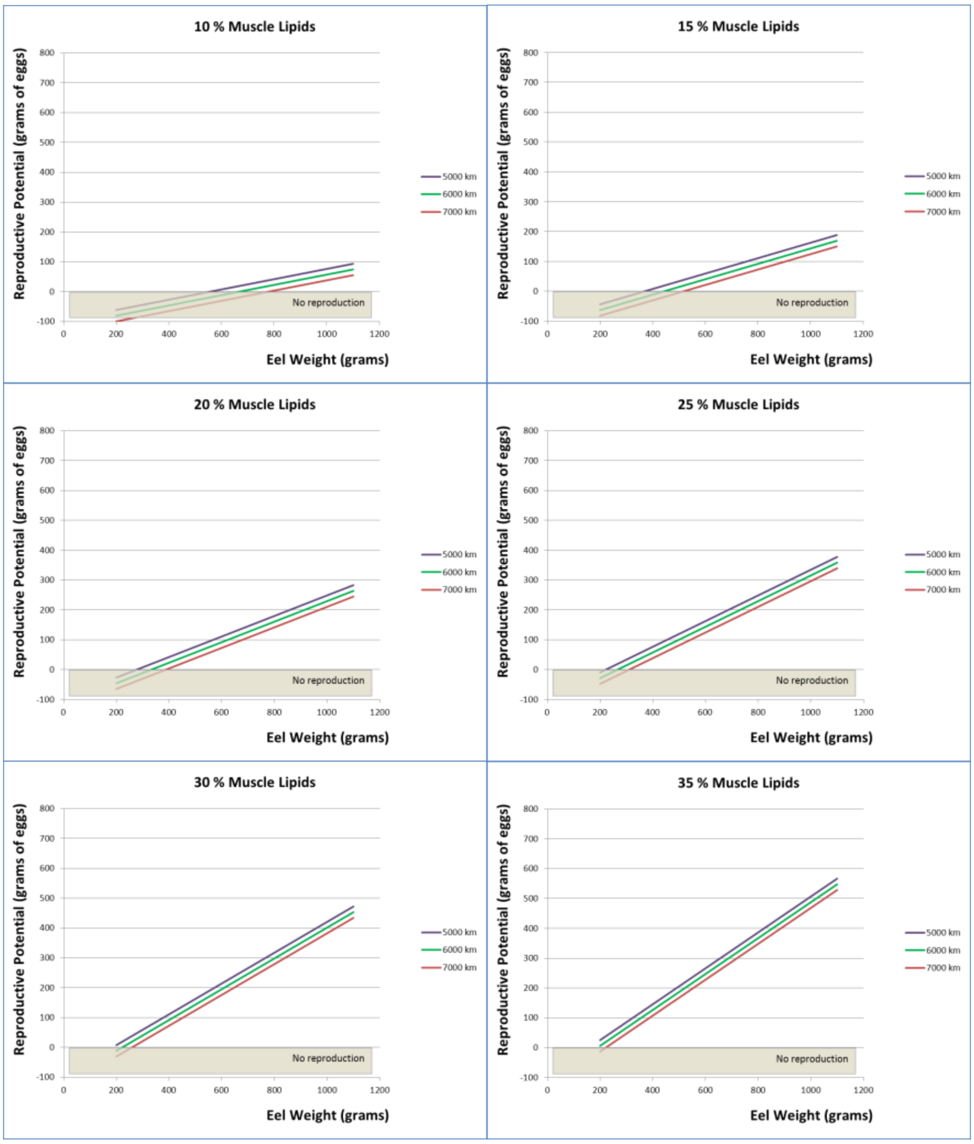


Figure 6-3. Modelled impact of body weight and distance to the Sargasso Sea on the reproductive potential of female silver eels leaving a catchment as a function of increasing muscle lipid levels.

Figures 6.4 A and B are based on available data on body weight and lipid content in female silver eels from several catchment:

- Preliminary data of lipid content in silver eels provided from Irish and UK catchments in Europe sampled and analysed during the Eeliad project (www.eeliad.com);
- Preliminary data of lipid content in silver eels from Belgium sampled during the Eeliad project and analysed by Belgium;
- Unpublished data of lipid content in silver eels from Poland as provided by T. Nermer;
- Unpublished data of lipid content in silver eels from Lough Neagh and Erne as provided by K. Bodles and D. Evans;
- Unpublished data of lipid content in silver eels from Norway as provided by C. Belpaire and E. Thorstad;

- Unpublished data of lipid content in silver eels from Sweden as provided by H. Wickström (Clevestam *et al*., 2011).

It should be stressed that the collection of these data was not designed to measure the RP of the catchment; and analysed individuals may not be representative for the entire catchments where they were sampled.

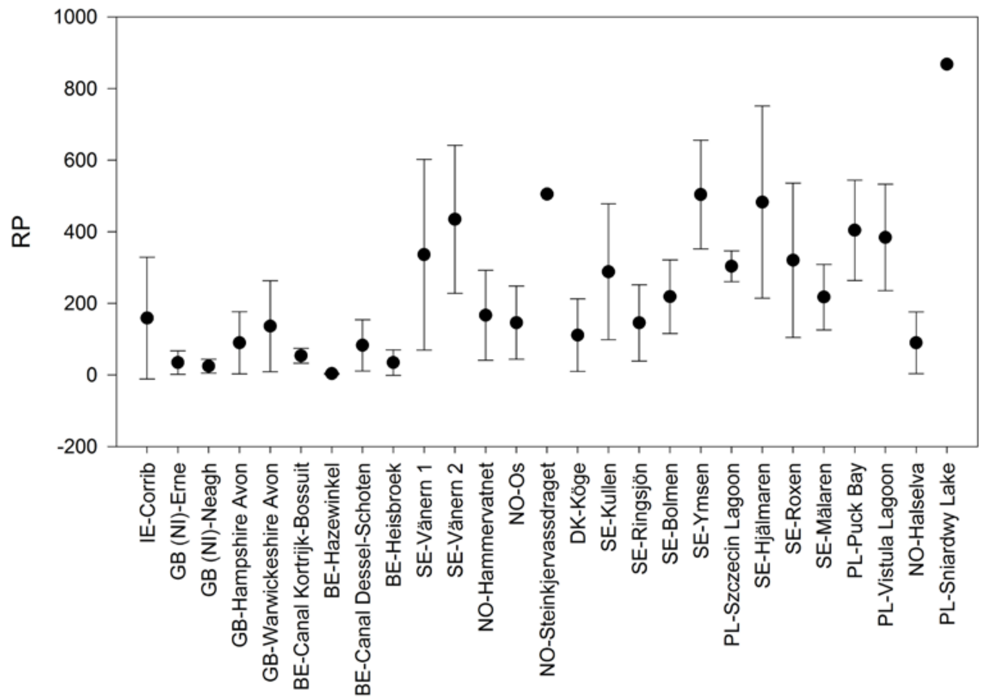
Hence, the results on individual RP presented in Figure 6.4 may not be representative for the RP of the catchment, the results are presented only to illustrate the concept, and conclusions must be interpreted with great care.

This demonstration indicates that RP varies between individuals and hence that various individuals might not contribute equally to the spawning stock. According to the thresholds and calculations applied, many (13%; n = 759) female silver eels included in this analysis would not have the energy requirements necessary to successfully migrate to the spawning ground and still have energy reserves to convert to eggs (mainly due to their small size and/or low lipid content). This is certainly not a sample representative for the European stock, considering the large contribution of eels from Sweden in this dataset.

Despite assumptions made in the analyses above (which should be further refined in future models, based on new data), and the fact that samples may not be representative of the catchments from where they were collected, these data show that there is a significant variation in RP of silver eel females in the sample. This example shows that given properly designed data collection, it is possible to integrate estimates of silver eel quality into quantitative assessments of the reproductive stock, providing that the assessments included information on the length and % lipid content distributions among the escapement of female silver eels.

Such assessments quantifying the effects of eel quality on reproductive potential should be integrated into local and international stock assessments.

Finally it must be noted that a similar approach is needed for male silver eels.



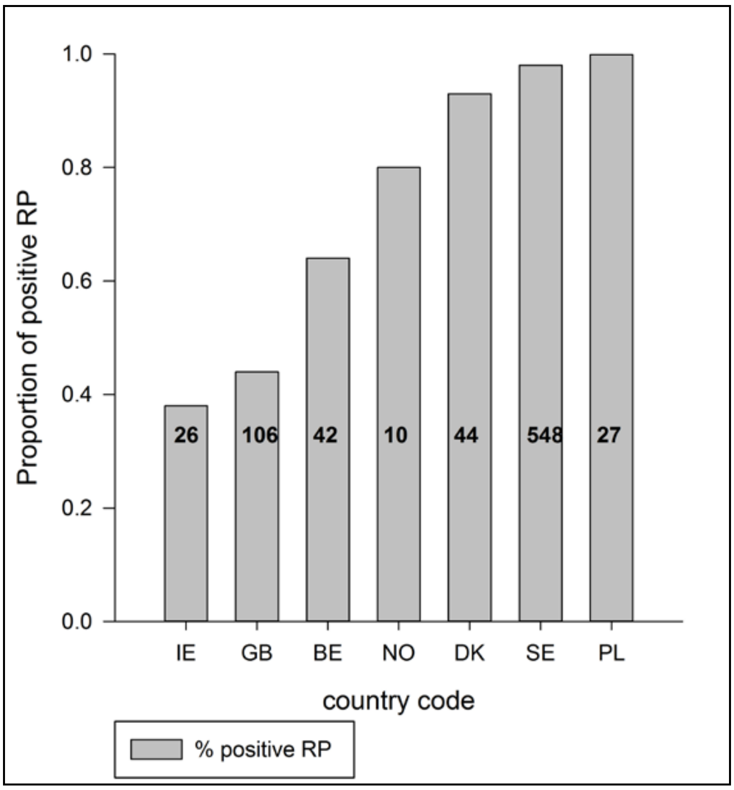


Figure 6-4. (Upper) Reproductive potential (in grammes of eggs) of female silver eels from various European catchments sampled during different projects. Only females with enough energy to reach the Sargasso Sea are included in this analysis. Means and standard deviation are indicated. Site order is according Distance to the Sargasso Sea. (Lower) Proportion of sampled female silver eels supposed to succeed in reproducing. Warning: These graphs are based on preliminary data; the intention is to show the technique, but specific outcomes will certainly change in future assessments. For source of samples and data see text.

6.4.2 Eel Quality Index for diseases

The WG 2012 session did not made further progress in the further development of this index. We refer to the WG Eel 2010 and 2011 reports.

Table 6-4. Boundary values of the quality classes for a series of selected contaminants *(From WGEel 2010).*

Class	Not impacted	Slightly impacted	Impacted	Strongly impacted
EQI value	****	***	**	*
Anguillicoloides	not infected	/	/	infected
EVEX	not present	/	/	present
HERPES Virus	not present	/	/	present

6.4.3 Eel Quality Index for Contaminants

The Eel Quality Index for Contaminants (EQI_{CONT}) was further developed including important contaminants such as Hg, Pb, dioxins and brominated flame retardants. Threshold values for classifying contamination levels of Hg and Pb were derived from (Belpaire and Goemans, 2007). However, within the time limit of this WG session it was not possible to deduce threshold values for dioxins and brominated flame retardants.

We adapted the threshold values of the quality classes as defined by WGEel 2010 for the Sum ICES 7 PCBs to values for the Sum ICES 6 PCBs (SUM of PCB28, PCB52, PCB101, PCB138, PCB153 and PCB180). Indeed since the new Dioxin Regulation (Com Reg EU No 1259/2011), the EU set those new harmonized Sum 6 ICES PCB maximum levels, and this will be used in further assessments. PCB 118 contributed to between 8 and 23% of the Sum ICES 7 PCBs (average 15%) (Belpaire *et al*., 2011). So the threshold values were adapted for Sum ICES 6 PCBs by lowering the Sum 7 PCBs by 15% to account for PCB 118.

Using these quality classes it is now possible to calculate EQI_{CONT} for individual yellow and silver stage eels. EQI_{CONT} is defined as the average value of the quality classes for the measured contaminants, resulting in a one, two, three or four star eel.

Using a dataset compiled by Belpaire *et al.* (2012, unpublished) of 1010 yellow or silver eels from >313 sites in seven countries which were collected from various sources including research and surveillance and/or targeted environmental and food safety programmes. The rationale of the collection of the national data may differ considerably between countries or reports. Efforts to monitor the health status of eel in a certain country are not always designed to be representative for the whole country or area. Therefore the results presented per country cannot be regarded as an overview of the environmental quality for specific countries (Figure 6-5).

Specifications on the origin of the data used are presented in Table 6-5.

Using these data results in the following figure showing the frequency distribution of eels of different quality classes in these catchments. Due to time constraints and shortness of data available this assessment of EQI_{CONT} is based only on the Sum ICES 6 PCBs. This figure clearly shows to what extent quality status of eels vary between catchments and countries. In central European countries eel quality status affected by contaminants is considerably lower compared to e.g. countries from more northerly latitudes. It must be noted that factors including site selection (industrial/rural), habitat type, number of sites, and differences between sampling program objectives may all contribute to the results as reported. The distribution of the EQI_{CONT} in French rivers (n=604) is visualized in Figure 6-6.

Table 6-5. Origin of the data presented in Figure 6-6: N_{sites} Number of sites, N_{an} Number of eels analysed individually (I) or number of analysed aggregate samples of several eels (A), DFs dioxins and furans, DL PCBs Dioxin-like PCBs, NDL-PCBs non dioxin-like PCBs, FW freshwater, BW brackish water, SW seawater, RNW Random National Network, NWP Network with sites chosen because of known or presumed pollution (Belpaire *et al.*, 2012, unpublished).

Country	Rationale	Nsites	Nan	Period	Reference
Norway	Fjords, sea or estuaries, BW and SW, RNW	29	144 (I)	2010	Duinker, Durif *et al.*, in prep.
UK (Scotland)	Small and large rivers, FW, RNW	31	146 (I)	2004–2009	Macgregor *et al.*, 2010
Ireland	Sampling for eel screening, Estuary and lakes	9	9	2005–2009	McHugh *et al.*, 2010
Germany	Lake Constance and River Rhine, FW	4	20 (I)	2008	Wahl *et al.*, 2010
Poland	Two BW lagoons	2	24 (I and A)	2000–2008	Szlinder-Richert *et al.*, 2010
Belgium	Rivers, canals and lakes, RNW	48	48 (A)	2000–2007	Belpaire *et al.*, 2011
Belgium	Rivers, canals and lakes, RNW	38	38 (A)	2000–2007	Geeraerts *et al.*, 2011
Belgium	Small rivers in Wallonia, FW, NWP	36	36 (A)	2001–2004	Thomé *et al.*, 2004
France	Large rivers, NWP	116	604	2008–2010	ANSES

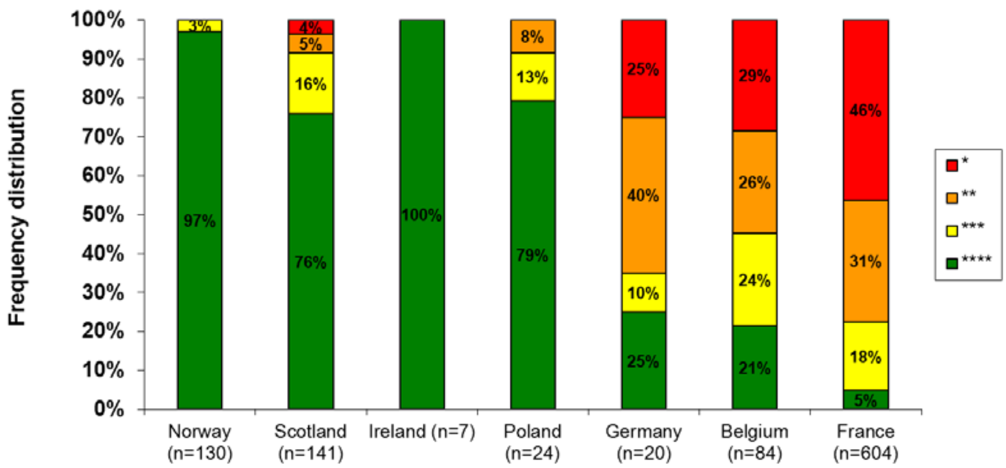


Figure 6-5. Demonstration of the Eel Quality Index of Contaminants (EQI_{COM}) based on ICES 6 PCBs of 1013 yellow or silver eels from >300 sites over seven countries from Belpaire *et al.* (2012, unpublished). Warning: This graph is based on preliminary data; the intention is to show the technique, but specific outcomes will certainly change in future assessments.

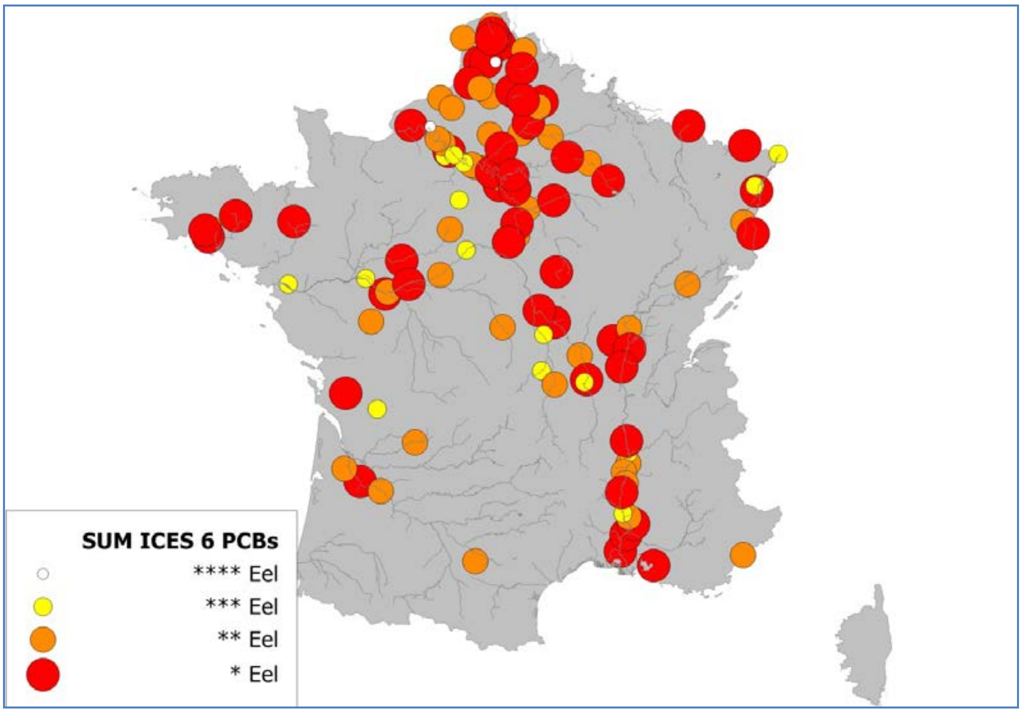


Figure 6-6. Map of France with indication of EQIcont index in eel (based on their Sum ICES 6 PCB value).

Table 6-6. Boundary values of the quality classes for a series of selected contaminants for the calculation of EQIcont. EQIcont is defined as the average value of the quality classes for the measured contaminants, resulting in a one, two, three or four star eel.

Class EQI value	Not impacted ****	Slightly impacted ***	Impacted **	Strongly impacted *
Sum 6 PCBs	<62	62–155	155–391	> 391
Sum DDTs	<40	40–101	101–254	>254
Cd	<5	5–12,6	12,6–31,7	>31,7
Hg	<100	100–252	–634	>634
Pb	<25	25–63	–158	>158
BFRs	To be identified	To be identified	To be identified	To be identified
Dioxines	To be identified	To be identified	To be identified	To be identified

6.5 Fisheries closure as a human health measure due to contamination

As reported earlier (WGEEL 2011), dioxin and PCB levels are measured in several countries in order to compare the levels with the EU consumption limits, and to protect the health of eel consumers. These EU limits were recently adapted and a new EU Dioxin Regulation (Com Reg EU No 1259/2011) came into force on 1 January 2012, which set maximum levels of dioxins, dioxin-like PCBs and non-dioxin-like PCBs in foodstuffs, This Regulation sets specific threshold values for wild-caught European eel (Table 6-7).

The new maximum levels for dioxins and dioxin-like PCBs are an update of the existing 2006 levels. They are now based on the 2005 WHO-Toxic Equivalence Factors. Those levels are at a similar level of stringency as former ones. Some countries had national PCB maximum levels, some not. Now the EU has harmonized Sum 6 ICES

PCB maximum levels. For comparison, maximum levels for most sea fish are set on 75 ng/g wet weight.

Table 6-7. Maximum levels in the Dioxin regulation as regards to dioxins, dioxin-like PCBs and non-dioxin-like PCBs in foodstuffs, which applies since 1 January 2012 (Com Reg EU No 1259/2011).

	MAXIMUM LEVELS		
Foodstuffs	SUM OF DIOXINS (WHO-PCDD/F-TEQ)32	SUM OF DIOXINS AND DIOXIN-LIKE PCBS (WHO-PCDD/F-PCB-TEQ)32	SUM OF PCB28, PCB52, PCB101, PCB138, PCB153 and PCB180 (ICES – 6)32
Muscle meat of wild-caught eel (*Anguilla anguilla*) and products thereof	3.5 pg/g wet weight	10.0 pg/g wet weight	300 ng/g wet weight

The primary objective of this Dioxin regulation is to protect human health. However, considering the high levels of repro-toxic compounds often reported in the eel, this Regulation may have implications on professional and/or recreational eel fisheries, and hence also on the stock of the European eel.

WGEEL (2011) reported that maximum consumption levels for PCDD/Fs and DL-PCBs were exceeded in a significant proportion of the cases.

Belpaire *et al*. (2012) collated information of Sum 6 PCB levels from 986 yellow or silver eels from 314 sites over eight countries (see Figure 6-7). These data were taken from various sources including both research and surveillance and/or targeted environmental and food safety programmes. The rationale of the collection of the national data may differ considerably between countries or reports. Efforts to monitor the health status of eel in a certain country are not always designed to be representative for the whole country or area. This analysis showed that 38.2% of the eels were not compliant with the Dioxin Regulation with regard to non-dioxin-like PCBs (N= 986 analyses) (Range 0–13 223 ng/g ww, Mean = 503 ng/g ww, Std Dev. = 960 ng/g ww).

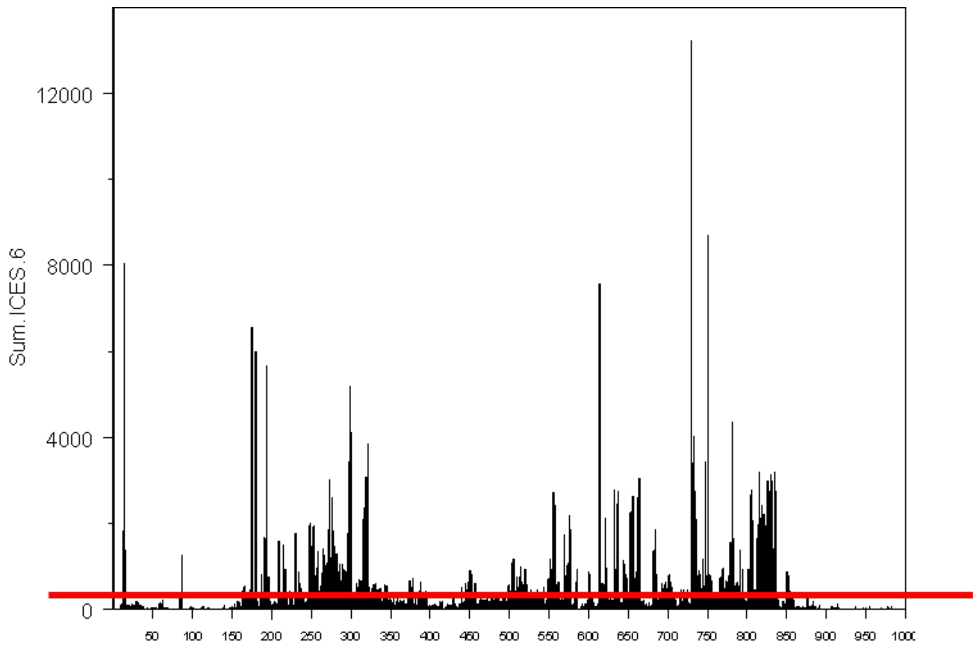


Figure 6-7. Sum ICES 6 PCBs in yellow and silver eels sampled over eight European countries, compared to the new PCB consumption limit (Belpaire *et al.*, 2012). x-axis is individual eels ordered by country.

High contaminant levels have been the basis for a closure or a restriction in the eel (or fish in general) fisheries. During the last years (2010–2012) fisheries restrictions/bans have been issued for an increasing number of waterbodies. This has been documented during WGEEL 2011. In France, in 2011–2012 an additional number of eel fisheries have been closed (see updated map Figure 6-8).

In Italy there was a closure of a large lake fishery, Lago di Garda, yielding approximately 500 kg/y, since 7 February 2011, due to dioxin contamination. The closure was applied exclusively eel; other fish species had not exceeded the limits.

In Germany, authorities recommended in July 2012 to avoid consuming wild eels caught in North Rhine Westphalian waters due to high contaminant levels (Dioxines and dioxin-like PCBs).

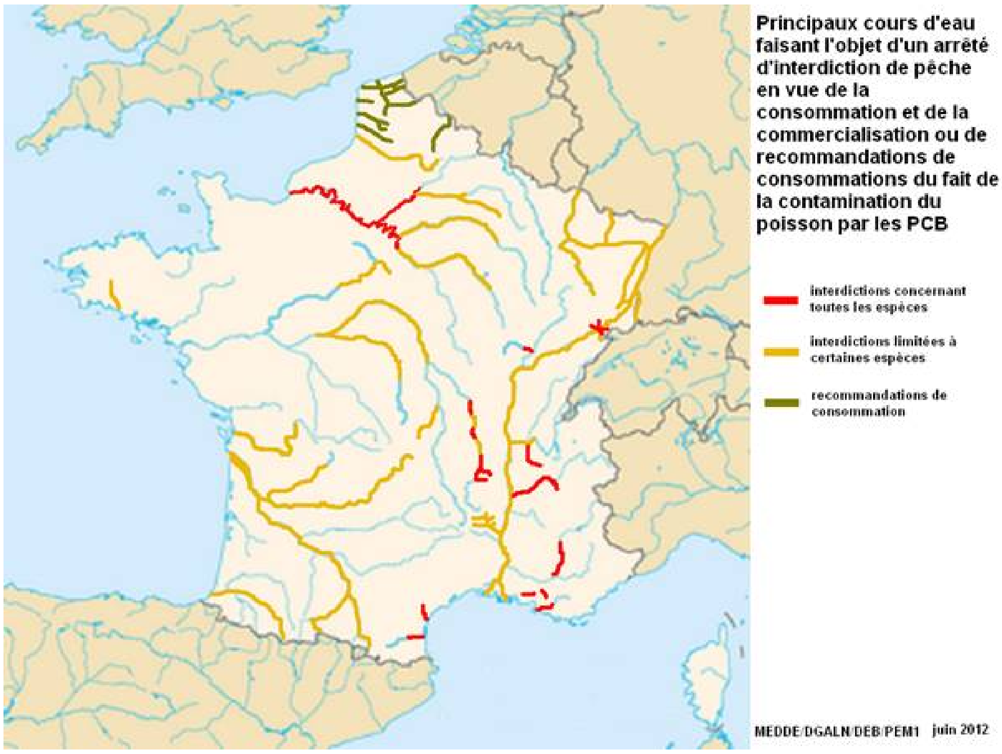


Figure 6-8. Map of France showing waterbodies where eel fisheries restrictions have been issued following the detection of high levels of contaminants in eel. Source Country Report France.

6.6 Eel kills due to contamination or diseases

No occurrence of recent eel kills due to pollution or disease outbreaks were reported through the Country Reports or by the delegates present at the meeting.

6.7 Conclusions

- Considerable progress has been made in developing an approach to include eel quality parameters in quantitative assessment of the SSB. The Eel Quality Index of Contaminants has been improved, and preliminary results show large variations in this index over the catchments. Eel condition parameters have been used to calculate the Reproductive Potential of individual female silver eels leaving their catchment. Distance to the Sargasso Sea, but mainly size and lipid content, have a large impact on reproductive potential. From the preliminary results the figures indicate that the northern countries with large sized, lipid rich eels produce female eels with the largest reproductive potential (expressed in quantity of eggs produced). This quantitative approach in estimating eel quality can be integrated into SSB analysis and has important applications for stock management. Nevertheless, it is unlikely that future stock wide assessments and integration of eel quality parameters in quantitative stock assessments of SSB will be possible, as the current Eel Regulation does not require routine monitoring of (silver) eel quality in the member states.
- The new EU Dioxin Regulation (Com Reg EU No 1259/2011) came into force on 1 January 2012 and sets new maximum levels of dioxins, dioxin-like PCBs and non-dioxin-like PCBs in foodstuffs. In recent years, fisheries restrictions/bans have been issued for an increasing number of waterbod-

ies, with new fisheries restrictions due to contamination in France and Italy. In other areas, new recommendations not to eat eels were issued (e.g. Germany).

- Some scientific surveys including eel quality aspects are in progress. However, essential issues to assess the importance of eel quality for reproductive success, such as to evaluate the effect of specific contaminants on the ability for eel to migrate and to reproduce are currently not included.

7 Natural mortality

Chapter 7 addresses the following Terms of Reference:

c) respond to specific requests in support of the eel stock recovery Regulation, as necessary;

and has links to:

a) assess the trends in recruitment, stock and fisheries indicative of the status of the European stock, and of the impact of exploitation and other anthropogenic factors; analyse the impact of the implementation of the eel recovery plan on time-series data (i.e. data discontinuities). Establish an international database for data on eel stock and fisheries, as well as habitat and eel quality (update EEQD) related data – seek advice from ICES Data Centre for this task; review and make recommendations on data quality issues;

and

e) assess state of current and historic data (including outputs from WKBALTEEL and GFCMEEL) and undertake an analysis of the possible stock–recruitment relationships, incorporating spatial differences (e.g. age-at-maturation, sex ratio), that could lead to establishing precautionary reference limits.

7.1 General introduction

Natural mortality (M) is one of the most influential parameters in fisheries stock assessment and management, since it is related directly to the productivity of the stock, the yields that can be obtained and to management quantities. On the other hand the estimation of natural mortality rates is often uncertain and difficult, the most critical element of many fish stock assessments. Errors in the estimation of such processes strongly affect the outcome of various models used in stock assessment (Hewitt *et al.*, 2007).

The drivers of natural mortality could be divided into intrinsic and extrinsic stresses: intrinsic factors include important correlations among lifespan, body size, and senescence, as well as between metabolic rate and body mass. These intrinsic factors can be linked to the development of a metabolic theory of ecology that relates metabolic rate to survival, growth, and reproduction (Brown *et al.*, 2002). Extrinsic factors affecting natural mortality include disease, predation (other than extremes of cormorant predation and control of cormorant populations), cannibalism and other exogenous sources of mortality that lead to death before expected lifespan was achieved (Brodziak *et al.*, 2011).

Body size and temperature are generally considered the main determinants of biological times and vital rates, including mortality (Hemmingsen, 1960; Robinson *et al.*, 1983; Brown *et al.*, 2004). Body size affects mortality by influencing resistance to environmental stresses, feeding behaviour, ability to avoid predation and competitive skill. Moreover, temperature affects mortality modifying metabolic kinetics (Savage *et al.*, 2004a), following the Boltzmann–Arrhenius law (Gillooly *et al.*, 2001) and increasing mortality in warmer habitat and decreasing in colder. Nevertheless, variations in mortality cannot just be explained in terms of body mass and temperature alone, but also other ecological mechanisms play a significant role in this variation (McCoy and

Gillooly, 2008). For instance density-dependence processes, through inter- and intra-specific competition have a major influence on vital rates (Lorenzen and Enberg, 2002). In eel, density-dependent mortality may be caused by competition for space, when elvers and young eels migrate further into the watercourse seeking suitable habitats with lower density and more food availability (Moriarty, 1986).

Commonly used methods, based on empirical evidences and relationships, life-history theory and maximum age, are notoriously problematic due to low species-specificity. Other methods, such as tagging and catch curve analysis, can also be imprecise since they allow the calculation of the total mortality as the sum of natural and anthropogenic effects (e.g. fishing mortality). Long series data from telemetry and tagging studies, by assigning fates to tagged individuals, allow reliable estimations of M only in unexploited fish stocks. These methods have been successfully used in some studies but they have not been applied to eel due to the rarity of unexploited eel stocks and the high cost of these experiments (Hewitt *et al*., 2007).

Very few estimates of natural eel mortality are available. A value of M=0.1386 yr^{-1} is frequently applied, giving Dekker (2000) as a reference even if Dekker assumed that value to be an empirically sound level of mortality rate.

Recently, Bevacqua *et al*. (2011) calibrated a general model for natural mortality, considering the effects of body mass, temperature, stock density and gender. Results showed eel mortality values appreciably lower than those of most fish, most likely due to the exceptionally low energy-consuming metabolism of eel. These findings have been recently confirmed by Dekker (2012) who found out that natural mortality on Swedish restocked eels has been much lower than the usual estimates (M=0.10 yr^{1}).

In this section, we present and review the models used by each European country to calculate M in their National Stock Assessment along with the most common models generally used in fish population dynamics. We tested eleven different methods on a huge European dataset in order to compare the differences of mortality predictions among them.

Approaches of each country regarding natural mortality estimation are described in Table 7-1. Finland, Norway, Morocco and Latvia didn't produce a national eel stock assessment, while Denmark, Portugal, Lithuania and Spain carried out the assessment without considering natural mortality processes. The other countries mainly used the Dekker (2000, 2012) approach or the Bevacqua *et al*. (2011) model.

Table 7-1. Natural mortality estimation used for stock assessment in the Country Reports.

Country	Stock assessment	Natural Mortality is considered	Model used to estimate natural mortality
Belgium	Yes	Yes	Dekker (2000)
Denmark	Yes	No	
Finland	No		
Germany	Yes	Yes	Bevacqua *et al*. (2011)
Norway	No		
Morocco	No		
Portugal	Yes	No	
Netherlands	Yes	Yes	Dekker (2000)
Italy	Yes	Yes	Bevacqua *et al*. (2006; 2011)
Lithuania	Yes	No	
France	Yes	Yes	Dekker (2000) with separate estimate for glass eel (80%) Jouanin (2012)
Ireland	Yes	Yes	Dekker (2000)
Spain	Yes	No	
Latvia	No		
Poland	Yes	Yes	Dekker (2000)
Sweden	Yes	Yes	M=0.05 and M=0.10 (Dekker, 2012)
UK	Yes	Yes	Bevacqua *et al*. (2011)

7.2 Overview of general and specific methods for estimating natural mortality in European eel

The models compared in this chapter are summarized in Table 7-2. We distinguish them in two main categories, one which considers a constant natural mortality rate throughout all eel lifetime and the other one based on the metabolic theory of ecology that takes into account body mass effect on survival. Table 7-2 also reports the mathematical formulation and parameter values for each method.

The former category is composed by seven different methods:

- one traditionally accepted empirical value (Dekker, 2000);
- three models depending upon the maximum expected age, e.g. silver eel age (Jensen, 1996; Rikhter and Efanov, 1976; Hoenig, 1983);
- two models based on von Bertalanffy growth parameter k (Jensen, 1996; Roff, 1986); and
- one model considering von Bertalanffy growth parameters k and L_{inf}, and water temperature (Pauly, 1980).

The latter comprises:

- three weight based models (Peterson and Wroblewski, 1984; Lorentzen, 1996; McGurk, 1986);
- one weight and temperature based model (Bevacqua *et al*., 2011).

Table 7-2. Equations used in this analysis for estimating instantaneous natural mortality rate in different European eel local populations.

Reference	Type	Equation μ (yr−1)
Dekker, 2000	Constant	0.1386
Jensen, 1996	Constant (silver age based)	1.65 / tm
Rikhter and Efanov, 1976		(1.52 / tm 0.72) – 0.16
Hoenig, 1983		3 / tm
Jensen, 1996	Constant (VBGP based)	1.5 k
Roff, 1986		3k / exp(tm k) – 1
Pauly, 1980	Constant (VBGP & Temperature based)	exp (-0.0152 - 0.279 ln [Linf]+ 0.6543 ln [k] + 0.4634 ln [T])
Peterson and Wroblewski, 1984	Weight based	1.29 W-0.25
Lorentzen, 1996		3Wwet-0.288
McGurk, 1986		5.26×10-3 Wdry-0.25
Bevaqua, 2011	Weight and temperature based	exp (-E / (B T) + q) W-0.46

tm: age-at-maturity (i.e. average silver eel age) [yr]

k and L∞: von Bertalanffy growth parameters [yr-1; mm]

W: body weight, dry or wet [g]

T: average water temperature [Celsius degree in Bevacqua's and Kelvin degree in Pauly's]

E: activation energy [1.22 eV males; 1.24 eV females]

B: Boltzmann constant [8.62×10-5 eV/K]

q: population density index (in this analysis we considered the same value for each population due to lack of information: 50.4 and 49.3 for females and males respectively).

Mortality was estimated for 152 eel populations all over Europe for both sexes, in order to compare the predictions of mortality rates using the WGEEL (2010) dataset. The comparison among constant values and time variant models has been performed evaluating the mortality over the average population lifetime (1):

$$M_{lt} = \int_0^{t_m} \mu(t)\, dt$$

In order to obtain a more biologically sound parameter we also calculated the average annual mortality rate (2):

$$M_{yr} = \frac{\int_0^{t_m} \mu(t)\, dt}{t_m}$$

7.2.1 Results

Figures 7.1 and 7.2 show the lifetime mortality rates of the considered male and female eel populations sorted along the x-axis from northern latitudes southwards.

In Figure 7.1 the results yielded a huge variability of lifetime mortality values (M_{lt}) $\Sigma_a M$ for both sexes with a cohort survival that ranges between 1% and 99%.

M_{yr} values that are averaged over their lifespan (Figure 7.2 and Table 7.3), show a general increasing trend towards South, due to shorter lifespan, faster growth and higher temperatures. For males M_{yr} ranges between $4\times10^{-3}a^{-1}$ and $1.97a^{-1}$ while for females between 4×10^{-3} and $1.77a^{-1}$.

Detailed differences between mortality curves obtained with the eleven models considered are shown demonstratively for three local populations one for each European main area (Northern EU, Atlantic EU and Mediterranean EU) in Figures 7.3, 7.4 and 7.5.

The three weight based models give maximum and minimum estimations of natural mortality. McGurk method provides unrealistic low values, probably due to the fact that the equation is based on dry mass and this might be misleading for eel. On the other hand, Lorentzen, and Peterson and Wroblesky models yield the highest values. Instead, VB based models, compared to the others show very different results from each other so that they encompass all other considered methods. This method has been applied in few populations, mainly in Mediterranean area (Figure 7.5) due to the lack of information about the Brody coefficient (k). Pauly's model that also considers temperature reduces the gap with the other constant approaches. It should be emphasized that all these approaches are basic models for general fish populations. The other two methods developed specifically for eel, Dekker and Bevacqua, give similar results in the Atlantic and Northern populations, while in the Mediterranean Bevacqua estimates higher M values than Dekker due to the strong sensitivity to the higher temperatures that characterize this area.

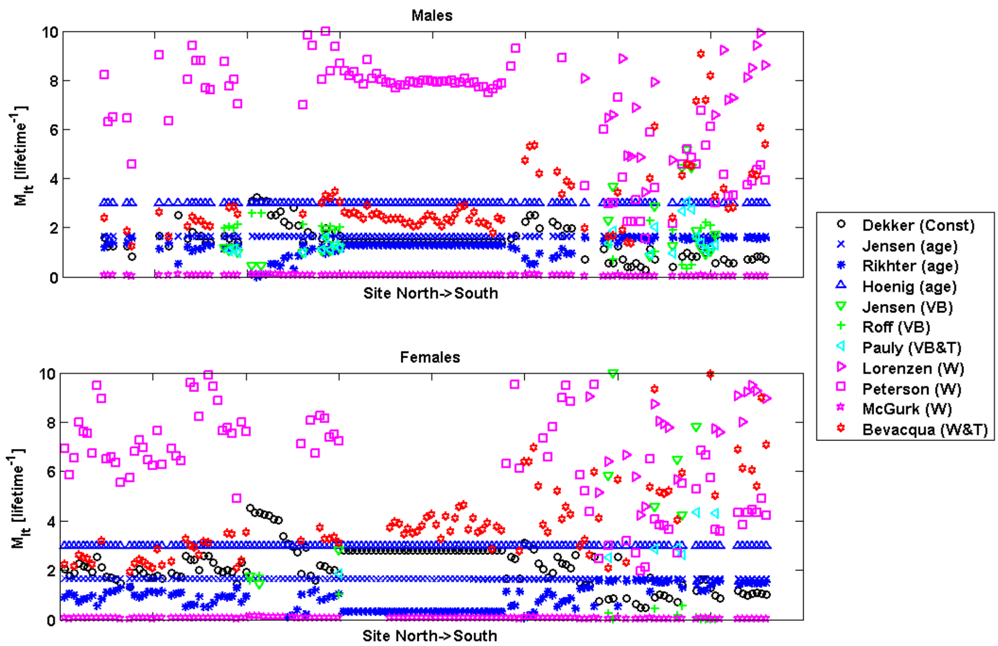


Figure 7-1. Lifetime natural mortality values for both sexes in 152 European eel populations from northern to southern latitudes.

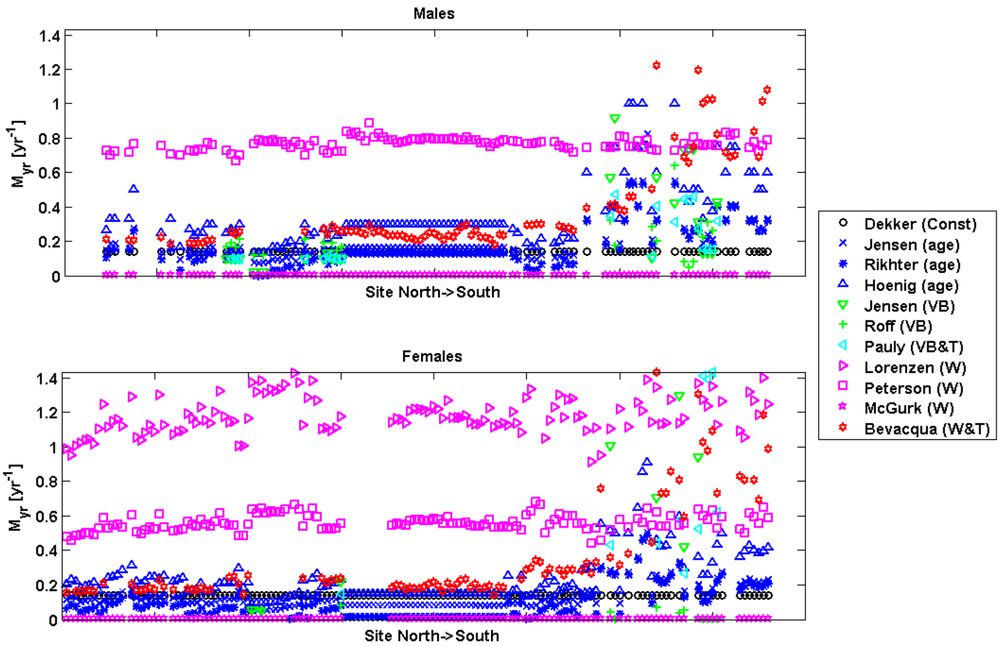


Figure 7-2. Averaged annual natural mortality values for both sexes in 152 European eel populations from northern to southern latitudes.

Table 7-3. Average annual natural mortality values obtained with different models in three latitude zones.

	Average Males Mortality	(yr−1)		Average Females Mortality (yr−1)		
Latitude zones	60°–50°	50°–40°	40°–30°	60°–50°	50°–40°	40°–30°
Models						
Dekker, 2000	0.140	0.140	0.140	0.140	0.140	0.140
Jensen, 1996	0.144	0.359	0.345	0.100	0.236	0.227
Rikhter and Efanov, 1976	0.102	0.337	0.332	0.040	0.208	0.204
Hoenig, 1983	0.263	0.652	0.628	0.181	0.430	0.413
Jensen, 1996	0.087	0.456	0.424	0.105	2.208	1.463
Roff, 1986	0.165	0.240	0.404	0.062	0.024	0.003
Pauly, 1980	0.099	0.308	0.317	0.143	0.806	0.620
Peterson and Wroblewski, 1984	1.675	1.658	1.706	1.180	1.184	1.216
Lorentzen, 1996	0.767	0.760	0.779	0.559	0.559	0.572
McGurk, 1986	0.005	0.005	0.005	0.003	0.003	0.003
Bevaqua, 2011	0.241	0.692	0.818	0.207	0.684	0.862

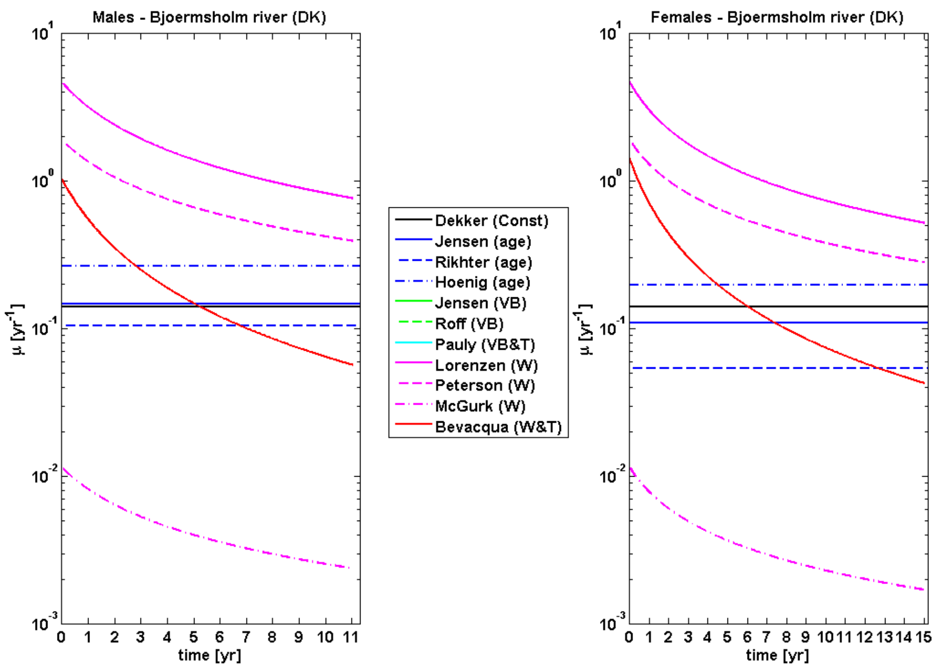


Figure 7-3. Natural mortality rates comparison during lifetime for both sexes in a northern eel population (Bjoermsholm River, Denmark).

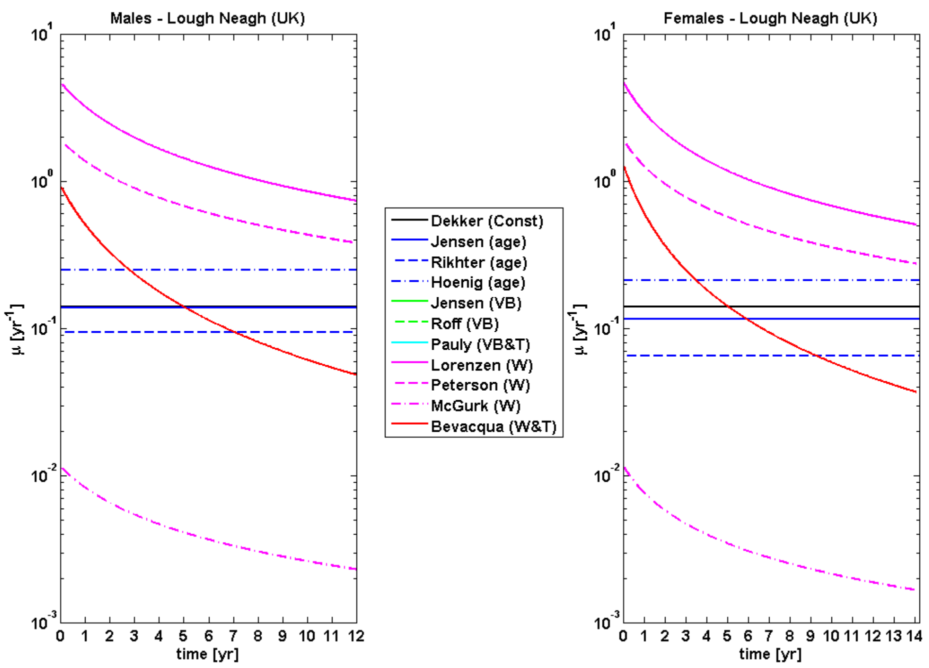


Figure 7-4. Natural mortality rates comparison during lifetime for both sexes in an Atlantic eel population (Lough Neagh, Northern Ireland).

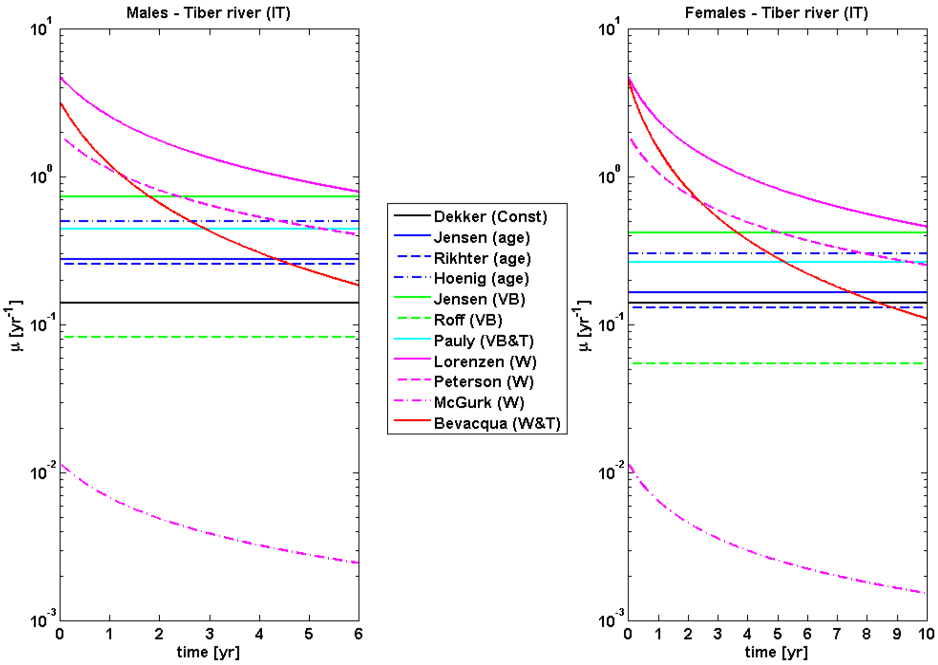


Figure 7-5. Natural mortality rates comparison during lifetime for both sexes in a Mediterranean eel population (Tiber River, Italy).

7.3 Discussion and recommendations

These calculations are based on preliminary data available to the WGEEL; the intention was to show the differences among the most common models to estimate natural mortality. Specific outcomes will certainly change in future with new and complete data.

At this point, WGEEL was not in a position to propose the best method to assess natural mortality without a comparison with field data. We can, however, conclude that the choice of the appropriate model is crucial because it potentially brings about enormous differences in the estimations of natural mortality rates.

The age based methods show an increasing trend in natural mortality from north to south, as does the method of Bevacqua. It would seem that the age based methods of Jensen (1996), and of Rikhter and Efanov (1976) give more realistic mortality rates of <0.1 for northern populations (Dekker, 2012). Unfortunately there were too few data to be able to evaluate the models using the von Bertalanffy growth parameters, especially for the males, but for females the model of Pauly looks encouraging as it follows a similar pattern to the age based models.

In the context of the worked example on Lough Neagh (Figure 7.4 above), Rosell (pers comm. to WGEEL 2012), estimates the parameters *F* as 0.11 and *M* as 0.08. This is based on a numerical estimate of the life table survivorship from glass eel input, phase-shifted to assign output numbers to their relevant input cohorts.

The weight based methods of Peterson and Lorenzen appear to give a high and unrealistic mortality rate, certainly for northern populations. In contrast the method of McGurk, again weight based, is too low giving a life time survival of ~99%.

The effect is a bias in the model outcomes and in the estimate of stock size and production. Siegfried and Sanso (2010) state in their review that weight based model are most appropriate and precise. In the case of European eel, the specific Bevacqua *et al.*

(2011) model seems to be the most complete approach, since it involves the main processes affecting mortality (body mass, temperature and population density), and it provides results in accordance with the empirical value of Dekker (2000). On the other hand the age based methods require less information and are easier to apply.

Research to investigate factors that cause Natural Mortality to vary in space and time should be given priority. Thus further data collection and research should be encouraged to support and improve the knowledge of this difficult research topic in order to obtain more and more reliable stock assessments.

Section B: International Stock Assessment; Planning for post-evaluation of the implementation of the Regulation on the eel stock

8 International Stock Assessment–data and assessment quality

Chapter 8 addresses the following Terms of Reference:

d) plan for an evaluation of the EU Regulation for recovery of the eel stock (EC No. 1100/2007), its target (40% SSB escapement compared to historic production) and its consistency with the precautionary approach, including planning for data exchange, quality control, methodology for stock-wide assessment;

e) assess state of current and historic data (including outputs from WKBALTEEL and GFCMEEL) and undertake an analysis of the possible stock–recruitment relationships, incorporating spatial differences (e.g. age-at-maturation, sex ratio), that could lead to establishing precautionary reference limits;

f) make recommendations on how WGEEL 2013 should undertake the post-evaluation and assessment using the 2012 reported data, taking note of previous WGEEL and SGIPEE reports.

8.1 Introduction

The European eel stock has been in decline for half a century at least with recruitment declining since the early 1980s, and coordinated protective measures have been enacted by the EU and others since 2009. The first post-evaluation of the effectiveness of these measures is being reported to the EU in 2012 for completion of the review with the Commission reporting to the European Parliament and Council by the end of 2013. WGEEL meetings have worked on developing a framework for scientific post-evaluation since 2009; a task not yet complete, but required imminently for application in 2013.

National assessments and stock indicators will be made available in the 2012 reports by Member States to the EU. This chapter suggests a way forward to applying control procedures to the analysis of the quality of assessment, using three separate analyses.

- The first concentrates on data quality control, a first attempt at a quality scorecard is presented in Chapter 8.3 and in Annex 10.
- The second, presented in Section 8.4, is an assessment of the quality of the model used. A preliminary assessment of the methods used to assess the stock, based on the national reports to this working group and internal discussions.
- The third approach requires some testing of the outputs from the model, using the model as a black box and is presented in Section 8.5

The existence a full assessment by the commission of the post evaluation presented by the member states will change the work that has to be done by the working group. In the present state of uncertainty, a decision diagram is presented in Section 8.6, with the aim of helping decision-making and planning.

8.2 Principles applicable to quality control

8.2.1 Basic approach: spatial cascading

The stock in the whole distribution area is considered to constitute one single panmictic population. This contrasts strongly with the scattered, small-scale pattern of the continental stock and the national/regional scale of management (Dekker, 2000; 2008). Management of the stock by uniform measures all over the EU (e.g. a common minimum legal size, a common closed season or a shared catch quotum, etc.) were not feasible or applied, since uniform measures could not be designed in a way that would be effective all over the continent. Regionalised management – i.e. a common objective and target, but local action planning, local measures and local implementation, was central to the EU Eel Regulation (Dekker, 2004; 2009) and on this basis Eel Management Plans have been developed per country/region. Few cross-boundary EMPs exist.

The post-evaluation process commencing with the reporting by Member States in 2012 has been first and foremost a synchronized process of national post-evaluations. National reports evaluate to what extent the implementation of the national EMP has been successful, and (it is to be hoped also) whether the national targets have been achieved. The international post evaluation is now being planned.

In the past two years, a framework for international post-evaluation and international stock assessment has been developed (Dekker, 2010a; ICES 2010a,b; ICES 2011a,b). At the heart of this framework is the notion of subsidiarity: monitoring, assessment and post-evaluation are organized and executed at the lowest management level being effective. This parallels the subsidiarity in the management process (Dekker, 2008) – parallel structures are probably easier accepted and implemented. The recent meeting of WKESDCF (ICES 2012) subscribed to the idea of region-specific monitoring, under international orchestration.

Standard fish stock assessments, for stocks exploited by several countries, usually proceed as follows: field data are collected in each country (total landings weight, length–frequency, length–age-key, etc.), worked up to a catch-at-age matrix, which is summed over the countries; and finally a single, international stock assessment based on the (summed) catch-at-age matrix yields the required stock indicators. That is: orchestrated data collection, feeding into a single, shared assessment. Though this approach could be followed for eel too, the assessment would be almost meaningless (ICES 2010a). For instance, the number-at-age-5 would combine small yellow eels far below the minimum legal size in Scandinavia, with large silver eels in the Mediterranean that have already endured almost all their anthropogenic mortalities; the estimated anthropogenic mortality at this age would represent a meaningless mix of northerly and southerly processes, that could no-where be related to specific anthropogenic actions. A single pan-European assessment of the continental stock (not: the oceanic stock!) is therefore not sensible. The alternative is to assess local stocks by country/area, to derive local stock indicators, and to design an international integration procedure for the local stock indicators (Dekker, 2010a). International stock indicators are based on national data only through the national stock indicators, not directly.

Following several rounds of discussions and additions to complete this assessment framework (Dekker, 2010a; ICES 2010a,b; 2011a,b), ICES (2011b) advised to use the indicators B_0, B_{best}, $B_{current}$ and ΣA – first labelled as the 3B-approach, but since the addition of ΣA, is now the 3Bs&ΣA-approach. The EU Template for the 2012 post-evaluation asks for these indicators in the Appendix.

Dekker (2010a) discussed the relation between national and international targets, concluding that the application of the international target at the national scales ensures the achievement of the international targets (one target for all areas), but only if all management areas do indeed achieve their targets (all areas for one common goal) - *Unus pro omnibus, omnes pro uno* or *One for all and all for one*. It is a parallel line of reasoning on (*post hoc*) indicators that will be discussed here. All countries (must) have reported on the 3Bs&ΣA indicators, from which international indicators can easily be derived (all to one) - but what quality requirements must be set on these national assessments, to enable a meaningful and acceptable international assessment?

8.2.2 Standardizing the unstandardized

SLIME (Dekker *et al.*, 2006) produced and tested a collection of eel models. POSE (Walker *et al.*, 2011) focused on inter-calibration between models and testing them on a standard dataset (CREPE) and on a common field dataset (Burrishoole – WRBD Ireland). No standardized methods have been enforced for the national 2012 post-evaluations, nor have minimum requirements been imposed (Dekker, 2010b). A wide range of different methods have been applied by the Member States with effectively no standardization. Whether or not that wide range of nationally applied methods allows deviation in the international indicators is a critical question for WGEEL. The specific subsidiary elements of this problem are:

- What conditions must be met by the national assessments?
- What quality criteria can be formulated?
- Can (and must) we adjust our procedures for the lack of standardization?

The simplest conceptual approach to standardization would be to discard all national estimates, ignore the variety of methods, and start all over again with the basic data, applying one (or a few) standardized method to each management unit all over Europe. Under this approach, there is just a need for data quality control; (ToR a. of WGEEL 2012). The obvious drawback of this approach is a heavy international workload (approximately 70 eel management units to be assessed assuming that data are available).

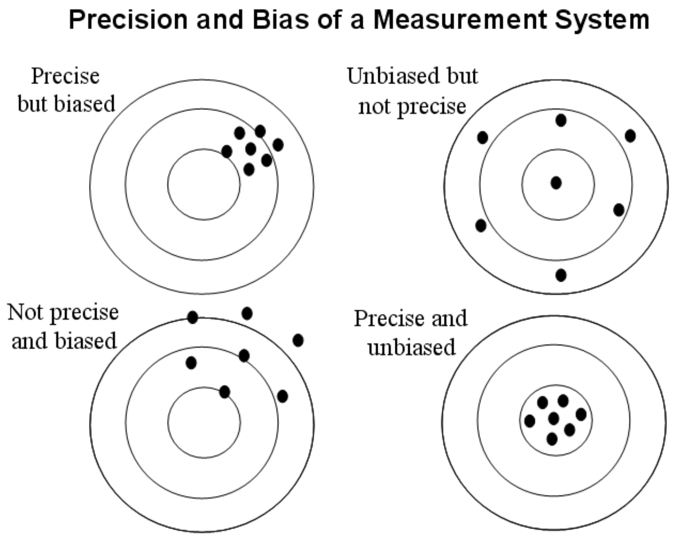
More importantly, this single standard method approach is not likely to be successful. Some data and assessment procedures might vary because of individual preferences or already established practices, and more variation arises due to differences in the field (e.g. fishery types, survey methods, habitat types) and differences in the biological processes operating. An internationally standardized re-assessment will have to cope with these field-based differences, as well as with the differing bases of the existing dataseries. An international re-assessment thus becomes almost as complex as the available national assessments. For those areas where no (national) assessment is available or no (standardized) indicators have been reported, an international (re)-assessment is the only way forward. For all other areas, it will be easier to scrutinise the national assessments and test their characteristics, in this way ensuring the quality of their output: the national stock indicators.

8.3 Data quality control

8.3.1 Introduction

Accuracy of the "3Bs&ΣAs" will be determined by the amount of bias (systematic errors) and the precision (random errors) of estimates of key input data or estimates.

The diagram below illustrates bias and precision for a parameter of interest, where the target, true value is the smallest circle in the middle, the bull's-eye.



Precise and unbiased estimates of the target values are accurate (bottom right corner). It should be noted (and emphasized) that accurate estimates cannot be obtained from significantly *biased* sampling schemes. Whereas precision can be improved by increasing the sample sizes in data collection programs, this is generally not the case with *bias*. Bias is a systematic departure from the true values caused by non-representative data collections and other persistent factors, and can generally not be quantified because the true values seldom are known. The focus should be to minimize or eliminate sources of bias by developing and following sound field data collection procedures and analytical methods.

Indicators of bias could be developed for estimates of the "3Bs&ΣA" by identifying the existence of bias in data collection schemes underlying the estimates. Indicators of bias could, for example, be developed following the experiences of the ICES 2008 workshop on "Methods to evaluate and estimate accuracy of fisheries data used for assessment" (WKACCU) and the ICES 2009 workshop on "Methods to evaluate and estimate the precision of fisheries data used for assessment (WKPRECISE)". It was recognized by ICES 2009 (WKPRECISE) that measures of precision estimates based on fisheries data used for assessments only are meaningful for catch sampling programs that obtain representative ("unbiased") data. In other words, and this will probably also be true for the estimates of the "3Bs&ΣA", a minimum requirement should be that these estimates first pass basic checks for *bias* before precision measures are addressed. In the following section, a scorecard for bias detection in eel stock assessments is presented. The scorecard developed by WKACCU was used here as a starting point and criteria were added/removed/modified to adjust for the specific demands of eel biology and eel stock assessments.

8.3.2 Developing a scorecard for bias detection

Bias in fisheries data used for stock assessments is difficult to quantify. A major focus of the WKACCU workshop was to review and develop practical methods for evaluating potential sources of bias in fisheries data collection programs, and means of minimizing or eliminating such bias. The approach was to develop simple indicators of bias in key parameters that could be summarized in a table with a scorecard of green (minimal or no risk of bias), yellow (some risk of bias), and red (established sources of bias). The scorecard can be used to evaluate the quality of data sources used for stock assessments, and to reduce bias in future data collections by identifying steps in the data collection process that must be improved.

A list of key parameters that should be scored to evaluate potential bias in data used for eel stock assessment was developed using the parameters (A–I) of WKACCU as a starting point and some new categories (J–L) were added:

A. Species Identification
B. Landings Weight
C. Discard Weight
D. Effort
E. Length Structure (market sampling and surveys)
F. Age Structure
G. Mean Weight
H. Sex-ratio
I. Maturity Stages
J. Silvering rate
K. Survey methods
L. Assessment models

Due to specific nature of the biology of the eel and the large variety of eel stock assessment models developed by the different MS, the parameters developed by ICES 2008 (WKACCU) (A–I) needed to be modified and new parameters (J–L) were added. The main differences with the scorecard developed by ICES 2008 (WKACCU) are that most eel stock assessments are not based on fisheries data but on fisheries-independent surveys. Therefore some issues related to Surveys Methods and Assessment Models for eel needed to be considered and incorporated in the score card. The scorecard has been progressed from that presented in ICES 2011 (SGIPEE) during the course of this meeting but is not finalized yet. The draft version of the scorecard can be viewed in Annex 8.

8.4 Assessment methods

This section looks at the local stock assessment methods and looks for similarities and differences between the approaches adopted across Europe.

8.4.1 Introduction

The quality of the international stock assessment depends on the quality of national assessments, and the consistency (and completeness) of these local and national assessments. It should be noted that some MS may not produce assessment stock indicators and also that the eel stock extends beyond the boundaries of the EU so EU

Member State data will not be sufficient for a complete assessment of the whole eel stock.

Here, we examine the values for B_0, B_{best}, B_{curr} and ∑A for countries and/or EMUs, and consider the quality, comparability and consistency of the local assessment methods (in terms of input data (raw and processed), the habitat types considered, and the anthropogenic mortality factors) used in those national assessments reported to the European Commission for the 2012 Review of Eel Management Plans that were made available to the WGEEL (by countries), along with information provided in the Country Reports and the original EMPs.

We examine the most obvious gaps and inconsistencies so to encourage data managers and assessors to address these issues in future and to provide a basic framework for quality assurance preceding the international assessment.

8.4.2 Sources of information

We reviewed in the Country Reports, the 2012 reports to the European Commission on the implementation of the EMPs, and the original EMPs. We also interviewed the authors of the Country Reports to WGEEL 2012, and other experts familiar with the local (and national) stock assessments. Note that stock indicators were not available from all countries and, in some cases, the approaches used to provide data for the WGEEL 2012 differed slightly from those used for the EMP Review, and modifications are foreseen in the near future, but we ignored these for present purposes.

We developed spreadsheets to capture the knowledge from these interviews:

1) Stock indicators: B_0 at some historic time; B_{best}, $B_{current}$, ∑A pre- and post-implementation of EMPs, and forecasting to 2016;*

2) Methods overview (biomass, anthropogenic mortality rates, habitat types & relative areas);

3) Input data for Biomass estimates (measured, derived, model processes, upscaling);

4) Anthropogenic Mortalities (types assessed, present but not assessed, not considered, not relevant);

5) Wetted areas (B_0, B_{best}, $B_{current}$) and time periods (B_0).

*** note that forecast stock indicators were suggested by SGIPEE (ICES 2010, 2011) but not specified as requirements in the EU Guidance on EMP Review, or the 2012 Country Reports to WGEEL.**

Information was available from 15 EU countries. No details were available for the other EU countries producing eels, either because they were represented but lacked information or were not represented at WGEEL 2012. Information was sought from WGEEL experts from two countries outside the EU, but neither country had derived stock indicators. The present-day range of European eel includes other countries outside Europe. Therefore, the picture of eel production and stock status is not yet complete (see Chapter 9).

The variety of local and national circumstances, and the methods applied, meant that none of the interview questions could be completed in every case, and therefore the summaries presented in the following text are not expected to all sum to the same total. The spreadsheet entries were assigned to countries and to EMUs. However, some countries reported on several EMUs and in some cases apply different methods to derive stock indicators for different EMUs, while other countries report only a national EMU.

8.4.3 Stock indicators

$B_{current}$

Data on $B_{current}$ since the implementation of EMPs were available from the majority of the countries, though five countries did not provide data and three only reported for parts of their areas. In some cases, the most recent information is not from 2011 (the full year closest to the mid-2012 reporting deadline), but from 2009 or given as average of several years between 2008 and 2010.

Data on $B_{current}$ for the period before EMPs were implemented were available from fewer countries (not provided by seven), including two countries where data were only given for parts of their areas. It is likely, however, that such data are available from at least some of these seven countries, because most of them should have included this information in their EMP. A forecast $B_{current}$ for 2016 was also sought, as this was recommended by SGIPEE (ICES, 2011), but only one country provided information on this parameter. Clearly, there must be an explicit request to countries for all the necessary stock indicators, which has not been the case to date.

B_{best}

Only about half of the countries provided information on B_{best} for the period since EMPs were implemented, despite the fact that this information should be provided to the European Commission in 2012. Similarly, only a few countries provided information on B_{best} for the period immediately before EMPs were implemented. This parameter could be used to assess, if and how the ratio of B_{best} and B_{curr} has changed after the implementation of the EMPs. If this is intended, the countries should be explicitly asked to provide this information in 2013.

B_0

The majority of the countries (eleven) provided estimates of B_0, the escapement biomass under undisturbed conditions and historical recruitment. Five countries did not give estimates, but one of them will have the data available for the 2013 assessment. One country provided an estimate of B_0 only for one part of the area. Data were usually given as absolute biomass in tons, but one country provided a range of kg/ha data. Yet, if these data are available in this country, it should be possible to give an absolute value as well in future.

ΣA

Information on $\sum A$ (for before and after EMP implementation) was available from fewer than half the countries. Furthermore, those data were provided in different ways: as total amount (t), as rate or as percentage. Accordingly, they were presented with no relation to a certain part of the stock (just total amount), as value for a cohort over its total lifespan or for the stock at a given year. The last case usually relates to certain age classes, but this was not specified in most cases.

8.4.4 Methods analysis

8.4.4.1 Biomass indicators

Some countries estimated $B_{current}$ and then added the losses due to anthropogenic impacts to derive estimates of B_{best}, whereas other countries estimated B_{best} and then subtracted losses due to anthropogenic impacts to estimate $B_{current}$. These two approaches might not give the same results, depending on the method of estimating anthropogenic losses.

In five countries, B_0 was assessed using data independent of those used to estimate B_{best} and $B_{current}$. In five other countries, B_0 was derived or back-calculated from either B_{best} or $B_{current}$.

Five countries reported independent exercises to 'ground-truth' estimates of stock indicators, based on counts of silver eels directly by trapping, cameras, resistivity counters, mark–recapture studies, or silver eel index estimates. However, these ground-truthing exercises were for select rivers or EMUs, and no country reported ground-truthing for all assessments.

Every country used a different method, or methods, to estimate biomass stock indicators (B_0, B_{best} and $B_{current}$), but these were largely based around the following:

- silver eel censuses, including mark–recapture estimates;
- habitat-based extrapolations from silver eel censuses;
- model-based extrapolations from stock surveys, fishery data and/or stocking history;
- By referring to escapement from similar habitats;
- Analysis of fishery data (landings, mortality rates, catch curves).

The assessment data that were directly measured were:

- wetted area;
- weight of glass eel input;
- yellow eel density (rivers);
- yellow eel lengths (rivers, lakes);
- weight or count of silver eel migrants (Didson, counter, trap) or premigrants (e-fishing);
- fishery catches (numbers by length and/or age);
- recapture rates (from mark–recapture studies).

Where local standing stock data were derived from scientific surveys or fishery catch data, these were corrected for fishing efficiency in four out of five countries.

The parameters that were derived from these analyses and used as input parameters for assessment models were:

- yellow eel density vs. distance from the sea;
- sex ratio in yellow eels;
- natural mortality rates;
- turbine mortality rates;
- standing stock vs. geology.

Three life-history processes were commonly, but not always, included in model-based approaches: silvering rate; growth rate; and, natural mortality. Silvering rates were derived from data collected in the EMU (two countries), national data (three countries), from the literature (one country), or using a fixed rate validated by field data (one country). Growth rates were derived from data collected in the EMU (seven countries), or from national data (two countries). Natural mortality rates were derived from Dekker (2000) but using various levels of precision: 0.14, 0.138 or 0.1386; from Bevacqua *et al.* (2011) adapted for local or national water temperature regimes;

or, from locally analysed data (i.e. comparing predicted production and landings) (0.05, 0.10) or local expert opinion (80% for glass eel).

Where results were presented as eel length data, biomass was derived using length–weight relationships based on field data from the EMU (one EMU), from the national datasets (most cases), or a fixed weight conversion (one country).

In the three countries where biomass calculations were split by males and females, sex ratio was derived from national data on relationships between eel density and sex ratio. Two countries used a fixed sex ratio (either 5% or 0% males) based on field data. Biomass calculations were not split by male and female eels in five countries.

Almost all riverine habitats were assessed, with limited exceptions where no wetted area data are available for this habitat type (three countries). Almost all lake habitats were assessed, with one exception where no wetted area data are available. Several countries did not assess escapement from estuaries, presumably because of lack of data on wetted area and/or eel production rates. Where present, lagoons were assessed by most countries, with one exception. Only three countries assessed production in coastal waters, whereas some coastal production might be expected in most countries with coastal waters. This is probably because little or nothing is known of eel production in this habitat type (see ICES 2009 SGAESAW).

Practically, therefore, most national assessments included fresh and transitional waters, but the most significant inconsistency (by relative area) is the lack of assessments of coastal marine waters.

Eel data from specific survey locations were upscaled to river reaches or similar habitat types for estimating basin or EMU level biomass in four countries (not applicable in five countries). Extrapolations were 'corrected' for distance from the shore in one country where surveys were limited to the marginal 1.5 m and extrapolated to areas further from the shore, whereas no such 'corrections' was applied in the other three countries. In two countries, the surface area over lake waters deeper than 20 m or 50 m were excluded from analyses (i.e. excluded from "eel producing waters").

Biomass estimates were estimated for all habitat types combined in four countries. In six other countries, biomass estimates for certain habitat types or river basins were upscaled to other habitat types in order to derive EMU or national stock indicators.

8.4.4.2 Anthropogenic mortalities

Information on $\sum A$ (for before and after EMP implementation) was available from fewer than half the countries. Furthermore, those data were provided in different ways: as total amount (t), as rate or as percentage. Accordingly, they were presented with no relation to a certain part of the stock (just total amount), as value for a cohort over its total lifespan or for the stock at a given year. The last case usually relates to certain age classes, but this was not specified in most cases.

A range of anthropogenic mortality factors were assessed across the countries considered, though not all occurred in every country, or nor were they assessed in all those countries where they occurred. The impact of pollution was not assessed in any country. Neither was the impact of parasites or other diseases, but it is unclear whether these should be considered as anthropogenic or natural impacts.

Predation by cormorants was assessed as an anthropogenic impact in four countries and assessed in another country but considered as a component of natural mortality. Predation by cormorants likely occurred but was not considered to be an anthropogenic impact in seven countries. No other predators were mentioned by any countries.

Losses of downstream migrants at hydropower facilities, and specifically passage through turbines, were assessed by all but two countries where these occurred, mostly based on mortality rates taken from the literature (reviewed by WGEEL 2008), but in a few cases based on local data (three countries). Only one country considered the effect of barriers to upstream migrations.

The impact of entrainment in pumps used to move water between waterbodies was assessed in two of the five countries where such pumping occurred in significant quantities. The impact of abstracting water for irrigation, cooling or consumption purposes (which can be by pumps or gravity fed) was assessed in only one of the seven countries and in five others where it was considered to occur in significant quantities.

The only habitat factors reported as anthropogenic impacts were the loss of potential production due to partial or complete habitat loss by tidal controls (flaps/gates), and the loss due to general urbanization of the territory. The impact of tidal controls was assessed in one of the two countries where it was thought to be a relevant factor. The impact of urbanization was only considered in one country, but can be assumed to be a factor everywhere.

Commercial fisheries were assessed in every country where they occurred, though impacts were variously reported as biomass (by stage or standardized, e.g. silver eel equivalents), mortality rates or both. Recreational fisheries in fresh and transitional waters were assessed in all but one country where they occurred, while recreational fisheries in marine waters were assessed in all countries where they occurred. In countries where catch and release was practised (voluntary or obligatory), however, no account was taken of the potential for an impact from post-release mortality.

The considerable lack of data for $\sum A$ and the variability of the type of data given complicate the process of summing national values to produce a single, international mortality rate. Data from more countries and mortality factors are required, and in a standard format.

8.4.4.3 Wetted area calculations and time periods

In addition to the differences between countries in whether eel production is assessed in rivers, lakes, estuaries or coastal waters (see above), the reference time periods and the 'rules' about wetted areas that were used to derive estimates of B_0 varied considerably between countries.

Article 2.5 of the EC Eel Regulation (1100/2007) states that the "target level of escapement shall be determined, taking into account the data available for each eel river basin, in one or more of the following three ways:

a) use of data collected in the most appropriate period prior to 1980, provided these are available in sufficient quantity and quality;

b) habitat-based assessment of potential eel production, in the absence of anthropogenic mortality factors;

c) with reference to the ecology and hydrography of similar river systems.

Only Article 2.5.a refers to a reference time period, and this is without a historic boundary. Our interviews revealed that assessments in five countries, or parts of one country, refer to the "pre-1980s" period without defining the time boundaries. Other countries refer to specific years (1980; 1983; 1990) or periods (1942–1982; 1950s; 1960–1979; 1960–1980; 1967–1982).

Most countries based their B_0 'eel-producing' habitats on the wetted areas that exist under present-day conditions, rather than on wetted areas that had existed at the relevant time in history. An obvious, though rarely quantified difference in wetted areas between the past and today is probably due to the presence of impoundments above dams. Whereas some countries took the changes caused by impoundments into account when defining B_0 wetted areas, i.e. only using the wetted area of the historic river before the impoundment, others ignored this change. These impoundment areas may well be consistent with the wetted areas that would have existed during the time period set by each country as the reference period for setting the management target, but are certainly not consistent with the Regulation's requirement for a target production level "if no anthropogenic influences had impacted the stock" (Article 2.4).

Assuming a 1:1 relationship between production in rivers and impoundments, the consequence of ignoring this change in the wetted area could be that B_0 is overestimated. Some countries have excluded deep lake waters from assessments, so it might be argued that production from marginal areas of lakes would be equivalent to that from the original rivers, but this would be a very simplistic assumption of a complex issue. Land reclamations and channel modifications are two other changes in habitat that ought to be considered.

This variation in the treatment of impoundments extends to present-day stock indicators. While most countries include impoundments in estimating B_{best}, some don't on the assumption that eel are unable to access these habitats. $B_{current}$ is universally assessed according to the habitat that eel are expected to occupy today, at least for those habitat types assessed.

8.4.4.4 Stocking

As eel restocking relies on a wild fishery, the donor EMU should incur a loss–a fishing 'mortality'–but the recipient EMU may gain additional production and escapement. This complicates the procedure for summing national stock indicators, given the risk of double accounting, and in its simplest terms for the potential of $B_{current}$ exceeding B_{best}. Therefore, it is essential that the treatment of stocking in the data analysis is clear and completed to a common standard. A series of questions were posed about the treatment of stocking in national methods:

Does B_0 include stocking?

Since B_0 should give an estimate for silver eel escapement under conditions in the absence of anthropogenic impacts (implicitly excluding the positive 'impact' of stocking), stocking should normally not be included and the common answer should be "no". Yet, different countries may use different methods to estimate B_0. Hence, the question could help to single out methods differing in that point. In the present analysis, the answer was (as expected) usually "no". For some countries no information was available and for one country the answer was "unclear".

Does B_{best} include stocking?

Since B_{best} is used in the further process of evaluation, it must be very clear how this parameter is calculated. It is described by SGIPEE (ICES, 2011) as escapement which could be achieved under present/recent recruitment but in the absence of any anthropogenic impacts. In most cases this is interpreted as "based just on **natural** recruitment" but the consequence is that the relation between anthropogenic mortality ∑A and the ratio $B_{current}/B_{best}$ is broken. If, on the contrary, B_{best} does not comprise restocked eels and ∑A includes a positive impact of restocking, ∑A is no longer the mortality incurred by (natural and restocked) recruits.

There were only a few answers available and most of them were "no" (as expected), but for one country the answer is "yes". This treatment has to be standardized and incorrect interpretations avoided.

<u>Does $B_{current}$ include stocking?</u>

The answer to this question should be consistent with information on stocking. If stocking is conducted in a country (an EMU) the answer should be "yes". Where information was available, the answers were "yes".

<u>Is ∑A lower due to stocking?</u>

This is an important question for examining any changes since EMP implementation. Both answers are possible (yes/no), and both may be correct. If ∑A is calculated as ratio of $B_{current}$ and B_{best} where B_{best} does not include stocking but $B_{current}$ does, then the answer would be "yes". This way of calculation would, e.g. be correct for the use in the modified precautionary diagram. If glass eels are removed from French estuaries and stocked in German waters, they will be counted as mortality in the French systems and as "negative" mortality in the German calculations.

However, this calculation should not be used, e.g. to prioritize waters for stocking, because the real mortalities in a river system may be obscured. If the stocking is high enough, $B_{current}$ may become higher than B_{best} despite the occurrence of anthropogenic mortalities. In that case the apparent mortality would be lower than the real one.

For an analysis of the real mortalities in the system, ∑A should be calculated on the basis of the stock, including natural recruitment and stocking. In that case, the answer should be "no".

Obviously, in systems where stocking occurs, two parameters should be calculated: ∑A on the basis of the stock including the stocked eels ("no") and the ratio of $B_{current}$ and B_{best}.

On the basis of the data available at present, there were few clear answers (five countries "no"; one EMU "yes").

8.4.5 Discussion

This review was not designed to evaluate the stock indicators themselves. The present conditions in the different countries are likely to differ considerably and hence the present data available for the countries could not be evaluated in the short time. This will require a tremendous effort and was not the task of the Working Group this year. The data on ∑A are related to these different conditions in the countries. Furthermore, they were given in different ways, which does not allow a comparison at the meeting. This inconsistency must be rectified in 2013, to enable the intended international assessment.

Hence, the only parameter, which could be considered at least roughly, is B_0. A great variation in the estimates for this parameter had already been noted in the report of the 2010 Meeting in Hamburg (WGEEL, ICES, 2010).

In the present reports, most countries estimate silver eel escapement related to area of between 2 and 20 kg/ha*year. For two countries, the data are in the range of 16 to 47 kg/ha. The variation in this range may possibly be explained by geographical aspects (e.g. Atlantic vs. eastern Baltic), differences in type of waters included and, of course, by the methods used for the calculation (including the availability of data). Yet, the value available for one remaining country with 662 kg/ha is far outside the range estimated by the other countries. Here it is not intended to judge whether the estimates (and especially this extremely high one) are correct, but the huge difference clearly asks for a logical explanation. Preferably, an assessment of these data should be done prior to the whole stock assessment in 2013. The values of B_0 are important in the evaluation process because the position of the "overall bubble" for the European eel stock in the modified precautionary diagram is strongly influenced by these data. With the given data, one country accounts for more than half of the total "pristine" spawner stock estimates. Therefore, this issue clearly has to be addressed in the post-evaluation process.

Though there are commonalities between countries in the data and methods used to derive national stock indicators, there are several differences that may have a significant impact on the relevance of combining national stock indicators into a stock-wide assessment.

The most obvious differences are:

Method

- Some countries estimated either B_{best} or $B_{current}$ and then derived the other indicator, rather than estimating each separately.
- Validations with independent data were relatively rare.
- Local eel data were not always corrected for gear efficiencies, therefore underestimating local stock size.
- Various life-history parameters were based on EMU or national datasets, or values taken from the scientific literature, and therefore might not be representative of the local eel population dynamics.
- Some assessments considered male and female eels separately whereas others assessed 'eels'.

Areas producing eels

- The reference time periods for setting the management target defined by the Eel Regulation ranged from the 1940s to the 1990s, or were listed as pre-1980s; but without a starting time. Most countries defined a time reference when impoundments would have existed, and therefore could justify including these areas, but some excluded the wetted area of impoundments when estimating B_0, in compliance with the principle of the Regulation that the target is set according to eel production in the absence of anthropogenic influences.
- None of the five gross habitat types (rivers, lakes, estuaries, lagoons and coastal waters) were assessed everywhere where they produce eels.
- Within gross habitat types, some extrapolations assumed relationships between eel production and habitat, with the extreme being exclusion of deep waters, whereas others assumed fixed extrapolations.
- The extremes of scale in the derivation of biomass estimates ranged from (i) extrapolating from gross habitat types within river basins to other habitat types and ultimately to the EMU, to (ii) other estimates were developed directly at the EMU scale.

Anthropogenic impacts

- Although commercial fisheries were assessed in every country where they occurred, treatment of recreational fishery impacts was incomplete, especially in relation to the potential losses from post-release mortalities.
- None of the other potentially major anthropogenic mortality types were universally assessed within and between those countries where they occurred.
- Predation by cormorants was assessed as an anthropogenic impact in some countries but treated as a natural mortality in others.

The historic and present-day productive range of European eel extends beyond the countries interviewed for this analysis. Therefore, the picture of eel production and the status of the stock are not complete. The analysis, or at least the standardization, needs to be extended to all countries reporting stock indicators, other countries need to produce stock indicators, or proxies need to be developed.

Locally and nationally, those who are responsible for collecting and analysing their data, and for deriving the stock indicators for local stock assessments, should make best efforts to fill these gaps where they are relevant to their local conditions. Ideally, these gaps should be addressed prior to the 2013 whole stock assessment planned by WGEEL (April 2013, September 2013), but it is recognized that this will not be practical in circumstances were new data or new methods are required.

The results of the interviews were also used to inform the development of an assessment quality assurance scoring procedure (Section 8.3).

8.5 Quality of stock indicators

The Eel Regulation is based on the assumption that current recruitment might be restricted by a low spawning–stock biomass. This is as yet unproven, as the complex ecology of eels makes it difficult to demonstrate a stock–recruitment relationship (see also ToR e). In Chapter 9, progress is made to describe a S/R relationship for eels, already assumed to exist under the precautionary approach, and to define reference limits. Dekker (2004) previously explored a tentative analysis of the actual stock–recruitment relation, based on the assumption that the historical trend in spawning stock size probably paralleled the observed trend in landings. That analysis found a strongly depensatory relation (recruitment falls more rapidly than the spawning stock), contradicting the (implicit) assumption of the scientific advice (ICES 2002) and the EU Regulation. Due to this mismatch between theoretical assumptions and actually observed trends (if the trends in landings and in SSB are indeed comparable), the 2012 post-evaluations require meticulous distinction between theoretical considerations and actual observations (Dekker, 2010a).

A quality control system for checking the stock indicators has not been fully worked out yet in the WGEEL, but a working paper (Dekker, 2012) was submitted and discussed. At the heart of the suggestion is the observation that field circumstances and management practices vary from country to country, and that assessment methods have not been standardized (see also Section 8.2.2). Rather than standardizing the unstandardized, it is suggested to design a number of relatively simple test-scenarios that can be applied to individual countries/EMUs. Each scenario defines a number of changes to the input data used in the national assessment, and considers the effects these changes have on the resulting stock indicators. Some changes are supposed to have none, others to have major effects on the results. Testing the net behaviour of national assessment methods, rather than considering all complexities within, might be an achievable/affordable way to detect the quality of the methods used.

It is suggested that such checking of the quality of stock indicators could be accomplished by applying the following test-scenarios:

0. **Null**. This is essentially the 3Bs&ΣA as reported in the national post-evaluation, applicable where the reported data are by direct measurement;
1. **Monitoring data**. Eel monitoring data have been collected before (*pre*) and after (*post*) the implementation of the Eel Management Plans. Replacing monitoring_{post} by monitoring_{pre} and re-assessing the stock, the change in the values of 3Bs&ΣA due to management action disappears (data-driven) or remains (assumption-driven). Data-driven results are to be preferred;
2. **Testing of the impact of covariates**. Where additional monitoring data have been collected on other factors influencing the eel stock (water discharge, temperature, etc.), temporarily replacing these covariates_{post} by covariates_{pre} and re-assessing the stock, the change in the values of 3Bs&ΣA due to management action either disappears (accidental effects) or remains (structural effects), but structural effects are to be preferred;
3. **Test the impact of management Controls**. Where, under an EMP, management measures have been taken to control the anthropogenic impacts (e.g. effort reduced), these measures will have affected the fishery (catch monitoring) and stock (stock monitoring). The question arises whether information on these Controls determines the stock indicators or independent ground-truth has been derived. Temporarily replacing controls_{post} by controls_{pre} in models (but leaving all monitoring data *as-is*) and re-assessing the stock, the management induced change in the values of 3Bs&ΣA disappears (circular post-evaluation) or remains (ground-truthed). Circular lines of reasoning prove nothing;
4. **Test parameter sensitivity**. Given the wide variety of parameters involved in assessment calculations/models, it is difficult to define a scenario for this. The most obvious parameters affecting outputs are Natural Mortality rate(s) or other factors driving mortality;
5. **Statistical uncertainty**. Even more unclear, since some (most) assessments are not stochastic at all! Jack-knifing? Probably few assessments are fully automated; jack-knifing would create an unacceptable workload.

This will result in one set of four indicators (3Bs + ΣA = 4) for each of the scenarios, which will need to be integrated and interpreted at the international level. For the 3Bs&ΣA-approach itself, this is achieved by summing biomasses over management units and standardizing units. The axes of the Modified Precautionary Diagram express lifetime mortality (dimensionless rate) and percentage biomass (relative to pristine biomass), both achieving the required standardization. For comparison of the above suggested scenarios, one might:

a) Express the change in output (biomass or mortality rate) as a percentage of the temporal change between *pre* and *post*. Denoting the indicator under consideration by X (X being B_0, B_{best}, $B_{current}$, or ΣA) and the scenario by s (1–5), this boils down to $\frac{X_s^{post} - X_0^{pre}}{X_0^{post} - X_0^{pre}}$. When all scenarios are applied at the same time, all inputs$_{post}$ have been replaced by inputs$_{pre}$ and $X^{post}_{\sum s}$ simply becomes X^{pre}_{0}, and hence $\frac{X^{post}_{\sum s}-X^{pre}_{0}}{X^{post}_{0}-X^{pre}_{0}}$ becomes zero. Effects sum to 100%; a triplot of (monitoring, controls, covariates)? What happens if $X^{post} \leq X^{pre}$, i.e. no change or the wrong direction...? Any of the scenarios can give a negative answer, but that then may indicate that a problem exists.

b) Express the change in output (biomass or mortality) as a percentage of the deviation from the target (B_{lim} resp. A_{lim}), that is $\frac{X^{post}_{s}-X_{lim}}{X^{post}_{0}-X_{lim}}$. Is there a natural expectation for this? Again, what if $X_{post} = X_{lim}$?

An example of how this process might work based on the Swedish scenarios

The assessment of the Swedish inland stock is essentially a prediction of eel production, based on past restocking and an average observed growth rate (Dekker, 2012). This yields a total production by lake and year, from which the observed catches are subtracted. Finally, each of the (observed) number of hydro-stations is assumed to kill 70% of the remaining silver eel. What is left is the escapement. The relation between predicted production and observed fishing yield indicates that natural mortality M must have been much lower than usually assumed; otherwise the fishery would catch more than the total production (and natural immigrants play no role; evidence comes from otolith Sr/Ca reading). It is worth noting that almost nowhere does this assessment use data from 2009–2011, i.e. scenario 1 fails. It is not dependent on covariates; scenario 2 is passed. It does rely on the reported measures (restocking), but the most recent measures have limited effect; scenario 3 is not ok in the long run. Sensitivity to M is tested informally; scenario 4 is not positive. Scenario 5 is unclear. Overall: the assessment for inland waters is not ok: it is not a post-evaluation, but a *post hoc* prediction.

The assessment of the Swedish coastal fisheries is quite different. For the west coast fishery for yellow eel, a catch curve analysis was made in 2008, yielding an estimate of fishing mortality; for the more recent years, that mortality is scaled proportionally to the landings (and the fishery is closed in 2012). For the east coast, historical mark-recapture data yield an estimate of the fishing mortality in 2006, which for the later years is scaled proportionally to the landings. The east coast fishery continues. Scenario 1 is passed; scenario 2 is not applicable; scenario 3 is passed (landings, not effort data are used); scenario 4 is not applicable; scenario 5: landings have no uncertainty... Overall: the coastal assessments are true assessments, ground-truthing the effects of management measures. However, the scenarios do not show that the west coast assessment is incomplete: the catch curve analysis did not consider the effect of declining recruitment on length frequencies; neither did it consider on-migration into the Baltic (animals leaving, showing up as mortality). Therefore, the suggested framework does not fully protect against questionable assumptions or missing elements.

8.6 Likely scenarios for the 2013 post-evaluation European eel stock

The WGEEL supports standardization in data collection and model design between MS when assessing the status of the eel stock. This process has effectively started during this meeting. However, the international stock assessment in 2013 has to live with the current level of complexity. Meanwhile, full analysis of model characteristics, their implementation and computer coding and limitations is not realistically achievable by WGEEL for the 2013 international stock assessment.

For the post-evaluation in 2013, several scenarios are available, but not all scenarios are realistic due to budget and time constraints. It is suggested that further clarification will be sought with ICES, and following that the different scenarios will be discussed between ICES and the EU in order to decide which path to follow during the 2013 post-evaluations.

Scenario 1: Conduct the evaluation on the whole European eel stock using the indicators supplied by Member States without quality checking the Data, Model or Indicators. This approach may appear easy and straightforward but several issues will need to be solved between now and the WGEEL meeting in autumn 2013:

1) preliminary screening of the available stock indicators from MS revealed that all or some of the stock indicators may be missing for some MS;
2) preliminary screening of the available stock indicators from MS revealed that $\sum A$ is given as a rate, percentage of tonnes;
3) a procedure will need to be developed to substitute estimates of missing stock indicators during the spring meeting of WGEEL in preparation of the evaluation during the autumn meeting of WGEEL.

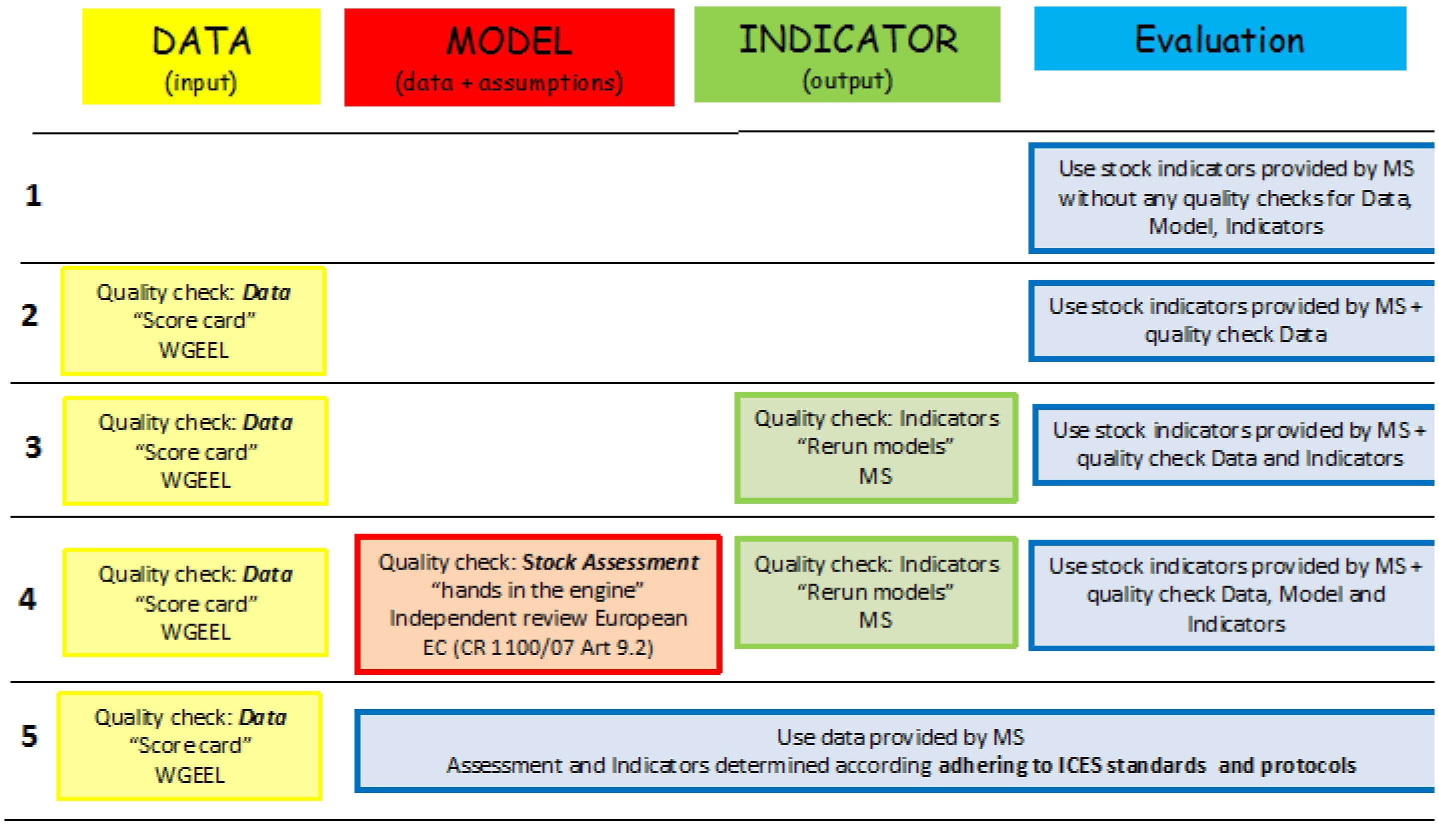


Figure 8-1. Overview of the different scenarios for the post-evaluation in 2013, with each scenario differing in the level of quality checks and standardization.

Scenario 2: Conduct the evaluation of the Eel Management Plans on the whole European Eel stock using the indicators supplied by Member States without checking the Assessment Model or Stock Indicators. The only realistically achievable check by WGEEL would be to evaluate the quality of the input data using a simple score card as described in Section 8.5. In addition to solving the issues mentioned under Scenario 1, when following Scenario 2:

4) the score card (list of data quality criteria)will need to be finalized by a "correspondence " working group meeting before 1 January 2013;

5) a procedure will need to be agreed on how to deal with an outcome of a score card; how many "orange" or "red" scores for data quality are acceptable; are the stock indicators of a MS removed from the post-evaluation if it fails the data quality check; can the stock indicators be replaced by better estimates?

Scenario 3: Conduct the evaluation of the Eel Management Plans on the whole European Eel stock using the indicators supplied by Member States without checking the Assessment Model but with a check for Data (see Scenario 2) and Stock Indicators. Creative solutions could be designed (Section 8.5) to test the performance and sensitivities of the stock indictors. MS states could be asked to conduct such "homework" to test their assessment models. In addition to solving the issues mentioned under Scenario 1 and 2, when following Scenario 3 the following problems will need to be taken in account:

6) due to time and budget restrictions this task cannot be performed by WGEEL but there is a realistic risk that even individual member states will not be able or willing to run the suggested tests on a short time frame;

7) even if the test can be done in time, it will need to be decided when a MS "passes" or "fails" these tests and what are the consequences; if a MS "fails" can the stock indicators be replaced by better estimates.

Scenario 4: Conduct the evaluation of the Eel Management Plans on the whole European Eel stock using the indicators supplied by Member States including a quality check for Data (Scenario 2), Stock Indicators (Scenario 3) and the Assessment Model ("hands in the engine").

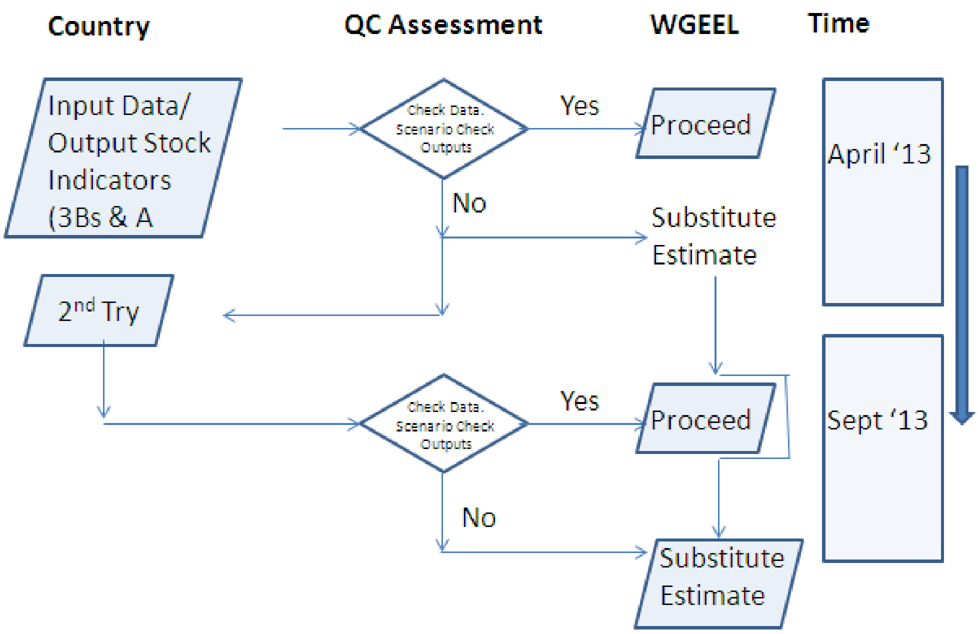
A full, in-depth review of the Stock Assessments by an independent review committee early 2013, orchestrated by the EC (Eel regulation Article 9.2). Such an independent review would lead to outcomes similar to the review process of scientific papers, e.g. "accepted with minor revisions", "accepted after major revisions" and "rejected". In the case of "major" revisions and/or "rejected" a MS will need to improve its assessment and report a new set of indicators to the review committee by mid-2013. If a second estimate of Stock Indictors also fails to pass the review committee, the Stock Indicators will need to be substituted with a "best guess".

This is an attractive scenario because this is the first time the MS have developed Stock Assessment Models to calculate the Stock Indicators. A thorough independent review would provide the MS with an idea if their assessments are on the right track or that a MS needs to return to the drawing board. The issue that remains to be solved in this scenario is how to provide best estimates of the stock indicators for a MS who fails an independent review.

It is at this stage unclear how the EC is planning to fulfil their obligation to deliver a "statistical and scientific evaluation of the outcome of the implementation of the Eel Management Plans". An independent review of the Assessment Models may be part of this process. An independent review (Scenario 4) could be supplemented by the quality checks for Data and Stock Indicators as described in Scenario 2 and 3, respectively.

Scenario 5: A full standardization for pan-European assessment is unrealistic at this stage but this scenario indicates the level of quality and standardization the evaluation of the whole European eel stock should aim for in 2015 or 2018. Every three years MS provide quality checked data to the working group who conducts the stock assessment using one or more assessment models.

It is noted that the earlier scenarios are more realistic, but the latter ones adhere better to ICES quality standards. Given the gap between achievable and recommendable in the short term, a pragmatic choice should be made for the assessment using the 2012 round of reporting. The following diagram provides a pragmatic suggestion and illustrates how such a quality control check could be made on the data and the stock indicators by ICES, allowing for countries to revise their estimates and/or for ICES to provide substitute estimates in the event of suitable data not being available for input to the international stock assessment.



8.7 Conclusion

Quality control procedures that are routinely applied in ICES are not applicable to eel due to the high variation in data, processes and methods with over 70 independent assessments. Options for quality control ranging from full check to pragmatic acceptance, with some creative solutions in between, such as a data score card and method scenario checking system have been discussed. Coordination between the EU, ICES and WGEEL is required to map the way forward.

The WGEEL further suggests that it is important to strive for at least some elements of standardization in future in order to cut down the potential variability of the reporting of stock indicators.

9 Objectives, targets and reference values

This chapter addresses the derivation of biological reference points using standard ICES protocols (where available) and developing a new line of thinking where no protocols are available yet or they do not fit the case of the eel well. This addresses the ToRs:

d) plan for an evaluation of the EU Regulation for recovery of the eel stock (EC No. 1100/2007), its target (40% SSB escapement compared to historic production) and its consistency with the precautionary approach, including planning for data exchange, quality control, methodology for stock-wide assessment;

e) assess state of current and historic data (including outputs from WKBALTEEL and GFCMEEL) and undertake an analysis of the possible stock recruitment relationships, incorporating spatial differences (e.g. age-at-maturation, sex ratio), that could lead to establishing precautionary reference limits;

f) make recommendations on how WGEEL 2013 should undertake the post-evaluation and assessment using the 2012 reported data, taking note of previous WGEEL and SGIPEE reports.

9.1 The framework for assessment

The EU Eel Regulation sets a long-term general objective ("the protection and sustainable use of the stock of European eel"), delegating the local management, the implementation of protective measures, the monitoring, and the local post evaluation to its Member States (EU 2007; Dekker, 2009). An objective is set for the biomass of silver eel escaping from each management area, at 40% of the notional pristine biomass. Eel management plans (EMPs) have been submitted by Member States in 2008/2009 and a post-evaluation of EMPs is underway; Member States submitted their national post-evaluations before July 2012, but those national reports are generally not available yet.

In the 2010 Report of ICES Study Group on International Post-Evaluation of Eel (SGIPEE), a pragmatic framework to post-evaluate the status of the eel stock and the effect of management measures has been presented, including an overview of potential post-evaluation tests and an adaptation to the eel case of the classical ICES precautionary diagram. In the Precautionary Diagram, annual fishing mortality (averaged over the dominating age groups) is plotted vs. the spawning–stock biomass. In the modified Precautionary diagram proposed by Dekker (2010), lifetime anthropogenic mortality ΣA (or the spawner potential ratio %SPR on a logarithmic scale) is plotted against silver eel escapement (as a percentage of B_0). This modified diagram allows for comparisons between EMUs (%-wise SSB; lifetime summation of anthropogenic mortality for lifetimes varying between EMUs) and comparisons of the status to limit/target values, while at the same time allowing for the integration of local stock status estimates (by region, EMU or country) into status indicators for larger geographical areas (ultimately: population wide). However, the Modified Precautionary Diagram shown in ICES (2010a, b) implicitly quantifies a number of management reference points, for which no value had been agreed. ICES (2011) analysed the ICES framework for setting reference values, and suggested specific values for the case of the eel. In this chapter, this process is extended: (assumed) relationships are updated using recent data, suggestions are given to complement the standard ICES protocols, and a format is proposed to present the stock indicators in relation to the targets (management and precautionary).

9.2 Historic and current stock and recruitment

9.2.1 Recruitment-series

The recruitment-series used for the analysis of the stock–recruitment relationship is the "Elsewhere" series (Section 4.1.5). The choice of this series was made as it represents the larger part of the eel distribution area. However, a change in recruitment-series may change the results. It thus becomes important to have a common recruitment-series.

9.2.2 Spawning-stock biomass (SSB) series

9.2.2.1 The procedure

Eel spawners at the spawning ground have never been observed. We should thus use a proxy for SSB. The last stage that can be monitored is the silver eel escaping from the continental habitat.

Due to its ecology and to anthropogenic mortalities, each eel watershed can have a different silver eel production even with the same recruitment. Long time-series of silver eel monitoring have only been collected from a limited number of sites (Section 4.2.2), and the WGEEL is aware of some additional series on yellow or silver eel series. However, such series have just been started to be gathered by the WGEEL (WGEEL, 2011) and have not yet been analysed. It is thus too early to rely on direct silver eel monitoring for a S–R analysis.

Previous attempts to assess the S–R relationship used catch data as a proxy for SSB (Dekker, 2004). A population-wide raising factor was used to scale up catches into SSB. Given the new available data (e.g. biomass estimate by EMU) improved region specific raising factors can now be applied.

In order to prepare for further improvement, or re-use, SSB figures were split into regions. This will allow treating these regions as subpopulations having different ecological or anthropogenic characteristics (e.g. TRANSLOCEEL in ICES, 2011). The regions used are those defined by DCF (Appendix IV of the decision 2010/93/EU (DCF):

- Baltic Sea (ICES Subdivisions 22–32);
- North Sea (ICES Areas IIIa, IV, VIId) and Eastern Arctic (ICES Areas I and II);
- North Atlantic (ICES Areas V–XIV and NAFO areas);
- Mediterranean Sea.

Landings series by country are available in Chapter 4. We use the corrected series.

Biomasses are evaluated by Member State as part of the EU Regulation 1100/2007. Data from EMP have been compiled and analysed by the WGEEL (WGEEL, 2010). An update of these figures has been compiled in this report (Chapter 4). However it is in most cases punctual (a given year) estimates. In the case where no update has been given, the WGEEL (2010) figure is used.

We need a transfer factor (α) to split catch by country into catch by country and region. This factor is equal to 1 for countries having their rivers flowing only into the given region, 0 if no river is flowing into the given region. The factor is comprised of between 0 and 1 for countries having rivers flowing into several regions (for example, France has some rivers flowing into the Mediterranean Sea, some into the Atlantic and some into the North Sea). For the last category of country, the transfer factor may vary from one year to the other. This factor can be based on real data for countries having already split their catch statistics into region or by local expertise.

We use a raising factor (β) to convert catch from one country and region into biomass. This factor is the ratio between catch and current escapement biomass. This ratio can be calculated from known values (for catch and biomass reported in EMP or 2012 report for example) and extrapolated to other years. Of course it can be refined by expert knowledge and/or by data indicating a change in this ratio (series of fishing mortalities or effort). At this point, **no refinement has been done** since the main goal was to set up and test the procedure rather than deriving the best estimate. We thus make the assumption that fishing mortalities and other anthropogenic mortalities from recruited yellow eel to silver are constant.

The following equation gives the method used to convert catch (C) into current silver biomass (B). The subscript c is for country, y for year and r for region.

$$B_{y,c,r} = C_{y,c} * \alpha_{y,c,r} * \beta_{y,c,r}$$

If data closest to $B_{y,c,r}$ or even this biomass is known, it is used instead of doing the conversion above. This procedure is designed to estimate biomass from catch when this figure is missing.

By applying this procedure to the available data we can calculate biomass by region (Figure 9-1) and overall biomass (Figure 9-2). This will allow analysing the trend in biomass in each region and be used by a spatial model.

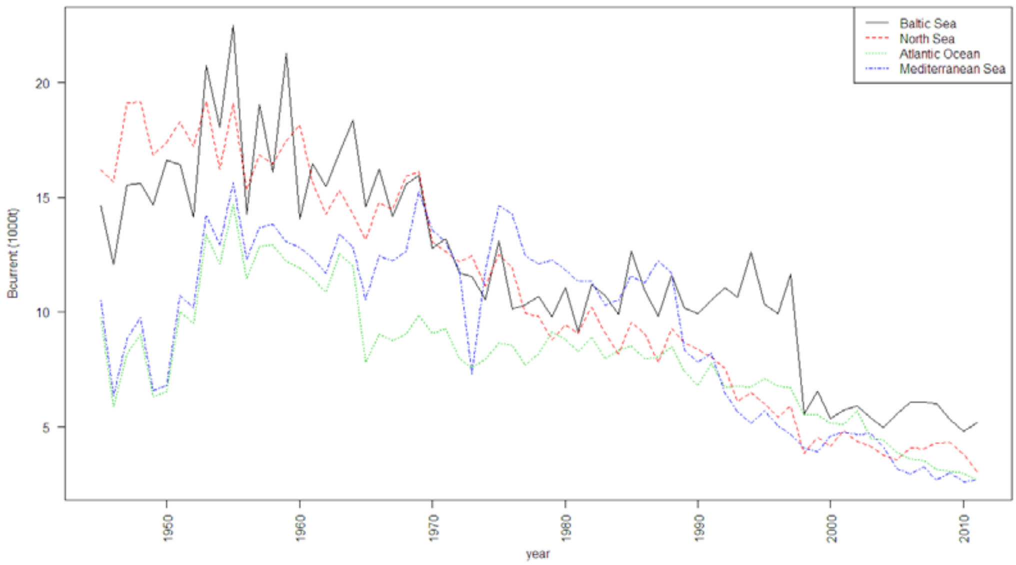


Figure 9-1. Trend in Biomass in the four regions. This figure is based on preliminary data; the intention is to show the technique, but specific outcomes will certainly change in future assessments.

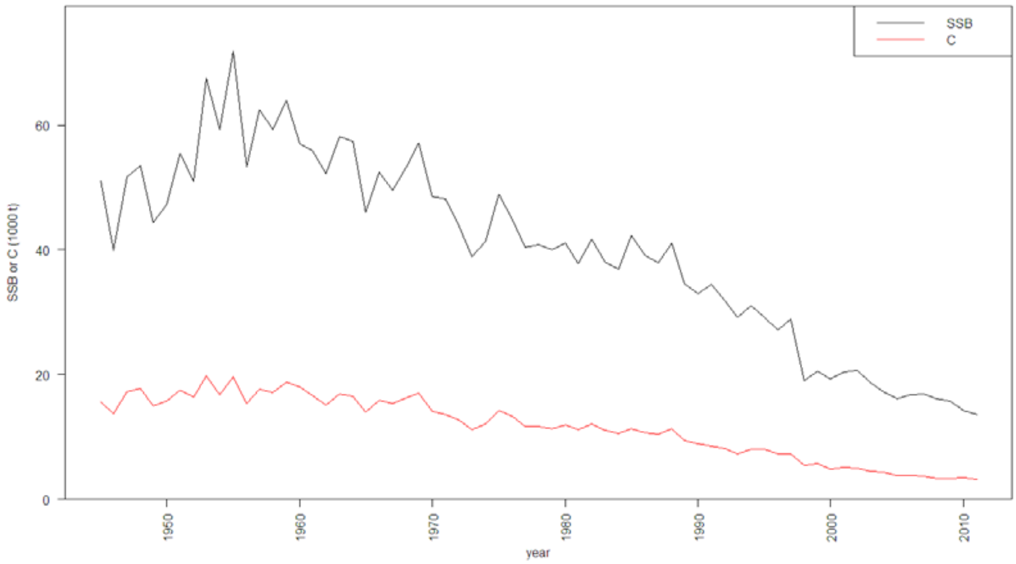


Figure 9-2. Overall trend in biomass and catches. This figure is based on preliminary data; the intention is to show the technique, but specific outcomes will certainly change in future assessments.

9.2.2.2 Discussion

Until now the compiled catch statistics do not separate the three stages of eels. In an ideal case, only silver eel catch statistics need to be used. In the case where only a yellow eel fishery has taken place, catch statistics may be used by using the additional assumption that fishing mortalities and other anthropogenic mortalities from recruited yellow eel to silver are constant and taking into account the time-lag between the age of yellow eel fished and the age of escaping silver eel.

The splitting of all stage catch statistics into silver catch statistics can be achieved by adding another conversion factor in the equation above giving the proportion of silver eel in the catches when separate statistics by stage are not available. The case of yellow eel catch statistics is more difficult (but feasible) to handle as it requires time-lagging.

Another method may be to use silver eel monitoring data, including silver eel fisheries with mark–recapture evaluation. But the assumption that the gathered series are representative of the whole distribution area should be made. A first step is to gather and analyse those series.

9.3 S-R relationship and B_{lim}

9.3.1 Method

$\mathbf{B_{lim}}$ is defined as the SSB below which there is a substantial increase in the probability of obtaining impaired recruitments.

The stock–recruitment scatterplot shows that eel falls into the categories of stock where recruitment has been impaired. In this case, ICES (2003) considered that a segmented regression is a statistically objective tool for estimating $\mathbf{B_{lim}}$. The classical approach assumes that recruitment is independent of SSB above some change point, below which recruitment declines linearly towards the origin at lower values of SSB. The method identifies the value of SSB at this breakpoint (**S***), which is therefore a candidate value for B_{lim}. The package FLR (Kell *et al.*, 2007) implements in R this approach for an easy use.

More general segmented models with one or two breakpoints with the last segment being horizontal (recruit independent of the SSB above the last breakpoint) were tested with the "Segmented" library (Vito and Muggeo, 2008).

9.3.2 Results

The FLR method highlights a breakpoint at 73.6 thousand tons of silver eels, to the highest observed spawning biomass. The fitting is not good since recruitment levels were overestimated at low levels of SSB (Figure 9-3) which leads to an overly optimistic prediction of recruitment in situations of scarcity.

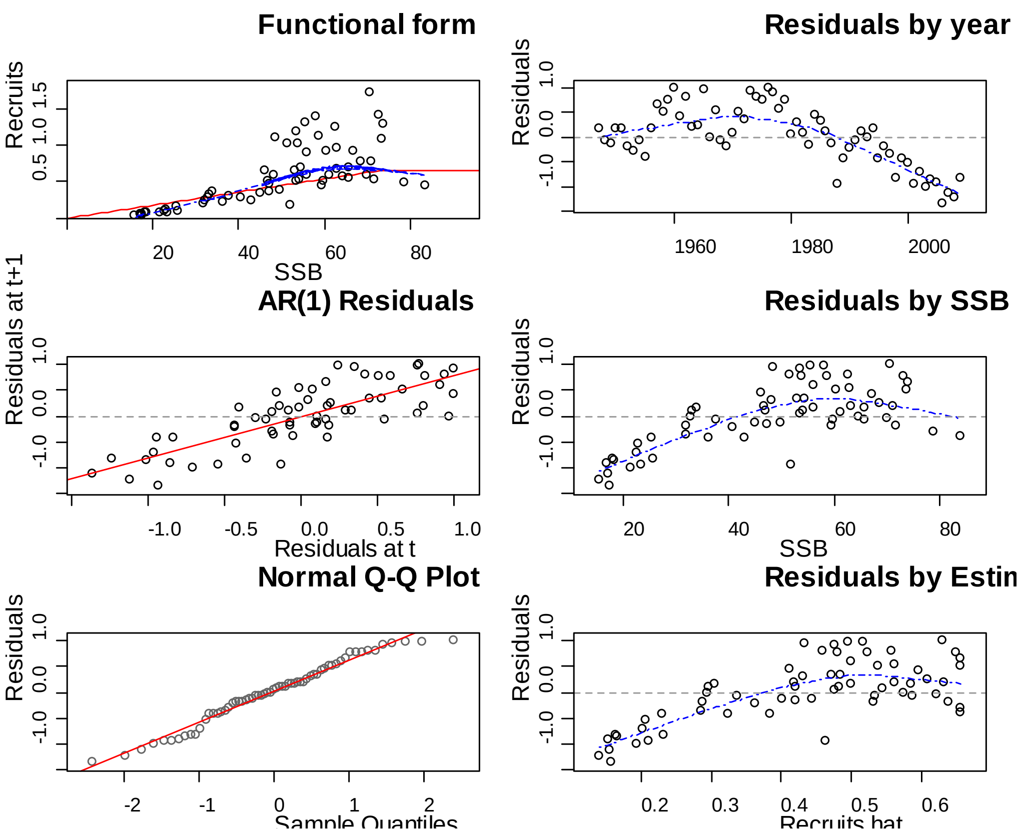


Figure 9-3. FLR stock–recruit summary plot for hockey stick model for the eel data. This graph is based on preliminary data; the intention is to show the technique, but specific outcomes will certainly change in future assessments.

A segmented regression with one breakpoint gives better results. The breakpoint is found at 44.8 thousand tons of silver eels (95% confident interval 38.8–51.7) with this approach (Figure 9-4). The Akaike Information Criterion (AIC) is 25.7. In a two breakpoint regression, the second breakpoint is at 37.1 thousand tons, the first breakpoint is at 40.0 (95% CI 35.7–44.3) thousand tons of silver eels (Figure 9-5), with an AIC equal to 20.4, lower than the previous value. The result with two-breakpoints is therefore better and is considered hereafter.

The non-zero intercept (and the convex curve in the left part of the relationship) could indicate an Allee effect. This effect (Allee, 1931) also known in the fishery literature as depensation (Hilborn and Walters, 1992), corresponds to a faster drop in the productivity when the stock size decreases. It can seriously accelerate population decline and drive a population to extinction, or at least heavily hamper its ability to recover (Walters and Kitchell, 2001). The previous analysis by Dekker (2004) had found a depensatory relation for the eel.

For statistical reasons (different computation of the likelihood function) it was not possible to compare FLR and Vito and Muggeo segmented regression results, during WGEEL meeting.

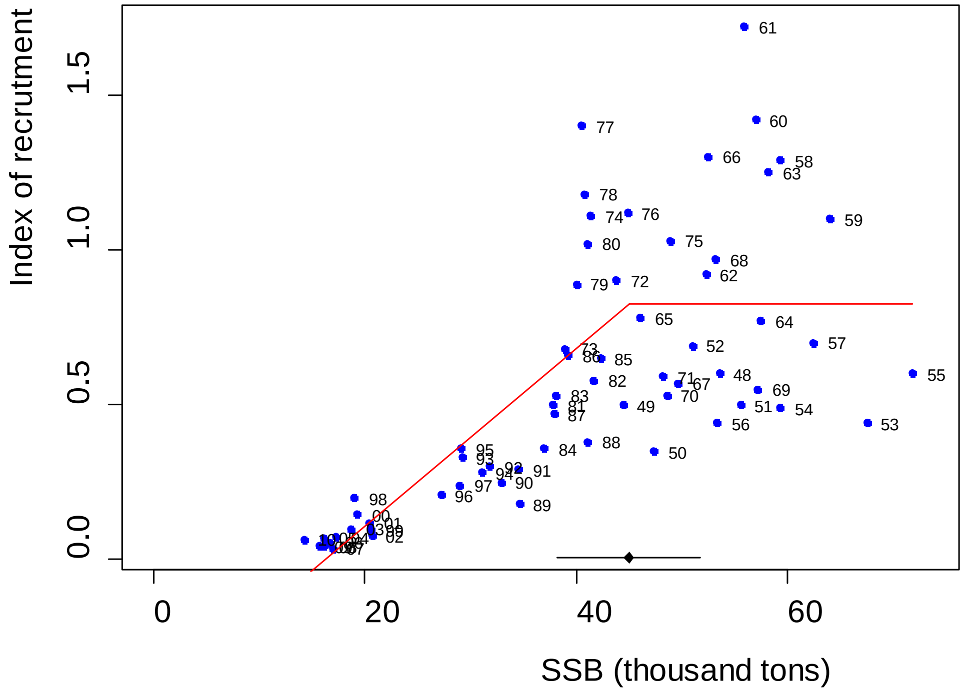


Figure 9-4. One breakpoint segmented regression between spawning–stock biomass and recruitment between 1947 and 2009 (Two-digit labels indicate the years of silver eel escapement 1950–2006). This graph is based on preliminary data; the intention is to show the technique, but specific outcomes will certainly change in future assessments.

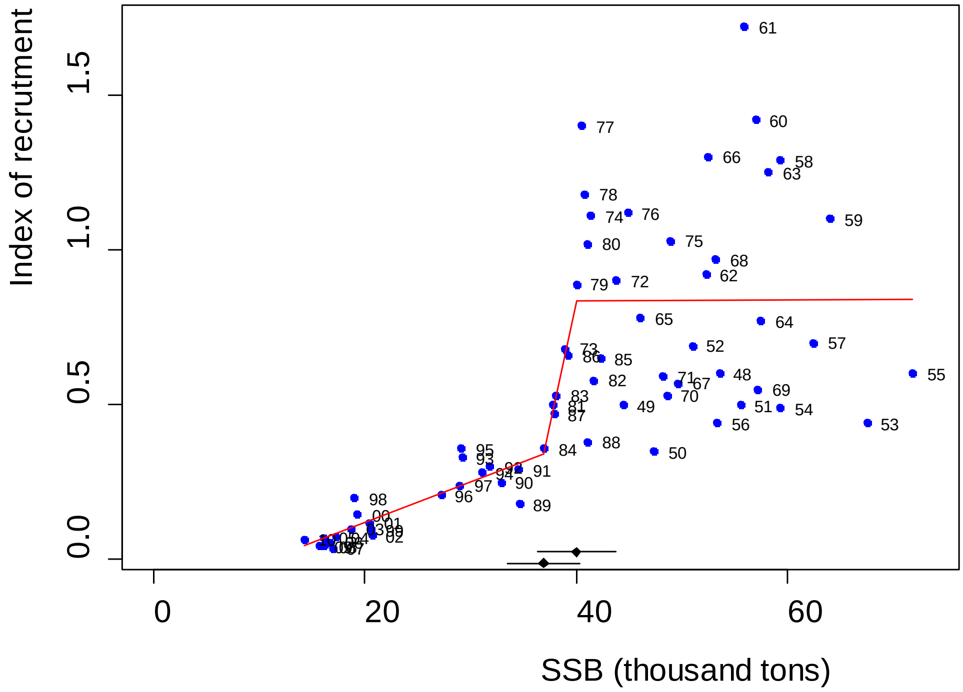


Figure 9-5. Two breakpoint segmented regression between spawning–stock biomass and recruitment between 1947 and 2009 (Two-digit labels indicate the years of silver eel escapement 1950–2006). This graph is based on preliminary data; the intention is to show the technique, but specific outcomes will certainly change in future assessments.

9.3.3 Conclusion

A B_{lim} value of 40 thousand tons of silver eels is used as a preliminary value. Considering the present estimation of 191 thousand tons for the biomass Bo at historic levels with no anthropogenic mortality, this would set a preliminary B_{lim} at 21% of the B_o biomass. This computation is based on preliminary data to show the technique used and the specific outcome will certainly change in future assessments.

9.4 Biological reference points for eel

9.4.1 Unquantified effects

In current eel stock assessments, only quantitative effects are represented. Pollution, for instance, could be included only if it had a quantified effect on survival during the continental stage or on growth rates (but little is known of either impact; see Chapter 6). In turn this means that only management measures which act on such quantitative parameters can be evaluated. Oceanic factors are also not directly included (only via potential effects on recruitment). This selective presentation, however, matches with the selective obligations in the Eel Regulation, mentioning but not enforcing, currently unquantifiable management actions.

9.4.2 Reference points used or implicated in previous ICES Advice

Since 1998 (ICES 1999 through to ICES 2010), ICES has given advice[2] that the stock has shown a long-term decline and therefore management is not sustainable; that fishing and other anthropogenic impacts should be reduced; that a recovery plan should be compiled and implemented; that preliminary reductions in mortality to as close to zero as possible are required until such a plan is implemented, respectively until stock recovery has been achieved.

ICES (2002a) discussed a potential reference value for spawning–stock biomass: "a precautionary reference point for eel must be stricter than universal provisional reference targets. Exploitation, which provides 30% of the virgin (F=0) spawning–stock biomass is generally considered to be such a reasonable provisional reference target. However, for eel a preliminary value could be 50%." That is: ICES advised to set B_{lim} above the universal value of 30%, at a value of 50% of B_0. ICES (2007) added: "an intermediate rebuilding target could be the pre-1970s average SSB level which has generated normal recruitments in the past."

The Eel Regulation (Council Regulation 1100/2007) sets a limit for the escapement of (maturing) silver eels at 40% of the natural escapement (in the absence of any anthropogenic impacts and at historic recruitment). That is: EU decided to set B_{lim} at 40% of B_0, in-between the universal level and the level advised. ICES (2008) noted that its 2002 advice was "higher than the escapement level of at least 40% set by the EU Regulation."

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[2] ICES 1999 (WGEEL) advised "The eel stock is outside safe biological limits and the current fishery is not sustainable. (…) Actions that would lead to a recovery of the recruitment are needed. The possible actions are 1) restricting the fishery and/or 2) stocking of glass eel."

ICES (2000) (WGEEL) recommended "that a recovery plan should be implemented for the eel stock and that the fishing mortality be reduced to the lowest possible level until such a plan is agreed upon and implemented."

ICES (2001) (WGEEL) recommended "that an international rebuilding plan is developed for the whole stock. Such a rebuilding plan should include measures to reduce exploitation of all life stages and restore habitats. Until such a plan is agreed upon and implemented, ICES recommends that exploitation be reduced to the lowest possible level."

ICES (2002) (WGEEL) recommended "that an international recovery plan be developed for the whole stock on an urgent basis and that exploitation and other anthropogenic mortalities be reduced to as close to zero as possible, until such a plan is agreed upon and implemented."

ICES (2006) (WGEEL) advice read: "An important element of such a recovery plan should be a ban on all exploitation (including eel harvesting for aquaculture) until clear signs of recovery can be established. Other anthropogenic impacts should be reduced to a level as close to zero as possible."

ICES (2008a) (WGEEL) concluded "There is no change in the perception of the status of the stock. The advice remains that urgent actions are needed to avoid further depletion of the eel stock and to bring about a recovery."

ICES (2009) (WGEEL) reiterated its previous advice that "all anthropogenic impacts on production and escapement of eels should be reduced to as close to zero as possible until stock recovery is achieved".

ICES (2010c) (WGEEL) reiterated its previous advice that "all anthropogenic mortality (e.g. recreational and commercial fishing, barriers to passage, habitat alteration, pollution, etc.) affecting production and escapement of eels should be reduced to as close to zero as possible until there is clear evidence that the stock is increasing."

ICES has not advised on specific values for mortality-based reference points, but the wordings "the lowest possible level" and "as close to zero as possible" imply that F_{lim} and therefore A_{lim} should be set close to zero. Over the years, the implied time frame for this advice has changed from "until a plan is agreed upon and implemented", to "until stock recovery is achieved" and "until there is clear evidence that the stock is increasing". The first and third phrases are more interim precautionary mortality advice than clear reference point related to any biomass.

9.4.3 Biological reference points specified in the Eel Regulation

The Eel Regulation sets a limit for the escapement of (maturing) silver eels, at 40% of the silver eel biomass relative to the best estimate of escapement that would have existed if no anthropogenic influences had impacted the stock, or B_o. Because current recruitment is generally far below the historical level and is assumed to be so due to anthropogenic impacts, a return to this limit level is not expected within decades or centuries, even if all anthropogenic impacts are removed (FAO EIFAC and ICES 2006, 2007; Åström and Dekker, 2007).

Regulation Article 2.4 specifies the limit as "The objective of each Eel Management Plan shall be to reduce anthropogenic mortalities so as to permit *with high probability* the escapement to the sea of at least 40% of the silver eel biomass relative to the best estimate of escapement that would have existed if no anthropogenic influences had impacted the stock. The Eel Management Plan shall be prepared with the purpose of achieving this objective in the long term".

In a following section, we will derive a probabilistic line of reasoning, and apply a probability level of α=5% (that is: a high probability of 1-α = 95%); if required, targets/limits for other probability levels can be derived.

9.4.4 Mortality reference point corresponding to the EU Regulation

The Eel Regulation specifies a limit reference point (40% of pristine biomass B_0) for the biomass of the spawning stock. For long-lived species (such as the eel) with a low fecundity (unlike the eel), biological reference points are often formulated in terms of numbers, rather than biomass. Though numbers-based and biomass-based reference points will differ slightly, a mortality-based reference point will be derived here, that results in 40% of the pristine stock *numbers*.

If no substantial density-dependent processes affect the stock abundance in the continental phase, the number of silver eels escaping to the ocean equals[3]:

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[3] Notation in these equations:

X* parameter X as applied in the silver eel stage. Hence: A* is the anthropogenic mortality (A) in the silver eel stage.

Esc silver eel escapement. the number of silver eels leaving the area towards the ocean.

t time, in years

a age, in years since recruitment to the continent

%SPR ratio of spawner per recruit (SPR), the current SPR as a percentage of SPR in the pristine state.

A anthropogenic mortality (fishing F & other anthropogenic mortality H)

M natural mortality.

$$Esc_t^* = N_t^* \times \exp^{-Z_t^*} = N_t \times \exp^{-Z_t^* - S_t} = R_{t-a} \times \exp^{-S_t - \sum_{i=0}^{a} M_{t-a+i,i}} \times \exp^{-Z_t^* - \sum_{i=0}^{a} A_{t-a+i,i}}$$

Without anthropogenic mortality, the last factor ($\exp^{-Z_t^* - \sum_{i=0}^{a} A_{t-a+i,i}}$) vanishes. Hence, the number of silver eels escaping, as a percentage of the number that would have escaped without anthropogenic impacts is

$$\%SPR_t = \exp^{-Z_t^* - \sum_{i=0}^{a} A_{t-a+i,i}} \quad (\times 100\%)$$

This is independent of the number of recruits and the natural mortality (unless density-dependence is significant). If the limit reference point on the *number* of silver eels escaping is set at 40%, it follows that

$$Z_t^* + \sum_{i=0}^{a} A_{t-a+i,i} = -\ln(\%SPR) \leq -\ln(40\%) = 0.92$$

i.e. the sum of all anthropogenic impacts, summed over the entire continental lifespan, should not exceed a fixed value of 0.92.

In cases where density-dependent processes substantially influence continental stock dynamics, no general mortality reference point can be derived. Here, anthropogenic mortality will be compensated for by reduced density-dependent natural mortality; biomass production and silver eel escapement become stable through compensatory survival. A much higher anthropogenic mortality, however, will eventually reduce the production and escapement of silver eels. To determine when and where this occurs, a more elaborate analysis of the density-dependent dynamics is required, referring directly to escapement levels and %SPR. As a rule of thumb, this more complex analysis will only be required in areas where stock production and/or silver eel escapement has not declined over time. However, density-dependence may influence young eel stages in areas where they recruit in relatively large numbers; even if inland densities are too low to influence subsequent eel production dynamics.

For reference points based on biomass rather than on numbers, the relationship between relative spawner escapement %SPR and mortality ∑A is much more complex, but numerical simulation indicates that the relationship comes close to that specified above.

Mortality based indicators and reference points routinely refer to mortality levels assessed in (the most) recent years. ICES (2011 *SGIPEE London*) noted that the actual spawner escapement will lag behind, because cohorts contributing to current spawner escapement have experienced different mortality levels earlier in their life. As a consequence, stock indicators based on assessed mortalities do not match with those based on measured spawner escapement. The time-lag applies to mortality based indicators as well as to %SPR-based indicators. It will be in line with the conventional ICES procedures and the standard Precautionary Diagram to focus on immediate

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N number of eels in the stock; N* is the number of silver eels produced (before mortality)

R recruitment

S instantaneous rate of the silvering process, i.e. the silvering process expressed as a rate effects (∑A), ignoring the inherent time-lag in spawner production. This will show the full effect of management measures taken (on the vertical mortality axis) although the effect on biomass (horizontal) has not yet fully occurred.

9.4.5 ICES approach for fisheries Advice

ICES (2009, 2010) provides advice on fish stock management. In the introduction, the general approach is explained.

ICES. 2009. Report of ICES Advisory Committee, 2009. ICES Advice, 2009. Books 1–11. 1,420 pp.

ICES. 2010. Report of ICES Advisory Committee, 2010. ICES Advice, 2010. Books 1–11. 1928 pp.

ICES provides fisheries advice that is consistent with the broad international policy norms of the Maximum Sustainable Yield approach, the precautionary approach, and an ecosystem approach while at the same time responding to the specific needs of the management bodies requesting advice.

For long-lived stocks with population size estimates, ICES bases its advice on attaining an anthropogenic mortality rate at or below the mortality that corresponds to long-term biomass targets. However, $B_{MSY\text{-}trigger}$ is a biomass level triggering a more cautious response. Below $B_{MSY\text{-}trigger}$, the anthropogenic mortality advised is reduced, to reinforce the tendency for stocks to rebuild. Below $B_{MSY\text{-}trigger}$, ICES suggests to use a proportional reduction in mortality reference values (i.e. a linear relation between the mortality rate advised and biomass).

For general fish stocks, the normal tendency to recover may break down at very low spawning stock levels. In these cases, the advised fishing mortality rate is likely to be so low that fishing may cease anyway. When stock size is so low that recruitment failure is a concern (e.g. at or below B_{lim}), additional conservation measures may be recommended for the stock to prevent a further decline. This special consideration at low stock sizes is depicted by a dotted line in Figure 9.6.

For eel in particular, current stock and recruitment are historically low, and indications are that the conventionally assumed mechanisms (e.g. a compensatory stock–recruitment relation) might not hold. The decline of the stock will have forced fishers to cease their exploitation, but side effects of other anthropogenic activities (such as hydropower generation) will not have reacted to low stock abundance. Conservation measures will be required, accommodating the exceptional low stock level, as well as accommodating for the apparently depleted resilience in stock dynamics. The discussion below therefore explores how to derive relevant advice in the "dotted" range of extremely low biomasses.

9.4.6 B_{stoppa}, a proposed new reference point to avoid extremely low stock biomass

At spawning–stock biomass below $B_{MSY\text{-}trigger}$, ICES advises to reduce fishing mortality below F_{MSY}. At extremely low spawning–stock biomass, normal recovery mechanisms might break down, and additional protection might be required. No protocol for these latter cases exists within ICES yet. These extremely low cases are obviously undesirable, are probably not very frequent, and stock dynamics are not well understood. Protective measures should be taken safeguarding against further deterioration of the situation, aiming at a high probability of success. It is the low probability of further deterioration that is at the heart of the protocol proposed here.

Figure 9-6 (below) sketches the proposed protocol for a 'normal' fish stock, for which a Beverton and Holt stock–recruitment relationship applies; Figure 9-7 sketches the same for a depensatory stock–recruitment relation, as found in eel. Note that both figures sketch the ideas, but presented data do not represent any actual case and regression lines were not actually fitted to the data, but drawn by hand.

Stock dynamics and biological reference points are governed by on the one hand the relation between spawner biomass and resulting recruitment (the oceanic phase in the case of eel), and on the other hand the relation between incoming recruitment and subsequent spawner production (the continental phase for eel). It is generally assumed that density-dependent processes primarily affect the reproductive phase. Plotting recruitment as a function of spawning–stock biomass, functions such as the Beverton and Holt stock–recruitment relation can be fitted; here, we will not assume any functional relationship, though we will assume that pristine stock biomass B_0 comes with a high (but varying) recruitment R_0. Historical data on spawning–stock biomass and recruitment can provide estimates of B_0 and corresponding average recruitment R_0; in the absence of direct estimates, extrapolations based on detailed stock assessments may be substituted. The line connecting the point (B_0, R_0) to the origin is known as the replacement line, at F=0 footnote [4]. Assuming that the growing phase is not substantially affected by density-dependent processes, this replacement line indicates the potential for spawning stock production *if all anthropogenic mortality would be set to zero*. Note that the replacement line gives spawning–stock biomass as a function of incoming recruitment; the replacement line is read from a given recruitment on the vertical axis towards a resulting biomass on the horizontal.

At high spawning–stock biomass, recruitment is almost not related to the size of the spawning stock. At lower spawning–stock biomass, recruitment is impaired by the low spawning stock size. Standard ICES protocols can be used to estimate the spawning–stock biomass B_{lim}, above which recruitment is not impaired. In the following, we will fit a flexible relationship between spawning–stock biomass and recruitment, for all datapoints below B_{lim}; however, if the data are well behaved and the fitted relationship is flexible enough, there is no need to exclude the high-SSB observations.

Below B_{lim}, recruitment is impaired by the low spawning stock size. The relation between spawning–stock biomass and resulting recruitment is characterized by the past observations; fitting a flexible regression line, such as R=GAM(B), will provide an estimate of expected recruitment as a function of biomass B, as well as a confidence interval for the individual prediction (95% confidence, one-sided, lower bound). By definition, where this lower confidence bound crosses the replacement line, the probability of a recruitment that cannot replace the current biomass, is α=5%. If it happens that recruitment is indeed below the replacement line, spawning–stock biomass is not fully replaced, i.e. the spawning stock is in further decline, at least for the next generation. Where the <u>mean</u> predicted recruitment crosses the replacement line, there is a 50% chance of further deterioration, even *if all anthropogenic impacts would be set to zero*. We label the biomass coming with a mean predicted recruitment equal to the replacement line as B_{stop}, and the biomass at which the 5% lower bound crosses the replacement line as B_{stoppa}. For 'normal' fish stocks with a Beverton and Holt stock–recruitment relation, B_{stop} = 0; for a depensatory case, B_{stop} >0; for both, B_{stoppa} >0. At B_{stoppa}, the probability of a further deterioration of B is exactly α=5%. Recommending

[4] In the case of eel this would be A=0 (all anthropogenic mortality, including outside the fishery) but we are using the standard ICES terminology in this section.

setting *all anthropogenic impacts to zero* at B_{stoppa} will be in agreement with the risk-averse strategy of the precautionary approach.

For cases where few years of low spawning–stock biomasses have been observed, the estimated lower confidence bound at low spawning–stock biomass is predominantly based on extrapolation; a wide confidence interval will result. In this case, a rapid reduction in spawning–stock biomass far below B_{stoppa} will take a considerable risk, since no such low biomass levels have ever been observed before. If, however, B_{stoppa} is approached slowly, the estimate of B_{stoppa} will be updated on the basis of the new observations, and it is likely that new estimates of B_{stoppa} gradually slide to the left.

Applying this protocol to a hypothetical case of a depensatory stock–recruitment relation (Figure 9-7) results in a B_{stoppa} at considerable higher spawning–stock biomass than for the 'normal' fish (Figure 9-6). Stocks showing depensation are much more likely to slide towards extremely low spawning–stock biomass, and are likely to end in a depensation trap. That is: B_{stoppa} correctly identifies the increased risk. Note that the estimation protocol was not specifically adapted for the depensatory case, but identified the increased risk automatically. Along the same line of thinking, B_{stoppa} will probably also adapt to potential changes in environmental covariates, if (and only if) the regression R=GAM(B) assigns more weight to more recent observations.

Repeating the above derivation of B_{stoppa}, replacing the replacement line (F=0) by a line characterizing F=0.1, an estimate is derived of a minimum biomass at which the risk of further deterioration is α=5%, *even if F is kept at F=0.1*. At this biomass, the recommendable advice is to reduce F to F=0.1. Repeating this derivation for a range of F-values generates a data-driven relation between (low) spawning–stock biomasses and recommended F-values. Note that no assumption is made on the form of the relation between the F advised and spawning–stock biomass, i.e. the straight line is omitted.

Time constraints during the meeting of WGEEL did not allow full implementation of this procedure, and hence, the lines in Figure 9-6 and Figure n9-7 have been drawn by hand. The next section, however, derives estimates of B_{stop} and B_{stoppa} for the eel using true, but preliminary data.

Summarising the derivation of B_{stoppa}:

1. In a plot of R versus B, determine B_{lim}, B_0, R_0, and the replacement line;
2. Fit R=GAM(B), for B < B_{lim} (optional: for all data, not just B < B_{lim});
3. Find the 5% confidence interval, one-sided, lower bound, of the single observation;
4. Where that confidence interval crosses the replacement line, we define B_{stoppa}. For B < B_{stoppa}, advice F=0.

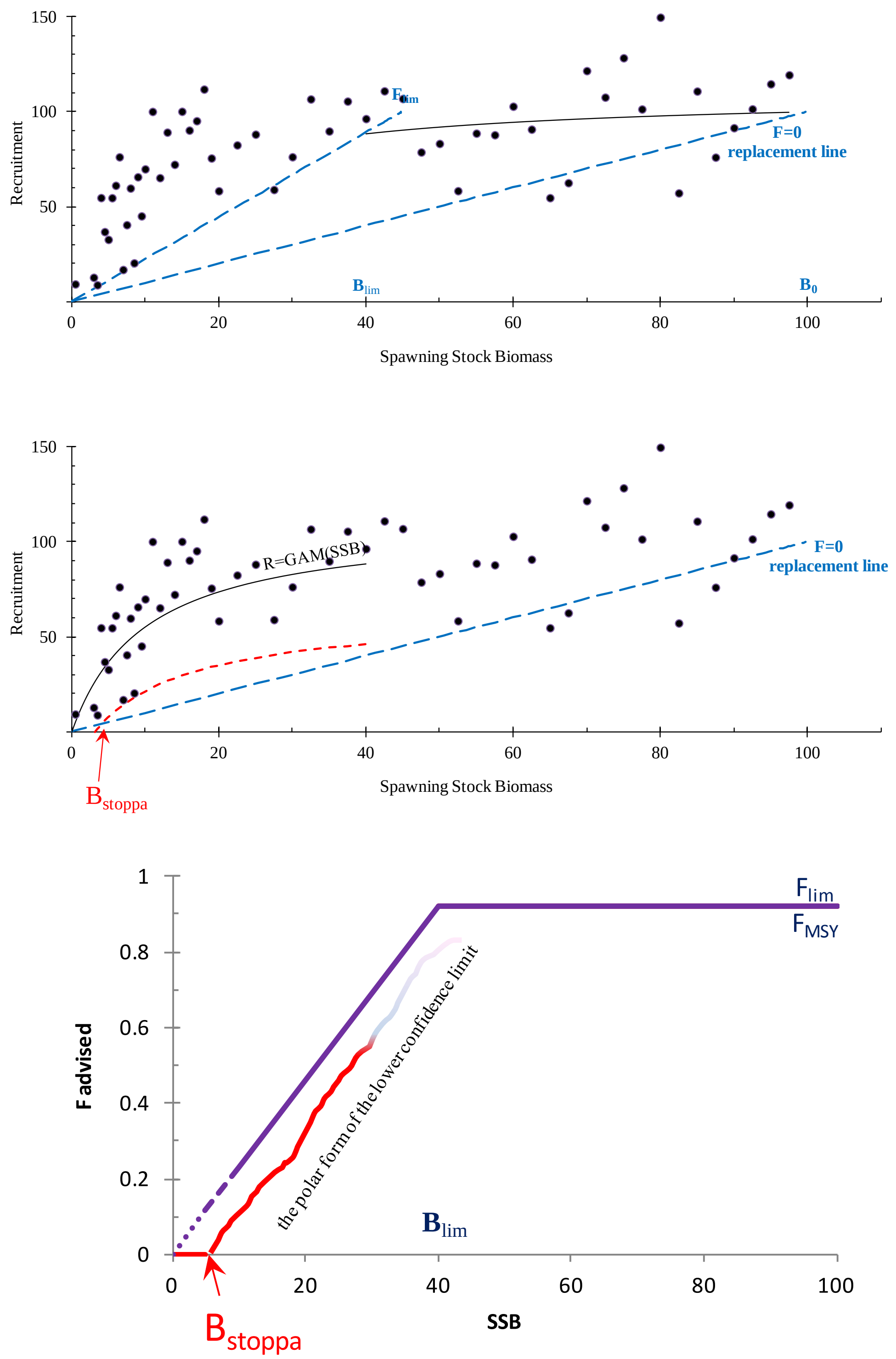

Figure 9-6. Hypothetical stock–recruitment relationship for a 'normal' fish stock (i.e. not eel data), assuming a Beverton and Holt stock–recruitment relationship, with added noise.

a. Derivation of B_{lim} and the replacement line, using standard methodology;

b. Fitting a flexible regression line to the lower datapoints, finding the intersection of the lower confidence bound with the replacement line; and

c. The resulting relationship between the mortality level advised and the spawning–stock biomass. The straight line ending in a dotted section conforms to the existing ICES protocol.

This figure is based on hypothetical data; the intention is to show the technique.

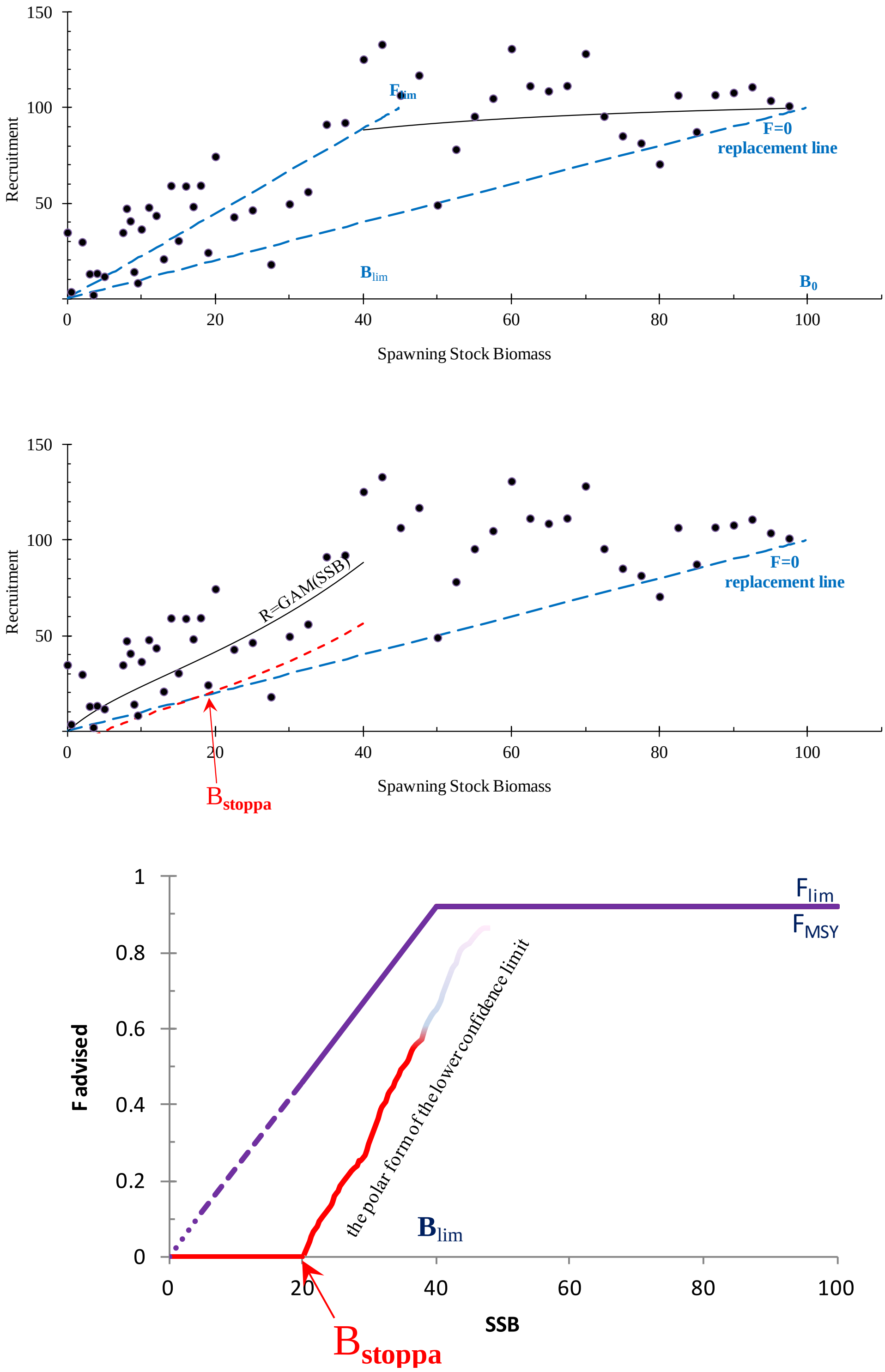

Figure 9-7. Hypothetical stock–recruitment relationship for a fish stock (i.e. not eel data), showing a depensatory stock–recruitment relationship, with added noise.

a. Derivation of B_{lim} and the replacement line, using standard methodology;

b. Fitting a flexible regression line to the lower datapoints, finding the intersection of the lower confidence bound with the replacement line; and

c. The resulting relationship between the mortality level advised and the spawning–stock biomass. The straight line ending in a dotted section conforms to the existing ICES protocol.

This figure is based on hypothetical data; the intention is to show the technique.

9.5 Estimation of B_{stoppa} using preliminary data on eel

In this section, B_{stop} and B_{stoppa} are estimated on the basis of real, but preliminary data on eel. For this, a lognormal GAM (Hastie and Tibshirani, 1990) was fitted to S–R data below a SSB of 40 000 t (the preliminary value for B_{lim}). A 5% lower bound is calculated as a one-side prediction confidence interval (Figure 9-8).

The replacement line (ΣA=0) is determined by the line crossing the origin and the point with coordinates B_0 and the plateau of recruitment as determined with the segmented regression (Section 9.3).

The intersection point of the 5% lower bound with the replacement line gives an estimation of B_{stoppa} at 26.5 thousand tons. Since 1997, biomass has been below this value. In the light of 2012 available data the B_{stoppa} reference point would have suggested to advice minimizing all anthropogenic mortality to zero at that date. The intersection point of the GAM curve leads to 18.0 thousand tons for B_{stop}. Since 2004, biomass has been below this value.

These results are based on preliminary data; the intention is to show the technique, but specific outcomes will certainly change in future assessments.

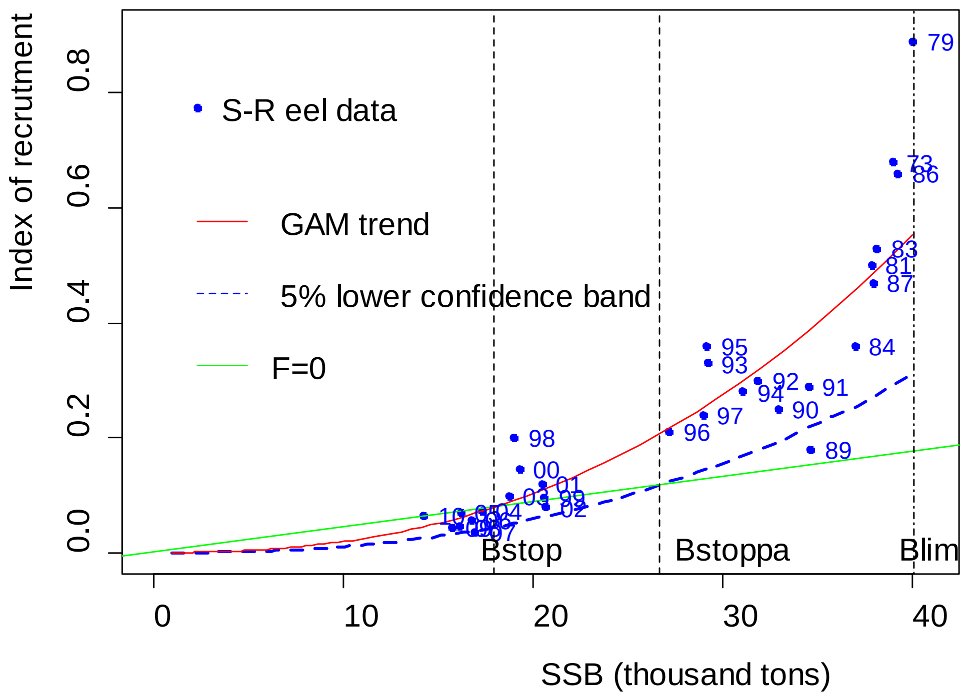

Figure 9-8. Result of B_{stoppa} procedure for eel data. This graph is based on preliminary data; the intention is to show the technique, but specific outcomes will certainly change in future assessments.

9.6 Single reference points for multiple eel management units

Due to the panmixia of the eel (i.e. local silver eel production contributes an unknown fraction to the entire European eel spawning stock, which in turn generates new glass eel recruitment), the efficacy of local protective actions (single EMPs, national export regulation) cannot be post-evaluated without considering the overall efficacy of all protective measures taken throughout the distribution range. This requires an international post-evaluation, as planned by WGEEL.

ICES (2010a, 2011) derived a framework for international assessment based on national/regional stock indicators, using four estimates:

a) B_{post}, the biomass of the escapement in the assessment year;
b) B_0, the biomass of the escapement in the pristine state. Alternatively, one could specify B_{lim}, the 40% limit of B_0, as set in the Eel Regulation;
c) B_{best}, the estimated biomass in the assessment year, based on the recently observed recruitment, but assuming no anthropogenic impacts have occurred (neither positive nor negative impacts);
d) $\sum A$, the lifetime anthropogenic mortality rate, or %SPR, the ratio of actual escapement B_{post} to best achievable spawner escapement B_{best}. ICES (2011 London) indicated that estimates of either $\sum A$ or %SPR usually refer to anthropogenic impacts in the most recent year, not to impacts summed over the life history of any individual or cohort in the current stock.

In the 2010 Report of ICES Study Group on International Post-Evaluation of Eel (SGIPEE), a pragmatic framework to post-evaluate the status of the eel stock and the effect of management measures has been designed and presented, resulting in a modified Precautionary diagram, in which lifetime anthropogenic mortality ΣA (or the spawner potential ratio %SPR on a logarithmic scale) is plotted against silver eel escapement (in percentage of B_0). This modified diagram allows for comparisons between EMUs (%-wise SSB; lifetime summation of anthropogenic mortality) and comparisons of the status to limit/target values, while at the same time allowing for the integration of local stock status estimates (by region, EMU or country) into status indicators for larger geographical areas (ultimately: population wide).

ICES (2011, Lisbon report) explored the standard ICES protocol for setting targets, especially focusing on the extra low mortality advised for stocks that are at extremely low SSB (that is: the linear relation between the F advised and SSB in ICES advice, see Figure 9-6 and 9-7 here leading to a curved line in the Modified Precautionary Diagram, see Figure 9-9, right). ICES (2011, Lisbon report) applied this framework to a preliminary dataset of country-wide stock indicators, noting that preliminary data on some countries indicated heavy overexploitation, while others appeared to be within precautionary bounds. This seems to imply that the precautious countries can be allowed to *expand* their exploitation, while the overall status of the stock is outside safe biological bounds. To adjust for this misleading presentation, it is recommended to split the graphs into two, as exemplified in Figure 9-9 below, using the preliminary data of the 2011 report again. The first graph shows the position of each unit, as well as the overall status of the stock, but does not compare to targets and limits. The second graph compares the overall status of the total stock to targets/limits, as agreed.

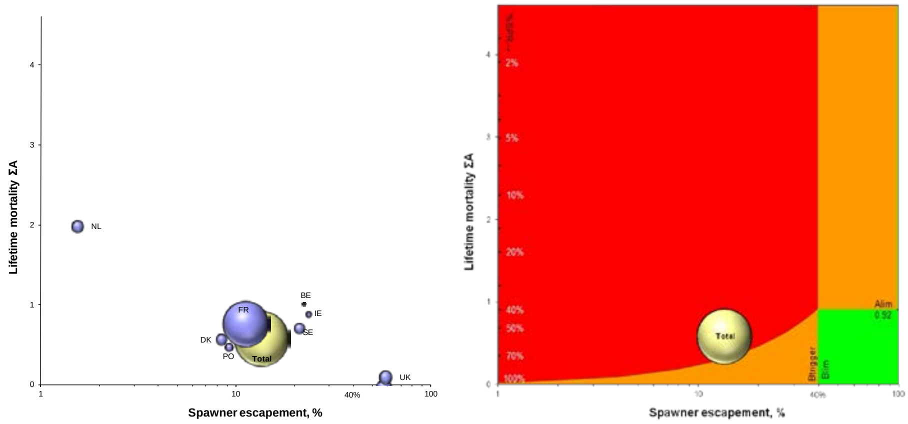

Figure 9-9. Modified Precautionary Diagram, presenting the status of the stock and the anthropogenic impacts, per country as presented in the Eel Management Plans in 2008 (left) and for the stock as a whole (right). The right had plot compares the stock status (bubble) to the targets/limits (colour). These graphs are based on preliminary data; the intention is to show the technique, but specific outcomes and the targets/limits shown will certainly change in future assessments.

Section C: WGEEL work in relation to ICES and other groups

10 Workshops

10.1 A Workshop on Eel and Salmon DCF Data (WKESDCF)

The Workshop on Eel and Salmon DCF Data [WKESDCF] (Co-chairs: Alan Walker (UK) and Ted Potter (UK)) met in Copenhagen on 3–6 July 2012 to:

a) Conduct preparatory work to develop a standard protocol for eel stock assessment, specify indicators for international stock assessment and recovery of the stock.

b) Determine the data requirements to support national and international assessments of eel stock, related to the EU Eel Regulation to support stock recovery and sustainable management of eel.

c) Describe the options available for national and regional eel monitoring and survey programmes required to meet the data requirements for eel outlined in 1a.

d) Propose a mechanism for data exchanges, quality assurance and availability for eel stock assessment.

e) Determine the data requirements to support national and international assessments of salmon required to undertake stock assessments and provide catch advice for NASCO and the EU to support sustainable management of salmon stocks.

f) Describe the national monitoring and survey programmes required to meet these data requirements for salmon.

g) Consider options for integrating salmon and eel surveys and monitoring.

The WKESDCF reported in August 2012 for the attention of ACOM and PGCCDBS. The WGEEL supports the recommendations in the WKESDCF report relating to eel data collection.

Below is the Executive Summary of the WKESDCF report:

The Workshop on Eel and Salmon DCF Data met at the IDA Centre, Copenhagen from 3rd to 6th July 2012, under the co-chairship of Ted Potter (UK) and Alan Walker (UK). The Workshop was attended by 23 experts in eel and salmon assessment and management, representing nine EU Member States (Finland, France, Germany, Italy, Ireland, Lithuania, Poland, Sweden and UK).

Changes to the EU Data Collection Framework (DCF) in 2007 introduced requirements to collect data on eel and salmon, but the specific data requested for these species did not meet the needs of national and international assessments. The proposed development of the new Data Collection - Multi-Annual Programme (DC-MAP) in 2013 provides the opportunity to coordinate and improve the collection of data used in assessments for these species.

The key tasks of the Workshop were therefore to:

- determine the data required to support international obligations for the assessment of eel and salmon;

- describe the national monitoring and survey programmes required to meet these data requirements; and
- consider options for integrating salmon and eel surveys and monitoring.

The Workshop met in plenary to discuss the current data collection requirements for these two diadromous species and the various ways that these had been addressed by different countries. The Workshop then split into two subgroups to address the future data collection requirements for eel and salmon, with the latter subgroup considering the different requirements for Baltic and North Atlantic salmon.

For each species/area, the subgroups structured their discussions by considering: the national/international management objectives; the assessments undertaken to support these objectives; the data required to undertake the assessments; and the proposed changes to the DC-MAP to provide these data. The existing DCF also requires the collection of data on economics and aquaculture. These data are important in the management of diadromous species, but the Workshop did not contain the expertise necessary to consider these elements in detail. Eel and salmon differ markedly from marine species in their biology, the nature and distribution of their fisheries, and the methods used to assess stock status and provide management advice. As a result, the data collection requirements do not fit well into the 'standard' approaches used for marine species. In particular, much of the assessment of both species is conducted at a local and national level even when the results contribute to international assessments (e.g. development of Conservation Limits for salmon river stocks and assessment of silver eel escapement for individual eel management units). These approaches may differ depending upon a range of factors including the practicalities of collecting particular data.

The Workshop made detailed recommendations for several tiers of data collection. For both eel and salmon, there are some data (e.g. catches) that are required for all stock components; these data are of little value if they are not collected in a consistent way for all fisheries. The collection of other data may depend on local requirements and constraints. A key recommendation of the Workshop was that ICES (through the assessment Working Groups) should, therefore, have a role in agreeing the data that should be collected in specific areas (e.g. agreeing 'index rivers'). This and other recommendations are summarized in Section 7 of this report.

The Workshop also identified a number of areas where coordinated data collection might offer opportunities for increased cost-effectiveness in some circumstances, including: electric fishing surveys; trapping programmes; operation of automatic counters; and habitat surveys.

10.2 WKBALTEEL

The Workshop on Baltic Eel has met in November 2010 with the aim of collating available information and stimulating the regional cooperation in eel. See separate workshop report and summary in Section 1.4 of the WGEEL 2011 report. A new meeting of this group is prepared for this fall, 2012.

10.3 WKGFCMEEL

The General Fisheries Commission for the Mediterranean has expressed interest in activating and starting up some actions in relation to the organization of an Eel Working Group in conjunction with EIFAAC and ICES. GFCM is interested, besides the scientific aspects, in future development of management plans under common standards. Hence, the terms of reference of such a group are currently being revisited in accordance with all interested parties. The WGEEL highlights the need for a preliminary evaluation of the situation of the eel in the Mediterranean area, and to start gathering data in this area, in order to join in the process of the stock-wide assessment foreseen for 2013.

11 Ecosystem advice

Within the changing dynamics of the ecosystems ICES recommends to make full use of other information sources e.g. potentially available in other Working Groups. There was a request to identify important needs for information with respect to ecosystem changes. The following issues were identified as important gaps of knowledge:

- Time-series of contaminants in the ocean (and freshwater ecosystems) (WG Marine Chemistry) and effect studies in eel (now not available, but feasible, considering the possibilities of using swimming tunnels and artificial reproduction) (WG Biological Effects of Contaminants) would help the WGEEL to better understand and integrate the effect of contaminants;
- A structural framework for larval surveys of leptocephali (as a proxy for SSB) and any ocean data would help understanding the interaction between leptocephali mortality and dispersion, and the role of leptocephali in the ecosystem, including feeding and predation. WGEEL proposes that an ICES Study Group is established to coordinate and plan research on the oceanic effects on leptocephali and metamorphosis to glass eel (see recommendation from WGEEL 2008). WGEEL also supports the proposal for larval surveys in the Sargasso (see Chapter 14) and recommends that this is internationally coordinated.
- In general WGEEL is concerned with all aspects of ecosystem change which have an impact on the eel habitat. WGEEL welcomes information on, for example, impact of hydropower, predation, dams and barriers to fish migration and habitat suitability. Information is often available at national levels, but international overviews are lacking.

12 WGBEC

The WG discussed the possibilities and need for an exchange of information with WGBEC (Working Group on Biological Effects of Contaminants). It was concluded that a future cooperation would be highly beneficial to WGEEL, to increase the expertise and knowledge in order to make progress into the quantitative assessment of the impact of contaminants on the eel stock.

13 ICES Data Centre and International databases

The WGEEL is currently maintaining datasets for aquaculture and landings, a database for glass eel, yellow eel and silver eel time-series. A database (**E**el **Q**uality **D**atabase) on diseases and contaminants is currently under development, which is currently being transferred from an Excel to a database format.

Transferring these databases to ICES Data Centre will require integration within the general frame of data currently being maintained in a single data scheme by ICES. This process will probably take several years and a strategy to achieve that goal is outlined below.

The first step will be to make our current databases on time-series and contaminants (EQD) evolve to a format compatible with the ICES format, both in term of structure, and by using standard ICES vocabulary http://vocab.ices.dk/, and identifying possible missing terms. Specifically, the chemical lists and species lists should be harmonized to ICES standards. Vocabulary lists will have to be developed by the next Working Group in 2013. Exchanges with the ICES Data Centre will steer that work. Cataloguing those datasets used by the Working Group, with a metadata description, should also be an easy task to be completed for the next Working Group.

The second step will be to expand the database to integrate dataseries currently being used by the Working Group. This step will also require the development of front-ends to facilitate uploads of the data.

The stock assessment done by the Working Group is evolving rapidly. As a consequence, in the coming years, keeping the database within the Working Group will help to adapt it quickly to the needs of the Working Group. At some point, the general data need will have been made clear, and the new data coming under the DCF will also have been clarified and incorporated. This time will probably be the appropriate time to put forward a request for integration within the ICES Data Centre.

This process will be an ongoing process for several year steered by the assistance of the ICES Data Centre.

14 Sargasso Sea surveys

The WGEEL supports the proposals (i.e. Sparholt, pers com.; Hanel, pers com.; ICES 2012) for standardized larval surveys of the Sargasso Sea with a clear target on monitoring and evaluating eel leptocephali (or egg) densities in the Sargasso Sea. Such surveys, continued on a regular basis, would enable more immediate detection of changes in the spawning–stock biomass than what could be achieved by monitoring medium and longer term trends in continental recruitment. The surveys would also give a clear indication of changes in the survival of leptocephali at sea.

The WGEEL recommends that the larval surveys for eel should be internationally planned and coordinated, as for other stocks such as mackerel and herring.

15 Research needs

International Stock Assessment of the Eel Stock in support of the EU Regulation for Eel Stock Recovery

Mortality based indicators and reference points routinely refer to mortality levels assessed in (the most) recent years. ICES (2011) noted that the actual spawner escapement will lag behind, because cohorts contributing to recent spawner escapement have experienced earlier mortality levels before. As a consequence, stock indicators based on assessed mortalities do not match with those based on measured spawner escapement. There is therefore, a need for both biomass and mortality reference points.

The diverse range of data collection and analysis methods used by MS to estimate their stock indicators, and the uncertainties associated with extrapolating from local to national stock assessments mean that there are inevitable but so far unquantifiable levels of uncertainty in the national and stock-wide assessments. These uncertainties need to be addressed at local, national and international levels, either through standardization of methods, setting minimum standards for data and methods (cf DCF), or both. Each of the following research needs should address and facilitate standardization wherever possible.

Biomass/density assessment

- An international calibration and standardization of eel standing stock estimates. Calibration between electro-fishing streams, cpue in lakes, estuaries, and other large waterbodies; standardization and intercalibration between methods. Links to DCF, WFD and EU Regulation.
- A coordinated programme of work should be undertaken to address the assessment of densities or standing stock of eels in large open waterbodies, such as lakes, deep rivers, transitional and coastal waters; this is a suitable topic for an international "Pilot Study" under the DC-MAP. Links to SGAESAW, DCF, WFD & EU Regulation;
- An international pilot study under the auspices of the new DC_MAP is required to establish minimum standards for data collection on the basis of current expert judgement; to analyse achieved precision levels where adequate databases exist; and to stimulate further analysis when and where more data become available within the framework of the DC-MAP.
- An EU-wide approach to assessing stocking and determining net benefit to the stock. Links to EU traceability, CITES, EU Regulation and ICES advice.
- Assess whether density-dependent influences (DD) on eel population dynamics occur at the local level and whether DD will play a role at the continental scale in the decline/recovery of the eel stock.
- International surveys at sea of eel in the spawning area in the Sargasso Sea. Links to DCF.

Mortality assessment

- The stock response to implemented management actions, in terms of silver biomass, will be slow and difficult to monitor. There is a need for developing methods for quantifying anthropogenic mortalities and their sum 'lifetime mortality' and estimating same across Europe. Links to DCF, WFD, EU Regulation. WKESDCF recommends that the new DC-MAP should include support for the collection of data necessary to establish the mortality caused by non-fisheries anthropogenic factors.

- It is recommended that research to investigate factors that cause Natural Mortality (M) to vary in space and time be given the high priority. Thus further data collection and research should be encouraged to support and improve the knowledge of this difficult research topic in order to obtain more and more reliable stock assessments.
- Research resulting in a better understanding of the eel's sensitivity towards parasites, diseases, and contaminants with respect to survival, migration and reproduction success should be supported, so that this can be integrated into stock assessments. This will require sensitivity thresholds to be quantified for eel. Links to EU Regulation and eel stock recovery.

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Annex 2: Agenda

Sunday 2nd September afternoon

Meeting of task leaders in the afternoon: 15:00–19.00

Monday 3rd September

9.00	Get organized
9.30–10.00	Welcome RP
	Local Welcome & Information: Helle Gjeding Jørgensen
10.00–10.15	Intro to Working Group, ToR, Tasks, etc. RP
10-15–10.30	Task 1 - introduced by Tomasz Nermer
10.30–10.45	Task 2 - introduced by Håkan Wickström
10.45–11.00	Task 3 - introduced by Derek Evans

11.00–11.30 Coffee Break

11.30–11.45	Task 4 - introduced by Claude Belpaire
11.45–12.00	Task 5 - introduced by Martin de Graaf
12.00–12.15	Task 6 - introduced by Willem Dekker
12.15–12.45	Sargasso Index – H. Sparholt, WKESDCF report (A Walker)
	& Workshop updates if there are any (BALTEEL, GFCM)

12.45–14.00 Lunch

	Country Report Highlights (10 min per Country)
14.00–14.30	Norway, Sweden, Estonia,
14.30–15.00	Latvia, Lithuania, Poland
15.00–15.30	Denmark, Germany, Netherlands

15.30–15.45 Coffee

15.45–16.15	Belgium, United Kingdom, Ireland
16.15–16.45	France, Spain, Portugal
16.45–17.30	Morocco, Italy, Discussion

17.30–18.30 Plenary – plan of attack, gaps etc. Subgroups.

Tues–All Subgroups breakout

(09.00–11.30 Subgroups, Data, Local Assessment & Precautionary Advice and International Stock Assessment – to be attended by H. Sparholt)

18.00 Subgroup/task leaders' coordination meeting

Wed–All Subgroups breakout

(09.00–11.00 Discussion on ICES Databasing, WGEEL data, etc. To be attended by N. Holdsworth and reps from all subgroups).

Task Leaders Coordinate Groups in pm

Thurs

09.00–11.00 Full Plenary

17.00 Draft Advice Session Subgroup leaders

Fri 09.00–11.00 Plenary and Draft conclusions and recommendations.

Producing draft report [**DEADLINE for text 18:00**]

pm Circulate draft advice & report for comment

Sat 09.00–13:00 Circulate draft advice and report for comment

14.00–18:00 Discuss and agree main conclusions, and agree advice draft

Sun 09.00–10:00 Outstanding issues

10.00–16:00 Review Report.

16.00 CLOSE Working Group

Annex 3: WGEEL draft ToRs–Joint EIFAAC/ICES Working Group on Eels 2013

The **Joint EIFAAC/ICES Working Group on Eels** (WGEEL), chaired by Martin de Graaf, The Netherlands and Russell Poole, Ireland, will meet in Sukarietta, Spain, 18–22 March 2013 and in ICES Copenhagen, Denmark, 5–11 **September** 2013, to:

In preparation for undertaking the international stock assessment, the joint EIFAAC/ICES Working Group on Eel (WGEEL) requires access to the most up to date stock indicators for each Eel Management Unit. To achieve this, ICES will issue a data call to the EU for these data and for supporting information to facilitate quality assurance of the stock indicators.

Preparatory work

a) Develop data call in conjunction with ICES for stock indicators and supporting information on local/national methods used to derive indicators;

b) Support ICES to issue data call to MS via EU in first week of December 2012 for return deadline 1st February 2013;

c) Collate the returns from the data call and from the Member States 2012 Reports to the EU.

Spring Meeting

d) Complete the broad-brush quality assurance checking of the reported Eel Management Unit biomass and mortality estimates, and prepare the data for the international stock assessment;

e) Provide a summary report on the reported data and stock indicators and the quality assurance of the indicators;

f) Provide a first compilation of the best available biomass and mortality data, along with additional data from the Baltic and GFCM areas;

g) Further develop the S/R relationship and reference points, following the ICES peer-review, and using the latest available data.

Autumn Meeting

h) Evaluate the EU Regulation (EC No. 1100/2007) and its consistency with the precautionary approach, following the plan developed in WGEEL 2012;

i) Apply the reported biomass and mortality data to the precautionary diagram using PA limits and the EU Regulation derived target/limits if different (WGEEL 2011) and provide appropriate advice on the state of the international stock and its mortality levels;

j) assess the latest trends in recruitment, stock (yellow and silver eel) and fisheries, including effort, indicative of the status of the European stock, and of the impact of exploitation and other anthropogenic factors; analyse the impact of the implementation of the eel recovery plan on time-series data (i.e. data discontinuities). Update international databases for data on eel stock and fisheries, as well as habitat and eel quality (EQD) related data;

k) In conjunction with WGBEC and MCWG, review and develop approaches to quantifying the effects of eel quality on stock dynamics and integrating these into stock assessments. Develop reference points for evaluating impacts on eel;

l) Respond to specific requests in support of the eel stock recovery regulation, as necessary.

Material and data for the meeting must be available to the group no later than 14 days prior to the starting date of each meeting.

WGEEL will report by 27th September 2013 for the attention of ACOM, WGRECORDS, SGEF and FAO, EIFAAC and GFCM.

Supporting Information

Priority	In 2007, the EU published the Regulation establishing measures for the recovery of the eel stock (EC 1100/2007). This introduced new challenges for the Working Group, requiring development of new methodologies for local and regional stock assessments and evaluation of the status of the stock at the international level. In its Forward Focus (2011), WGEEL mapped out a process for post-evaluation of the EU Regulation, based on 2012 reporting to the EU by Member States, including an international assessment of the status of the stock and the levels of anthropogenic mortalities. ICES understands the evaluation of the 2012 reports will be undertaken by the EU Commission. The international eel stock assessment will require a process that collates good quality local biomass and anthropogenic mortality data and aggregates to the national and international levels. The 2012 meeting of WGEEL was the first step in this process. A further two meetings are envisaged, with data preparation in advance, in order to complete the international stock assessment. Countries must be committed to this process in order for it to succeed and it must be internationally coordinated.

Scientific justification	European eel life history is complex and atypical among aquatic species. The stock is genetically panmictic and data indicate random arrival of adults in the spawning area. The continental eel stock is widely distributed and there are strong local and regional differences in population dynamics and local stock structures. Fisheries on all continental life stages take place throughout the distribution area. Impacts vary from almost nil to heavy overexploitation. Other forms of anthropogenic mortality (e.g. hydropower, pumping stations) also impact on eel and should also be quantified in the 2012 national reports to the EU. Exploitation that leaves 30% of the virgin spawning-stock biomass is generally considered to be a reasonable target for escapement. Due to the uncertainties in eel management and biology, ICES proposed a limit reference point of 50% for the escapement of silver eels from the continent compared with pristine conditions (ICES, 2003). This is higher than the escapement of at least 40% "pristine" set by the EC Regulation for the escapement of silver eels. ICES has evaluated the conformity of country management plans with EC Regulation 1100/2007 (ICES Advice Reports 2009 and 2010, Technical Services), but it has not evaluated the consistency of the regulation itself with the precautionary approach. ICES will undertake such an evaluation based on country reports due in 2012 under EC Regulation 1100/2007. WGEEL (ICES, 2010a; Annex 5) recommended that Eel Management Plan reporting must provide the following biomass and anthropogenic mortality data: Bpost, the biomass of the escapement in the assessment year; Bo, the biomass of the escapement in the pristine state. Alternatively, one could specify Blim, the 40% limit of B0, as set in the Eel Regulation; Bbest, the estimated potential biomass in the assessment year, assuming no anthropogenic impacts (and without stocking) have occurred and from all potentially available habitats. ∑A, the estimation of Bbest will require an estimate of A (anthropogenic mortality (e.g. catch, turbines)) for density-independent cases, and a more complex analysis for density-dependent cases. Most EU Member States now have quantitative estimates of Bo and Bpost silver eel production, although the reliability and accuracy of these data have not yet been fully evaluated. Estimates of current anthropogenic mortality have only been made by some Member States, although it is anticipated this information will be available when reporting by Member States under the Regulation in 2012 is completed.
Resource requirements	Access to Member States 2012 Reports to the EU
Participants	ICES and EIFAAC Working Group Participants, Invited Country Administrations, EU representative
Secretariat facilities	SharePoint
Financial	At Country expense
Linkages to advisory committees	ACOM
Linkages to other committees or groups	WGRECORDS, SCICOM
Linkages to other organizations	FAO EIFAAC, GFCM, EU DGMARE, EU DGENV

Annex 4: Recommendations

	Recommendation	Adressed to
1.	An international program of recruitment monitoring would help replacing lost series in the glass eel fishing area	PGCCDBS
2.	The working group welcomes the revival of the Tiber series in the Mediterranean and advocates the development of other series in that area	GFCM DCF PGCCDBS
3.	The proposed new DC-MAP (ICES 2012) supports the need for surveys at sea of eel in the spawning area in the Sargasso Sea. These should be internationally coordinated.	PGCCDBS
4.	Establish a Planning Group to set the minimum standard for Sargasso Sea Eel Larval Surveys	PGCCDBS
5.	Build metadata description for ICES catalogue	ICES Data center, WGEEL
6.	Review vocabulary used by the working group and make it evolve to standard ICES vocabulary. Identify gaps in the ICES vocabulary and propose list of new vocabulary where needed	ICES Data center, WGEEL
7.	Provide GIS maps of EMU under ETRS1989, to be integrated in the coming database	ICES Data center, WGEEL
8.	A metadatabase record should be entered in the ICES DataCentre catalogue to describe the Eel Quality Database and data. The EQD should be maximally harmonized with the ICES Data Centre. Specifically, the chemical lists and species list should be harmonized.	ICES Data center, WGEEL
9.	Deliver national stock indicators to ICES in support of the stock-wide assessment, by March 2013 for countries outside EU or those not having reported their assessment	GFCM, PGCCDBS
10.	Where eel quality is poor, silver eels leaving catchments may not be able to contribute to the overall spawning and recruitment of the European stock. There is need to quantify the effects of eel quality on stock dynamics and integrating these into stock assessments. As a useful medium-term solution, we recommend a regular monitoring of the lipid content of escaping silver eels. As a key factor for reproduction and spawner quality, this information allows an approximate quantification of the number of potentially successful female spawners leaving each river basin and their reproductive potential in terms of eggs produced.	EU Countries

Recommendation	Adressed to
11. To improve the assessment of impact of contaminants and diseases on effective spawner biomass and reproductive success, it is urgently needed to establish national routine monitoring programmes. The Eel Regulation does not refer to the health status of the population of European eel or possible impacts on the population due to contamination and diseases. Hence, regular monitoring programmes are neither run nor reported to the EU, and reliable assessment of the eel stock quality and its quantitative effect on the reproductive stock is currently not possible. We recommend to take up an obligation of the Member States for the realization of routine monitoring of lipid levels, contamination and diseases in the Eel Regulation.	ICES Secretariat => EU
12. We recomment to initiate (e.g. by organizing a Workshop of a Planning Group on the Monitoring of Eel Quality) the development of standardized and harmonized protocols for the estimation of eel quality, preferably using non-lethal methods, including contaminants and diseases, with the objective to integrate eel quality parameters in quantitative assessment of the reproductive potential of the stock.	ICES Secretariat
13. Research resulting in a better understanding of the eel's sensitivity towards parasites, diseases, and contaminants with respect to survival, migration and reproduction success should be supported. When the effects of different stress factors are better quantified and thresholds for contaminants and diseases better defined, the importance of "eel-quality" in eel management can be better evaluated.	ICES Secretariat => EU and ICES Delegates
14. We recommend an exchange of information between WGBEC (Working Group on Biological Effects of Contaminants) and WGEEL concerning the influence of contaminants on fish, in order to progress in developing crucial Eel Quality Index components. We propose to enable an exchange via a joint meeting of the two working groups in 2014.	WGEEL, WGBEC
15. Establishment of traceability system as per Article 12 of Regulation, this sytem should permit cross-checking of imports and exports between countries for each batch of glass eel. An analysis by TRAFFIC would help the WGEEL.	WKSTOCKEEL, ICES Secretariat => EU, CITES
16. Countries should put in place a system that can determine the quantity of glass eel which are classified as destined for aquaculture but are in fact subsequently stocked	ICES Secretariat => Member States, EU, CITES

Annex 5: Action list for WGEEL

This section contains the recommendations from the group to itself. Address the two working group to be held in 2013 with the objective to develop and test methods to post-evaluate effects of management actions at the stock-wide level and give advice concerning the eel regulation.

1. Recruitment-series:gather information on effort and integrate them in the recruitment analysis	WGEEL
2. Build time-series of catches separated by stage, build time-series of effort data and analyse those data (see Action 11)	WGEEL
3. Continue work on yellow eel and silver eel time-series, including series such as the IJselmeer scientific trawl series, those series could be used as an independent estimate of silver eel production (see Action 13)	WGEEL
4. Build metadata description for ICES catalogue	WGEEL
5. Review vocabulary used by the working group and make it evolve to standard ICES vocabulary. Identify gaps in the ICES vocabulary and propose list of new vocabulary where needed	WGEEL
6. Provide GIS maps of EMU under ETRS1989, to be integrated in the coming database	WGEEL
7. Identify those inconsistencies within local stock assessments that invalidate the combination of national stock indicators in support of the stock-wide assessment.	WGEEL
8. Solve the problem of separate recruitment-series	WGEEL
9. Work out ways to reconstruct catch-series when data are missing	WGEEL
10. Fill in the matrix of transfer factor (α) (which part of an EMU biomass or catch, belongs to which area). Fill in data on raising factor (β) (relating biomass and catch) with the best data or expertise.	WGEEL
11. Solve the statistical problem to enable the comparision between the two approaches.	WGEEL
12. update B_{lim}, and derive the other reference points B_{pa}, F_{lim}, F_{pa} from the B_{lim}	WGEEL

Annex 6: Tables for Chapter 4

Table 4-1. Description of the recruitment-series.

Series name	area	Co.	Sampling type	unit	life stage	Short name
IYFS scientific	North Sea	SE	scientific	Index	glass	YFS1
IYFS2 scientific	North Sea	SE	scientific	Index	glass	YFS2
Ringhals scientific survey	North Sea	SE	scientific	Index	glass	Ring
Viskan Sluices trapping all	North Sea	SE	trapping all	Kg	g+y	Visk
Bann Coleraine trapping partial	British Isle	GB	trapping partial	Kg	g+y	Bann
Erne Ballyshannon trapping all	British Isle	IE	trapping all	Kg	g+y	Erne
Shannon Ardcrusha trapping all	British Isle	IE	trapping all	Kg	g+y	ShaA
River Feale	Atlantic Ocean	IE	trapping all	Kg	glass	Feal
River Maigue	Atlantic Ocean	IE	trapping all	Kg	glass	Maig
River Igh	Atlantic Ocean	IE	trapping all	Kg	glass	Ig
Severn EA com. catch	British Isle	UK	com. catch	t	glass	SeEA
Severn HMRC com. catch	British Isle	UK	com. catch	Kg	glass	SeHM
Vidaa Højer sluice com. catch	North Sea	DK	com. catch	Kg	glass	Vida
Ems Herbrum com. catch	North Sea	DE	com. catch	Kg	glass	Ems
Lauwersoog scientific	North Sea	NL	scientific	nb/h	glass	Lauw
Rhine DenOever scientific	North Sea	NL	scientific	Index	glass	RhDO
Rhine IJmuiden scientific	North Sea	NL	scientific	Index	glass	RhIj
Katwijk scientific	North Sea	NL	scientific	Index	glass	Katw
Stellendam scientific	North Sea	NL	scientific	Index	glass	Stel
Ijzer Nieuwpoort scientific	North Sea	BE	scientific	Kg	glass	Yser
Vilaine Arzal trapping all	Atlantic Ocean	FR	trapping all	t	glass	Vil
Loire Estuary com. catch	Atlantic Ocean	FR	com. catch	Kg	glass	Loi
Sèvres Niortaise com. cpue	Atlantic Ocean	FR	com. cpue	cpue	glass	SevN
Gironde (catch) com. catch	Atlantic Ocean	FR	com. catch	t	glass	GiTC
Gironde Estuary com. cpue	Atlantic Ocean	FR	com. cpue	cpue	glass	GiCP
Gironde scientific	Atlantic Ocean	FR	scientific	Index	glass	GiSc
Adour Estuary com. catch	Atlantic Ocean	FR	com. catch	t	glass	AdTC
Adour Estuary com. cpue	Atlantic Ocean	FR	com. cpue	cpue	glass	AdCP
lon Estuary com. catch	Atlantic Ocean	ES	com. catch	Kg	glass	lo
Albufera de Valencia com. catch	Mediterannean	ES	com. catch	Kg	glass	Albu
Minho spanish part com.catch	Atlantic Ocean	ES	com. catch	Kg	glass	MiSp
Minho portugese part com. catch	Atlantic Ocean	PT	com. catch	Kg	glass	MiPo
Ebro delta lagoons	Mediterannean	ES	com. catch	Kg	glass	Ebro
Albufera de Valencia com.cpue	Mediterannean	ES	com. cpue	cpue	glass	AlCP
Tiber Fiumara Grande com. catch	Mediterannean	IT	com. catch	t	glass	Tibe

Series name	area	Co.	Sampling type	unit	life stage	Short name
Imsa Near Sandnes trapping all	North Sea	NO	trapping all	Nb	glass	Imsa
Dalälven trapping all	Baltic	SE	trapping all	Kg	yellow	Dala
Motala Ström trapping all	Baltic	SE	trapping all	Kg	yellow	Mota
Mörrumsån trapping all	Baltic	SE	trapping all	Kg	yellow	Morr
Kävlingeån trapping all	Baltic	SE	trapping all	Kg	yellow	Kavl
Rönne Å trapping all	North Sea	SE	trapping all	Kg	yellow	Ronn
Lagan trapping all	North Sea	SE	trapping all	Kg	yellow	Laga
Göta Älv trapping all	North Sea	SE	trapping all	Kg	yellow	Gota
Shannon Parteen trapping partial	British Isle	IE	trapping partial	Kg	yellow	ShaP
Guden Å Tange trapping all	North Sea	DK	trapping all	Kg	yellow	Gude
Harte trapping all	Baltic	DK	trapping all	Kg	yellow	Hart
Meuse Lixhe dam trapping partial	North Sea	BE	trapping partial	Kg	yellow	Meus
Bresle	Atlantic Ocean	FR	trapping all	Nb	yellow	Bres

Table 4-3. Working group on eel recruitment index, GLM N=area:year+site.

A/ Glass eel "Elsewhere Europe"

	1950	1960	1970	1980	1990	2000	2010
_0	0.6	1.29	0.97	1.18	0.38	0.2	0.045
_1	0.5	1.1	0.55	0.89	0.18	0.097	0.043
_2	0.35	1.42	0.53	1.02	0.25	0.146	0.065
_3	0.5	1.72	0.59	0.5	0.29	0.119	
_4	0.69	0.92	0.9	0.58	0.3	0.079	
_5	0.44	1.25	0.68	0.53	0.33	0.099	
_6	0.49	0.77	1.11	0.36	0.28	0.073	
_7	0.6	0.78	1.03	0.65	0.36	0.07	
_8	0.44	1.3	1.12	0.66	0.21	0.057	
_9	0.7	0.57	1.4	0.47	0.24	0.037	

B/ Glass eel "North Sea"

	1950	1960	1970	1980	1990	2000	2010
_0	0.23	1.86	0.94	0.78	0.15	0.05	0.007
_1	0.3	1.09	0.59	0.62	0.03	0.01	0.005
_2	1.05	1.68	0.88	0.32	0.09	0.029	0.008
_3	0.93	2.09	0.45	0.27	0.08	0.023	
_4	1.55	1.05	1.09	0.1	0.08	0.007	
_5	1.54	0.8	0.52	0.1	0.05	0.014	
_6	1.13	0.82	0.92	0.1	0.05	0.005	
_7	0.62	0.93	0.8	0.11	0.05	0.014	
_8	1.22	1.14	0.6	0.1	0.03	0.007	
_9	1.52	0.84	0.91	0.04	0.06	0.012	

C/ Yellow eel series

	1950	1960	1970	1980	1990	2000	2010
_0	1.84	1.6	0.52	0.89	0.27	0.16	0.126
_1	2.34	1.68	0.56	0.36	0.4	0.168	0.13
_2	2.34	1.64	1.02	0.47	0.19	0.365	0.021*
_3	3.78	1.39	1.25	0.42	0.12	0.186	
_4	1.82	0.55	0.58	0.31	0.54	0.235	
_5	2.79	1.02	1.09	0.62	0.12	0.066	
_6	1.34	1.42	0.34	0.4	0.1	0.121	
_7	1.49	0.93	0.65	0.44	0.2	0.194	
_8	1.5	1.57	0.61	0.57	0.14	0.08	
_9	3.15	1.05	0.53	0.34	0.21	0.072	

*** One series only.**

Table 4-5. Coefficient of deviation from the common trend for European series. Glass and yellow eel series have been ordered by value, and separated for clarity.

nam	*coeff*	*area*	*sampling_type*	*stage*	*name*
			1970>1990		
RhIj	2.50	North Sea	scientific estimate	glass eel and yoy	Rhine IJmuiden scientific estimate
Ems	2.27	North Sea	commercial catch	glass eel and yoy	Ems Herbrum commercial catch
Yser	1.49	North Sea	scientific estimate	glass eel and yoy	Ijzer Nieuwpoort scientific estimate
Vida	0.92	North Sea	commercial catch	glass eel and yoy	Vidaa Højer sluice commercial catch
Lauw	0.84	North Sea	scientific estimate	glass eel and yoy	Lauwersoog scientific estimate
RhDO	0.81	North Sea	scientific estimate	glass eel and yoy	Rhine DenOever scientific estimate
Ring	0.81	North Sea	scientific estimate	glass eel and yoy	Ringhals scientific survey
ShaA	0.81	British Isle	trapping all	glass eel and yoy	Shannon Ardnacrusha trapping all
Katw	0.53	North Sea	scientific estimate	glass eel and yoy	Katwijk scientific estimate
Loi	0.29	Atlantic Ocean	commercial catch	glass eel and yoy	Loire Estuary commercial catch
Stel	0.14	North Sea	scientific estimate	glass eel and yoy	Stellendam scientific estimate
Visk	0.12	North Sea	trapping all	glass eel and yoy	Viskan Sluices trapping all
Ebro	0.02	Mediterannean Sea	commercial catch	glass eel and yoy	Ebro delta lagoons
GiCP	-0.02	Atlantic Ocean	commercial cpue	glass eel and yoy	Gironde Estuary (cpue) commercial cpue
SevN	-0.05	Atlantic Ocean	commercial cpue	glass eel and yoy	Sèvres Niortaise Estuary commercial cpue
Tibe	-0.13	Mediterannean Sea	commercial catch	glass eel and yoy	Tiber Fiumara Grande commercial catch
Bann	-0.13	British Isle	trapping partial	glass eel and yoy	Bann Coleraine trapping partial
AdTC	-0.19	Atlantic Ocean	commercial catch	glass eel and yoy	Adour Estuary (catch) commercial catch
Nalo	-0.19	Atlantic Ocean	commercial catch	glass eel and yoy	Nalon Estuary commercial catch
Imsa	-0.30	North Sea	trapping all	glass eel and yoy	Imsa Near Sandnes trapping all
Vil	-0.30	Atlantic Ocean	trapping all	glass eel and yoy	Vilaine Arzal trapping all
GiTC	-0.32	Atlantic Ocean	commercial catch	glass eel and yoy	Gironde Estuary (catch) commercial catch
SeHM	-0.34	British Isle	commercial catch	glass eel and yoy	Severn HMRC commercial catch
AlCP	-0.35	Mediterannean Sea	commercial cpue	glass eel and yoy	Albufera de Valencia commercial cpue
SeEA	-0.44	British Isle	commercial catch	glass eel and yoy	Severn EA commercial catch
MiSp	-0.52	Atlantic Ocean	commercial catch	glass eel and yoy	Minho spanish part commercial catch
Albu	-0.60	Mediterannean Sea	commercial catch	glass eel and yoy	Albufera de Valencia commercial catch
MiPo	-0.93	Atlantic Ocean	commercial catch	glass eel and yoy	Minho portugese part commercial catch
Erne	-1.68	British Isle	trapping all	glass eel and yoy	Erne Ballyshannon trapping all
Ronn	0.60	North Sea	trapping all	yellow eel	Rönne Å trapping all
Gota	-0.23	North Sea	trapping all	yellow eel	Göta Älv trapping all
Laga	-0.26	North Sea	trapping all	yellow eel	Lagan trapping all
Mota	-0.36	Baltic	trapping all	yellow eel	Motala Ström trapping all
Hart	-0.60	Baltic	trapping all	yellow eel	Harte trapping all
ShaP	-0.63	British Isle	trapping partial	yellow eel	Shannon Parteen trapping partial
Morr	-1.09	Baltic	trapping all	yellow eel	Mörrumsån trapping all
Dala	-1.13	Baltic	trapping all	yellow eel	Dalälven trapping all
Gude	-1.80	North Sea	trapping all	yellow eel	Guden Å Tange trapping all

nam	*coeff*	*area*	*sampling_type*	*stage*	*name*
			1991>2012		
Ems	1.90	North Sea	commercial catch	glass eel and yoy	Ems Herbrum commercial catch
Stel	1.59	North Sea	scientific estimate	glass eel and yoy	Stellendam scientific estimate
Visk	1.50	North Sea	trapping all	glass eel and yoy	Viskan Sluices trapping all
RhIj	1.49	North Sea	scientific estimate	glass eel and yoy	Rhine IJmuiden scientific estimate
Tibe	1.33	Mediterannean Sea	commercial catch	glass eel and yoy	Tiber Fiumara Grande commercial catch
Lauw	1.13	North Sea	scientific estimate	glass eel and yoy	Lauwersoog scientific estimate
Erne	1.10	British Isle	trapping all	glass eel and yoy	Erne Ballyshannon trapping all
Bann	1.00	British Isle	trapping partial	glass eel and yoy	Bann Coleraine trapping partial
YFS2	1.00	North Sea	scientific estimate	glass eel and yoy	IYFS2 scientific estimate
Yser	0.98	North Sea	scientific estimate	glass eel and yoy	Ijzer Nieuwpoort scientific estimate
GiSc	0.91	Atlantic Ocean	scientific estimate	glass eel and yoy	Gironde scientific estimate
ShaA	0.81	British Isle	trapping all	glass eel and yoy	Shannon Ardnacrusha trapping all
Nalo	0.72	Atlantic Ocean	commercial catch	glass eel and yoy	Nalon Estuary commercial catch
Imsa	0.66	North Sea	trapping all	glass eel and yoy	Imsa Near Sandnes trapping all
Ring	0.57	North Sea	scientific estimate	glass eel and yoy	Ringhals scientific survey
SeEA	0.52	British Isle	commercial catch	glass eel and yoy	Severn EA commercial catch
SeHM	0.51	British Isle	commercial catch	glass eel and yoy	Severn HMRC commercial catch
GiTC	0.43	Atlantic Ocean	commercial catch	glass eel and yoy	Gironde Estuary (catch) commercial catch
Katw	0.42	North Sea	scientific estimate	glass eel and yoy	Katwijk scientific estimate
Vil	0.39	Atlantic Ocean	trapping all	glass eel and yoy	Vilaine Arzal trapping all
RhDO	0.35	North Sea	scientific estimate	glass eel and yoy	Rhine DenOever scientific estimate
Loi	0.30	Atlantic Ocean	commercial catch	glass eel and yoy	Loire Estuary commercial catch
GiCP	0.17	Atlantic Ocean	commercial cpue	glass eel and yoy	Gironde Estuary (cpue) commercial cpue
MiPo	0.15	Atlantic Ocean	commercial catch	glass eel and yoy	Minho portugese part commercial catch
AlCP	0.06	Mediterannean Sea	commercial cpue	glass eel and yoy	Albufera de Valencia commercial cpue
Albu	0.05	Mediterannean Sea	commercial catch	glass eel and yoy	Albufera de Valencia commercial catch
AdTC	0.01	Atlantic Ocean	commercial catch	glass eel and yoy	Adour Estuary (catch) commercial catch
MiSp	-0.06	Atlantic Ocean	commercial catch	glass eel and yoy	Minho spanish part commercial catch
Ebro	-0.96	Mediterannean Sea	commercial catch	glass eel and yoy	Ebro delta lagoons
Gota	2.59	North Sea	trapping all	yellow eel	Göta Älv trapping all
Ronn	0.90	North Sea	trapping all	yellow eel	Rönne Å trapping all
Morr	0.51	Baltic	trapping all	yellow eel	Mörrumsån trapping all
Hart	0.48	Baltic	trapping all	yellow eel	Harte trapping all
ShaP	-0.12	British Isle	trapping partial	yellow eel	Shannon Parteen trapping partial
Gude	-0.26	North Sea	trapping all	yellow eel	Guden Å Tange trapping all
Mota	-0.34	Baltic	trapping all	yellow eel	Motala Ström trapping all
Kavl	-0.55	Baltic	trapping all	yellow eel	Kävlingeån trapping all
Laga	-1.25	North Sea	trapping all	yellow eel	Lagan trapping all
Dala	-1.36	Baltic	trapping all	yellow eel	Dalälven trapping all

Table 4-6. Total landings (all life stages) from 2012 Country Reports, except note Finland, Latvia, Lithuania, Netherlands, Portugal, Spain, France and UK (see Table notes at bottom of table). Norway (NO), Sweden (SE), Finland (FI), Estonia (EE), Latvia (LV), Lithuania (LT), Poland (PL), Germany (DE), the Netherlands (NL), Belgium (BE), United Kingdom (UK), Ireland (IE), France (FR) and Spain (ES), Portugal (PT) and Italy (I).

	NO	SE	FI Δ	EE	LV	LT	PL	DE	DK	NL ●	BE	UK	IE	FR Δ	ES ●	PT #	I
1945	102	1664							4169	2668							
1946	167	1512			1				4269	3492							
1947	268	1910			10	8			4784	4502							
1948	293	1862			10	14			4386	4799							
1949	214	1899			11	21			4492	3873					9		
1950	282	2188			14	29			4500	4152					4		
1951	312	1929			13	32			4400	3661					92		
1952	178	1598			14	39			3900	3978					102		
1953	371	2378			30	80			4300	3157					97		
1954	327	2106			24	147	609		3800	2085					112		
1955	451	2651			47	163	732		4800	1651					117		
1956	293	1533			26	131	656		3700	1817					124		
1957	430	2225			25	168	616		3600	2509					97		
1958	437	1751			27	149	635		3300	2674					128		
1959	409	2789			30	155	566	84	4000	3413					120		
1960	430	1646			44	165	733	51	4723	2999					125		
1961	449	2066			50	139	640	48	3875	2452					125		
1962	356	1908			46	155	663	67	3907	1443					119		
1963	503	2071			64	260	762	55	3928	1618					115		
1964	440	2288			43	225	884	56	3282	2068					108		
1965	523	1802			41	125	682	56	3197	2268		566			97		
1966	510	1969			43	238	804	68	3690	2339		618			126		
1967	491	1617			46	153	906	92	3436	2524		570			133		
1968	569	1808			34	165	943	103	4218	2209		587			140		
1969	522	1675			43	134	935	302	3624	2389		607			127		2469
1970	422	1309			29	118	847	238	3309	1111		754			146		2300
1971	415	1391			29	124	722	255	3195	853		844			166		2113
1972	422	1204			25	126	696	239	3229	857		634			109		1997
1973	409	1212			27	120	636	257	3455	823		725			91		588 *
1974	368	1034			20	86	796	224	2814	840		767			100		2122
1975	407	1399			19	114	793	226	3225	1000		764			110		2886
1976	386	935	6		24	88	803	205	2876	1172		627			142		2596
1977	352	989	4		16	68	903	214	2323	783		692			89		2390
1978	347	1076	3		18	70	946	163	2335	719		825			137		2172
1979	374	956	4		21	57	912	158	1826	530		1206			90		2354
1980	387	1112	5		9	45	1221	140	2141	664		1110			102		2198
1981	369	887	3		10	27	1018	131	2087	722		1139			90		2270
1982	385	1161	2		12	28	1033	166	2378	842		1189			146		2025
1983	324	1173	2		9	23	822	155	2003	937		1136			71		2013

	NO	SE	FI ∆	EE	LV	LT	PL	DE	DK	NL ●	BE	UK	IE	FR ∆	ES ●	PT #	I
1984	310	1073	2		12	27	831	114	1745	691		1257			98		2050
1985	352	1140	2		18	29	1010	477	1519	679		1035			100		2135
1986	272	943	3		19	32	982	405	1552	721		926		2462	63		2134
1987	282	897	0		25	20	872	359	1189	538		1006		2720	84		2265
1988	513	1162	0		15	23	923	364	1759	425		1110		2816	55		2027
1989	313	952			13	21	752	379	1582	526		1172		2266	46	14	1243
1990	336	942			13	19	697	374	1568	472		1014		2170	37	13	1088
1991	323	1084			14	16	580	335	1366	573		1058		1925	35	23	1097
1992	372	1180			17	12	584	322	1342	548		915		1585	40	30	1084
1993	340	1210		59	19	10	495	250	1023	293		857		1736	41	34	782
1994	472	1553		47	19	12	531	246	1140	330		1077		1694	34	27	771
1995	454	1205		45	38	9	507	242	840	354		1312		1832	49	24	1047
1996	353	1134		55	24	9	499	220	718	300		1246		1562	61	26	953
1997	467	1382		59	25	11	384	263	758	285		1190		1537	61	25	727
1998	331	645		44	30	17	397	28	557	323		943		1345	79	23	666
1999	447	734		65	26	18	406	38	687	332		963		1253	91	23	634
2000	281	561		67	17	11	305	36	600	363		702		1200	85	22	588
2001	304	543		65	15	12	296	141	671	371		742	98	1103	149	15	520
2002	311	633	0	50	19	13	236	130	582	353		650	123		157	27	415
2003	240	565	0	49	11	12	204	125	625	279		574	111		142	11	446
2004	237	551	1	39	11	16	148	117	531	245		634	136		110	9	379
2005	249	628	0	36	11	22	284	108	520	234		545	101		126	7	75 *
2006	293	670	0	33	8	16	257	87	581	230		408	133		114	10	56 *
2007	194	568	1	31	10	15	244	317	526	130		427	114	698	152	11	277
2008	211	495	1	30	13	14	227	398	457	122		397	125	657	79	7	56*
2009	69	388	2	22	5	9	156	446	467	275		458	0		99	8	280
2010	32	417	2	19	9	19	178	313	422	517	0	434	0	781	76	11	249
2011	0	440	2		7	11	119	357	370	550	0	459	0	392	337	7	150

● Partial, for area (Netherlands till 2010) or life stage (Spain till 2010) ∆ Partial, discontinued #Coastal yellow eel landings only (Portugal till 2010).

Table 4.8. Stocking of glass eel. Numbers of glass eels (in millions) stocked in Sweden (SE), Finland (FI), Estonia (EE), Latvia (LV), Lithuania (LT), Poland (PL), Germany (DE), the United Kingdom (UK), Belgium (BE), Northern Ireland (NI), France (FR), Spain (ES) and Canada (CAN - *A. rostrata*).

	SE	FI	EE	LV	LT	PL	DE	NL	BE	UK	FR	ES	IT	Total
1927				0.3										
1928					0.1									
1929					0.2									
1930														
1931				0.4	0.2									
1932					0.2									
1933				0.3	0.2									
1934					0.3									
1935				0.2	0.6									
1936					0.3									
1937				0.3	0.3									
1938					0.4									
1939				0.2	0.1									
1940														
1941														
1942														
1943														
1944														
1945														0
1946								7.3						7.3
1947								7.6						7.6
1948								1.9						1.9
1949								11						10.5
1950								5.1						5.1
1951								10						10.2
1952						18		17						34.5
1953						26	2.2	22						49.6
1954						27	0	11						37.1
1955						31	10	17						57.5
1956			0		0.3	21	4.8	23						49.4
1957						25	1.1	19						44.8
1958						35	5.7	17						57.6
1959						53	11	20						83.3
1960			1	3.2	2.3	64	14	21						105.3
1961						65	7.6	21						93.7
1962			1	1.9	2	62	14	20						100.3
1963				1.5	1	42	20	23						87.8
1964			0	0.9	2.4	39	12	20						74.4
1965			1	0.4	2.1	40	28	23						93.3
1966		1.1			0.7	69	22	8.9						101.6
1967		3.9		1	0.5	74	23	6.9						109.3
1968		2.8	1	3.7	3	17	25	17						69.7

	SE	FI	EE	LV	LT	PL	DE	NL	BE	UK	FR	ES	IT	Total
1969					0	2	19	2.7						23.9
1970			1	1.8	2.8	24	28	19						75.6
1971					1.6	17	24	17						60.3
1972			0	1.6	0.3	22	32	16						71.1
1973					1.4	62	19	14						96
1974			2		1.8	71	24	24						122.7
1975					2.2	70	19	14						105.2
1976			3	0.6	1	68	32	18						121.7
1977			2	0.5	1.4	77	38	26						145.2
1978		3.7	3		2.7	73	39	28						148.8
1979					0.8	74	39	31						144.65
1980			1		1.8	53	40	25						120.5
1981			3	1.8	3	61	26	22						116.4
1982			3		4.6	64	31	17						119.4
1983			3	1.5	3.7	25	25	14						72.1
1984			2			49	32	17		4				103.1
1985			2	1.5	1.6	36	6	12		10.9				70.52
1986			3		2.6	54	24	11		17.8				111.61
1987			3	0.3		57	26	7.9		13.8				107.55
1988				2.2		16	27	8.4		6.32				59.42
1989						5.9	14	6.8						27
1990	0.7	0.1				8.6	17	6.1						32.2
1991	0.3	0.1	2			1.7	3.2	1.9						9.2
1992	0.3	0.1	3			14	6.5	3.5		2.36				29.06
1993	0.6	0.1				11	8.6	3.8	0.8					24.5
1994	1.7	0.1	2		0.1	12	9.5	6.2	0.5	2.32				34.52
1995	1.5	0.2		0.6	1	24	6.6	4.8	0.5	2.06				40.96
1996	2.4	0.1	1		0.4	2.8	0.8	1.8	0.5	0.1		0.1		10.37
1997	2.5	0.1	1			5.1	1	2.3	0.4	0.21		0.1		12.58
1998	2.1	0.1	1		0.1	2.5	0.4	2.5		0.05		0.1		8.36
1999	2.3	0.1	2	0.3		4	0.6	2.9	0.8	3.6		0.2		17.02
2000	1.4	0.1	1			3.1	0.3	2.8		0.45		0.1		9.23
2001	0.8	0.1				0.7	0.3	0.9	0.2			0		3
2002	1.7	0.1		0.2			0.3	1.6		3.02		0		6.94
2003	0.8	0			0.4	0.5	0.1	1.6	0.3	4.1		0.1		7.89
2004	1.3	0.1				2.3	0.2	0.3		1.28		0.1		5.5
2005	1	0.1		0.1			0.6	0.1		2.16				4.05
2006	1.1	0.1		0				0.6	0.3	0.99				3.08
2007	1	0.1		0			1	0.2	0	3		0		5.3
2008	1.4	0.2					0.5		0.3	1.28				3.68
2009	0.8	0.1					0.76	0.3	0.4	0.65				3.01
2010	1.9	0.2					4.8	2.7	0.4	3	1	0		14
2011	2.63	0.31	0.7	0.4				0.8	0.5	3.3	2.2	0	0.2	11.04
2012	2.56	0.18	0.9	1.0				2.4	0.6	4.0	9.3	0.1	0.8	21.84

Table 4.9. Stocking of young yellow eel. Numbers of young yellow eels (in millions) stocked in Sweden (SE), Finland (FI), Estonia (EE), Latvia (LV), Lithuania (LT), Poland (PL), Germany (DE), Denmark (DK) the Netherlands (NL), Belgium (BE), and Spain (ES).

	SE	FI	EE	LV	LT	PL	DE	DK	NL	BE	ES	IT	Total
1947									1.6				1.6
1948									2				2
1949									1.4				1.4
1950							0.9		1.6				2.5
1951							0.9		1.3				2.2
1952							0.6		1.2				1.8
1953							1.5		0.8				2.3
1954							1.1		0.7				1.8
1955							1.2		0.9				2.1
1956							1.3		0.7				2
1957							1.3		0.8				2.1
1958							1.9		0.8				2.7
1959							1.9		0.7				2.6
1960							0.8		0.4				1.2
1961		0		1			1.8		0.6				3.5
1962		0		0.7			0.8		0.4				2
1963				0.4			0.7		0.1				1.2
1964		0		0.4			0.8		0.3				1.6
1965		0		0.3			1		0.5				1.9
1966		0					1.3		1.1				2.5
1967				0.8			0.9		1.2				2.9
1968							1.4		1				2.4
1969							1.4						1.4
1970				0.4			0.7		0.2				1.3
1971							0.6		0.3				0.9
1972							1.9		0.4				2.3
1973						0.2	2.7		0.5				3.4
1974							2.4		0.5				2.9
1975							2.9		0.5				3.4
1976				0.3			2.4		0.5				3.2
1977						0.1	2.7		0.6				3.4
1978							3.3		0.8				4.1
1979		0					1.5		0.8				2.4
1980							1		1				2
1981							2.7		0.7				3.4
1982				0.3		0.1	2.3		0.7				3.4
1983				0.4		2.3	2.3		0.7				5.7
1984						0.3	1.7		0.7				2.7
1985						0.5	1.1		0.8				2.4
1986						0.2	0.4		0.7				1.3
1987							0.3	1.58	0.4				2.28
1988			0.2	0.8		0.1	0.2	0.75	0.3				2.35

	SE	FI	EE	LV	LT	PL	DE	DK	NL	BE	ES	IT	Total
1989						0.7	0.2	0.42	0.1		0.06		1.48
1990	0.8					1	0.4	3.47			0.03		5.7
1991	0.9					0.1	0.5	3.06			0.06		4.62
1992	1.1					0.1	0.4	3.86			0.06		5.52
1993	1						0.7	3.96	0.2	0.2	0.17		6.23
1994	1				0.1	0.1	0.8	7.4		0.1	0.12		9.62
1995	0.9		0.2				0.8	8.44		0.1	0.22		10.66
1996	1.1					0.5	1.1	4.6	0.2	0.1	0.1		7.7
1997	1.1					1.1	2.2	2.53	0.4	0.1	0.14		7.57
1998	0.9				0.1	0.6	1.7	2.98	0.6	0.1	0.09		7.07
1999	1				0.1	0.5	2.4	4.12	1.2	0.04	0.04		9.4
2000	0.67					0.8	3.3	3.83	1		0.05		9.65
2001	0.44		0.44			0.6	2.4	1.7	0.1		0.06		5.74
2002	0.26		0.36	0.2		0.6	2.4	2.43	0.1	0.01	0.04		6.4
2003	0.27		0.54			0.50	2.60	2.24	0.10	0.01	0.06		6.32
2004	0.18		0.44		0.10	0.50	2.20	0.75	0.10	0.01	0.06		4.34
2005	0.07		0.37			0.70	2.10	0.30		0.01	0.12		3.67
2006	0.003		0.38			1.10	5.50	1.60					8.58
2007	0.03		0.33			0.90	8.7	0.83			0.02		10.81
2008	0.12		0.19			1.00	8.5	0.75	0.23		0.04		10.83
2009	0.02		0.42			1.40	8.3	0.81	0.30		0.02		11.27
2010			0.21			1.40	8.2	1.55	0.10		0.01		13.41
2011			0.20	0.004	0.13	2.70		1.56	1.0		0.02	0.69	6.30
2012			0.10		0.44	3.90		1.53	0.5		0.16		6.63

Annex 7: Additional material to Chapter 6; Eel Quality: Information on eel quality provided by countries

Contaminants

There were no new or available data from the following countries: **Finland**, **Latvia**, **Lithuania, Denmark, Ireland, UK** and **Spain**.

In **Norway**, eels were sampled from 19 sites and analysed for lipid levels and PCBs. Prevalence and number of *A. crassus* were also recorded. Results have been integrated into the EQD.

In **Sweden**, there has been no analysis for dioxins or PCB since 2010. Also the threshold values have been slightly changed, both in values (lowered), as well as the use of toxic equivalents (from WHO TEF 1998 to WHO TEF 2005) (Regulation (EU) nr 1259/2011).

In **Poland**, the chemical compounds in muscle tissues of eel caught in 2011 in Puck Bay, the Vistula Lagoon, in the vicinity of Świnoujścia and Mielno, and in inland waters were analysed. The samples varied in fat content from 8.86% to 28.79%. Higher fat contents were found in individuals of a higher body weight and in a more advanced stage of sexual maturity. The protein content varied between 14.75% and 19.25%. The content of zinc and copper were compared with the recommended daily allowances (Commission Directive 2008/100/EC), which are 10 000 μg for zinc and 1000 μg for copper. The mean contents of zinc and copper indicated that 200 g of eel tissue meet 40% of the daily requirement of an adult person for zinc and approximately 4% of that of copper. Cadmium contents varied between 0.5 μg/kg and 5.5 μg/kg, which mean that the maximum cadmium content was only 5.5% of the allowed limit. The lead contents varied between 8.0 μg/kg and 38.4 μg/kg; thus, the maximum lead content was 10.8% of the allowable limit. No sample exceeded the allowable limit of mercury (1000 μg/kg), but the content in one tissue sample from an eel caught in Puck Bay was 999 μg/kg.

In the case of ΣDDT, none of the analysis indicated that the allowable limit was exceeded; the highest residue level of this group of pesticides (776.21 μg/kg in tissues of an eel from the vicinity of Świnoujścia weighing 1207 g) was 77.6% of the allowed limit. Elevated levels of Σ DDT were confirmed in the tissues of an eel from the Vistula Lagoon in which the residues of this group of pesticides was 317.55 μg/kg. In all other samples, the ΣDDT levels ranged from 2.32 μg/kg to 168.75 μg/.

Maximum level of Σ PCB_6 (300 μg/kg) in eel tissues was exceeded (375.20 μg/kg) in one sample from an individual caught in the Puck Bay. The lowest Σ PCB_6 content was noted in samples of eel tissue from inland waters; the Σ PCB_6 residues in a sample from Lake Bukowo weighing 290 g were only 1.87 μg/kg.

The results obtained for indicator PBDEs were compared to the content of 4 μg/kg tissues, which is the reference value designated as allowable for living aquatic organisms during work on the Water Directive. In one individual, the limit was exceeded fourfold and in another individual it was exceeded by 5%. PBDE exceeded 2 μg/kg in five samples; there included two samples from inland water, and one sample each from the Vistula Lagoon, the Puck Bay, and Mielno.

Assay results indicated that dioxin residues (PCDD/Fs) in the examined eel tissues are at relatively low levels. The highest level was found in an individual from the vicinity of Świnoujścia (1.10 ng WHO-TEQ/kg).

The eel assayed presented much higher dioxin-like polychlorinated biphenyl (dl-PCB) contamination. This is also why excessive amounts of total dioxin and dl-PCB (10 ng WHO-EQ/kg) were noted. In other samples assayed, the total dioxin and dl-PCB was lower, and did not even exceed the allowable limit permitted for other fish (6.5 ng WHO-TEQ/kg).

In **Germany**, a study by Nagel *et al.* (2012) demonstrated how silvering affected metabolite concentrations of biliary PAH (polycyclic aromatic hydrocarbons). The authors detected increasing absolute PAH metabolite levels in bile during the silvering process. The largest increase was observed at the transition from pre-migration stage III to the migrating stage IV, possibly due to cessation of feeding at this stage. The authors recommend 1) to regularly monitor PAH-metabolites in bile, 2) to determine silvering index of eel and 3) to normalize PAH-metabolite values in bile based on silvering status.

Eel samples of monitoring programmes in North Rhine-Westphalia showed high values in the range of or above the maximum level for dioxins and dioxin-like PCBs. Due to these results the "Landesamtfür Natur, Umwelt und Verbraucherschutz" (LANUV NRW) recommended in July 2012 to avoid consumption of wild eels caught in North Rhine-Westphalian waters (www.lanuv.nrw.de).

In **the Netherlands**, five locations were monitored in 2011. There was no change compared to previous years. Compared to the 1980s, a substantial decrease in PCB concentrations has been achieved, but the current rate of decline is low or non-existent. Similar results were found in another study including eels from 29 locations. Locations that have eels with concentration of sum-TEQ or PCB 153 above the regulatory levels are fed by the river Rhine or Meuse. Only waterways not influenced by the Rhine, Meuse or local industry can be considered as little contaminated.

Specific actions have been carried out in **Belgium** in 2011. Flanders has contributed to the scientific work about the status and effects of hazardous substances on the eel. Eels from many places in Flanders are considerably contaminated and their consumption presents risks for human health. Flanders continues to coordinate the Eel Quality Database, for which a new application is currently under development. In the last years reports (Belpaire *et al*. 2009, 2010, 2011ab) extensive information has been provided about the status and effects of contaminants in the eel. Full information is to be find in the original papers (see e.g. Belpaire *et al*., 2011b; Reyns *et al*., 2010; Geeraerts *et al*., 2011; Belpaire *et al*., 2011a; Roosens *et al*., 2010; Geeraerts and Belpaire, 2010). A significant contribution has been given to the Eeliad program and to several other international cooperations (see abstracts under Subchapter 11.3). Eel quality data gathered during the Eeliad program are currently in process. Other cooperations with regard to surveys on eel contamination have been set up with different countries (Spain, Norway, Italy). In Wallonia a monitoring survey on the levels of contaminations in invertebrates and fish is in progress. In the Walloon region eel fishing is prohibited to avoid human consumption of contaminated eels.

In **France**, Amilhat *et al.* (submitted) evaluated the level of contamination of migrant silver eels from Mediterranean habitats presenting different degrees of contamination. They considered simultaneously pathogens (*Anguillicoloides crassus*, virus Evex) and chemical contaminants (PCBs, OCs and heavy metals) concentrations. A total of 222 silver males were sampled from three coastal lagoons in Southern France. Each silver eel was contaminated by at least one type of contaminant (pathogens/PCBs/OCs/Cadmium). Most of the specimens (42%) harboured two types of contaminant, 38% three types and 10% four types.

A national plan against PCBs including eel sampling have been set up since 2008. All details and data can be found here (http://www.pollutions.eaufrance.fr/pcb/). Some samples have also been analysed for mercury. Data can be accessed through http://www.pollutions.eaufrance.fr/pcb/resultats-xls.html and http://pollutions.eaufrance.fr/Demo/Resultats_hydro.aspx. Following those analyses some fisheries bans have been taken that sometimes only concerns eels above a given size.

Samples of eels caught from five brackish water systems in **Portugal**, were analysed for some trace metals (Hg, PB, Zn, Cu, Cd) revealing low contamination loads when compared to their European congeners (Passos, 2008; Neto, 2008; Neto *et al.*, 2011a). The most contaminated eels were obtained from the Tagus estuary. However, in this estuary no clear relationships could be established between contaminant concentrations in eel tissues (liver and muscle) and in sediment, probably because of the general heterogeneity in environmental conditions (Neto *et al.*, 2011b). A comparative study about the effects of pollution on glass and yellow eels from the estuaries of Minho, Lima and Douro rivers was developed by Gravato *et al*. (2010). Fulton condition index and several biomarkers indicated that eels from polluted estuaries showed a poorer health status than those from a reference estuary, and adverse effects became more pronounced after spending several years in polluted estuaries.

In **Italy,** some lake fisheries were closed in 2011, and have triggered concerned also eel, in relation to fish contamination by dioxin or other contaminants. Contaminant data are carried out by local Health Agencies, but are not available.

In **Morocco,** heavy metals (Pb, Cd and Cr) were assessed in liver, gills and muscle of eel (*Anguilla anguilla*) inhabiting two ecosystems along the Moroccan Atlantic coast. In these areas *A. Anguilla* is widespread and a common predator at the top of the food chain. Metal concentrations were higher in eel caught from Sebou estuary than in Loukkos, with preferential accumulation in liver for Cd (chronic accumulation) and in gills for Cr and Pb (recent accumulation).

Parasites and diseases

There were no new or available data from **Norway, Finland, Latvia, Lithuania, Spain** and **Italy**.

In **Poland**, studies to evaluate the health of eel from different fisheries enterprises and from different environmental conditions in various aquatic basins were performed as part of a monitoring project. A special protocol for monitoring eel health was developed and applied in the studies, and the eel from each of the enterprises were subjected to the same diagnostic procedures. Before the examinations, the eel were anaesthetized with Propiscin (IFI Olsztyn). Each of the fish was examined individually for clinical and anatomopathological changes on the skin or in the gills and internal organs that would indicate the presence of disease. Blood samples were collected for further haematological, biochemical, and immunological test and samples were collected from particular parts of the fish and from the organs for virological, bacteriological, and immunological tests. The immunological tests included determining the activity of non-specific cellular and humoral immune defence mechanisms and resistance to infections. Full parasitological tests were also performed in order to confirm parasitic infection of skin, gills, and internal organs (swimbladder, digestive tract). Bacteriological tests included isolating and identifying pathogenic bacteria that threatened the health and life of the fish. The virological tests focused on isolating and identifying two viruses that are highly pathogenic to eel: EVEX, which is required by the European Union, and anguillid *herpes virus* (AnHV). Simultaneously, tests were performed to determine if other viruses that are pathogenic for fish were present (VHSV, IHNV, IPNV, SVCV).

The analysis of the test results indicated that no significant differences were observed in the health of the fish that were subjected to clinical, anatomopathological, biochemical, or immunological tests. No pathology that would indicate disease was noted on the skin or in the gills of the tested fish, and anatomopathological examinations confirmed this evaluation as no pathology was noted in any of the internal organs (liver, kidneys, spleen, and digestive tract). Bacteriological tests on the skin, gills, and internal organs did not indicate the presence of any pathogenic bacteria that could threaten health, and only saprophytic bacterial flora that occurs permanently in waters was isolated. Simultaneously, neither the EVEX nor the AnHV viruses, which are both pathogenic to eel, were detected among the fish tested. A significant element of the test was that no viruses that are pathogenic to other fish species were isolated among the eel tested which indicates that they are not carriers of pathogenic viruses of other fish species cultured in Poland. However, the parasitological tests focused on the eel swimbladder indicated a very high infection prevalence with the nematode *Anguillicoloides crassus* among the fish tested. The analysis of the test results of individual eel permit concluding that the degree of infection with the parasitic nematode *A. crassus* has an impact on the activity of non-specific cellular and humoral immune defence mechanisms that provide resistance to infections and on levels of total protein and glucose, which are fundamental parameters used to evaluate fish condition. A strict dependence between the degree of parasitic infection and fish condition was noted. In conclusion, the eel tested did not exhibit pathological changes, and microbiological and immunological tests confirmed the good health of the fish.

Stocking material imported to Poland

The condition and health of eel destined to be released as stocking material into the open waters of Poland were also included in the eel health evaluation project, and the health and condition of eel fry were evaluated similarly to the eel inhabiting Polish waters.

The analysis of the test results indicated there were no significant differences in health evaluations based on clinical, anatomopathological, biochemical, or immunological tests. Among the fish examined no pathology that would indicate disease was noted on the skin or in the gills of the tested fish, and anatomopathological examinations confirmed this evaluation as no pathology was noted in any of the internal organs (liver, kidneys, spleen, and digestive tract). Parasitological tests indicated that no parasites occurred on the skin or gills or in the digestive tract. However, in single instances the swimbladder was infected with the nematode *Anguillicoloides crassus*. Comprehensive bacteriological tests detected increased incidences of the pathogenic bacteria *Aeromonas hydrophila*, while on other organs and the skin no pathogenic bacteria flora was noted. Simultaneously, neither the EVEX nor the AnHV viruses, which are both pathogenic to eel, were detected among the fish tested, and no other viruses were isolated that are pathogenic to other fish species cultured in Poland.

Comprehensive tests indicated unequivocally that eel destined to be released as stocking material into open waters were in good condition and were clinically healthy as was indicated by specialized virological and bacteriological tests, while the level of non-specific cellular and humoral immune defence mechanisms indicated high levels of immunity and good resistance to infection which guarantees survival under changing environmental conditions.

In **Germany**, Thieser *et al*. (2012) studied infestation of European and American eel with the swimbladder nematode *Anguillicoloides crassus* in two north German Lakes. The background of this study is the unintended stocking of *A. rostrata* in several lakes in Mecklenburg-Pomerania in the period 1998–2002. In both lakes, the eel stocks result almost exclusively from re-stocking. In total, the authors analysed 91 eels (48 European, 43 American). Infection with *A. crassus* was found in both species and there was no clear difference in prevalence. Prevalence of *A. crassus* larvae was between 24% and 53% in *A. anguilla* and between 48% and 50% in *A. rostrata*. For adult nematodes, prevalence was 48% to 68% in *A. anguilla* and 43–80% in *A. rostrata*. A heterogeneous picture without noteworthy differences between the two species was found for the Swimbladder Degenerative Index (Lefebvre, 2002). The authors did not find a significant effect of *A. crassus* infection on Condition Factor and Spleen-Somatic Index.

In the **Netherlands**, the swimbladder nematode *Anguillicoloides crassus* was introduced in wild stocks of European eels in The Netherlands in the start of the 1980s, from SE-Asia. The market sampling for Lake IJsselmeer collects information on the percentage of eels showing *A. crassus* infection based on inspection of the swimbladder by the naked eye. Following the initial break-out in the late 1980s, infection rates have stabilized between 40 and 60%. As part of the extended market sampling program in 2009, data on *Anguillicoloides* infection rates was also collected in two other areas (Friesland and Rivers). In both areas the infection rate was similar to the levels observed in Lake IJsselmeer over the past years. In 2011 the market sampling was conducted in most of the country (Table NL.H).

In **Belgium, in the Flemish Region,** Flanders has cooperated to a pan European survey on the actual status of *A. crassus* in silver eels. This extensive study was conducted during the EELIAD project (www.eeliad.com) to test the relationship between silver eel health indicators and infestation by *A. crassus*. This parasitic nematode of the swimbladder of the Japanese eel, *Anguilla japonica* was introduced in the early 1980s from Asia to Europe and infested the European eel. Since then, this invasive parasite has been able to spread rapidly through most of its new host geographic range. Being haematophagous *A. crassus* induces pathogenic changes in the swimbladder and has been considered as an additional pressure on the European eel population by potentially hampering the transoceanic migration of the silver eels. We present here the results of the first study covering eleven European catchments (seven countries) sampled from 2007 to 2009. A total of 492 silver eels, considered as future spawners, were examined for epidemiologic parameters and SDI (swimbladder degenerative index). In most of the investigated catchments more than 50% of the eels were infested with *A. crassus*, except in the French Mediterranean lagoon Bages-Sigean (8%) and the Irish Burrishoole River (0%). The highest prevalences (81–94%) and mean intensities (7.9–10.6%) were recorded in Belgium, Denmark, France, Ireland and UK sites. Eels from UK and Danish catchments displayed the highest SDI. No significant geographical pattern was observed. The implication of these results regarding the framework of the eel restoration plans was discussed (Faliex *et al*., 2012). In the **Walloon Region**, there was no new information compared to earlier reports.

Table 6-8. Overview of *A. crasssus* infection rates the Netherlands.

	IJSSELMEER		FRIESLAND		MEUSE & RHINE		NOORD HOLLAND		RANDMEREN		ZEELAND		ZUID HOLLAND	
year	%	# eels	%	# eels	%	# eels	%	# eels	%	# eels	%	# eels	%	# eels
1986	31	699	44	421	70	30								
1987	93	244												
1988	75	520												
1989	51	423												
1990	60	200												
1991	61	240												
1992	57	165												
1993	65	238												
1994	64	224												
1995	55	225												
1996	67	241												
1997	58	240												
1998	60	240												
1999	60	255												
2000	57	450												
2001	62	240												
2002														
2003														
2004	52	1654												
2005	56	45												
2006	55	1520												
2007	45	1215												
2008	41	1319												
2009			44	991	55.3	262								
2010	46	390	46	589	47	456								
2011	41	345	30	164			32.2	115	57	76	37	153	41	130

In **Ireland**, all eels captured in the eel specific fykenet surveys and in the WFD surveys that are sacrificed for age determination will also be sexed and examined for parasites. Parasite data will be supplied to the EQD.

In the **UK**, the following reports present new information available in the last twelve months. The historic information, albeit limited, on parasite levels in UK eels has been reviewed in recent UK reports.

England & Wales

Anguillicoloides crassus

A. crassus is widely distributed throughout England and Wales. Since 2009, yellow eels from 30 rivers have been examined for this parasite. Of these, 24 rivers were found to be infected, with up to 83% of eels harbouring nematodes. A small number of catchments and isolated rivers in North Wales and Northern England remain either sparsely infected or tentatively free of the parasite. Studies are underway in collaboration with Salford University to confirm and progress these findings.

Efforts have also been made to establish whether *A. crassus* infections occur in other life stages of eels. During 2011, a sample of 200 silver eels obtained from the River Avon, Hampshire for research purposes was examined for parasites. *A. crassus* was found in 85% of these fish, with infections ranging from 1 to 58 parasites (mean = 8.2). Five samples of elvers were also examined for parasites during routine health checks prior to stocking. Only one sample from the River Severn revealed *A. crassus*, with 16 out of 30 elvers (53%) infected. These included a number of heavy infections resulting in total occlusion of the swimbladder. Other notable infections included *Dermocystidium anguillae* in 20% of these fish, with cysts engulfing large areas of the gills.

Mortality investigations

Two eel-specific disease outbreaks investigated during 2009 and 2010 revealed infections of Herpes virus anguillae (HVA). These represent the first records of this virus in wild UK eels. Histopathological changes in the gills, skin and liver, combined with observations from transmission electron microscopy, indicated that HVA was the cause for these losses. Although no further mortalities have been attributed to this virus, efforts have been made to establish the distribution of HVA in England and Wales.

During 2011, yellow eels from a total of 16 rivers were tested for HVA, with at least one river sampled from each RBD. A further six samples of elvers and two samples of silver eels were also tested for antibodies to this virus. Preliminary results suggest that HVA is present in a small number of rivers but at a low prevalence (1.2–6.7%). Further monitoring is currently underway, with development of additional diagnostic tests for other eel viruses (e.g. EVE and EVEX). This work, in collaboration with Cefas, will inform existing disease risk assessments and eel management measures.

Since 2010, no large-scale mortalities of eels have been reported in England and Wales. A single case of vibriosis was investigated in summer 2011 in the River Thames, but this was limited to just a single fish exhibiting gross bacterial lesions.

Collaborative studies

Continued efforts have been made to evaluate the importance of other parasites and pathogens in wild UK eels. This has been conducted in collaboration with various institutes across the UK using archived material, information from disease investigations and samples obtained from elvers, yellow and silver eels, from a range of habitats.

A collaborative study involving the Environment Agency, Southampton and Cardiff Universities was set up in 2011 to investigate the influence of parasites and other health factors on eel behaviour and passage. The behaviour of silver eels in response to a range of flow regimes was observed within flume facilities. Comprehensive health examinations were then completed. Initial results suggest that *A. crassus* infection alters the behaviour of eels during downstream migration. This could have important implications for eel passage, escapement and spawning success.

These studies have led to the development of a comprehensive fish health protocol to assist practitioners with the collection, examination, handling, storage and archiving of eel tissues. This includes a framework for the detection and identification of parasites from both fresh and fixed tissues with methods for tissue sampling to support virology, bacteriology, histopathology, immunology, microchemistry and contaminant analysis. This approach has already helped coordinate resources, enhanced collaborative research opportunities and progressed our understanding of eel health and spawner quality.

Northern Ireland

A. crassus is now considered to be ubiquitous throughout Northern Ireland.

North East RBD

It was first recorded from the North East RBD in 2010 where it was found in eels sampled from the Quoile system (N = 52, prevalence 30% mean intensity <one worm per infected eel). In 2011, *A. crassus* was found in other lakes connected to this initial location, but was not detected in three other areas.

North Western International RBD

The first records of *A. crassus* in Ireland were from this RBD in July 1998. No new data are available since the last report.

Neagh/Bann RBD

A. crassus was first found in Lough Neagh yellow and silver eels in 2003, and its spread has been monitored via the analysis of over 2200 yellow and over 800 silver eels from 2003 to 2011. Prevalence has always been higher in silver than yellow eels, but has reduced in both stages since 2005 (Table 6-9).

Table 6-9. Prevalence (% eels sampled) of *A. crassus* in Lough Neagh yellow and silver eels.

year	% yellow eels	% silver eels
2005	93	100
2008	67.3	86
2009	53.6	73
2010	48.8	80.7
2011	56.7	74

Scotland

Prior to 2008, the only reported instance of *A. crassus* in Scottish RBD was from a site near a fishfarm on the Tay catchment (Lyndon and Pieters, 2005), and, while recognizing the absence of any coordinated survey, it was tentatively thought that *A. crassus* was not widespread in Scotland. A survey in 2008 and 2009 revealed the presence of adult *A. crassus* in eels from the following catchments: Forth, Leven, and Monikie Burn, at prevalences from 25–40%. The small numbers of eels sampled at each site do not allow confident demonstration of the absence of *A. crassus* where none were found at a site. However, it is noteworthy that all four of the catchments now known to be infected are concentrated in a relatively small part of the east coast of Scotland.

In **France,** Amilhat *et al.* (submitted) evaluated the level of contamination of migrant silver eels from Mediterranean habitats presenting different degrees of contamination. They considered pathogens (*A. crassus*, virus Evex) and chemical contaminants (PCBs, OCs and heavy metals) concentrations simultaneously. A total of 222 silver males sampled from three coastal lagoons (Canet-Saint-Nazaire, Salses-Leucate and

Bages-Sigean) and a river (La Berre) were analysed. Each silver eel was contaminated by at least one type of contaminant (pathogens/PCBs/OCs/Cadmium). Most of the specimens (42%) harboured two types of contaminant, 38% three types and 10% four types. Based on available literature (providing contaminants threshold values for migration and/or reproduction success), we estimated that, depending on the site and year, 3 to 100% of the eels would probably be unable to reproduce successfully.

In **Portugal**, there is no national programme to monitor parasites or pathogens. *A. crassus* is however probably spread throughout the country.

Annex 8: Overview of research projects and ongoing work

IMMORTEEL: Among the reasons cited for decline of European and American eels, the role of pollution in the decline of these fish is still unknown. This research project is a joint initiative of Québec and French researchers with as main objective to examine the links between pollution and health of Atlantic eels. Indeed, contaminants released into the water by urban, industrial, mining and agricultural accumulate strongly in yellow eels during their long growth phase in freshwater habitats and can affect the growth rate and cause injury or tumours. In eels of two continents, this project will examine the relationship between the accumulation of pollutants, diversity genetics, health and reproductive potential. Ultimately, this research in partnership with government agencies will greatly enhance our ability to prevent the extinction of these fish developing relevant management policies.

ISOGIRE (2012–2014) International project (France and Belgium): The ISOGIRE project aims at investigating heavy stable Cu, Zn and Ag isotope fractionation in the large-scale (80 000 km^2) and well constrained Gironde continuum (as a model case system). The objective is to use MTE isotopes to identify and discriminate different (diffuse and point) source of pollutions and their evolution in time, accounting for biogeochemical processes (non-conservative behaviour by reactive estuarine mixing and biological uptake by oysters) that may modify their isotopic signatures. The ISOGIRE project relies on a multidisciplinary approach linking metallic trace elements isotope geochemistry, biology/ecotoxicology and mineralogical analysis. Include European eel but not the principal aim of work.

Belgium project "Integrated study of the impacts of pollutants on the nervous system of the European eel" FNRS–FRFC Unité de Recherche en Biologie Environnementale et Evolutive (FUNDP) – Systems Ecotoxicology Laboratory: The objective is to study *in vitro* and *in vivo* the effects of sublethal concentrations of pollutants on the nervous system of the European eel by integrating several additional approaches (proteomic, transcriptomic, biochemical and behavioural) to bind the cellular and behavioural effects. The results will allow verification of the possibility that the neurological effects of pollutants can play a significant role in the regression of the European eel populations.

Other research work since 2011

1) **Orphy Laboratory** (University of Brest, Moisan C, Sébert P, Farhat F, Belhomme M, Amérand A):

In the context of energy metabolism of European eel, interactions such as the combined effects of swimming, pressure, salinity and temperature are studied. Research seeks to allude to metabolic specificities at a cellular level in terms of cost and energy efficiency. The species is used as a model, because of its unique physiological characteristics (resistance to hypoxia, metamorphosis, swimming performance, etc.). Spawning migration of the European eel is a juxtaposition of multiple extreme conditions relating to temperature, salinity, fasting and finally pressure. Energy expenditure in terms of migration is very important (swimming, gonad development, gamete production). There is little margin for additional physiological activities within a limited energy budget of reserves, since the animal is fasting during migration. Questions of research are: Is there a hierarchy in physiological functions? How are they optimized? At what price? How is the animal able to cope with new situations of imbalance?

2) **Eel Diseases Workshop EAFP 2011 Split, Croatia:**

The aim of this workshop was to get an overview of the eel diseases in aquaculture and natural stock. The results are summarized in EAFP (2011).

3) **Galilau Meeting Bordeaux 2011 (linked with Micang and Immorteel):**

Three topics were discussed at this meeting:

(1) EPOC Impacts of metal contamination and organic systems Gironde and St Lawrence on two declining species, the European eel and American. (IMMORTEEL, M. Baudrimont);

(2) Development of a DNA chip to detect the stress of environmental exposure to contaminants in Atlantic eels (Micang project F. Pierron);

(3) Impacts of contamination on the health of American and European eel: physiological, histopathological and reproductive aspects (P. Couture for Québec).

4) **New PhD:** Ecotoxicological study of the impact of metal contamination of European eel in the estuary of the Gironde (EELSCOPE - UMR EPOC – OASU 2011).

This work is a composition of field studies, aiming to identify the main contaminants in yellow eels of the Gironde estuary, their major bioaccumulation ways and impacts on physiological, biochemical and molecular parameters. In the context of these studies, preliminary experiments aimed to verify whether some field and handling procedures are consistent with ecotoxicological analyses. It was demonstrated that European eels of downstream areas of the estuaries, are likely to be subject to very high poly metallic contamination. It was concluded, that the different chemical disturbances, suffered by the yellow eels in the estuary of the Gironde, seem to participate significantly to this species vulnerability.

Annex 9: Scorecard to detect bias in eel stock assessment

The review and practical methods to evaluate the bias for each parameter are the following:

A-Species identification

1a) Species subject to confusion: The risk of bias is inherent to the species itself, depending on the difficulty of its identification. A way of evaluating the bias could be through a reference table of species to be agreed by an international forum. A sudden increase of an unexpected species may occur in the statistics, thus pointing out a potential risk of species misreporting. Examples of possible confusion could be conger in the marine environment and ammocytes of brook lamprey.

1b) Staff trained for species identification: information such as the time since the last training or information on the experience at sea are the elements to determine the risk of bias on species identification at the end of a sampling. This source of bias must be combined to the previous one as on one hand a species easy to identify do not present major risk of bias even for a novice, and on the other hand a species difficult to identify is not a source of bias if sampled by a taxonomist.

2) Species misreporting: A sudden increase of an unexpected species may occur in the statistics, thus pointing out a potential risk of species misreporting. This case is generally linked to quota consumption. Another way of detecting such a bias is dissimilarities between on-board observers reporting for the same fishing activity, or dissimilarities between on-board observers and landing statistics. The only way of avoiding this bias is by genetically testing shipments of glass eel before stocking.

3) Glass eel stocking: Examples of stocking *A. rostrata* instead of *A. Anguilla* have been reported. The only way of avoiding this bias is by genetically testing shipments of glass eel before stocking.

B-Landings weight

1) Commercial and Recreational fishery: are landings of both the commercial and recreational fishery being monitored

2) Missing part: ratio between the retained fractions estimated onboard by observers and the landings of a species. A statistical test can be performed to evaluate if the slope is significantly different from one.

3) Area misreporting: like for the species misreporting, there may be a sudden increase of a species reported in an uncommon neighbouring area. This type of bias may be assessed by checking the consistency between different sources e.g. logbooks, VMS, sales notes, cpue trends of commercial vs. surveys,

4) Quantity misreporting: known as the most current bias in fisheries statistics, this bias may be assessed together with area misreporting and with the addition of sources like economic surveys and EU control database.

5) Population of vessels: are all vessels included in the population that forms the sampling frame?

6) Source of information: it is unlikely that one source of information encompasses the statistics of all fisheries, including the temporal, spatial and fishing activity stratification. In all cases, the advantages and limitations of the sources used should provide a clear view on the related bias.
7) Conversion factor: information such as the age and the methodology used for the conversion factor, are indications on the potential induced bias. The magnitude of the conversion factor used is also an indication, e.g. estimating landing weight from fillet or from gutted fish will lead to different amplification of a bias.

C-Discards weight

1) Sampling allocation scheme: estimation of the randomness of the sampling. Is sampling pure random with a sampling protocol well followed, or is sampling allocation made on ad hoc or opportunistic observations? A non-random sampling is clearly a source of bias which needs to be reported.
2) Raising variable: For raising to the population, different raising procedures must be compared and also raising the retained fraction to be compared with the landing statistics is a solution to assess the relevance of the variable used for raising (WKDRP, 2007).
3) Damaged/dead fish discarded: bias in fishing mortality if not corrected. Examples are Catch & Release (C&R) mortality of commercial longline fishery, C&R mortality recreational fishery, and discarded damaged/dead eel in fyke fishery.
4) Non response rate: the percentage of refusal is one of the most important sources of bias for on-board observers. This case discussed in general in Cochran, 1977 has also been addressed by the recent workshop on discards (Anon, 2003) in the frame of the DCR.
5) Temporal coverage: it has been discussed during the workshop that any discrepancy between the sampling and fishing effort coverage do not lead to a bias when the sampling is done randomly following a well-designed protocol. In other cases, the temporal coverage in terms of mean discrepancy between proportion by units of time plus existence of non-sampled strata must be evaluated.
6) Spatial coverage: identical as temporal coverage above.
7) Highgrading: selecting a given size range for landing a species depending on the market demand or to reduce the quota consumption automatically change the discarding ogive. Highgrading behaviour may be evaluated by interviews and/or on-board observers.
8) Management measures leading to discarding behaviour: the specification of the measure (e.g. size and quota) and the date of entry into force are indications of potential bias, if not monitored through a well-designed sampling programme.
9) Working conditions: evaluating the sampled weight with a scale needs proper conditions, which are not always possible. Sampling for discards needs also good conditions for taking the sample and enough time and space for carrying the scientific work. Any constraint on working conditions may lead to a bias in the final estimates.

D-Effort

1) Unit definition: Existence and follow-up of an international agreed definition and specifications. Effort statistics obtained through a census or a sampling programme.
2) Area misreporting: This bias may be assessed by checking the consistency between on-board observers, questionnaire surveys, VMS and logbooks. If there is a bias on area misreporting for the landings weight (bias no B-2), it is likely that a similar bias exists for effort.
3) Effort misreporting: similar to quantity misreporting for landings (bias no B-3). This major risk of bias is to evaluate the total effort on an incomplete population. The way of evaluating it is by checking different sources like the area misreporting above.
4) Source of information: identical with the same bias for landings weight (bias no B-4).

E-Length structure (market sampling [M] and field surveys [S])

1) Sampling protocol [M+S]: Existence and adherence to a sampling protocol that yields representative selection of fish for length measurements.
2) Temporal coverage [M+S]: it was discussed during the workshop that any discrepancy between the sampling and fishing effort coverage do not lead to a bias when the sampling is done randomly following a well-designed protocol. In other cases, the temporal coverage in terms of mean discrepancy between proportion by units of time plus existence of non-sampled strata must be evaluated.
3) Spatial coverage [M+S]: identical as temporal coverage above.
4) Random sampling of boxes/trips [M]: This bias, linked to the follow-up of a sampling protocol (bias no E-1), focuses more on the randomness of both the choice of boxes to sample (always the top box, vs. real random,) and the choice of trips (opportunistic, real random).
5) Availability of all the landings/discards [M+S]: this bias is linked to the missing part (bias no B-1 of landings weight; small yellow eels in field surveys), but more focused on the special conditions linked to the auction sales conditions. The responsible for sampling are the experts having the knowledge of this information.
6) Non sampled strata [M+S]: Usually, imputation rules exist for non-sampled strata, thus this bias will be an evaluation of the appropriateness of the imputation rules used.
7) Raising to the trip [M+S]: This bias, linked to the follow-up of a sampling protocol (bias no E-1), focuses on the raising variable used (exact knowledge of the landings weight, guest mates).
8) Change in selectivity [M+S]: bias linked to the characteristics of the gear and evaluation whether the length structure sampled is representative of the exact characteristics of the gears used at the population level.
9) Sampled weight [M]: Is the sampled box weight measured by the staff responsible for sampling, by the crew or by the port staff?

F-Age structure

1) Quality insurance protocol: Existence and follow-up of a sampling protocol.

2) Conventional/actual age validity: Existence of a validity control for the appropriateness of the reading to evaluate the true age (check with tagging or in vivo growing programmes).

3) Calibration workshop: Existence of a recent age reading workshop (WKAREA).

4) International exchange: Existence of a recent international exchange in order to compare the results of age reading by several readers from different countries on the same material. Usually, the exchange is carried out in preparation of an age reading workshop or at regular interval to assess the need of convening such a workshop.

5) International reference set: Existence and routinely use of an agreed international reference set.

6a) Species/stock reading easiness: The risk of bias is inherent to the species/stock itself, depending on the difficulty of reading the age. The international calibration workshops use software able to evaluate such a bias.

6b) Staff trained for age reading: information such as the time since the last training or information on the experience of the staff are the elements to determine the risk of bias on age reading. Some international calibration workshop evaluate the competence of age readers for estimating age structure for stock assessment purpose, Age readers formally approved by such a forum, would lead to an absence of bias for this parameter.

7) Age reading method: Some reading methods are known to be biased for estimating some or all ages. This information is usually found in the reports of international calibration workshops.

8) Temporal coverage: identical as temporal coverage of the length structure, focused on the collection of materials for age reading.

9) Spatial coverage: identical as temporal coverage above.

G-Mean weight

1) Sampling protocol: Existence and follow-up of a sampling protocol.

2) Temporal coverage: identical as temporal coverage of the length structure (E-2), focused on the data used for mean weight estimates.

3) Spatial coverage: identical as temporal coverage above.

4) Statistical processing: Appropriateness of the statistical method used, if any. It is often the case that a length–weight relationship is used or a van Bertalanffy model. The time between the references used for modelling and the actual time strata is an indication on the potential induced bias.

5) Calibration of equipment: Existence of a routine calibration validation of the equipment used.

6) Working conditions: evaluating the mean weight with a scale needs proper conditions, which are not always possible. Any constraint on working conditions may lead to a bias in the final estimates.

H-Sex-ratio

1) Sampling protocol: Existence and follow-up of a sampling protocol; is the sex ratio of one cohort (early yellow eel stage <30 cm) determined or mixed over multiple cohorts (when determining sex ratio at silver eel stage).
2) Temporal coverage: due to difference in migration between sexes, this needs to be taken into account following agreed protocol.
3) Spatial coverage: sex-ratio can vary considerable spatially (e.g. distance to river mouth); this needs to be taken into account following agreed protocol.
4) Staff trained: information such as the time since the last training or information on the experience of the staff are the elements to determine the risk of bias on estimating the sex of a species.
5) Size/maturity effect: How are immature issues being addressed? Is the method used well described and approved?
6) Catchability effect: for eel the catchability by sex may vary over time (male migrate before females) and/or fishing gear (small males are likely to escape capture). If such behaviour related change in catchability occurs, do the estimates take this into account following an agreed protocol?

I-Maturity stage

1) Sampling protocol: Existence and follow-up of a (international) staging protocol (e.g. Durif protocol).
2) Staff trained: information such as the time since the last training or information on the experience of the staff is the elements to determine the risk of bias on estimating the maturity stages.

J-Silvering rate

1) Sampling protocol: Existence and adherence to a sampling protocol that yields representative selection of fish to determine silvering rate.
2) Temporal coverage: the silvering rate curve is sensitive to the time of the year. If sampling occurs in autumn the silvering curve will move to the "left" (smaller size at silvering); if sampling occurs early in the year the silvering curve will move to the "right" (large size at silvering) as early in the year yellow eels that will silver that year may not have started their transition to the silver stage yet. If individuals are assumed to mature at younger ages or lengths, estimates of mortality will decrease (and vice versa).
3) Spatial coverage: sampling will need to occur in areas with both male and female eel present.

The proposal for the bias indicator is the following for each parameter:

A – Species identification	NO BIAS	RISK OF BIAS	CONFIRMED BIAS
1 - Species subject to confusion & trained staff	Staff trained and experienced OR Easily defined species	Any other situation	Species difficult to identify AND novice staff
2 - Species misreporting	Checked and no problem OR checked and corrected	Any other situation	Checked + not corrected
3 – Glass eel stocking	Genetic tests performed before stocking	No genetic testing	Glass eel tested + non-A. anguilla detected
Final indicator	All green	List of potential bias	List of confirmed bias

B – Landings weight	NO BIAS	RISK OF BIAS	CONFIRMED BIAS
Recall of bias indicator on species identification	All green	List of potential bias	List of confirmed bias
1 Commercial and Recreational fishery	Commercial and/or Recreational fishery monitored is present	Any other situation	Confirmed missing but not corrected
2 Missing part	Checked and Ratio = 1 OR checked and corrected	Any other situation	Confirmed missing but not corrected
3 Area misreporting	Checked and no problem OR checked and corrected	Any other situation	Checked and problem not corrected
4 Quantity misreporting:	Checked and no problem OR checked & corrected	Any other situation	Checked and problem not corrected
5 No. of vessels	All covered	-	Partially covered
6 Source of information:	Several sources considered	Only one source used	
7 Conversion factor:	Whole fish OR appropriate conversion factor	Any other situation	CF Wrong OR Not whole and CF not used
Final indicator	All green	List of potential bias	List of confirmed bias

C – Discards weight	NO BIAS	RISK OF BIAS	CONFIRMED BIAS
Recall of bias indicator on species identification	All green	List of potential bias	List of confirmed bias
1 Sampling allocation scheme	Well designed random sampling	*Ad hoc* OR opportunistic sampling	No sampling
2 Raising variable	No raising factor needed OR follow accepted raising procedure	Any other situation	No raising factor when needed
3 Damaged/dead fish discarded:	No damaged/dead fish discarded	Any other situation	Problem not corrected
4 Non response rate:	High response rate/low refusal rate (figure needed)	Any other situation	Low response rate/high refusal rate
5 Temporal coverage	Documented and OK	Any other situation	Documented and not OK
6 Spatial coverage	Documented and OK	Any other situation	Documented and not OK
7 Highgrading	no Highgrading OR Highgrading estimated	Any other situation	Highgrading existing but not estimated
8 Management measures leading to discarding behaviour	management not leading to impact discards behaviour OR impact corrected	Any other situation	Strong management leading to discarding and limited at sea sampling
9 Working conditions:	good conditions OR conditions not ideal but compensated for	Any other situation	Difficult conditions and not compensated for
Final indicator	All green	List of potential bias	List of confirmed bias

D – Effort	NO BIAS	RISK OF BIAS	CONFIRMED BIAS
Recall of bias indicator on species identification(if needed for métier allocation)	All green	List of potential bias	List of confirmed bias
1 Unit definition	Definition available	Any other situation	Problem not corrected
2 Area misreporting	Checked and no problem OR checked and corrected	Any other situation	Checked and problem not corrected
3 Effort misreporting	Checked and no problem OR checked and corrected	Any other situation	Checked and problem not corrected
4 Source of information	Several sources considered	Only one source used	
Final indicator	All green	List of potential bias	List of confirmed bias

E –Length structure	NO BIAS	RISK OF BIAS	CONFIRMED BIAS
Recall of bias indicator on discards/landings weight	All green	List of potential bias	List of confirmed bias
1 Sampling protocol:	Existence and follow-up of a well documented protocol	Any other situation	Non existing protocol OR Existing but not followed
2 Temporal coverage	Documented and OK	Any other situation	Documented and not OK
3 Spatial coverage	Documented and OK	Any other situation	Documented and not OK
4 Random sampling of boxes/trips:	Representative sampling	Any other situation	Known unrepresentative sampling
5 Availability of all the landings/discards	Known complete availability	Any other situation	Known to be unavailable and uncorrected
6 Non sampled strata:	All strata sampled OR not all sampled but corrected by proper imputation technique	Any other situation	Not all strata sampled and problem uncorrected
7 Raising to the trip:	Follow-up an agreed procedure	Any other situation	No raising factor when needed
8 Change in selectivity	Checked and no problem OR problem corrected	Any other situation	Checked and problem not corrected
9 Sampled weight:	Described and controllable	Any other situation	Known inaccurate uncontrollable procedures
Final indicator	All green	List of potential bias	List of confirmed bias

F – Age structure	NO BIAS	RISK OF BIAS	CONFIRMED BIAS
Recall of bias indicator on length structure	All green	List of potential bias	List of confirmed bias
1 Quality insurance protocol	Existence and follow-up of a well documented protocol	Any other situation	Non existing protocol OR Existing but not followed
2 Conventional/actual age validity	Checked and actual reading validated	Any other situation	Checked and invalidated
3 Calibration workshop	Not needed OR Recently conducted	Any other situation	problem identified during a workshop not corrected
4 International exchange:	Recently assessed and made use of	Any other situation	Recently assessed and problem not corrected
5 International reference set:	Yes	No	
6 Species/stock reading easiness: AND trained staff	Trained and experienced OR Easily defined Species	Any other situation	Difficult to read age, and novice staff
7 Age reading method	Method described and appropriate	Any other situation	
8 Temporal coverage	Documented and OK	Any other situation	Documented and not OK
9 Spatial coverage	Documented and OK	Any other situation	Documented and not OK
Final indicator	All green	List of potential bias	List of confirmed bias

G – Mean weight	NO BIAS	RISK OF BIAS	CONFIRMED BIAS
Recall of bias indicator on length/age structure	All green	List of potential bias	List of confirmed bias
1 Sampling protocol:	Existence and follow-up of a well documented protocol	Any other situation	Non existing protocol OR Existing but not followed
2 Temporal coverage	Documented and OK	Any other situation	Documented and not OK
3 Spatial coverage	Documented and OK	Any other situation	Documented and not OK
4 Statistical processing	Not needed OR Method described and approved	Any other situation	Problem but not taken into account
5 Calibration of equipment	Equipment Properly calibrated	Any other situation	Known use of non-calibrated equipment
6 Working conditions	Good conditions OR conditions not ideal and compensated for	Any other situation	Difficult conditions not compensated for
Final indicator	All green	List of potential bias	List of confirmed bias

H – Sex ratio	NO BIAS	RISK OF BIAS	CONFIRMED BIAS
Recall of bias indicator on length/age structure	All green	List of potential bias	List of confirmed bias
1 Sampling protocol:	Existence and follow-up of a well documented protocol	Any other situation	Non existing protocol OR Existing but not followed
2 Temporal coverage	Documented and OK	Any other situation	Documented and not OK
3 Spatial coverage	Documented and OK	Any other situation	Documented and not OK
4 Staff trained	Trained and experienced	Any other situation	Novice
5 Size/maturity effect:	Method described and approved	Any other situation	No method OR Method available but not used
6 Catchability effect:	No problem OR problem assessed + corrected	Any other situation	problem assessed and not corrected
Final indicator	All green	List of potential bias	List of confirmed bias

I – Maturity stage	NO BIAS	RISK OF BIAS	CONFIRMED BIAS
Recall of bias indicator on length/age structure	All green	List of potential bias	List of confirmed bias
1 Sampling protocol:	Existence and follow-up of a well documented protocol	Any other situation	Non existing protocol OR Existing but not followed
4 Staff trained	Trained and experienced	Any other situation	Novice
Final indicator	All green	List of potential bias	List of confirmed bias

J – Silvering Rate	NO BIAS	RISK OF BIAS	CONFIRMED BIAS
Recall of bias indicator on length/age structure	All green	List of potential bias	List of confirmed bias
1 Sampling protocol:	Existence and follow-up of a well documented protocol	Any other situation	Non existing protocol OR Existing but not followed
2 Temporal coverage	Documented and OK	Any other situation	Documented and not OK
3 Spatial coverage	Documented and OK	Any other situation	Documented and not OK
Final indicator	All green	List of potential bias	List of confirmed bias

k – Survey Methods	NO BIAS	RISK OF BIAS	CONFIRMED BIAS
	List of optimal conditions	List of potential Bias	Likely/confirmed Bias
Electrofishing surveys	Calibrated against ground-truth (efficiency) and shown to representative for eel		No ground-truthing
	Established and consistent protocols followed.		Variable or *ad hoc* protocols
	Standardized effort, gear, water condition		Changes in gear, effort over time
	Semi quantitative methods where used calibrated with quantitative surveys		No such calibration
	Techniques eel targeted	Techniques generic for all spp and including eel (e.g. WFD surveys)	Eel as bycatch in other targeted surveys (e.g. Salmonind surveys)
	Trained and regular staff base	Inadequate training or passing on of skills to new staff	Regularly changing or temporary survey staff
Fykenet surveys (for catch-curve analysis)	Calibration between low effort (e.g. WFD) and large eel dedicated surveys	Low effort semi quantitative only	*Ad hoc* or bycatch surveys
	All size classes present caught (Not often)		Small size classes not caught (usual situation)

k – Survey Methods	NO BIAS	RISK OF BIAS	CONFIRMED BIAS
	Standard methods. Mesh and gear recorded and consistent over time		Inconsistent or unrecorded methods
	Standard methods with cpue available		Not standard or no cpue
Acoustic Surveys (E.G Didson) silver eel escapement	Consistent sites, clean bed and bank profiles, double bank monitoring in wide rivers (>15–20 m),		One bank only at wide river sites, changing sites, Rough River profiles, turbulence
	High % cross sectional area (CSA), coverage > 50% including main flow		< 10% CSA coverage, missing centre/main flow
	Trained, consistent staff based		*Ad hoc*, Changing staff
	Flow compensated/standardized data		
Mark–recapture Silver eel escapement	Mark and recapture on complete run		Multiple runs or carry over between years
	Multiple recording stations or means of measuring/recovering tags bypassing first recording station	Tagging on different phase (e.g. yellow) and needing to know silvering rates to interpret data	Unchecked assumption that non recaptures are escapement
	Tagging and handling mortality by full control experiment		No monitoring of mortalities
Eel trap data	Known proportion of run calibrated by mark-recapture or other method (acoustics, telemetry)	-	Unknown proportion (index only), no verification
	Consistent effort between years		*Ad hoc* or market related
	Flow compensated		
Factors affecting productivity			

L – assessment models	NO BIAS	RISK OF BIAS	CONFIRMED BIAS
General	List of optimal conditions	List of potential Bias	Likely/confirmed Bias
Are models predictions validated?	Models are validated by independent field observations		No
Model is data driven (e.g. survey data)	Model is data driven and data conform to quality standards	Model based only on assumptions	
Scaling and habitat coverage			
Are all present habitats covered (rivers, lakes, estuaries,lagoons, coastal waters), for habitats >1% total eel area	Yes	Partial coverage	No
Upscaling density results from the littoral zone to whole water surface in narrow rivers, wide rivers and lakes.			1:1 upscaling without evidence support
Ratio #/ha waterbodies sampled in relation to the total #/ha waterbodies in assessment	>80%	20–80%	<20%
# WFD water types/ # WFD water types sampled	>80%	20–80%	<20%
Modelled life-history processes	Derived from local data	Derived from EMU data	Derived from literature, except where habitats are comparable
Temperature effects			

Annex 10: Country Reports 2011: Eel stock, fisheries and habitat reported by country

In preparation to the Working Group, participants of each country have prepared a Country Report, in which the most recent information on eel stock and fishery are presented. These Country Reports aim at presenting the best information, which does not necessarily coincide with the official status.

Participants from the following countries provided an (updated) report to the 2012 meeting of the Working Group:

- Belgium
- Denmark
- Finland*
- France
- Germany
- Ireland
- Italy
- Latvia
- Lithuania
- Morocco*
- Netherlands
- Norway
- Poland
- Portugal
- Spain
- Sweden
- The United Kingdom of Great Britain and Northern Ireland

* Not present at Working Group

For practical reasons, this report presents the country reports in electronic format only (URL). Available at:

http://www.ices.dk/workinggroups/ViewWorkingGroup.aspx?ID=75

Report on the eel stock and fishery in Belgium 2011/'12

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Reporting Period: This report was completed in August 2012, and contains data up to 2011 and some provisional data for 2012.

2 Introduction

This report is written in preparation of the EIFAC/ICES Working Group on Eel meeting at Copenhagen (2–9 September 2011). Extensive information on the eel stock and fishery in Belgium has been presented in the previous Belgian country reports (i.e. Belpaire *et al*., 2006; 2007; 2008; 2009; 2010 and 2011), in the Belgian Eel Management Plan (EMP) and in the first report to be submitted in line with Article 9 of the eel Regulation 1100/2007 (Vlietinck *et al*., 2012). This report should thus be read in conjunction with those documents.

Four international RBDs are partly lying on Belgian territory: the Scheldt (Schelde/Escaut), the Meuse (Maas/Meuse), the Rhine (Rijn/Rhin) and the Seine. For description of the river basins in Belgium see the 2006 Country Report (Belpaire *et al*., 2006).

In response to the Council Regulation CE 1100/2007, Belgium has provided a single Eel Management Plan (EMP), encompassing the two major river basin districts (RBD) present on its territory: the Scheldt and the Meuse RBD.

Given the fact that the Belgian territory is mostly covered by two internationals RBDs, namely the Scheldt and Meuse, the Belgian Eel Management Plan was prepared jointly by the three Regional entities, each respectively providing the overview, data and measures focusing on its larger RBDs. The Belgian EMP thus focuses on the Flemish, Brussels and Walloon portions of the Schelde/Escaut RBD, and the Walloon and Flemish portions of the Meuse/Maas RBD.

The Belgian EMP has been approved by the European Commission on January 5th, 2010.

The three Belgian authorities (Flanders, Wallonia or Brussels Regions) will be responsible for the implementation and evaluation of the proposed EMP measures on their respective territory.

In the next years, all eel-related measures proposed in the Belgian EMP will be fine-tuned according to the existing WFD management plans and implemented in such manner by the responsible Regional authorities.

The Belgian EMP focuses on:

For the Flemish region

- the ban of fyke fishing on the lower Scheldt in 2009;
- making up an inventory of the bottle necks for upstream eel migration (priority and timing for solving migration barriers).

Specific action in 2010–2012: In Flanders, 38 fish migration bottlenecks of high priority were identified. 90% has to be solved at the end of 2015 and the remaining part by 2021. Until mid-2012, eight of the 38 bottlenecks were remediated and for several of them remediations are planned. In addition, a number of bottlenecks of moderate priority were remediated. In 2012, a study was conducted at the sea sluices of the Canal from Ghent to Ostend to optimize management of the sluices in order to allow glass eel migration. By a controlled and limited opening of the sluices, glass eel migration could be substantially increased. Through the experience gained it will be possible to set up appropriate management in different salt-freshwater transition sites along the Belgian coast.

- for downward migration: update inventory of draining pumps and fixing priorities for sanitation.

Specific action in 2012–2013: The inventory has been finished. Fixing priorities for sanitation is planned. From 2012–2013, a study of the pumping station at Boekhoute is being performed. The mortar was indeed adjusted to be more fish-friendly. The effect on mortality of eels will be monitored. The study will include estimations of the actual present eel stock and the effective escape of silver eel. This research may contribute to the refinement of the Flemish estimates of current eel densities and production.

- controlling poaching.

Specific action in 2010–2012: actions have been focused and will be continued specifically on the Scheldt estuary, on the Nete catchment and in the polders. Illegal fishing equipment was seized.

- Glass eel restocking programme.

Specific action in 2011–2012: In Flanders 120 kg and 156 kg were stocked respectively in 2011 and 2012.

- achieving WFD goals for water quality.

Specific action in 2010–2015: Flanders continues to work to the development of water treatment infrastructure to achieve the good ecological status and ecological potential for the WFD. In the course of 2011, Flanders fully complied with the Urban Waste Water Directive.

- eel stock monitoring.

Specific action in 2011–2012: Glass eel: the monitoring of the glass eel recruitment at Nieuwpoort (River IJzer) has been continued in 2011 and 2012, and will be continued in upcoming years.

Yellow eel: In the polder of Boekhoute a survey of the yellow eel density is going on from 2011–2012.

Silver eel: In the polder of Boekhoute a survey of the silver eel escapement is going on from 2011–2012.

- eel quality monitoring.

Specific action in 2011–2012: Flanders has contributed to the scientific work about the status and effects of hazardous substances on the eel. A significant contribution has been given to the Eeliad program and to several other international cooperations (see abstracts under subchapter 11.3). Flanders continues to coordinate the Eel Quality Database, for which a new application is currently under development.

For the Walloon region

- avoiding mortality at hydropower stations;
- sanitation of migration barriers on main waterways (especially in the Meuse catchment);
- Glass eel restocking programme.

Specific action in 2012: in Wallonia 50 kg of glass eel was stocked in 2012.

- controlling poaching.

Specific action in 2010–2012: actions have been focused specifically on the river Meuse and in the canals during the night. Numerous illegal fishing equipment was seized.

In the coming years, Belgium will pursue with its neighbouring countries the development and implementation of cross boundary eel management plans. These coordination activities will take place within the International Scheldt Commission (ISC) and the International Meuse Commission (IMC).

In June 2012 Belgium submitted the first report in line with Article 9 of the eel Regulation 1100/2007. This reports outline focuses on the monitoring, effectiveness and outcome of the Belgian Eel Management Plan.

3 Time-series data

3.1 Recruitment-series and associated effort

3.1.1 Glass eel

3.1.1.1 Commercial

There are no commercial glass eel fisheries.

3.1.1.2 Recreational

There are no recreational glass eel fisheries.

3.1.1.3 Fishery independent

Glass eel recruitment at Nieuwpoort at the mouth of River Yser (Yser basin)

In Belgium, both commercial and recreational glass eel fisheries are forbidden by law. Fisheries on glass eel are carried out by the Flemish government. Former years, when recruitment was high, glass eels were used exclusively for restocking in inland waters in Flanders. Nowadays, the glass eel caught during this monitoring are returned to the river.

Long-term time-series on glass eel recruitment are available for the Nieuwpoort station at the mouth of the river Yser. Recently new initiatives have been started to monitor glass eel recruitment in the Scheldt basin (see below).

For extensive description of the glass eel fisheries on the river Yser see Belpaire (2002, 2006).

Figure 1 and Table 1 give the time series of the total annual catches of the dipnet fisheries in the Nieuwpoort ship lock and give the maximum day catch per season. Since the last report the figure has been updated with data for 2012.

Fishing effort in 2006 was half of normal, with 130 dipnet hauls during only 13 fishing nights between March 3rd, and June 6th. Catches of the year 2006 were extremely low and close to zero. In fact only 65 g (or 265 individuals) were caught. Maximum day catch was 14 g. These catches are the lowest record since the start of the monitoring (1964).

In 2007 fishing effort was again normal, with 262 dipnet hauls during 18 fishing nights between February 22nd, and May 28th. Catches were relatively good (compared to former years 2001–2006) and amounted 2214 g (or 6466 individuals). Maximum day catch was 485 g. However this 2007 catch represents only 0.4% of the mean catch in the period 1966–1979 (mean = 511 kg per annum, min. 252–max. 946 kg).

In 2008 fishing effort was normal with 240 dipnet hauls over 17 fishing nights. Fishing was carried out between February 16th and May 2nd. Total captured biomass of glass eel amounted 964.5 g (or 3129 individuals), which represents 50% of the catches of 2007. Maximum day catch was 262 g.

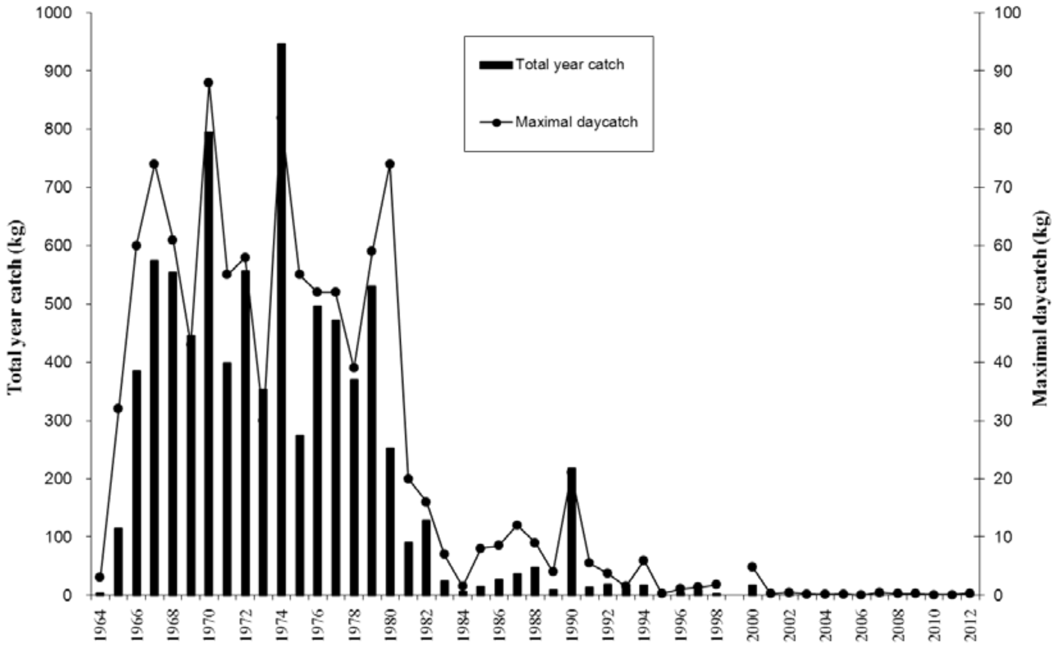
In 2009 fishing effort was normal with 260 dipnet hauls over 20 fishing nights. The fishing was carried out between and February 20th and May 6th. Total captured biomass of glass eel amounted 969 g (or 2534 individuals), which is similar to the catches of 2008). Maximum day catch was 274 g.

In 2010 fishing effort was normal with 265 dipnet hauls over 19 fishing nights. The fishing was carried out between and February 26th and May 26th. Total captured biomass of glass eel amounted 318 g (or 840 individuals). Maximum day catch was 100 g. Both total captured biomass, and maximal day catch is about at one third of the quantities recorded in 2008 and 2009. Hence, glass eel recruitment at the Yser in 2010 was at very low level. The 2010 catch represents only 0.06% of the mean catch in the period 1966–1979 (mean = 511 kg per annum, min. 252–max. 946 kg).

In 2011 fishing effort was normal with 300 dipnet hauls over 20 fishing nights. The fishing was carried out between and February 16th and April 30th. Compared to 2010, the number of hauls was ca. 15% higher, but the fishing period stopped earlier, due to extremely low catches during April. Total captured biomass of glass eel amounted 412.7 g (or 1067 individuals). Maximum day catch was 67 g. Total captured biomass is similar as the very low catches in 2010. Maximal day catch is even lower than data for the four previous years (2007–2010). Overall, the quantity reported for the Yser station should be regarded as very low, comparable to the 2010 record. The 2011 catch represents only 0.08% of the mean catch in the period 1966–1979 (mean = 511 kg per annum, min. 252–max. 946 kg).

In 2012 fishing effort was higher than previous years with 425 dipnet hauls over 23 fishing nights. The fishing was carried out between and March 2nd and May 1st. Compared to 2010, the number of hauls was 42% higher. Total captured biomass of glass eel amounted 2407.7 g (or 7189 individuals). Maximum day catch was 350 g. Both, the total captured biomass and the maximum day catch are ca. six times higher than in 2010. Overall, the quantity reported in 2012 for the Yser station increased significantly compared to previous years and is similar to the 2007 catches. Still, the 2012 catch represents only 0.47% of the mean catch in the period 1966–1979 (mean = 511 kg per annum, min. 252–max. 946 kg).

See below in Chapter 7 for cpue data for the period 2002–2012.



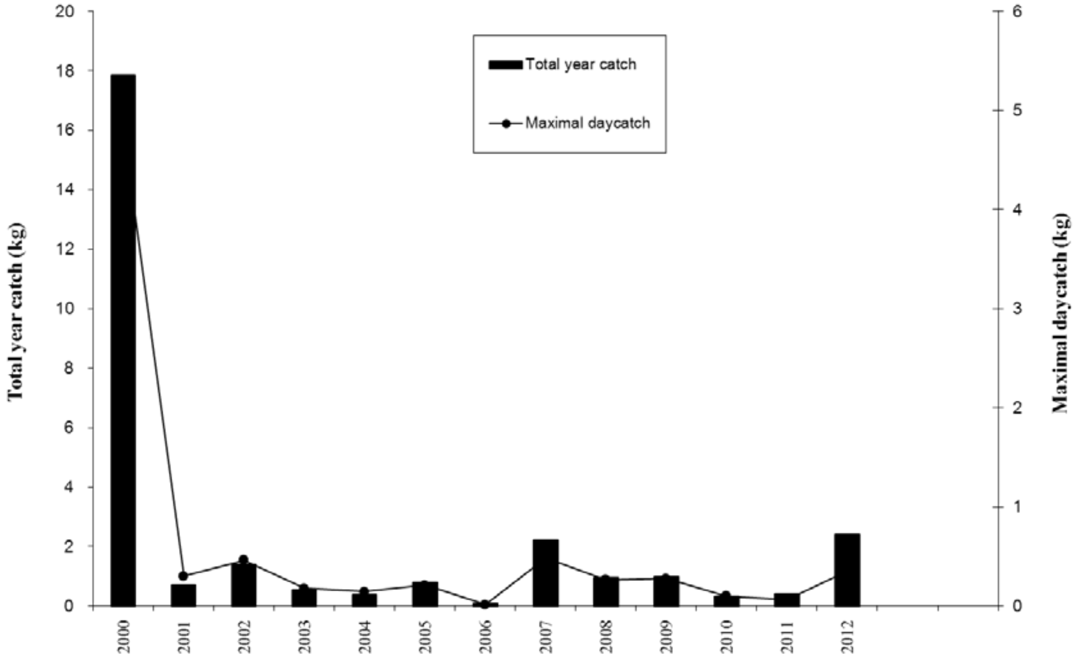


Figure 1 and Table 1. Annual variation in glass eel catches at river Yser using the dipnet catches in the ship lock at Nieuwpoort (total year catches and maximum day catch per season). Figure 1A represents the data for the period 1964–2012; Figure 1b shows the data for the period 2000–2012.

In Table 1 the presented data are the total year catches between 1964 and 2012. Data Provincial Fisheries Commission West-Vlaanderen.

Decade Year	1960	1970	1980	1990	2000	2010
0		795	252	218.2	17.85	0.318
1		399	90	13	0.7	0.413
2		556.5	129	18.9	1.4	2.408
3		354	25	11.8	0.539	
4	3.7	946	6	17.5	0.381	
5	115	274	15	1.5	0.787	
6	385	496	27.5	4.5	0.065	
7	575	472	36.5	9.8	2.214	
8	553.5	370	48.2	2.255	0.964	
9	445	530	9.1		0.969	

Other glass eel recruitment studies

The glass eel recruitment-series for the Schelde estuary which was reported in the 2011 Country Report (See Belpaire *et al.*, 2011) for the period 2004–2011 has been stopped temporarily. Data for 2012 are not available.

3.1.2 Yellow eel recruitment

3.1.2.1 Commercial

There is no commercial fishery for yellow eel in inland waters in Belgium. Commercial fisheries for yellow eel in coastal waters or the sea are negligibly small.

3.1.2.2 Recreational

No data available.

3.1.2.3 Fishery independent

On the Meuse, the University of Liège is monitoring the amount of ascending young eels in a fish-pass. From 1992 to 2012 upstream migrating eels were collected in a trap (0.5 cm mesh size) installed at the top of a small pool-type fish-pass at the Visé-Lixhe dam (built in 1980 for navigation purposes and hydropower generation; height: 8.2 m; not equipped with a ship-lock) on the international River Meuse near the Dutch–Belgium border (290 km from the North Sea; width: 200 m; mean annual discharge: 238 $m^3 s^{-1}$; summer water temperature 21–26°C). The trap in the fish-pass is checked continuously (three times a week) over the migration period from March to September each year, except in 1994. A total number of 36 776 eels was caught (biomass 2382 kg) with a size from 14 cm to 85 cm and an increasing median value of 28,5 cm (1992) to 35,5 cm (2010) corresponding to yellow eels. The study based on a constant year-to-year sampling effort revealed a regular decrease of the annual catch from a maximum of 5613 fish in 1992 to minimum values of 423–758 in 2004–2007) (Figure 2). In 2008 2625 eels were caught. This sudden increase might be explained by the fact that a new fish pass was opened (20/12/2007) at the weir of Borgharen-

Maastricht, which enabled passage of eels situated downward the weir in the uncanalized Grensmaas. Nevertheless the number of eels were very low again in 2009 (n=584) and 2010 (n = 248). The figure for 2011 (n=239) is the lowest ever recorded since the start of the controls (1992, n = 5613). The figure for 2012 (n= 296 at 1/09/2012) is still incomplete. The decreasing trend in the recruitment of young eels in this part of the Meuse was particularly marked from 2004 onwards. The University of Liège (Ovidio *et al.*, 2012) is currently starting a research program financed by EFF-EU to continue to follow the upstream migration of yellow eels at Lixhe and to analyse the historical trends. Since 2011, every individual yellow eel is pit-tagged and its upstream migration will be followed along detection stations placed at fish-passes located upstream in the Meuse and in the lower course of the river Ourthe (main tributary of River Meuse).

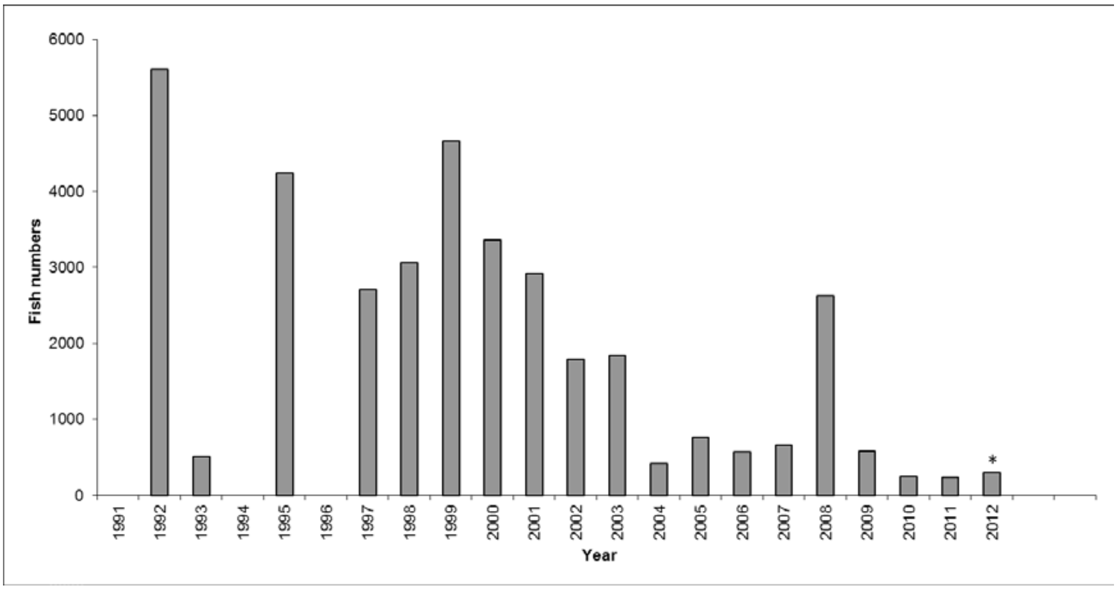


Figure 2. Variation in the number of ascending young yellow eels trapped at the fish trap of the Visé-Lixhe dam between 1992 and 2012. Data from University of Liège (J.C. Philippart) in Philippart and Rimbaud (2005), Philippart (2006) and Ovidio (pers. comm. 2012). * Data for 2012 are incomplete (situation 1/9/2012).

3.2 Yellow eel landings

3.2.1 Commercial

See Section 3.1.2.1.

3.2.2 Recreational

No time-series available.

Based on an inquiry by the Agency for Nature and Forest in public waters in Flanders in 2008, recreational anglers harvest on a yearly basis 33,6 tons of eel (Vlietinck, 2010). In 2010 a small restriction of eel fishing was aimed by a new regulation (Besluit van de Vlaamse Regering 5/3/2010). Between April 16th and May 31th, and during the night, eels may not be taken home. This results in a roughly estimate of 10% reduction of eel harvest. Hence estimates for 2010 and 2011 are an annual eel harvest of 30 tons (Vlietinck, pers. comm.). There is no distinction between the catch of yellow eel and silver eel, but due to the specific behaviour of silver eel, it is considered that these catches are mainly composed of yellow eel.

3.2.3 Fisheries independent

No data available.

3.3 Silver eel landings

3.3.1 Commercial

There is no commercial fishery for silver eel in inland waters in Belgium. Commercial fisheries for silver eel in coastal waters or the sea are negligibly small.

3.3.2 Recreational

No time-series available. Due to the specific behaviour of silver eel catches of silver eel by recreational anglers are considered low.

3.3.3 Fisheries independent

No data available.

3.4 Aquaculture production

There is no aquaculture production of eel in Belgium.

3.4.1 Seed supply

3.4.2 Production

3.5 Stocking

3.5.1 Amount stocked

Stocking in Flanders

Glass eel and young yellow eels were used for restocking inland waters by governmental fish stock managers. The origin of the glass eel used for restocking from 1964 onwards was the glass eel catching station at Nieuwpoort on river Yser. However, due to the low catches after 1980 and the shortage of glass eel from local origin, foreign glass eel was imported mostly from UK or France.

Also young yellow eels were restocked; the origin was mainly the Netherlands. Restocking with yellow eels was stopped after 2000 when it became evident that also yellow eels used for restocking contained high levels of contaminants (Belpaire and Coussement, 2000). So only glass eel is stocked from 2000 on (Figure 3). Glass eel restocking is proposed as a management measure in the EMP for Flanders.

In recent years the glass eel restocking could not be done each year due to the high market prices. Only in 2003 and 2006 respectively 108 and 110 kg of glass eel was stocked in Flanders (Figure 3 and Table 3). In 2008 117 kg of glass eel from U.K. origin (rivers Parrett, Taw and Severn) was stocked in Flemish water bodies. In 2009 152 kg of glass eel originating from France (Gironde) was stocked in Flanders. In 2010 (April 20th, 2010) 143 kg has been stocked in Flanders. The glass eel was originating from France (area 20–50 km south of Saint-Nazaire, small rivers nearby the villages of Pornic, Le Collet and Bouin). A certificate of veterinary control and a Cites certificate were delivered.

In 2011 (21 April 2011) 120 kg has been stocked in Flemish waters. The glass eel was originating from France (Bretagne and Honfleur). A certificate of veterinary control and a Cites certificate were delivered.

In 2012 156 kg has been stocked in Flemish waters. The glass eel was supplied from the Netherlands but was originating from France.

The cost of the glass eel per kg (including transport but without taxes) is presented in Table 2.

Table 2. Prices of restocked glass eel in Belgium (2008–2012).

Year	Cost (€/kg)
2008	510
2009	425
2010	453
2011	470 (Flanders) 520 (Wallonia)
2012	416 (Flanders) 399 (Wallonia)

Glass eel restocking activities in Flanders are not taking account of the variation in eel quality of the restocking sites.

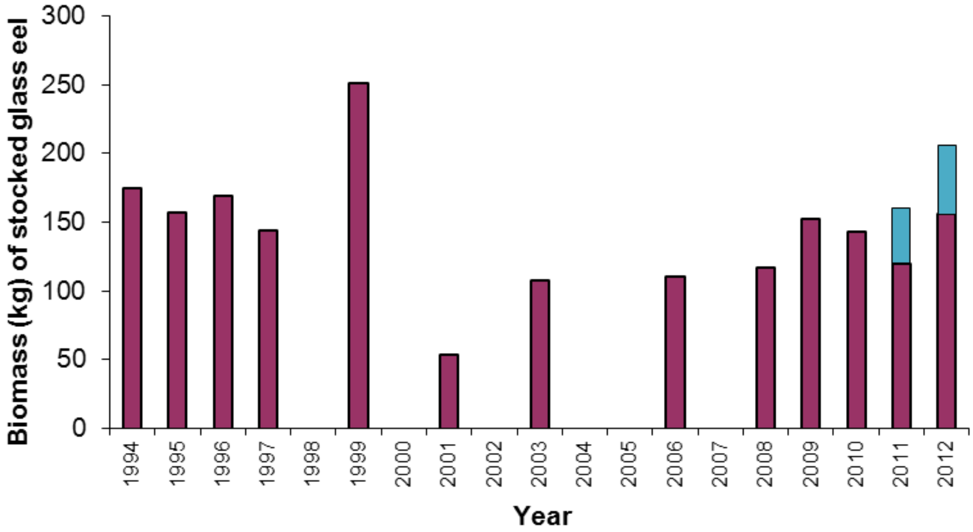


Figure 3 and Table 3. Restocking of glass eel in Belgium (Flanders and Wallonia) since 1994, in kg of glass eel. Flanders is represented in red and Wallonia in blue in the figure. * left Flanders/right Wallonia.

Decade				
Year	1980	1990	2000	2010
0	0	0	0	143
1	0	0	54	120/40*
2	0	0	0	156/50*
3	0	0	108	
4	0	175	0	
5	0	157,5	0	
6	0	169	110	
7	0	144	0	
8	0	0	117	
9	0	251,5	152	

Stocking in Wallonia

In Wallonia, glass eel restocking was initiated in 2011, in the framework of the Belgian EMP. In March 2011 40 kg of glass eel was restocked in Walloon rivers and lakes, in 2012 the amount stocked was 50 kg.

More information on stocking details for Wallonia is presented in Table 4 (Cost of the glass eel), 5 (origin) and 4 (restocked sites).

Table 4. Restocked sites and amounts of glass eel stocked (in kg) in Wallonia in 2011 and 2012 (partial information).

	2011	2012
River Ourthe	12	
River Amblève	8	

River Aisne	1	
River Méhaigne	2	
River Lesse	?	
River Dyle	1	
River Vesdre		6
Upper Lesse		6
River Viroin		4
Upper Sambre		6
Hantes		2
Thure		2
Biesme		2
Biesmelle		2
Eau d'Heure		4
Lac d'Eau d'Heure		2

These first restockings in Wallonia will be followed by a stocking programme over four years, which was developed in part to help the target set by the Regulation (EC) 1100/2007 and will be co-financed by the European Fund for Fisheries (EFF). A budget of €250 000 is provided for the purchase of glass eel. Restocking will be made for a maximum of Walloon rivers, with the exception of parts of rivers located in Hainaut (area not eligible for EFF in Wallonia and also suffering from a deteriorated physico-chemical water quality). The location of restocking will consider habitat conditions (water quality, capacity, migration possibilities. The import of elvers from France or the United Kingdom will be privileged (Vlietinck *et al*., 2012).

The University of Liège is currently starting a research program financed by EFF to test the efficiency of glass eel restocking in waterbodies of diverse typology.

3.5.2 Catch of eel <12 cm and proportion retained for restocking

There are no glass eel fisheries in Belgium. Glass eel caught for monitoring purposes by the Flemish authorities at the sluices at the mouth of River Yzer are released directly above the sluices.

3.5.3 Reconstructed time-series on stocking

All glass eel used for the Flemish and Walloon restocking programs are purchased from foreign sources (usually UK or France). There are no quarantine procedures. Nowadays, no bootlace eels, nor ongrown cultured eels are restocked.

Table 5. Origin and amounts of glass eel restocked in Belgium (Flanders and Wallonia) between 2008 and 2012.

Year	Region	Origin	Amount (kg)
2008	Flanders	UK	125
2009	Flanders	France	152
2010	Flanders	France	143
2011	Wallonia	UK	40
2011	Flanders	France	120
2012	Flanders	France	156
2012	Wallonia	France	50

See for the full time-series under Section 3.5.1.

4 Fishing capacity

4.1 Glass eel

Commercial nor recreational fishery for glass eels is allowed in Belgium.

4.2 Yellow eel

Professional coastal and sea fisheries

Following a global European downward tendency, the Belgian fleet consisted at the start of 2009 of a total of 100 motorized vessels, with a power of 60 620 kW and a gross registered tonnage of 19 007 GT (De Belgische Zeevisserij Aanvoer en Besomming, 2008). The national fishing fleet represents 0.1% of the European fleet, 1.1% of the European tonnage and 0.9% of the total engine power (2005 data). The fleet consists mostly of beam trawlers, the remainder being otter trawlers. There are data available on fishing effort. But as mentioned before, eel catches through professional and coastal fisheries are negligible.

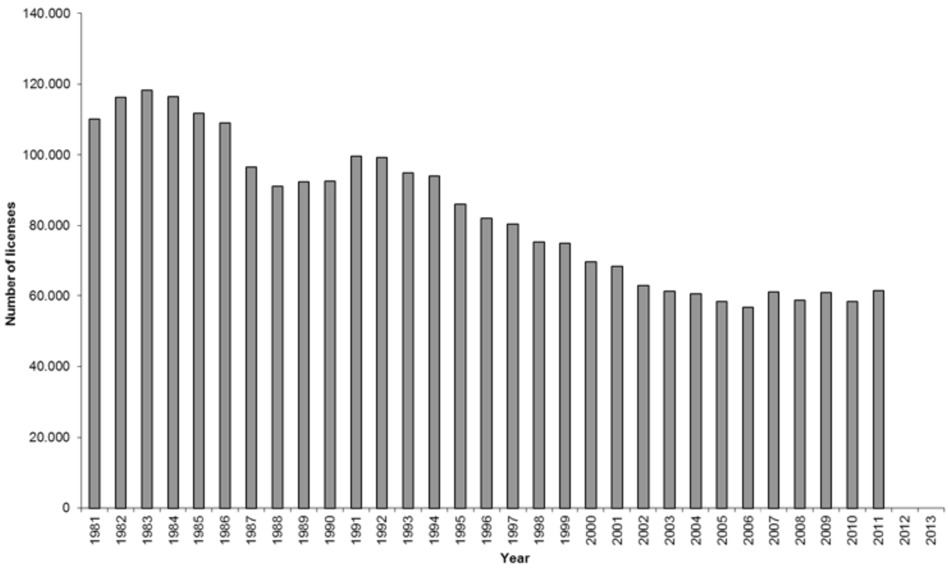
Estuarine fisheries on the Scheldt

Fishing capacity has decreased from 1999 onwards and this fishery has been closed in 2009. The estuarine Scheldt fisheries around 2000 was performed by two boat trawlers (one beam trawler and one otter trawler) and by ca. 30 semi-professional fishermen fishing with fykes (estimated at 150 fykes). The trawl fisheries were focused on eel, but since 2006 boat fishing has been prohibited, and only fyke fishing was permitted until 2009. The number of licensed fishermen fishing with fykes decreased from 17 in 1999 to nine licences in 2006–2008. See Figure 5 for a time-series between 1992 and 2009. A licence allows a fisherman to use a maximum of 5 fykenets; which means that at most 45 legal fykenets are used in the estuary. Since 2009 no more licences are issued, which is as a measure of the Eel Management Plan of Flanders to reduce catches. A new Decree (Besluit van de Vlaamse Regering van 5 maart 2010) was issued to regulate the prohibition of fyke fishing in the lower Seascheldt.

For a figure of the time-series of the number of licensed semi-professional fishermen on the Scheldt from 1992 to 2009 (Data Agency for Nature and Forests) we refer to Belpaire *et al.*, 2011 (Belgian Eel Country Report 2011).

Recreational fisheries in the Flemish region

The number of licensed anglers was 60 520 in 2004, 58 347 in 2005, 56 789 in 2006, 61 043 in 2007, 58 788 in 2008, 60 956 in 2009, 58 338 in 2010 and 61 519 in 2011. The time-series shows a general decreasing trend from 1983 (Figure 6). However in 2007 there was again an increase in the number of Flemish anglers (+7.5% compared to 2006). From an inquiry of the Agency for Nature and Forests in 2008 among 10 000 recreational anglers (36% feedback) it appeared that ca. 7% fishes for eel.



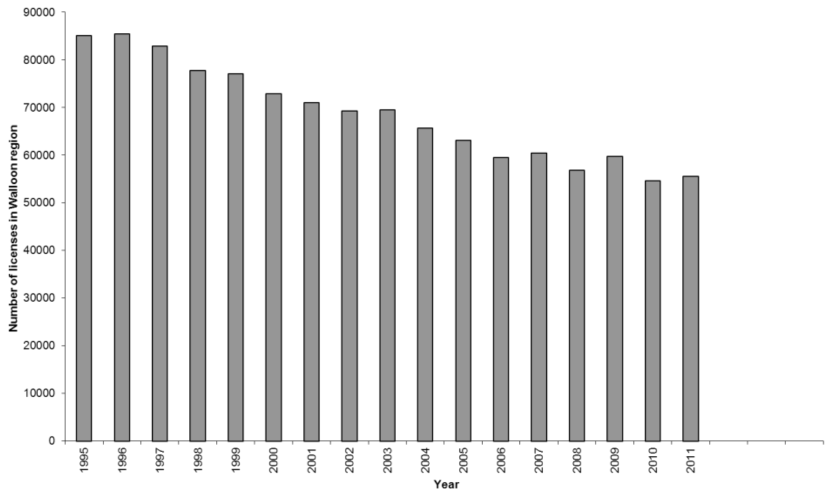


Figure 4. Time-series of the number of licensed anglers in Flanders (above) and Wallonia (below) since 1980 and 1995 respectively (Data Agency for Nature and Forests and Nature and Forestry Division (DNF) of the Walloon Environment and Natural Resources DG (DGRNE).

Recreational fisheries in the Walloon Region

Although in constant decline since the nineties, fishermen are still a well-represented community in the Walloon region. The number of licensed anglers was 65 687 in 2004, 63 145 in 2005, 59 490 in 2006, and 60 404 in 2007. Since then, numbers have decreased with 56 864 in 2008, 59 714 in 2009, 54 636 in 2010 and 55 592 in 2012 (Figure 4).

Recreational fisheries in the Brussels capital

The number of licensed anglers is approximately 1400 (Data Brussels Institute for Management of the Environment).

4.3 Silver eel

See Sections 3.3.1 and 3.3.2.

4.4 Marine fishery

See Section 4.2. Professional coastal and sea fisheries.

5 Fishing effort

5.1 Glass eel

There is no professional or recreational fisheries on glass eel.

5.2 Yellow eel

See Section 4.2 for the number of recreational fishermen and the proportion of eel fishermen.

5.3 Silver eel

There are no professional or recreational fisheries on silver eel.

5.4 Marine fishery

Marine fisheries on eel are not documented and are assumed to be negligible.

6 Catches and landings

6.1 Glass eel

Commercial nor recreational fishery for glass eels is allowed in Belgium.

6.2 Yellow eel

Catches and landings–estuarine fyke fisheries on river Scheldt

Fyke fishing for eel on the lower Scheldt estuary is prohibited now. Since 2009 no more licences for fyke fisheries on the river Scheldt are issued, which is as a measure of the Eel Management Plan of Flanders to reduce fishing capacity. Before 2009 annual catches of eel by semi-professional fyke fishermen was estimated between 2.8 and 12.4 tons. This is thus reduced to zero in 2009 and 2010.

Catches and landings–recreational fisheries in Flanders

Based on an inquiry by the Agency for Nature and Forest in public waters in Flanders in 2008, recreational anglers harvest on a yearly basis 33,6 tons of eel (Vlietinck, 2010). This figure holds for 2009 too (Vlietinck, pers. comm.). In 2010 a small restriction of eel fishing was aimed by a new regulation (Besluit van de Vlaamse Regering 5/3/2010). Between April 16th and May 31th, and during the night, eels may not be taken home. This results in a roughly estimate of 10% reduction of eel harvest. Hence estimate for 2010, 2011 and 2012 is an annual eel harvest of 30 tons (Vlietinck, pers. comm.). There is no distinction between the catch of yellow eel and silver eel, but due to the specific behaviour of silver eel, it is considered that these catches are mainly composed of yellow eel.

Other earlier estimates were 121 tonnes per annum and 43 tonnes per annum (Belpaire *et al*., 2008).

In 2000 a catch and release obligation for the recreational fishing of eel was issued due to high contaminant concentrations, however this law was abolished in 2006.

This resulted in an increase in yield of yellow eel by recreational fisheries from nihil to the actual 30 tons.

It is worth mentioning that based on the 2008 inquiry in a population of recreational anglers (Vlietinck, 2010), the majority (77%) of anglers are in favour of a restriction in the fishing or the harvest of eel (in the framework of the protection of the eel). 27% of the respondents are in favour of (among other options) the obligatory release of caught eel as management option (Figure 5).

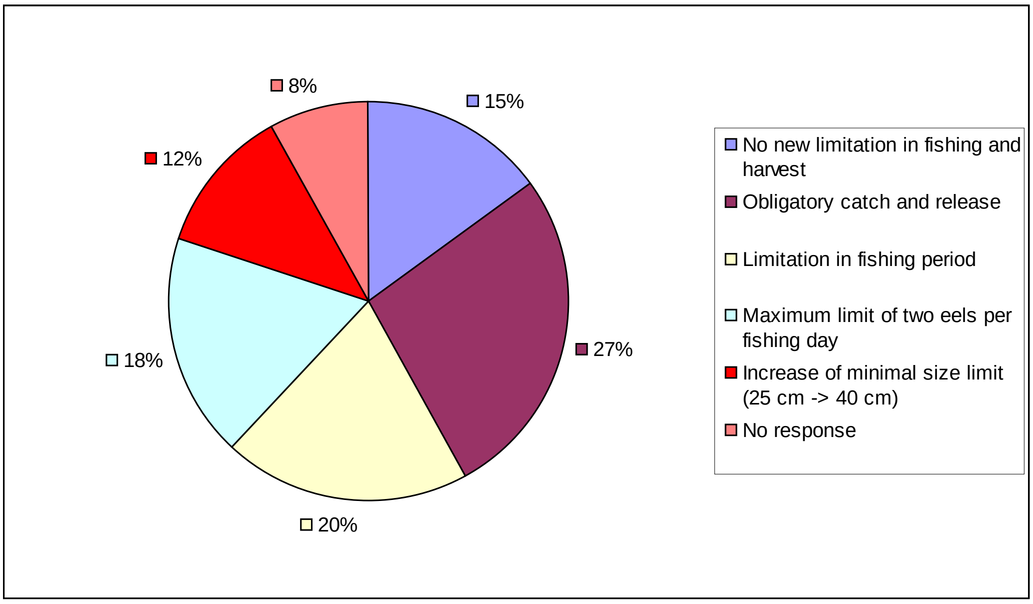


Figure 5. Results of a 2008 inquiry among 10 000 Flemish recreational anglers for their preference in management options for restoring the eel stock. 36% (N = 3627 anglers) responded (Vlietinck, 2010).

Catches and landings–recreational fisheries in Wallonia

No new data available for recreational fisheries in the Walloon Region. See Belpaire *et al*. (2008) for an overview. In the Walloon region, fishing of eels is prohibited since 2006 (Walloon Government, 2006). By modification of the 1954 law on fishing activities, there is an obligation to release captured eels whatever their length. So from 2006 on, recreational catches of eel in Wallonia should be zero.

Recreational fisheries in Brussels capital

No information on eel catches.

6.3 Silver eel

There are no professional or recreational fisheries on silver eel.

6.4 Marine fishery

Marine fisheries on eel are negligible and not documented.

7 Catch per unit of effort

7.1 Glass eel

Commercial nor recreational fishery for glass eels is allowed in Belgium.

There is some information available on the cpue trend in the governmental glass eel monitoring at Nieuwpoort (River Yzer) (Table 6).

Table 6. Temporal trend in catch per unit of effort for the governmental glass eel monitoring by dipnet hauls at the sluices in Nieuwpoort (River Yzer, 2002–2012). Cpue values are expressed as Kg glass eel caught per fishing day with catch and as Kg glass eel per haul.

Year	Total year catch	Max daycatch	Total year catch/Number of fishing days with catch (Kg/day)	Total year catch/Number of hauls per season (Kg/haul)
2002	1,4	0,46	0,140	0,0081
2003	0,539	0,179	0,034	0,0040
2004	0,381	0,144	0,042	0,0029
2005	0,787	0,209	0,056	0,0044
2006	0,065	0,014	0,006	0,0005
2007	2,214	0,485	0,130	0,0085
2008	0,964	0,262	0,060	0,0040
2009	0,969	0,274	0,057	0,0037
2010	0,318	0,1	0,017	0,0012
2011	0,4127	0,067	0,021	0,0014
2012	2,4077	0,35	0,105	0,0057

7.2 Yellow eel

There are only rough estimates about the catches of eel by recreational fishing. These data are based on an inquiry (N=3627 responses) by the Agency for Nature and Forest in public waters in Flanders in 2008 (Vlietinck, 2010). At that time recreational anglers harvest on a yearly basis 33,6 tons of eel. 6.6% of the recreational fishermen (N=58 788) are eel fishermen. So 3880 eel fishermen are catching 33.6 tons, or an average eel fishermen is fishing 8.7 kg eel per year.

7.3 Silver eel

There are no professional or recreational fisheries on silver eel.

7.4 Marine fishery

Marine fisheries on eel are negligible and not documented.

8 Other anthropogenic impacts

In Belgium, the eel stock is considerably impacted by an overall poor water quality (especially for Flanders), and by a multitude of migration barriers (draining pumps, sea sluices, dams, weirs, impingment by power stations and hydropower units).

Water quality

Improvement of water quality by installing purification units is an on-going process (within the objectives of the Water Framework Directive). As an example the installation of an important purification unit in 2007 on the River Senne (north of Brussels) purifying the waste waters of the capital, has led to an impressive increase in the eel population in river Senne and Rupel during 2008 and 2009. Due to a temporary closure of the water treatment plant (for technical reasons) at the end of 2009 all eels disappeared, subsequent monitoring showed that the eel population restored approximately six months after restart of the plant.

Restoring migration possibilities

On April 26, 1996, the Benelux Decision about free fish migration was adopted. The Decision sets that the Member States should guarantee free fish migration in all hydrographic basins before January 1, 2010. Recently, the 1996 Benelux decision has been evaluated. The general conclusion is that a lot of barriers have been removed, but also that the timing is not achievable and that the focus should be on the most important watercourses. On June 16, 2009 a new Benelux Decision (M (2009) 1) was approved. According to this new Decision, Member States commit themselves to draw up a map indicating the most important watercourses for fish migration. Hereto, the Research Institute for Nature and Forest (INBO) drew up a proposal for this prioritization map based on ecological criteria (Figure 6).

The proposal for the new prioritization map accounts for both the distribution of EU Habitat Directive species and the recommendations of the eel management plan. In addition, the Benelux Decision allows accounting for regionally important fishes. Therefore, we also accounted for the distribution of the rheophilic species for which Flanders has developed a restoration program (dace, chub and burbot).

The total length of the prioritization network of Flemish water courses is 3237 km (almost 15% of the total length of the watercourses in Flanders). Besides the barriers on the selected watercourses, also pumping stations and hydro turbines on unselected water courses should be taken into account. Depending on their location and functioning, pumping stations and hydro turbines may have a significant impact on the survival of downstream migrating fish and eel in particular. The results of a survey of pumping stations in Flanders will be used to draw up a list of the most harmful pumping stations. This list will then be added to the prioritization map.

The prioritization map gives an overview of the water courses that should be barrier-free in order to preserve the populations of the target species. Hereto a distinction is made between obstacles of first and second priority. Obstacles of first priority are those located on the main rivers of the major river basins (Scheldt and Meuse). 90% of these barriers should be eliminated by 2015, the remaining 10% by 2021. In Flanders, the highest priority is given to the obstacles on the River Scheldt and to the obstacles that should be removed first according to the eel management plan. The remaining obstacles on the water courses of the prioritization map are assigned to the second priority. These obstacles will be divided into three groups. 50% of these should be removed before December 31, 2015. 75% should be removed before December 31, 2021 and 100% by December 31, 2027.

Additionally, water courses of special attention were selected. These are water courses that have important fish habitat, but where the removal of migration barriers is not a priority. These water courses are important for the restoration of the eel stock, have an ecologically valuable structure or are located in a sub-basin where Habitat Directive species occur. They are not part of the prioritization map and have no timing for the removal of existing migration barriers. However, downstream migration should be guaranteed in these water courses and if an opportunity arises, the existing fish migration barriers should be removed.

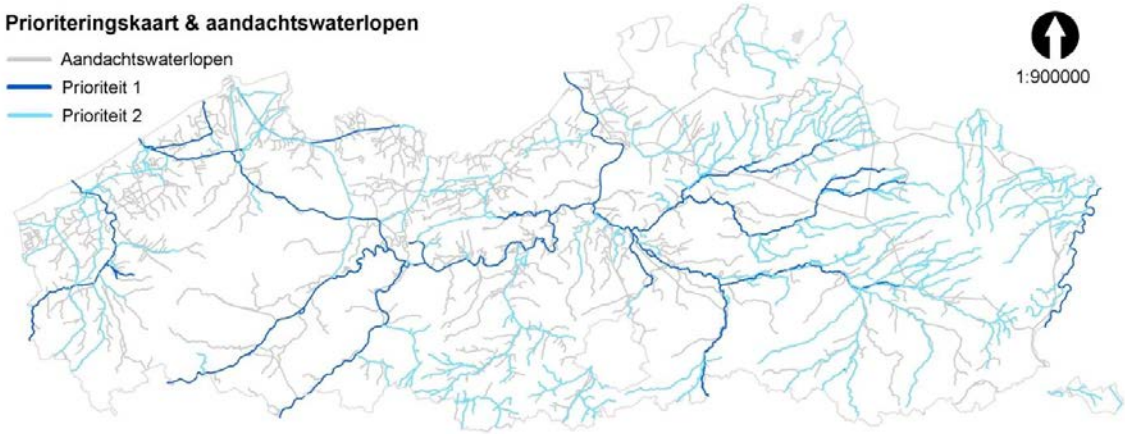


Figure 6. Fish migration prioritization network of Flemish water courses (blue) and water courses of special attention (grey) following the Benelux Decision "Free migration of fish" M(2009)1.

An update of the anthropogenic impacts has recently been made in the framework of the report of the evaluation of the Belgian EMP (Vlietinck *et al*., 2012). We refer to this document for a more complete description of the anthropogenic impacts on the stock.

In summary following management measures are foreseen:

Table 7. Status of measures of habitat restoration as reported in the evaluation of the Belgian EMP (Vlietinck *et al*., 2012).

Measures	region	status	timing
Resolving migration barriers for upstream migration	Flanders	In progress	2027
Resolving migration barriers for upstream migration	Wallonia	In progress	2027
Measures to protect eels from impingment (by industries using cooling water) during their downward migration.	Wallonia	In progress	To be defined
Measures to protect eels from hydropower installations during their downward migration.	Wallonia	In progress	To be defined
Measures to protect eels from hydroturbines and pumping stations during their downward migration.	Flanders	In progress	To be defined
Measures to attain good ecological status or good ecological potential of water bodies.	Belgium	In progress	2027
Measures for sanitation of polluted sediments	Flanders	To be started	To be defined
	Wallonia	In progress	To be defined

A new paper published by Van Liefferinge *et al*. (2012) studied the role of a freshwater tidal area with controlled reduced tide as feeding habitat for eel. The study showed that with a controlled reduced tide to restore lateral connectivity of large tidal rivers with their adjacent floodplains, high quality habitats for the European eel are created. These measures could significantly contribute to the production of eels in better condition, which have better chances to reproduce successfully. Hence, wetland restoration is a way to enhance the recovery of the European eel stocks.

9 Scientific surveys of the stock

9.1 Glass eel

See Section 3.1.1.3 Glass eel recruitment at Nieuwpoort at the mouth of River Yser (Yser basin).

9.2 Yellow eel

Fish stock monitoring network in Flanders

Since 1994, INBO runs a freshwater fish monitoring network consisting of ca. 1500 stations in Flanders. These stations are subject to fish assemblage surveys on regular basis (on average every two to four years depending of the typology of the station). This network includes all water types, head streams as well as tributaries (stream width ranging from 0.5 m to 40 m), canals, disconnected river meanders, water retaining basins, ponds and lakes, in all of the three major basins in Flanders (Yser, Scheldt and Meuse). Techniques used for analysing fish stocks are standardized as much as possible, but can vary with water types. In general electrofishing was used, sometimes completed with additional techniques, mostly fyke fishing. All fish are identified, counted and at each station 200 specimens of each species were individually weighed and total length was measured. As much as possible biomass (kg/ha) and density (individuals/ha) is calculated. Other data available are number (and weight) of eels per 100 m electrofished river bank length or number (and weight) of eels per fyke per day. The data for this fish monitoring network are available via the website http://vis.milieuinfo.be/.

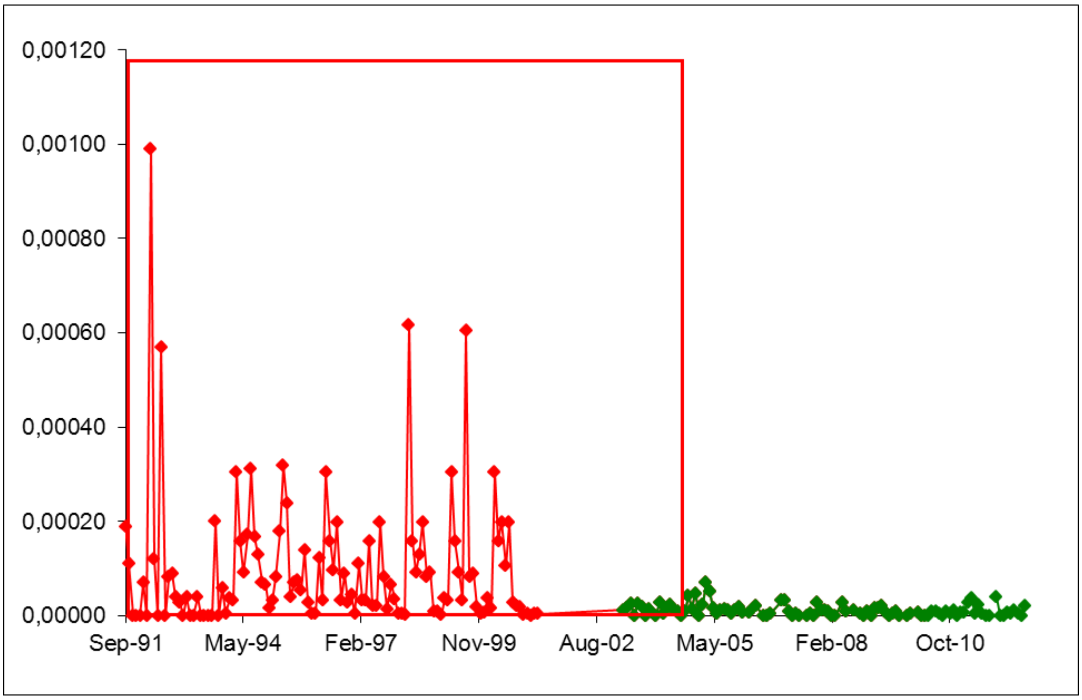
This fish monitoring network is now been further developed to cope with the guidelines of the Water Framework Directive.

A temporal trend analysis has been performed based on a dataset including fish stock assessments on locations assessed during the periods 1994–2000, 2001–2005 and 2006–2009. 334 locations were assessed in those three periods (30 on canals and 304 on rivers). These results have been reported in the 2011 Country Report; see Belpaire *et al*. (2011) for further details. No new data-analysis has been carried out for the most recent period.

River Scheldt fish monitoring at the power station of Doel

INBO is following the numbers of impinged fish at the nuclear power station of Doel on the Lower Scheldt. The numbers of impinged eels are given in Figure 7.

There is a clear decrease in numbers of eels between period 1991–2001 (red) and period 2002–2012 (green); this is not necessarily reflecting the real state of the stock on the River Scheldt, but might be the result of a change in sampling procedure between both periods. Since 2003, sampling has been standardised to a three hour time spam around low tide, which was not the case for the sampling during the earlier period.



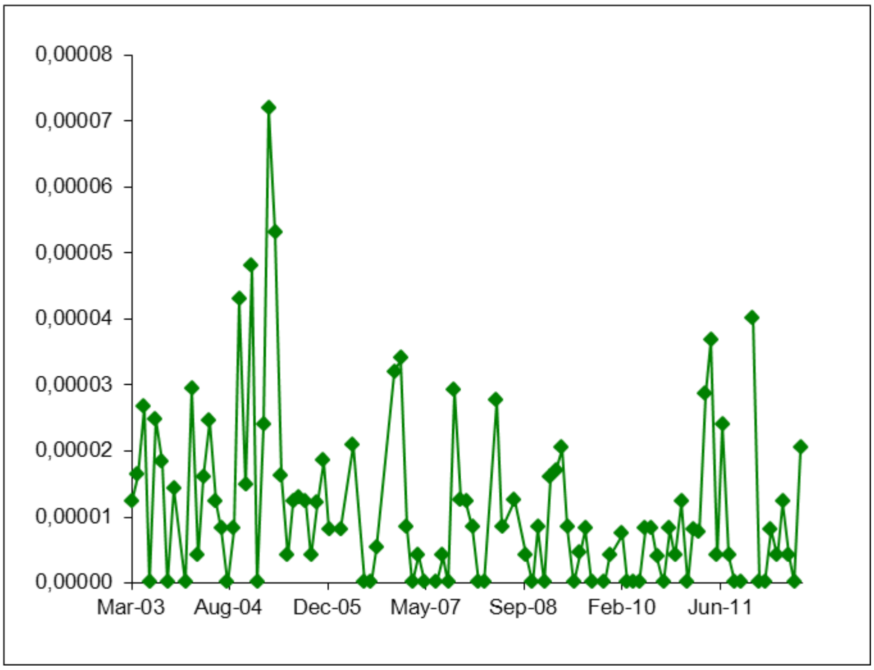
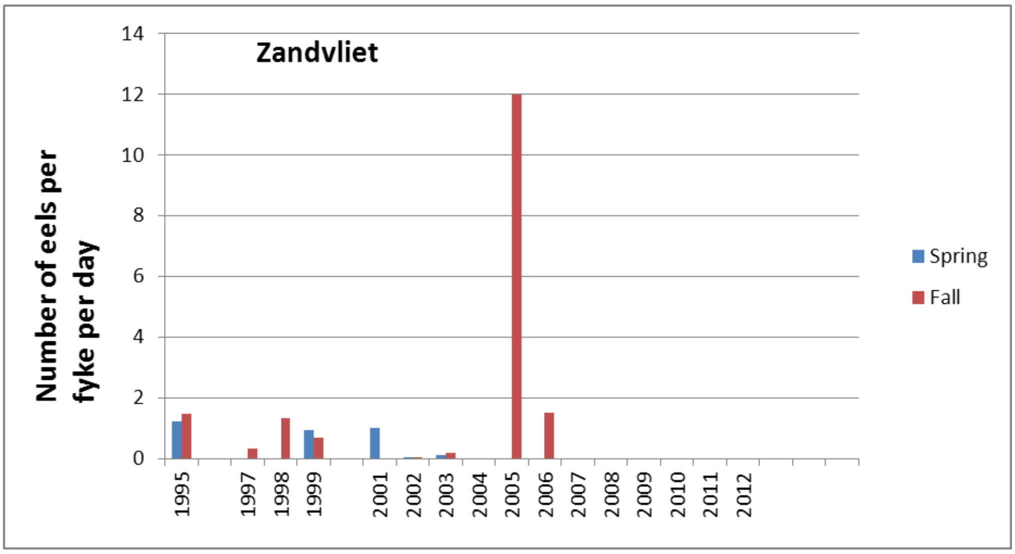
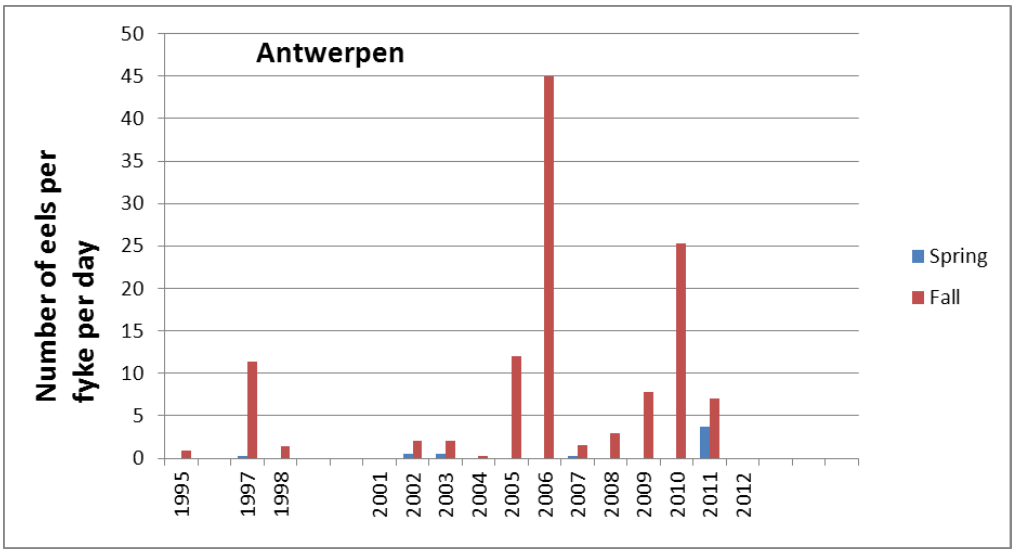


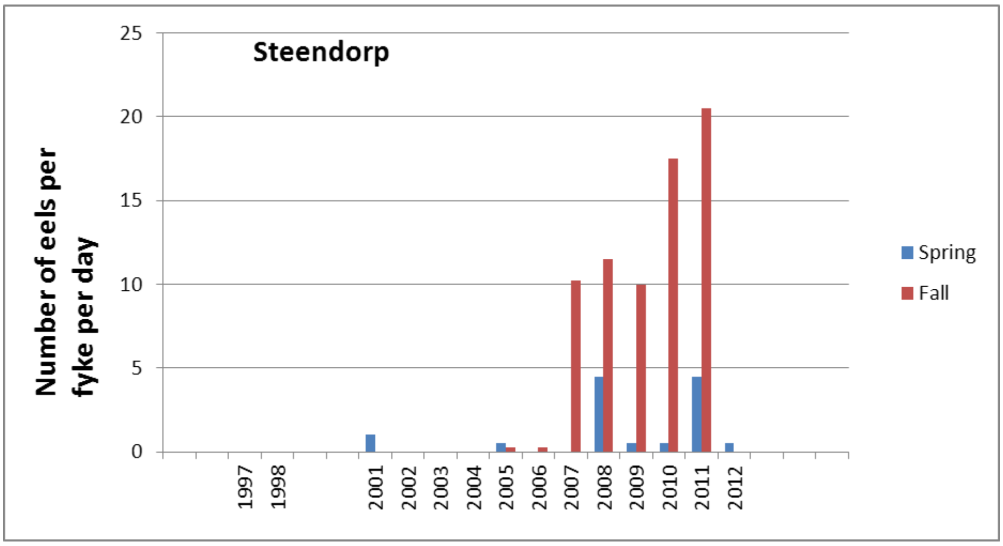
Figure 7. Time trend in the quantities of eels impinged at the Doel power station on the River Scheldt nearby Antwerp (1991–2011). Quantities are expressed as number of individuals per m³ water. Data period 1991–2001 (red) from Maes *et al.* (2005); period 2002–2009 (green) from Wambacq (2010). Data KU Leuven and INBO. Later data from INBO.

Estuarine fish monitoring by fykes

A fish monitoring network has been put in place to monitor fish stock in the Scheldt estuary using paired fykenets. Campaigns take place in spring and autumn. At each site, two paired fykenets were positioned at low tide and emptied daily; they were placed for two successive days. Data from each survey per site were standardized as number of fish per fyke per day. Figure 8 gives the time trend of eel catches in four locations along the Scheldt (Zandvliet, Antwerpen, Steendorp and Kastel). In the mesohaline zone (Zandvliet) catches are generally low. This could be due to the applied methodology. However, a decline is apparent as no eel was caught in Zandvliet since 2007. On the other hand, since 2005, more eel were caught upstream in the oligohaline zone (Antwerpen, Steendorp) and freshwater zone (Kastel). Generally eel catchability is higher in autumn than in spring. (Data Jan Breine, INBO).







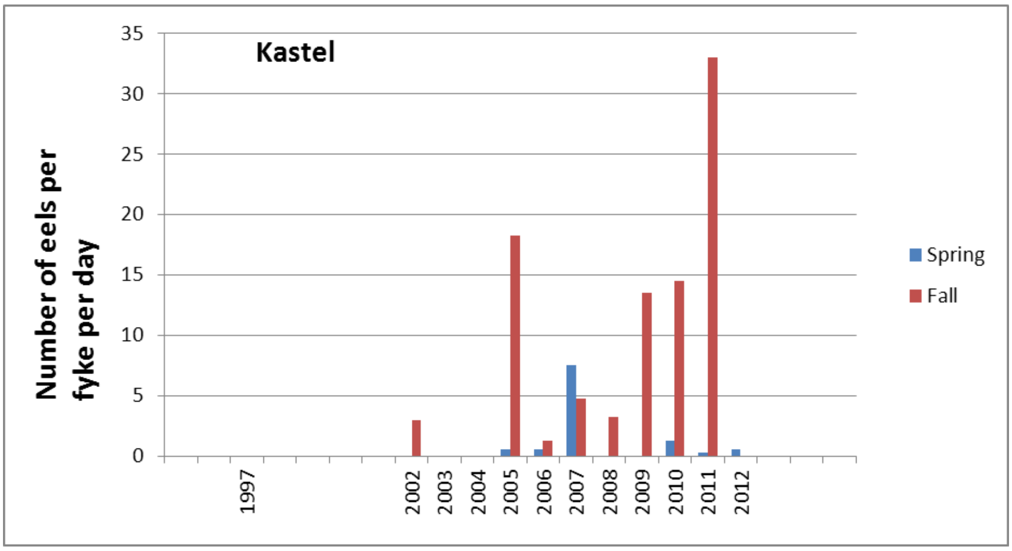


Figure 8. Time trend of fyke catches of eel along the River Scheldt estuary. Numbers are expressed as mean number of eels per fyke per day. Data are split up in spring catches and fall catches. Years without monitoring data are excluded from the X-axis. Data Jan Breine, INBO.

Yellow eel telemetry study in the Méhaigne (Meuse RBD)

In 2009, University of Liège started up a telemetry study on 50–80 cm yellow eels in the Méhaigne, tributary of the river Meuse. The objectives are the evaluation of home range, mobility, habitat choice, impact of alterations of water regime by hydropower stations and the assessment of up and downstream migration. This study aims to study habitat choice of eels in support of the management of river habitat in Walloon rivers. In March-June 2009, radio-tagged eels (505–802 mm; 220–1226 g) occupied longitudinal home ranges ranging from 2 m (0,002 ha) to 341 m (0,3 ha) and displayed cumulated net movements ranging from 9 to 940 m with an average value of 305 m. Eels were a little less mobile in habitat with natural flow (more stable) than in habitat with reduced flow (less stable) due to water abstraction for hydropower generation. Telemetry data on microhabitat use reveal a strong preference of eels for blocks, undercuts banks and tree roots. Improving the quantity and quality of these types of microhabitats in the river stretch should help increase the carrying capacity and hence the eel population density. This management hypothesis remains to be tested in the field (study by Seredynski, 2009 reported in Philippart *et al.*, 2010).

9.3 Silver eel

Verbiest *et al*. (2012) published the results of a study on the downstream migration of female silver eel by remote telemetry in the lower part of the River Meuse (Belgium and the Netherlands) using a combination of nine detection stations and manual tracking. N = 31 eels (LT 64–90 cm) were implanted with active transponders and released in 2007 into the River Berwijn, a small Belgian tributary of the River Meuse, 326 km from the North Sea. From August 2007 till April 2008, 13 eels (42%) started their downstream migration and were detected at two or more stations. Mean migration speed was 0.62 m/s (or 53 km/day). Only two eels (15%) arrived at the North Sea, the others being held up or killed at hydroelectric power stations, caught by fishermen or by predators or stopped their migration and settled in the river delta. A majority (58%) of the eels classified as potential migrants did not start their migration and settled in the River Berwijn or upper Meuse as verified by additional manual tracking. More details are to be found in the paper.

10 Catch composition by age and length

Not applicable for Belgium as there are no commercial catches in inland waters. Commercial catches of eel in coastal waters or marine fisheries are not reported to DCF.

See Section 11.1 for data on length and weight gained from research sampling.

There are no routine surveys on age of eels. Some silver eels from Flanders have been aged in the framework of the Eeliad program.

11 Other biological sampling

11.1 Length and weight and growth (DCF)

Flemish Region

Length and weight data of individual eel collected through the freshwater fish monitoring network are available via the website http://vis.milieuinfo.be/.

An analysis of the length of yellow eels per catchment has been made for the EMP and is presented there.

Verreycken *et al*. (2011) describe the length–weight relationship ($W = aL^b$) in eel (and other species) from Flanders. Nearly 263 000 individual length–weight (L/W) data, collected during 2839 fish stock assessments between 1992 and 2009, were used to calculate L/W relationships of 40 freshwater fish species from Flanders. Those stock assessments were performed by INBO in the framework of the Flemish Freshwater Fish Monitoring Network. The study area includes 1426 sampling locations characterized as lacustrine as well as riverine habitats, including head streams, tributaries, canals, disconnected river meanders, water retaining basins, ponds and lakes. Eel was the fifth most abundant species in our surveys. The equation was based on 17 586 individual eels recorded for total length and weight (Figure 9).

Following equation was found:

$$W = 0.0011\ L^{3.130}$$
$$r^2 = 0.98$$

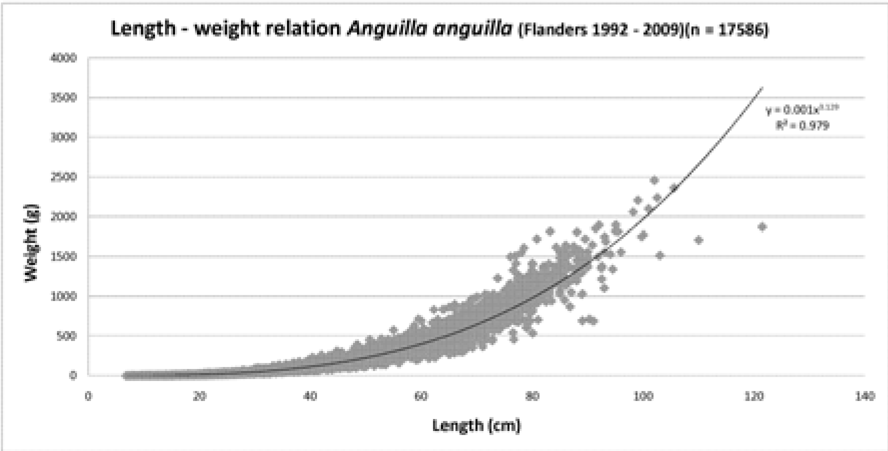


Figure 9. Length–weight relation of European eel (n = 17 586) sampled over Flanders in the period 1992–2009.

In order to ascertain to what extent the log10a and b values calculated for the Flemish populations fell within the range available from other studies, we compared the Flemish values with the values available in FishBase (Froese and Pauly, 2010) from other countries. Flemish *a* and *b* values both fell within the 95% CL of the mean European *a* and *b* values (Figure 10).

Our data originate from over almost two decades, irrespective of sampling sites, dates and seasons. Because of the dense sampling network in a small geographic area over a long sampling period, extremes are balanced out. Therefore and through the fact that Flanders is situated centrally in Europe, our *a* and *b* values may be applicable as reference marks for an European L/W relation for eel. Moreover, our TL range covered the whole range between minimum and maximum length in sufficient numbers, making *a* and *b* values valid as mean values for all length ranges (Verreycken *et al.*, 2011).

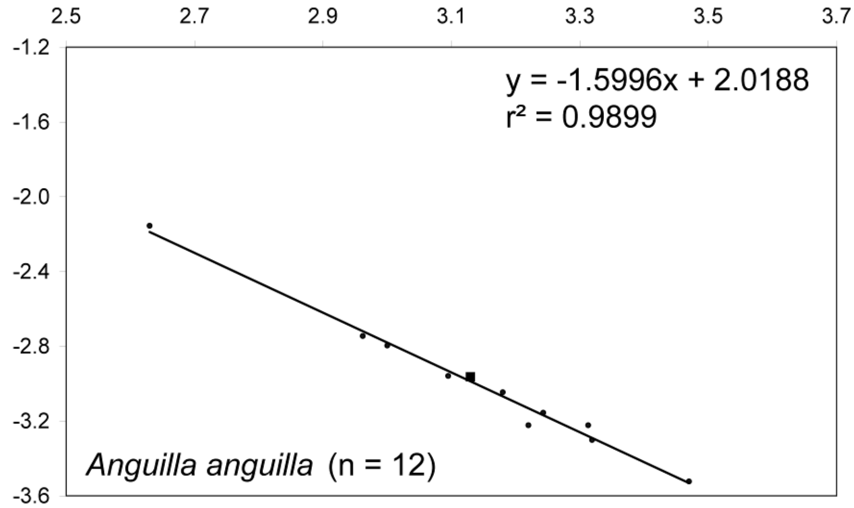


Figure 10. Estimated intercepts (log10a; Y-axis) versus estimated slope (b; X-axis) for the log10 transformed L/W regression and regression line for European eel from European datasets, as available in Fishbase (Froese and Pauly, 2010), compared to the Flemish populations (■; 1992–2009). Linear regression equation and r^2 are given (n = number of L/W relationships, including Flanders). (Verreycken et al., 2011).

Results from a study on head dimorphism (Ide *et al.*, 2011) are presented in the 2011 Country Report (See Belpaire *et al.*, 2011) for details).

Walloon Region

An analysis of the length of yellow eels in some rivers of the Meuse catchment has been made for the EMP and is presented there.

11.2 Parasites and pathogens

Flemish Region

Flanders has cooperated to a pan European survey on the actual status of Anguillicoloides in silver eels. This extensive study was conducted during the EELIAD project (www.eeliad.com) to test the relationship between silver eel health indicators and infestation by *Anguillicoloides crassus*. This parasitic nematode of the swimbladder of the Japanese eel, *Anguilla japonica* was introduced in the early 1980s from Asia to Europe and infested the European eel. Since then, this invasive parasite has been able to spread rapidly through most of its new host geographic range. Being hematophagous *A. crassus* induces pathogenic changes in the swimbladder and has been considered as an additional pressure on the European eel population by potentially hampering the transoceanic migration of the silver eels. We present here the results of the first study covering eleven European catchments (seven countries) sampled from 2007 to 2009. A total of 492 silver eels, considered as future spawners, were examined for epidemiologic parameters and SDI (swimbladder degenerative index). In most of the investigated catchments more than 50% of the eels were infested with *A. crassus*; except in the French Mediterranean lagoon Bages-Sigean (8%) and the Irish Burrishoole

River (0%). The highest prevalences (81–94%) and mean intensities (7.9–10.6) were recorded in Belgium, Denmark, France, Ireland and UK sites. Eels from UK and Danish catchments displayed the highest SDI. No significant geographical pattern was observed. The implication of these results regarding the framework of the eel restoration plans was discussed (Faliex *et al*., 2012).

Walloon Region

No new information compared to earlier reports.

11.3 Contaminants

In the last years reports (Belpaire *et al*., 2009, 2010, 2011) extensive information has been provided about the status and effects of contaminants in the eel. Full information is to be find in the original papers (see e.g. Belpaire *et al*., 2011b; Reyns *et al*., 2010; Geeraerts *et al*., 2011; Belpaire *et al*., 2011a; Roosens *et al*., 2010; Geeraerts and Belpaire, 2010).

New information dealing with the quality of eels, or the presence and impact of contaminants, has been provided during several recent scientific meetings. Abstracts are provided below.

Eel quality data gathered during the Eeliad program are currently in process. Other cooperations with regard to surveys on eel contamination have been set up with different countries (Spain, Norway, Italy).

Flanders continues to coordinate the Eel Quality Database, for which a new application is currently under development. The database is a compilation of eel quality data over the world, including contaminants and diseases. The new application will be a more performant system (from Excel worksheets to an Access database) and will include opportunities to include more data fields and validation mechanisms. The database expands now to all Anguillid species and hence will be renamed (from EEQD (European Eel Quality Database) → EQD (Eel Quality Database)). Technical specifications are Backend: SQL-Server 2008; Frontend: Local Microsoft Access 2010 (Form-Builder Model PTQ7.15); Connection type: ODBC; Network entrance: VPN. Further timing: Further development of the database and test phase (End of 2012) and Migration of all available data and data validation (2013).

In Wallonia levels of contaminations in invertebrates and fish is in progress.

Abstract at 2012 Symposium of the Ontario Int Assoc for Great Lakes Research

Spatial and temporal patterns of embryotoxicity of contaminants extracted from American eel (*Anguilla rostrata*).

Peter V. Hodson, Sharilyn Kennedy, Cyril Rigaud, Jonathan Byer, Catherine M. Couillard, Mehran Alaee, Jocelyne Pellerin, Benoit Legaré, John Casselman, Claude Belpaire.

Dioxin-like compounds (DLCs) are a possible cause of the decline of American eel recruitment to the upper St. Lawrence and L. Ontario since the 1980s. Eels in L. Ontario accumulate DLCs to the same extent as lake trout, whose reproductive failure has been tied to DLC accumulation. The eel reproduces only once after migrating from L. Ontario to the Sargasso Sea, during which feeding stops, tissues are catabolized to sustain migration and oocyte maturation, and lipid stores, including their contaminants, are transferred to oocytes. Thus, embryotoxicity may result from maternally-derived DLCs. The extended life cycle of eels means that juveniles recruiting to L. Ontario in the 1980s–1990s were spawned from parents that integrated the contaminant history from the 1960s–1970s, the period of highest contamination. Contaminants extracted from L. Ontario eels captured in 1988 and 1998 and archived in frozen storage were embryotoxic when injected into the eggs of mummichog. However, extracts from eels captured in 2008 were not toxic to embryos of mummichog or Japanese medaka. In 2008, extracts of eels from other locations on the St Lawrence River and estuary, and from Gaspé and Maritime rivers, were also non-toxic, in contrast to extracts of Hudson R. eels and European eels from a highly contaminated site in Belgium.

Abstract 6th SETAC World Congress 2012, Berlin, 20–24 May 2012

Contamination Status and Spatial Distribution of Persistent Chlorinated and Brominated Organic Contaminants in the European Eel (*Anguilla anguilla*) in Flanders, Belgium.

Govindan Malarvannan, Claude Belpaire, Caroline Geeraerts, Hugo Neels, Adrian Covaci.

Pooled yellow eel (*Anguilla anguilla* (L.)) samples, consisting of 3–10 eels, collected between 2000 and 2009 from 60 locations in Flanders (Belgium) were investigated for their content of lipohpilic and persistent contaminants, such as polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs) and hexabromocyclododecanes (HBCDs). Eel is a fatty and sedentary fish species, assuring a high accumulation of lipophilic contaminants and providing a representative estimate of contamination patterns within the catching area. European eel stocks are in decline in most of their geographical distribution and their status is considered below safe biological limits. A variety of contaminants have been found to affect the eel and effects were reported on several levels of biological organization, including population level. The aims of the present study were to investigate the current PCB, PBDE and HBCD contamination levels in wild eels throughout a biomonitoring network in the freshwater system in Flanders, Belgium. The current study expands the knowledge regarding these contaminant concentrations, their patterns, distribution profiles and time trends in aquatic ecosystems. PCBs, PBDEs and HBCDs were detected in all analyzed eel samples and some samples had high concentrations (up to 41 600, 1400, 9500 ng/g lipid wt., respectively). CB-153 was the most dominant PCB congener, closely followed by CB-138 and CB-149. Among PBDEs, BDE-47, -100 and -99 were the predominant congeners, similar to the composition reported in the literature. For HBCDs, α-HBCD was predominant followed by □and β- isomers in almost all eel samples. The broad range in PCB, PBDE and HBCD concentrations reported in the current study is likely due to the variety in sampling locations, from highly industrialized areas to small rural creeks. PCB levels accounted for the majority of the contamination in most samples. The contribution to the total human exposure through local wild eel consumption was also highly variable. Some eels (16 sites) exceeded largely the new EU consumption threshold for PCBs (300 ng/g ww for the sum 6 indicator PCBs: CB-28, -52, -101, -138, -153 and -180). The current data show an ongoing exposure of Flemish eels to PCBs, PBDEs and HBCDs through indirect release from sediments or direct releases from various industries. Therefore concerns are raised regarding the impact of these contaminants on eels and on the human exposure close to industrialized hotspots.

Abstract 10th International Congress on the Biology of Fish, Madison, July 15–19, 2012

Comparative study of the accumulation of heavy metals and organochlorinated compounds in muscle, liver and brain of European eels *Anguilla anguilla* L. from Belgium.

D. Scaion, C. Belpaire, A. Lebel, J-P. Thomé, M. Leermaker, C. Debier, F. Silvestre, J-F. Rees and P. Kestemont.

Stocks of European eel *Anguilla anguilla* have shown a rapid decline, and contamination with xenobiotics has been suggested to play an important role in this collapse. 69 wild yellow eels have been collected in 23 sites in Belgium, and 18 metals, mercury, methylmercury and organochlorinated compounds (eight polychlorinated biphenyls and six organochlorinae pesticides) have been measured in the brain, liver and muscle tissues. The results show that brain contamination pattern is different to liver and muscle. Brain exhibits for most of toxic heavy metals significant difference in accumulation between tissue; especially for mercury suggesting different forms present. Brain PCB profile is different from liver and muscle. Concerning hexachlorocyclohexane (HCH) and dichlorodiphenyltrichloroethane (DDT), a higher concentration of α-HCH is detected in the brain as in the liver, then, concentration of β-HCH+lindane is far higher in the brain than in other tissues. Finally, for summarize, brain appears to be the main target organ for lipophilic organic pollutants. Significant accumulation of xenobiotics in the brain could lead to neurological effects and induce physiological or behavioural disturbances which may jeopardise reproductive migration.

Abstract Dioxin 2012, 26–31 August, Cairns, Australia

Spatial distribution of persistent chlorinated and brominated organic contaminants in the European eel in Flanders, Belgium

Malarvannan G, Belpaire C, Geeraerts C, Neels H, Covaci A.

The European eel (*Anguilla anguilla* (L.)) stock is in steep decline. Several suggestions have been made on the reasons of this decline: extensive fisheries on all life stages, climate change, pollution, endocrine disruption, insufficient energy for migration, oceanic changes, habitat loss, migration barriers, diseases and others. Due to its complex life cycle, very little is yet known about the eel's reproduction. It is unclear if reproductive failure, if taking place, is due to fewer eels reaching the Sargasso Sea due to low fat content and related energy reserves or due to effects of chemicals on the reproduction itself. Two large and independent datasets from Belgium and The Netherlands showed on an average of one-third decrease in fat content of yellow eels over the past 15 years, and this decrease could have been caused by the bioaccumulation of toxic substances during the eel's growth. Eel is a fatty fish species, which leads to a high accumulation of lipophilic contaminants, such as polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs) and hexabromocyclododecanes (HBCDs). The aim of the present study was to investigate the current PCB, PBDE and HBCD levels in wild eels from the freshwater system of Flanders, Belgium. Yellow eel stage was chosen as a bio-indicator for the monitoring of environmental contaminants as this stage is characterised by primarily sedentary behaviour. Additionally, we aimed at enhance our knowledge on these contaminant concentrations, their patterns and distribution profiles in aquatic ecosystems.

The contribution to the total human exposure through the consumption of local wild eel was highly variable. Some eels (16 sites) exceeded largely the new EU consumption threshold for PCBs (300 ng/g ww for the sum 6 indicator PCBs: CB 28, 52, 101, 138, 153 and 180; data not shown). Mean Sum of 6 PCBs measured in wild eels is 100 fold higher than the mean value of 7.1 ng/g ww in fish and seafood from the Belgian market. Intake of PBDEs and HBCDs, through consumption of wild eel, is below the RfD values for the average population (2.9 g

eel/day), although the exposure of risk groups/fishermen (12–86 g eel/day) significantly exceeds these levels (data not shown). PCB intake seems to be at a level of high concern, and body burden in fishermen in Flanders might reach levels of toxicological relevance.

Abstract Dioxin 2012, 26–31 August, Cairns, Australia

Identification of unknown organohalogenated compounds in eel samples from Burrishoole catchment, Ireland.

Covaci A, Ionas AC, Malarvannan G, Weiss JM, McHugh B, Poole R, White P, Belpaire C.

European eel (*Anguilla anguilla* L.) has been frequently used as a bioindicator for the monitoring of POPs, because this stage is characterised by primarily sedentary behaviour. In this way, the analysis of eel samples gives a representative description of contamination patterns in the close vicinity of the areas where it was caught. Furthermore, eel is a fish with high body fat percentage and a long lifespan, assuring an optimal accumulation of lipophilic contaminants, such as PCBs or brominated flame retardants (BFRs). Recently, it has been suggested that PCBs, dioxin-like chemicals and other POPs may play an important role in the actual decline of the European eel, although causative relationships between chemical exposure and effects on population level are difficult to demonstrate, considering the complex life cycle of this species.

During the Eeliad project (an EU FP7 research project, www.eeliad.com), silver eels were sampled from ten different European catchments. Samples have been analyzed for a broad range of POPs, which included PCBs, PBDEs, HBCDs and OCPs. However, during the analysis of eel extracts from the Burrishoole catchment, western Ireland, a number of peaks with a signal much more intense than that of PBDEs were seen in the ECNI chromatogram, acquired in SIM for m/z 79 and 81. It was clear that these unknown compounds were brominated, but their identity could not be confirmed with this analytical setup. We present here the tentative structural identification of these unknown peaks in eels from Burrishoole, Ireland using a number of GC-MS techniques.

Elevated OCDD levels in biota have often been associated with pentachlorphenol (PCP) contamination. While PCP levels may be historic in origin, it is not uncommon for the parent PCP to be at low concentrations in biota, with the more persistent by-products of the manufacture of PCP (e.g. OCDD and PCDEs) being accumulated within biota. Analysis of PCP and its more stable metabolic product, pentachloroanisol (PCA), in sediment and eels collected between 2005 and 2009 from the Burrishoole catchment has not shown elevated levels relative to reference locations. Yet, this is not unexpected given the ease of PCP metabolism in organisms. Literature-derived PCDD/F profiles in technical PCP suggest that the PCDD/F profile in Burrishoole eels is more similar to that of PCP formulations rather than to that of other Irish eels.

Abstract from 6th World Fisheries Congress, Edinburgh, United Kingdom, 7–12 May 2012

Is the EU Dioxin Regulation contributing to the Restoration of the Eel Stock?

Belpaire C, Brinker A, Ferrante M, Geeraerts C, Hoogenboom R, Kotterman M, Leblanc JC, Leroy D, Macgregor K, McHugh B, Poole R, Schindehütte K, Szlinder-Richert J, Thome JP, Vinkx C, Wahl K.

The European eel *Anguilla anguilla* is in decline and several international measures have been taken to restore the stocks: the species is listed by CITES on the Appendix II list and by IUCN as critically endangered, and is the object of an EU eel recovery plan (Council Regulation EC No 1100/2007). The latter is focusing on recovering the stock to a defined silver eel escapement target. One of the possible management options outlined in this Regulation is to close or restrict the eel fisheries, aiming to maximize silver eel escapement. Another recent EU regulation, the Dioxin Regulation (Commission Regulation EC No 1881/2006), indirectly has a significant impact on the eel, as very recently professional and/or recreational eel fisheries have been closed or restricted in a number of catchments (e.g. in The Netherlands, Belgium and France). Dioxin and PCB levels recorded in the eel warranted closure of the fisheries to protect human health. It is anticipated that the recent update of the Dioxin Regulation (including maximum levels for non-dioxin like PCBs and updating TEFs, applying since 1 January 2012) will have similar constraints. Considering the high contaminant levels in the eels saved by this regulation, it is however questionable how much these human health based fisheries restrictions contribute to stock restoration. This paper describes and discusses the impact of the Dioxin Regulation on the stock and stock recovery, using recent data of dioxin and PCB levels in eel from several countries. By assessing and comparing combined quantity and quality of local eel stocks, indications are presented about their potential contribution to the spawning stock biomass.

Abstract from 6th World Fisheries Congress, Edinburgh, United Kingdom, 7–12 May 2012

Feunteun, E., Acou A., Aarestrup K., Amhilat E., Becerra Jurado B., Belpaire C., Boisneau C., Bustamante P., Cargan P., Covaci A., Dufour S., Faliex B, Gerard C., Lobón-Cerviá J., Maes G., Poole R., Virag L., Walker A., Wickström H., Righton D.

Are life-history traits and quality of European silver eels (*Anguilla anguilla*) affected by organic and metallic pollutants and parasites? A large scale approach.

Individual biological traits of silver European eels sampled across the species geographic range were measured to assess the reproductive ‘quality’ of the eels; e.g. an expression of their ability to migrate, to breed successfully and to produce a viable offspring, in relation to geography, catchment characteristics and contamination with a broad range of metals and persistent organic pollutants. We sampled 13 different catchments from Sweden to Spain, and flowing to the Baltic, the North Sea, the Atlantic Ocean and the Mediterranean Sea. For each eel the quality was inferred from a large range of life-history traits derived from biometric measurements (i.e. length, weight, eye diameter, pectoral fin dimensions, girth), estimated age from otoliths, calculated condition indices (i.e. body condition, fat content, GSI, HSI), measured hormonal status (11 kt) and undertook otolith microchemistry to determine the life history of each eel. The parasite loads, including *Anguillicoloides crassus* but also monogeans and *Acanthocephalus* were also determined. These characteristics are combined to provide assessment of the eels’ ‘quality’. Our results, which represent the most comprehensive assessment of silver eel quality undertaken to date, will enable us to explore the general patterns of age and size at silvering, life-history traits and ‘quality’ of eels and the possible effects of contamination and parasite loads. These results underline the requirement to take regional differences in life history into account when designing Europe-wide management measures to protect eel populations.

Abstract from 6th World Fisheries Congress, Edinburgh, United Kingdom, 7–12 May 2012

Evolutionary implications of differential gene expression and poor health of European eel populations chronically exposed to environmental pollutants.

Maes, Gregory*, Volckaert, Filip, Raeymaekers, Joost, Geeraerts, Caroline, Belpaire, Claude.

Understanding the long-term effects of chronic exposure to pollutants on the genome and transcriptome of diadromous fish populations is crucial for their evolutionary resilience under combined anthropogenic and environmental selective pressures. The catadromous European eel (*Anguilla anguilla* L.) has suffered a dramatic decline in recruitment for three decades, necessitating a thorough assessment of the genetic effects of environmental pollutants on resident and migrating eels in natural systems. We investigated the relation between muscular bioaccumulation levels of metals (Hg, Cd, Pb, Cu, Zn, Ni, Cr, As and Se), PCBs and organochlorine pesticides (DDTs), the health status (condition factor and lipid reserves) and the associated transcriptional response in liver, gill and brain tissues for genes involved in metal detoxification, oxidative metabolism of xenobiotic compounds, osmoregulation, maturation and energy metabolism. As well resident yellow eels originating from three Belgian river basins (Scheldt, Meuse and Yser) as migrating silver eels were analyzed. There was a large spatial variation in intensity and contaminant profile, while pollution levels were strongly and negatively associated with condition indices, suggesting an important impact of pollution on the health of subadult resident eels. Gene expression patterns revealed a complex response mechanism to a cocktail of pollutants, with a high variation at low polluted levels, but strongly down-regulated hepatic and gill gene expression in highly polluted eels. Resident eels clearly experience a high pollution burden and seem to show a dysfunctional gene expression regulation of detoxification genes at higher pollutant levels, correlated with low energy reserves and condition. Analyzing the transcriptome-wide gene expression response would be appropriate to unveil the complex responses associated with multiple interacting stressors and the long-term consequences at the entire species level.

11.4 Predators

Flemish Region

New information on the occurrence and distribution of the cormorant has been provided for Flanders in the Belgian EMP.

It was estimated that the yearly consumption of eels by cormorants amounts 5.6–5.8 tonnes for Flanders.

Walloon Region

For the Walloon region, no new data were available for 2010. See 2008 report and the Belgian Eel Management Plan.

12 Other sampling

Information on habitat, water quality, migration barriers, turbines is available in the Belgian Eel Management Plan.

13 Stock assessment

13.1 Local stock assessment

13.2 International stock assessment

13.2.1 Habitat

Wetted Area: lacustrine

riverine

transitional and lagoon

coastal

See EMP.

13.2.2 Silver eel production

Table 8. Current silver eel escapement in relation to the objectives of the Belgian EMP (as reported in Vlietinck *et al.*, 2012).

River district and EMU		Surface of water courses (ha)	B_0	B_{best}	ΣF	ΣH	ΣA =ΣF+ΣH	$B_{current}$ =B_{best}− ΣA	R	% actually escaping =$B_{current}/B_0$
		hectare	ton							%
Scheldt	Flanders	16.613	165	39	6,0	1,27	7,3	32	0	**19%**
	Brussels	78	0,8	0,2	0	0,05	0,05	0,15	0	**19%**
	Wallonia	2.219	22	2,1	0	0,1	0,1	2	0	**9%**
	Subtotal Scheldt	*18.910*	*187*	*41*	*6*	*1*	*7*	*34*	*0*	***18%***
Meuse	Flanders	1.439	14	4,3	0,7	0,24	0,9	3	0	**24%**
	Wallonia	4.000	39,5	34,3	0	24,1	24,1	10,2	0	**26%**
	Subtotal Meuse	*5.439*	*54*	*39*	*1*	*24*	*25*	*14*	*0*	***25%***
Belgium (Scheldt+ Meuse)	**Total**	**24.349**	**241**	**80**	**7**	**26**	**32**	**47**	**0**	**20%**

B_0: The amount of silver eel biomass that would have existed if no anthropogenic influences had impacted the stock.

$B_{current}$: The amount of silver eel biomass that currently escapes to the sea to spawn.

B_{best}: The amount of silver eel biomass that would have existed if no anthropogenic influences had impacted the current stock.

ΣF: The fishing mortality rate, summed over the age-groups in the stock, and the reduction effected.

ΣH: The anthropogenic mortality rate outside the fishery, summed over the age-groups in the stock, and the reduction effected.

R: The amount of glass eel (of the glass eel caught) and used for restocking within the country.

ΣA: The sum of anthropogenic mortalities, i.e. ΣA = ΣF + ΣH.

B_0 is in the Regulation, as a denominator for the 40%, and in Art 2.5.

$B_{current}$ is in the Regulation, as the nominator of the proportion of silver eel biomass actually escaping, in Art 9.1 a.

ΣH is in the Regulation, in Art 9.1c ('level of mortality factors').

B_{best} is not in the Regulation. It could be calculated from $B_{current}$, ΣF and ΣH. In line with the ICES framework this would allow for a cross-check in the interpretation of the quantities above.

R is in the regulation, in Art 9.1 d, ('the amount of eel less than 12 cm in length caught and the proportions of this utilised for different purposes').

13.2.3 Stocking requirement eels <20 cm

The Belgian EMP describes an evaluation of the biomass of eels <20 cm required to stock Belgian waters. Figures are based on a restocking rate of 1 kg/ha.

Table 9. Stocking requirements of glass eel and small eel as estimated in the Belgian EMP.

Region	Surface suited for restocking	Restocking rate	Amount required
Flemish Region	1500 ha	1 kg/ha	1500 kg glass eel
Walloon region	700 ha	1 kg/ha	700 kg eel <20 cm

13.2.4 Summary data on glass eel

Table 10. Summary data on glass eel for Belgium.

Year	Region	Used in stocking Amount (kg)	Origin	Commercial fishery	Export	Aquaculture	Mortalities	Consumed
2008	Flanders	125	UK	0	0	0	0	0
2009	Flanders	152	France	0	0	0	0	0
2010	Flanders	143	France	0	0	0	0	0
2011	Wallonia	40	UK	0	0	0	0	0
2011	Flanders	120	France	0	0	0	0	0
2012	Flanders	156	France	0	0	0	0	0
2012	Wallonia	50	France	0	0	0	0	0

13.2.5 Data quality issues

14 Sampling intensity and precision

Until now, no special eel stock assessment in the framework of the Belgian Eel Management Plan has been set up.

15 Standardisation and harmonisation of methodology

Until now, no special eel stock assessment in the framework of the Belgian Eel Management Plan has been set up.

15.1 Survey techniques

15.2 Sampling commercial catches

15.3 Sampling

15.4 Age analysis

15.5 Life stages

15.6 Sex determinations

16 Overview, conclusions and recommendations

Conclusion

Recent (2011–2012) data from recruitment-series or other scientific stock indicators in Belgium indicate a further decrease of the stock, although the glass eel recruitment at Nieuwpoort (River Yzer) showed an increase with recent years.

Special fisheries management actions to restore the stocks in Flanders are confined to the prohibition of the semi-professional fyke fisheries in the Lower Scheldt. In the Walloon region eel fishing is prohibited to avoid human consumption of contaminated eels.

In Flanders, restocking practises with glass eel are going as in former years. Glass eel restocking activities are not taking account of the variation in eel quality (diseases/contamination) of the restocking sites. In the Walloon Region restocking with glass eel has been initiated in 2011 and continued in 2012.

In Belgium, habitat and water quality restoration is a (slow) ongoing process within the framework of other regulations, especially the Water Framework Directive and the Benelux Decision for the Free Migration of Fish (which has been reformulated in 2009). Numerous migration barriers, pumps and hydropower stations still affect the free movement of eels and many rivers and brooks still have an insufficient water quality to allow normal fish life.

Specific programs for eel sampling and other biological sampling for stock assessment purposes of eel as required in the context of the Belgian EMP has not been initiated until now.

Recommendations

It is recommended that the sampling programmes as required in the Belgian EMP and the European restoration plan is initiated asap.

Considering further downward trend in the stock indicators, additional protection of the local stock is required. In the Walloon Region the harvest of eels by recreational fishermen is prohibited for human health considerations (as the eels are contaminated). Similarly Flanders could envisage the same management option. Eels from many places in Flanders are considerably contaminated and their consumption presents risks for human health. Furthermore apparently recreational fishermen are not reluctant for a limitation in eel fishing. Putting in place a catch and release obligation in Flanders would save 30 tons of eel on annual basis.

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Report on the eel stock and fishery in Denmark 2011/'12

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Reporting Period: This report was completed in August 2012, and contains data up to 2011 and some provisional data for 2012.

2 Introduction

The eel can be found in fresh and marine waters all along the ca. 7000 km Danish coast line. In the marine areas relatively dense eel populations are found in shallow water on the protected coast (e.g. in Bays and Lagoons) contrary to the open coast where assumed fewer eels are present. In inland waters eels may be found in ponds, lakes and streams throughout the country.

The economical important eel fisheries are concentrated in the southern and eastern parts of Denmark. Here local and Baltic silver eels are exploited during the spawning migration while passing through the Danish straits heading to the North Sea. These fisheries catch the emigrating eel by poundnets out to the 10+ meter depth line.

A combined yellow and silver eel fishery takes place, throughout the country, in shallow Fjords, Bays, Lagoons and Inland waters. Most of the catch ca. 97% is reported from marine areas reflecting professional fisheries in freshwater are few compared to the marine.

From 1st July 2009 the eel is managed according to the EU regulation, aiming at 40% (relative to the prestine) silver eel escapement in freshwater and 50% effort reduction in the marine waters. The Danish territory is managed as one freshwater EMU excluding two small transboundary river basins named Kruså and Vidå shared with Germany. Intermediate and coastal waters are treated together with community waters constituting the entire marine area.

From 1st July 2009, professional fishing operations are based on licenses and landings and number and type of gear must be registered with the Danish AgriFish Agency. The professional fishermen in saline areas are given a licence to use a limited number of gear in order to meet the 50% reduction within five years following the EU eel regulation.

Recreational fishermen operating in the marine may use six fykenets or 6 hooklines but in a reduced period of the year. Fishing is closed from the 10th of May to 31th of July to reduce effort by 50%.

In freshwater a few professional fishermen are given a licence to use a limited number of gears. For landowners and recreational fishermen the fishing season has been limited to a period of 2.5 months and fishing is closed from 16 October–31 July.

The escapement target of 40% in freshwater has been calculated to be achieved after ca. 85 years if a total ban on freshwater fisheries will commence. Licences are provisionally issued until 31st December 2013. The Ministry of Food, Agriculture and Fisheries may implement further reductions pending the development in the eel stock.

3 Time-series data

3.1 Recruitment series and associated effort

No data.

3.1.1 Glass eel

3.1.1.1 Commercial

No data; glass eel fishery is forbidden.

3.1.1.2 Recreational

No data.

3.1.1.3 Fishery independent

No data.

3.1.2 Yellow eel recruitment

The recruitment of young eels to Danish freshwater is currently monitored in passtraps at Harte hydropower stations in river Kolding Å and at Tange hydropower station in river Guden Å. Both rivers empty into Kattegat on the east coast of Jutland. On the west coast of Jutland no passive trapping facilities are available. Here the recruitment is monitored in Vester Vedsted brook using an annual population surveys (electro fishing four sections three times a year) in a small brook by the Wadden Sea. (Further details in Pedersen (2002)).

At Harte Hydro power station the condition for monitoring recruitment has changed. As part of a river restoration project in River Kolding Å, the water supply to Harte Hydropower station has been reduced by 60% since spring/summer 2008. The effect of lower water supply to the trapping site is a marked decrease in recruitment at Harte hydropower station from 2008. This is the second time a major change of eel monitoring in River Kolding Å has taken place since monitoring started in 1967. The first change was in 1991, a bypass stream was made at the Stubdrup Weir allowing eels to bypass and the trapping facility was terminated in 1990. This is also reflected in the recruitment data (Table 3.1.2).

Table 3.1.2. Recruitment data from Tange and Harte Hydropower stations and Vester Vedsted brook. Mean density during the year and maximum density at any electrofishing occasion.

Year	Tange	Harte	Vester Vedsted brook	Year	Tange	Harte	Vester Vedsted brook	Year	Tange	Harte	Vester Vedsted brook			
			Density eel/m²				Density eel/m²				Density eel/m²			
Year	Kg	Kg	Mean	Max (season)	Year	Kg	Kg	Mean	Max (season)	Year	Kg	Kg	Mean	Max (season)
1967		500	-	-	1983	146	164	-	-	1998	29	18	0.3	0.4
1968		200	-	-	1984	84	172	-	-	1999	346	15	0.4	0.5
1969		175	-	-	1985	315	446	-	-	2000	88	18	0.6	0.7
1970		235	-	-	1986	676	260	-	-	2001	239	11	0.6	0.8
1971		59	-	-	1987	145	105	-	-	2002	278	17	0.5	0.6
1973		117	-	-	1988	252	253	-	-	2003	260	9	0.6	0.7
1974		212	-	-	1989	354	145	-	-	2004	246	9	0.3	0.4
1975		325	-	-	1990	367	101	-	-	2005	88	7	0.5	0.5
1976		91	-	-	1991	434	44	-	-	2006	123	7	0.3	0.7
1977		386	-	-	1992	53	40	-	-	2007	62	7	0.4	0.5
1978		334	-	-	1993	93	26	-	-	2008	131	0.9	0.2	0.2
1979		291	2.8	6.5	1994	312	35	-	-	2009	20	1.3	0.2	0.2
1980	93	522	7	13	1995	83	23	2.6	2.6	2010	14	5	0.2	0.4
1981	187	279	7.8	13	1996	56	6	4.6	6.8	2011	84.6	3.6	0.3	0.3
1982	257	239	-	-	1997	390	9	0.7	1	2012			0.1	0.2

3.1.2.1 Commercial

No data.

3.1.2.2 Recreational

No data.

3.1.2.3 Freshwater independent

No data.

3.2 Yellow eel landings

3.2.1 Commercial

The time-series on Yellow eel landing below (see Section 3.3.1).

3.2.2 Recreational

Available information is reported below (see Section 3.3.2 recreational).

3.3 Silver eel landings

3.3.1 Commercial

The official data on separate landings of yellow and silver eel in fresh and salt water is given below. Data origin is catch reports by commercial fishermen reported to the ministry. From the middle of 2009 catches are only reported from those given a licence to fish for eel.

Table 3.3.1.1. Freshwater landings (ton) of yellow and silver eels.

Year	Silver	Yellow	Total	Year	Silver	Yellow	Total	Year	Silver	Yellow	Total
1960	-	-	214	1978	-	-	157	1996	-	-	34
1961	-	-	235	1979	-	-	78	1997	-	-	39
1962	-	-	215	1980	-	-	147	1998	-	-	40
1963	-	-	238	1981	-	-	140	1999	-	-	30
1964	-	-	223	1982	-	-	163	2000	4	24	28
1965	-	-	205	1983	-	-	116	2001	2	34	36
1966	-	-	211	1984	-	-	126	2002	5	27	27
1967	-	-	243	1985	-	-	111	2003	2	21	24
1968	-	-	258	1986	-	-	120	2004	4	12	15
1969	-	-	254	1987	-	-	90	2005	3	10	14
1970	-	-	249	1988	-	-	119	2006	7	8	14
1971	-	-	183	1989	-	-	114	2007	5	6	11
1972	-	-	200	1990	-	-	107	2008	5	4	9
1973	-	-	201	1991	-	-	99	2009	8	5	13
1974	-	-	163	1992	-	-	109	2010	10	3	13
1975	-	-	260	1993	-	-	57	2011	11	4	15
1976	-	-	178	1994	-	-	60	2012			
1977	-	-	179	1995	-	-	52	2013			

Table 3.3.1.2. Marine landings (ton) of yellow and silver eels.

Year	Silver	Yellow	Total	Year	Silver	Yellow	Total	Year	Silver	Yellow	Total
1960	2756	1967	4509	1978	1187	1148	2178	1996	381	336.5	684
1961	2098	1777	3640	1979	887	939	1748	1997	375	383	719
1962	2132	1775	3692	1980	911	1230	1994	1998	306	251	517
1963	1837	2091	3690	1981	897	1190	1947	1999	380	307	657
1964	1417	1865	3059	1982	1003	1375	2215	2000	382	218	572
1965	1498	1699	2992	1983	884	1119	1887	2001	446	225	635
1966	1829	1861	3479	1984	830	915	1619	2002	365	217	555
1967	1673	1763	3193	1985	793	726	1408	2003	437	188	601
1968	2063	2155	3960	1986	818	734	1432	2004	343	187	516
1969	1552	2072	3370	1987	538	651	1099	2005	372	149	506
1970	1470	1839	3060	1988	799	960	1640	2006	427	154	567
1971	1490	1705	3012	1989	785	797	1468	2007	411	115	515
1972	1662	1567	3029	1990	834	734	1461	2008	364	93	448
1973	1697	1758	3254	1991	724	642	1267	2009	367	87	454
1974	1378	1436	2651	1992	687	655	1233	2010	304	105	409
1975	1534	1691	2965	1993	523	500	966	2011	271	84	355
1976	1477	1399	2698	1994	509	631	1080	2012			
1977	1141	1182	2144	1995	408	432	788	2013			

3.3.2 Recreational

An interview survey among recreational marine fishermen revealed landings of a 100 tonne of eel in 2009. Recreational fishermen are only allowed to use fykenets and the catch supposedly consists mostly of yellow eels**.** The reduction in recreational fishery in marine waters is estimated to have been reduced from approximately 100 tonne in 2009 to approximately 80 tonnes in 2011.

The reduction in recreational fishery in freshwater is estimated to have been reduced by 50% from approximately 16 tonnes to 8 tonnes.

3.4 Aquaculture production

3.4.1 Seed supply

Glass eels to Danish aquaculture are imported from France and England. The eel farmers have reported to the Danish AgriFish Agency that 7002 tonnes of young eel was imported during 2011. That is possibly **glass eel** used as seed stock for the production presented in Table 3.4.1.

3.4.2 Production

Aquaculture production of eel in Denmark started in 1984. The production takes place at eight indoor, heated aquaculture systems.

Table 3.4. Annual aquaculture eel production (1984–2011).

Year	Production Units	Production [ton]	Year	Production units	Production [ton]
1984	??	18	1998	28	2483
1985	30	40	1999	27	2718
1986	30	200	2000	25	2674
1987	30	240	2001	17	2000
1988	32	195	2002	16	1880
1989	40	430	2003	13	2050
1990	47	586	2004	9	1500
1991	43	866	2005	9	1700
1992	41	748	2006	9	1900
1993	35	782	2007	9	1617
1994	30	1034	2008	9	1740
1995	29	1324	2009	9	1707
1996	28	1568	2010	9	1537
1997	30	1913	2011	8	1156

Table 3.4.1. Usage of aquaculture production 2011 (Source: Danish AgriFish Agency).

Usage / size		Biomass kilo	Mean weight of eel (kg)	Number	Glass eel used. kg
Stocking	Small/young fish (stocking export)	10,133	0,006	1,688,833	676
	Dk stocking (3,5 g)	5,369	0,004	1,534,000	614
	Large fish	2.000	0.150	13.333	5
Live export	Large fish	322.540	0.150	2.150.267	860
	Small/young fish	14.500	0.006	2.416.667	967
Consumption	Large fish	799.466	0.150	5.329.773	2132
Dead/destroyed	Large fish	1.933	0.150	12.887	5
Total		1.155.941		13.145.760	5258

Mortality in aquaculture takes place in the early growth stage before reaching the size of 3 gram. After 3 gram mortality is insignificant (Pers com. M. Lauritsen, Jupiter eel and O. Soerensen, Steensgaard eel). The mortality in aquaculture from glass eel to the weight of 3 gram eel is ca. 17%. Therefore, one kilo of glass eel (3000 glass eel) make up 2500 individuals at size 3 gram or larger.

The price per kilo glass eel purchased in France in 2011 was on average € 400 (300–425).

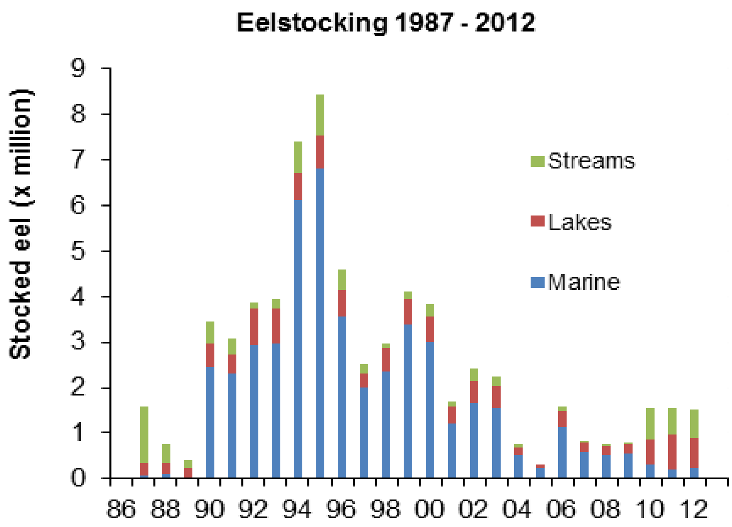
3.5 Stocking

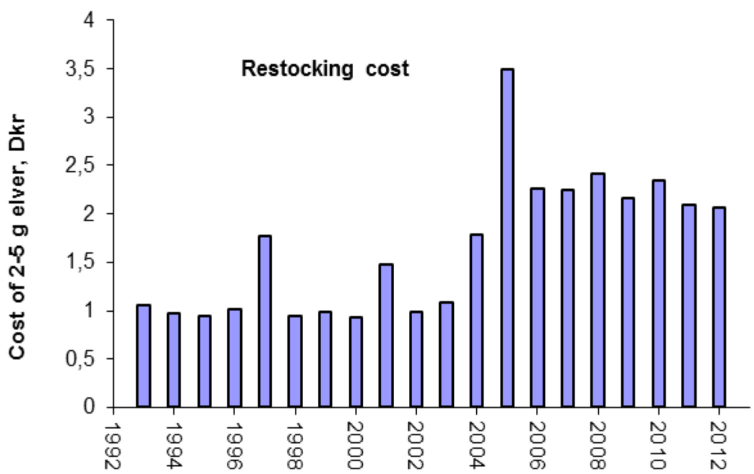
3.5.1 Amount stocked

In 2012 a total of 1284 million eels of size 2–5 gram were stocked in lakes and rivers as a management measure and 0.25 million was stocked in marine waters (Table 3.5.1 below).

Restocking has taken place for decades by fishermen in inland waters, in places where recruitment of young eel was limited or absent, because of migration barriers or distance to the ocean. From mid-1960s to the end of the 1980s a number of licences were given to sell young eels for restocking. These eels were captured at passtraps and glass eels at the sluices in the Wadden Sea. This is now forbidden due to the low recruitment. In 1987 a restocking programme has been financed by the Danish Government and the eel fishermen. Since 1994 the restocking programme has been financed solely by the recreational licence fee.

The eels stocked today are imported, as glass eels mostly from France and are grown to a weight of 2–5 grammes in heated culture before they are stocked. The amount stocked has been decreasing during the last years because the price for stocked eel has increased dramatically in the same period.





Figures 3.5.1. Restocking of elvers (2–5 g) in marine and fresh waters from 1987–2012 (numbers in millions) and cost per stocked eel.

Table 3.5.1. Restocking of elvers (2–5 g) in marine and fresh waters from 1987–2012. Numbers of eels stocked (in millions).

Year	Marine	Lake	River	Total	Year	Marine	Lake	River	Total
1987	0.07	0.26	1.26	1.58	2000	3.02	0.55	0.25	3.83
1988	0.11	0.24	0.4	0.75	2001	1.2	0.38	0.12	1.7
1989	0	0.24	0.17	0.42	2002	1.66	0.47	0.3	2.43
1990	2.46	0.49	0.51	3.47	2003	1.54	0.49	0.22	2.24
1991	2.3	0.44	0.32	3.06	2004	0.52	0.18	0.06	0.75
1992	2.94	0.81	0.11	3.86	2005	0.24	0.06	0	0.3
1993	2.97	0.76	0.23	3.96	2006	1.15	0.35	0.1	1.6
1994	6.12	0.61	0.67	7.4	2007	0.59	0.21	0.02	0.83
1995	6.83	0.72	0.9	8.44	2008	0.52	0.19	0.04	0.75
1996	3.58	0.58	0.44	4.6	2009	0.55	0.20	0.05	0.81
1997	2.02	0.29	0.22	2.53	2010	0.30	0.57	0.67	1.55
1998	2.35	0.53	0.1	2.98	2011	0.20	0.77	0.59	1.56
1999	3.38	0.56	0.18	4.12	2012	0.25	0.64	0.64	1.53

3.5.2 Catch of eel <12 cm and proportion retained for restocking

No data; catch of small eels are not allowed.

4 Fishing capacity

4.1 Glass eel

No data; not allowed.

4.2 Yellow eel

No data.

4.3 Silver eel

No data.

4.4 Marine and freshwater fishery

From 1st July 2009, commercial eel fishing in marine and fresh waters are based on licences, and all gear must be registered with the Danish AgriFish Agency.

Commercial eel fishing effort and the reduction in fishing effort

Of the 783 commercial fishermen and entities with registered landings and registered poundnets in the reference period 2004–2006, a total of 525 applied for licences. A total of 406 commercial licences were allocated in 2009. Since then a total of 45 licences have been cancelled reducing the number of **active commercial fishing licences in 2012 to 361**. According to Danish national regulation stipulating the conditions for commercial eel fishery cancellation of inactive licences will be effected by the Danish fisheries authorities (Danish AgriFish Agency).

Table 4.4 below illustrates the level of commercial fishing effort that catches eel each year specified into types of gear and the gradual reduction in fishing effort from the period 2004–2006, 2007, 2009, 2010 and 2011 (Danish AgriFish Agency).

Table 4.4. The level of commercial fishing effort by gear type from 2004–2006 to 2011 (Danish AgriFish Agency).

	Fyke nets		Small Pound nets		Large Pound nets		Hook lines	
Number of gear	Number	Reduction	Number	Reduction	Number	reduction	Number	Reduction
Avg. 2004-2006	43.500 *		1.588		1.572		6.366	
2007	41.114	5,5%	1.578	0,6%	1.582	-0,6%	5.875	7,7%
2009	38.336	11,9%	1.292	18,6%	1.466	6,7%	1.932	69,7%
Ultimo 2010	33.661	22,6%	1.082	31,9%	1.177	25,1%	1.200	81,1%
Ultimo 2011	32.761	25,6%	1.000	37,0%	1.139	27,5%	1.200	81,1%

***The total number of 40 077 fykenets registered by the fishermen who applied for commercial eel licences in 2009 and an estimate of 3423 fykenets used by the 258 fishermen who reported landings of eel in the reference period 2004–2006 but who did not apply for eel licences in 2009.**

In May and June 2012 the Danish AgriFish Agency met with representatives from all segments of eel fishing and with environmental NGOs in order to give an up to date status of eel fishing and to inform of this report. As the reduction in the number of fykenets and large poundnets indicates a lower reduction rate, it was suggested that some commercial eel fishermen might hold licences to use more gear than is actually used for eel fishing. It was therefore decided that the Danish AgriFish Agency (and the Danish Fishermen's Association) later in 2012 will contact the commercial fishermen in order to adjust the individual fisherman's licence to the actual number of gear and thus obtain an expected further reduction in commercial eel fishing effort.

5 Fishing effort

5.1 Glass eel

No data.

5.2 Yellow eel

No data.

5.3 Silver eel

No data.

5.4 Marine fishery

No data.

6 Catches and landings

6.1 Glass eel

Not allowed.

6.2 Freshwater landings

Best estimate of freshwater eel catches for 2011 are 23 tonnes. The official landings reported to the ministry (Table 6.2) were 15 tonnes. Estimated recreational (including landowners) landings make up additional 8 tonnes.

Table 6.2. Freshwater landings (ton) from 2004–2011.

Year	Silver	Yellow	Total
2004	4	12	15
2005	3	10	14
2006	7	8	14
2007	5	6	11
2008	5	4	9
2009	8	5	13
2010	10	3	13
2011	11	4	15

6.3 Marine landings

The commercial marine fishery reported 355 tonnes of eel in 2011. The recreational fishery was estimated to have captured 80 tonnes. In total commercial and recreational landings were 435 tonnes of eel.

Table and Figure 6.3.1. Marine landings (ton) from 2004–2011.

Year	Silver	Yellow	Total
2004	343	187	531
2005	372	149	520
2006	427	154	581
2007	404	115	519
2008	364	93	457
2009	367	87	454
2010	304	105	409
2011	271	84	355

7 Catch per unit of effort

No data on catch per unit of effort.

8 Other anthropogenic impacts

Some mortality has been documented due to hydropower turbines especially from Tange Hydropower plant but not from Vestbirk Hydropower plant (see below). An estimate of mortality from all hydropower plants may be ~5 tonnes. At flow-through trout farms located at the bank of rivers the mortality is estimated at ~5 tonnes (see below).

Predation from cormorants and mammals in freshwater is difficult to estimate. An estimate is ~10 tonnes. Cormorants do eat eel from rivers and lakes but they mainly forage in coastal waters where results from Ringkøbing Fjord show a predation of

40% of stocked eel during the first year. Mortality outside the fishery adds up to 20 tonnes.

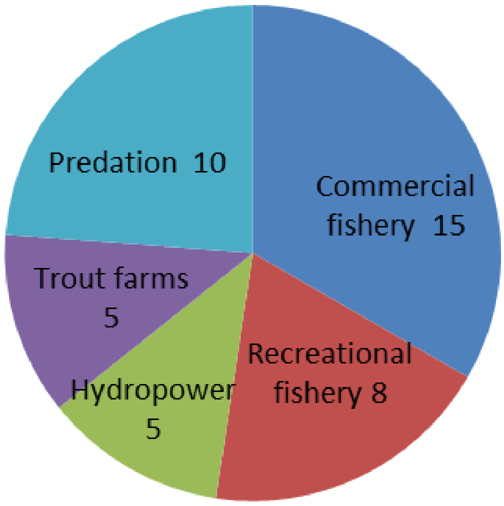


Figure 1. Best estimates of mortality (43 tonne) in freshwater. The number refers to tonne in each category.

8.1.1 Hydropower

In 2006 there were 43–61 hydroelectric power units in operation in Denmark. Since then several hydropower units have been closed down (e.g. Vilholdt, Karlsgårdeværket, Harte).

Danish legislation stipulates that physical screens with a maximum bar distance of 10 mm must be installed in front of hydropower turbines. Bypasses guiding the eel around the power plant are established at some power plants although at most power plants only fishladders to guide salmonids are present. The knowledge of the efficiency of the different bypasses for the downstream migrating silver eel is limited and may differ from place to place. It is known that fish impinge on the turbine screens and die there.

Recent research at the biggest hydropower unit in Denmark, Tange Hydropower plant, suggests that up to 77% of the eels are lost bypassing the Hydropower plant. There is no exact knowledge of the proportion of eels that impinge on the screens or are lost for other reason e.g. predation and fisheries but approximately 10% of the migrants overwinter upstream the power plant and resume migration in the next year. At Tange Hydropower plant there is a significant bypass problem for eels (Pedersen *et al.*, 2011).

At Vestbirk Hydro power station 25% of the water discharge is passed around the turbines in two bypass facilities. One bypass stream is the old river bed and the other is at the turbine screens guiding the fish around the turbines. The bypass facility seems appropriate and fish including eels do not impinge on the screens except at very low temperatures < 5°C in combination with very high water discharge. These situations usually occur during winter outside the normal eel migration period.

Similar problems likely appear at other hydropower facilities in e.g. Holstebro Hydropower plant. This has not yet been investigated.

8.1.2 Aquaculture

Danish trout farms are often located on the banks of rivers depending on water intake from the rivers. To guide the river water into the trout farm a weir is built in the river. Less than 250 trout farms use "flow through" river water and approximately ten have systems for recirculation of water. To prevent fish from entering the trout farms a screen with a maximum 6 mm bar distance is obligatory at the point of the water inflow and a maximum 10 mm bar distance at the point of outflow. Small eel can easily enter trout farms and are possibly predated by the trout. However, for the past years there has been an ongoing process in collaboration with municipal environmental authorities to improve measures for the unhindered migration of several different fish species.

Research in relation to weirs of trout farms have been conducted in connection with three trout farms in River Kongeåen and River Mattrup Å.

Mattrup Å. At Brejnholt trout farm in River Mattrup Å the National Institute of Aquatic Resources studied the behaviour of silver eels while bypassing the weir at the trout farm. The river water is guided into the farm by a weir and screens prevent the eels to enter the farm. Fish passage is through an overflow spillway at the weir and the water discharge in the spillway may be significantly reduced depending on the hydrological conditions. The study was conducted during two years. The first year the water discharge was low and only 56% of the eels bypassed the weir. The second year the river discharge was normal and several more eels succeeded to pass the weir (82%) during the same year as they were released. It was concluded that the weir had a significant effect in delaying migrating silver eels. The delay varied with water discharge in the migration period. It is therefore recommended that a constant amount of water in the fish pass should be available e.g. 25% of the river discharge to neutralize the effect of the weir (and screens are placed appropriate to guide the fish) (Pedersen, 2012).

In **River Kongeå** two trout farms are situated on the bank of the river at Vejen and Jedsted. In autumn 2011 forty fish were radio tagged and their downstream migration was monitored while passing the two trout farms. Both trout farms have 6 mm bar distance at the water intake. At Vejen fish farm several fish entered the fish farm despite the 6 mm bar screen which seems not correctly installed or damaged. At Jedsted no fish entered the fish farm and the screen was working well. If the screen at Vejen fish farm is fixed properly, eels would not be able to enter the fish farm. However, it is quite difficult to see by eye if there is any such problem at other comparable fish farms unless the place where the screen is mounted is dried out.

9 Scientific surveys of the stock

9.1 Glass eel monitoring

Weirs in streams are being removed as a part of National river restoration projects e.g. to meet the requirements of the water frame directive. Monitor young eel recruitment the traditionally way using eel passtraps has become more difficult. New methods and locations are urgently needed in order to monitor the effect of the EU regulation in terms of recruitment of young eel from the ocean.

Since 2008 three small brooks situated on the North Sea coast of Jutland were selected for monitoring. At each brook two stations of 10–20 m length (close to the shoreline <1000 m) are electrofished at three different times from May to August and the population of eels at each station is calculated using the removal method. The brooks have a water depth <50 cm and width 1–4 m.

The aim is to have this type of monitoring replacing eel passtraps but data quality issues are not clear. E.g. is the number of times that we electrofish during the year sufficient and is the number of stations large enough to reproduce a clear signal from the data?

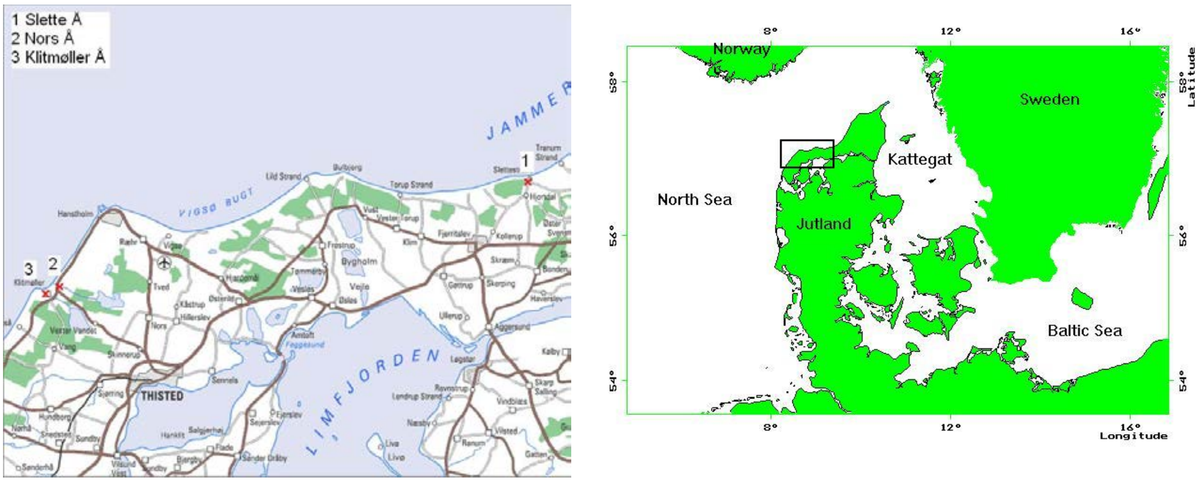
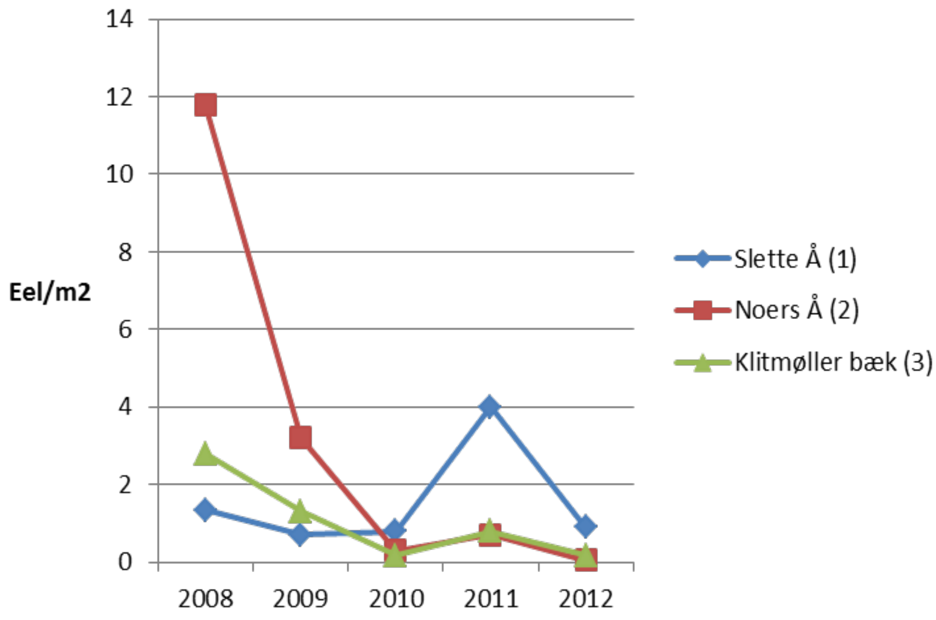


Figure 9.1. Map with New glass eel monitoring sites (1, 2 and 3) in the North Sea.

Table 9.1. Density of eel (eel/m²) as a mean of three different times of electrofishing starting medio May to medio August. The maximum density during the season is given.

	Slette Å (1)		Noers Å (2)		Klitmøller bæk (3)	
	Mean	Max,season	Mean	Max,season	Mean	Max,season
2008	1.4	1.4	11.8	11.8	2.8	2.8
2009	0.7	0.8	3.2	5.2	1.3	2.2
2010	0.8	1.0	0.3	0.3	0.2	0.2
2011	4.0	4.7	0.7	0.7	0.8	1.2
2012	0.9	1.1	0.1	1.7	0.2	0.2



Picture. The author monitoring glas eel recruitment in Slette Å. Photo by Jan Skriver.

9.2 Silver eel escapement from freshwater

In River Gudenå trapped silver eels are tagged annually with PIT tags and released during autumn. Downstream movements are monitored by remote listening stations. These data are believed suitable for evaluating silver eel escapement from the river Guden Å. including anthropogenic mortality due to fishing and turbines. Monitoring silver eel escapement in other river basins is currently considered. River Ribe å has been monitored in 2010 and will be again in 2013.

Production of silver eel in Lake Vester Vandet is monitored in an eel trap.

9.3 Effect of stocking

Concerning stocking and the expected outcome in relation to the recovery programme of the eel DTU Aqua have initiated a programme to monitor the effect by stocking tagged (cw) eels in selected areas. Also short time experiments in ponds have been initiated to evaluate fitness of stocked eel compared to wild eels.

10 Catch composition by age and length

Age and length data are collected at different sites (Arresø, Isefjord and Ringkøbing Fjord and other sites) as part of the DCF programme.

11 Other biological sampling

11.1 Length and weight and growth (DCR)

No relevant data.

11.2 Parasites and pathogens

The swimbladder parasite *Anguillicola crassus* is widely distributed throughout both brackish and fresh waters in Denmark. Monitoring of Anguillicola parasites takes place on a yearly basis at three locations. This was started in 1987 and 1988. The number of Anguillicola infected eels (prevalence) is relatively constant during 1987–2011 at all three locations.

Table 1. Anguillicola monitoring data for 2011.

Location	Salinity ppt	Coordinates	Year	Total	Infected	Prevalence	Intensity
				N	n	%	n
Arresø	0	55.59N;11.57E	2011	70	39	55.7	5.4
Isefjord	18	55.50N;11.50E	2011	100	43	43.0	2.9
Ringk. Fj	5–10	55.55N;08.20E	2011	66	45	68.2	3.6

11.3 Contaminants

No new data available.

11.4 Predators

Cormorants

Predation on eel may occur from various species of birds e.g. heron and cormorants and from mammals, e.g. otter, mink, seals and harbour porpoises. Cormorants are possibly the only important predators due to the large number of nesting birds; predation is expected to be largest in the vicinity of the colonies, but migrating birds may have significant impact during fall.

The number of cormorants nesting in Denmark during the last 10–15 years can be regarded as stable, but with downward trend. In the year 2000 42 481 nests were counted in colonies throughout Denmark. In 2010 there were 27 910 nests (see figure below).

In the Danish EMP it was suggested that in the period 2004–2006 approximately 80 tonnes of yellow eel was eaten by cormorants. However, recent work from Hirsholmene (57.29’N; 10.37’E) a cormorant colony in Kattegat analyzing 350 regurgitated pellets showed that eel otoliths occurred with a frequency of 0.3% (Poul Hald, 2007). The frequency of occurrence of eel otoliths found in cormorant pellets in 2005 was only 0.12% (Sonnesen, 2007) suggesting that wild eels are not important as food in Ringkøbing Fjord (55.55’N;08.20’E). However, despite this low occurrence the estimated number of eels eaten in Ringkøbing Fjord by cormorants in 2004 was 38 000-more individuals than was caught in the fishery-and recovery of cw-tags from 20 000 tagged stocked eels showed a 40% predation from cormorants during the first season (Jepsen *et al.*, 2010). Thus cormorant predation can be a very significant factor in areas with a high cormorant density. The number of cormorants in Ringkøbing Fjord is not higher than most coastal areas in Denmark.

Recent analyses of data from ongoing studies of silver eel migration using PIT tagging showed that even relative large silver eels can be eaten by cormorants as PIT tags were recovered from nearby colonies and roosting sites. The recoveries may provide a basis for quantification of the predation in future studies.

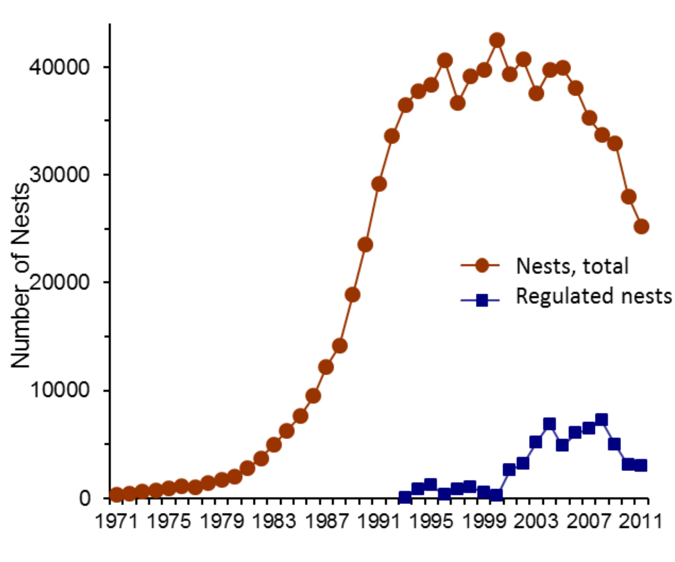


Figure 13.4. Number of cormorant nests in Denmark. Data from NERI. University of Århus.

12 Other sampling

No data.

13 Stock assessment

13.1 Local stock assessment

No data.

13.2 International stock assessment

13.2.1 Habitat

The present area of inland waters where eel may be found is approximately 15 000 ha of running water and 45 000 ha of lakes. Historic information suggests that before draining and land reclamation took place (during the 18th and 19th century) inland waters (i.e. permanent and temporary areas) covered 25% relative to the total Danish landmass. The present inland waters of 60 000 ha cover approximately 1.5% of the present landmass.

13.2.2 Silver eel production

13.2.2.1 Historic production

In determining potential silver eel escapement prior to the 1980s surveys using production models and mark–recapture studies have been used.

Silver eel production in Danish streams

Silver eel production in Køge Lellinge stream was estimated at about 105 kg/ha river (wetted area) (Rasmussen and Therkildsen, 1979). The estimate was based on the density of resident Yellow eels observed growth (derived from age reading) and mortality with data collected during the period 1965–1968. The estimate is therefore based on glass eel recruitment during the period from the late 1950s and early to mid-1960s one eel generation earlier. The population in Køge Lellinge stream consisted mostly of males with a mean silver eel weight of 100 grams. The experiment was undertaken in the lowest part of the stream and downstream of a weir; the estimate therefore cannot be taken as representative of silver eel escapement for the catchment as a whole but only for the lower part of the river.

Silver eel production in River Brede was estimated at 49 kg/ha river (wetted area) (Nielsen, 1982). The silver eel were caught in autumn 1981 using fykenets; escapement was estimated using mark–recapture and is thus based on the recruitment of glass eel during the period 1965–1975. The population of silver eel was 82% males and 18% females. Average weight of silver eels was 120 grammes.

Silver eel production in the River Bjornsholm was in 1988 estimated in the range 9–39 kg/ha river (wetted area) (Bisgaard and Pedersen, 1990). Densities of resident Yellow eel observed growth rate (derived from age reading) and mortality produced an estimate of 39 kg/ha river (wetted area). This compares to an estimate of 9 kg/ha river (wetted area) from mark-recapture on silver eel carried out in August and September and therefore should be considered a minimum estimate of escapement. Sex ratios of silver eel were 40% males and 60% females. The average weight of the silver eels was 280 grammes.

From the above studies it is proposed that 50 kg/ha (wetted area) represents "pristine" escapement for the freshwater environment. This translates into the 40% EU escapement target of 20 kg/ha (wetted area) of silver eel.

Silver eel production in Danish lakes

Silver eel escapement from lakes is estimated based on fisheries yield prior to 1980. Fisheries yield were then in the range of 3–5 kg/ha. Assuming fisheries mortality of F= 0.5 the production is roughly in the range of 6–10 kg/ha.

Potential silver eel escapement

The potential silver eel escapement from freshwater in the absence of anthropogenic mortality is estimated at 1110 tons prior to the 1980s. The figure is based on the present area of inland water.

Table 13.2.2.1. Potential silver eel escapement prior to the 1980s.

Inland water	Area (ha)	Silver eel production (kg/ha)	Total production (tons)
Running water	15 000	50	750
Lakes	45 000	8	360
Total	60 000		1110

Stocking

To meet the 40% escapement target for silver eel in fresh and marine waters annual stocking of 5–6 tons glass eel in freshwater and 33 tons of glass eel in marine waters are needed.

Freshwater

13.2.2.2 Current production

$\mathbf{B_o}$ = 1110 tonne
$\mathbf{B_{current}}$ = 129.5 tonne
$\mathbf{B_{best}}$ = 172.5 tonne

The current best estimate of silver eel production ($\mathbf{B_{best}}$) in freshwater is 172.5 tonnes.

Table 13.2.2.2. Current escapement from inland waters; mortality factors and Target level.

Inland water	Area (ha)	Silver eel production kg/ha (range)	Total production Tonne (range)
Running water	15.000	7(2–12)	105(30–180)
Lakes	45.000	1.5 (1–2)	67.5(45–90)
Total	60.000		172.5 (75–270)
Mortality (fisheries. hydropower. predation)			43
Current escapement			129.5
Target level; 40% prestine.			444

Marine

There are no surveys of silver eel production in the marine waters prior to 1980 or later. For the Danish territory it is estimated that 7000 tons of silver eel was produced annually when the fisheries yield were stable in the period 1920 and 1960. Current silver eel production is estimated at 600 tonnes.

13.2.2.3 Current escapement

Current escapement is ($\mathbf{B_{current}}$) is 129.5 tons. For marine assume 600 tonnes. See Table 13.2.2.2.

13.2.2.4 Production values e.g. kg/ha

Current production values are 1.5 kg/hectare for lakes, and 7 kg/hectare for running water. See Table 13.2.2.2.

13.2.2.5 Impacts

Impacts from fisheries, hydropower and predation add up to estimated 43 tonnes. See Table 13.2.2.2.

13.2.2.6 Stocking requirement eels <20 cm

In **freshwater**: To meet the 40% target within one eel generation of approximately 15 years in freshwater, it is necessary to stock 3–4 tonnes of glass eel per year combined with the termination of all eel fishing activities in fresh water and free (non-fisheries) migration routes along the coastline to-wards the Sargasso Sea.

In **saltwater:** To meet the 40% target within one eel generation of approximately 15 years, it is necessary to stock ca. 33 tonnes of glass eel per year.

13.1 Data quality issues

No data.

14 Sampling intensity and precision

No data.

15 Standardisation and harmonisation of methodology

No data.

16 Overview, conclusions and recommendations

This report is an update of earlier reports on the eel stock and fishery in Denmark. Time-series data reported include commercial yellow and silver eel landings in marine and inland waters and recruitment of yellow eel in three river basins using eel passtraps and electrofishing. Data for fishing capacity (fishing gear) is available but no data for actual effort are available. Scientific surveys include a project evaluating silver eel escapement in the Gudenå river and River Ribe Å system focusing on anthropogenic mortality due to fishing and turbines and predation.

Eel fisheries are planned to be managed according to the EU regulation aiming at 40% (relative to the prestine) silver eel escapement in freshwater and 50% effort reduction in the marine waters. Available data suggest that to meet the 40% target stocking of 3–4 tonnes of glass eel are needed in inland waters and 33 tons in marine waters. The Baltic eel passing through the Danish Belts and the Sound are managed as if they were local Danish eels, however they should be managed in agreement with the other Baltic countries.

Glass eel monitoring is becoming more and more difficult because of river restoration projects removing barriers where passtraps traditionally have been used in the past. Therefore it is currently considered to monitor Glass eel/Yellow eel recruitment in selected index systems by electrofishing as a supplement to monitoring at the traditional passtraps.

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Report on the eel stock and fishery in Finland 2011/'12

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Reporting Period: This report was completed in August 2012, and contains data up to 2011 and some provisional data for 2012.

Contributors to the report:

2 Introduction

In Finland eel are on their northeastern limits of natural geographical distribution. Natural eel populations have probably always been very sparse, and the overall importance of the species has been low. In fresh waters only in few areas in southern parts of the country eel has been a target in the recreational fisheries. According to old fishermen the catch and the importance of eel to local fisheries were still high in 1940–1960 in some parts of the Gulf of Finland, mainly in the estuary of the river Kymijoki and east of the city of Kotka. Also in Finnish Archipelago eel was a common species at that time. Almost all rivers running to the Baltic are closed by hydroelectric power plants. Natural eel immigration is possible only in few freshwater systems near the coast and in the coastal areas of the Baltic. Eel populations and eel fisheries in Finnish inland waters depend almost completely on introductions and restockings. First introductions were conducted in 1893 but until now the most numerous introductions were made in the sixties and 1970s. During the years 1979–1988 it was not allowed to import eels because eel was detected to be a possible carrier of some viral fish diseases. For this reason it was decided in 1989 to carry on restockings only with glass eels reared in a careful quarantine. Since then glass eel originating from River Severn in the UK have been imported through a Swedish quarantine and restocked in almost one hundred lakes in Southern Finland and in the Baltic along the southern coast of Finland.

3 Time-series data

3.1 Recruitment-series and associated effort

3.1.1 Glass eel

No glass eel recruitment at all.

3.1.1.1 Commercial

3.1.1.2 Recreational

3.1.1.3 Fishery independent

3.1.2 Yellow eel recruitment

No available data.

There is only occasional side-catch in lamprey pots in rivers running to the Baltic Sea, but only few individuals a year.

3.1.2.1 Commercial

3.1.2.2 Recreational

3.1.2.3 Fishery independent

3.2 Yellow eel landings

No available data.

3.2.1 Commercial

3.2.2 Recreational

3.3 Silver eel landings

No available data.

3.3.1 Commercial

3.3.2 Recreational

3.4 Aquaculture production

No aquaculture production.

3.4.1 Seed supply

3.4.2 Production

3.5 Stocking

3.5.1 Amount stocked

Table 1. Eel stockings in Finland in 1961–2012 (number of individuals).

	Glass eels	Quarantined/on grown glass eels	Bootlace	Origin
1961			53 000	Denmark, Germany
1962			143 000	Denmark, Germany
1963				
1964			83 000	Denmark, Germany
1965			114 000	Denmark, Germany
1966	1 077 000		53 000	France, Denmark, Germany
1967	3 935 000			France
1968	2 803 000		4000	France, Denmark, Germany
1969			35 000	Denmark, Germany
1970			30 000	Denmark, Germany
1971–1974	no	introductions	allowed	
1975			38 000	Denmark, Germany
1976			19 000	Denmark, Germany
1977			30 000	Denmark, Germany

	Glass eels	Quarantined/on grown glass eels	Bootlace	Origin
1978	368 000		12 000	France, Denmark, Germany
1979			75 000	Denmark, Germany
1980–1988	no	introductions	allowed	
1989		9700		River Severn (Swedish quarantine)
1990		58 840		River Severn (Swedish quarantine)
1991		108 515		River Severn (Swedish quarantine)
1992		102 450		River Severn (Swedish quarantine)
1993		105 000		River Severn (Swedish quarantine)
1994		103 500		River Severn (Swedish quarantine)
1995		216 600		River Severn (Swedish quarantine)
1996		74 580		River Severn (Swedish quarantine)
1997		82 200		River Severn (Swedish quarantine)
1998		77 550		River Severn (Swedish quarantine)
1999		62 500		River Severn (Swedish quarantine)
2000		61 015		River Severn (Swedish quarantine)
2001		45 500		River Severn (Swedish quarantine)
2002		55 000		River Severn (Swedish quarantine)
2003		0		
2004		63 500		River Severn (Swedish quarantine)
2005		64 000		River Severn (Swedish quarantine)
2006		55 000		River Severn (Swedish quarantine)
2007		107 000		River Severn (Swedish quarantine)
2008		206 000		River Severn (Swedish quarantine)
2009		117 500		River Severn (Swedish quarantine)
2010		153 000		River Severn (Swedish quarantine)
2011		306 000		River Severn, France (Swedish quarantine)
2012		177 000		River Severn (Swedish quarantine)

3.5.2 Catch of eel <12 cm and proportion retained for restocking

There are no eels less than 12 cm long in the catch. The smallest individuals ever caught in Finland have been about 20 cm long.

3.5.3 Reconstructed time-series on stocking

	Local Source				Foreign Source			
Year	Glass Eel	Quarantined Glass Eel	Wild Bootlace	On-grown cultured	Glass Eel	Quarantined Glass Eel	Wild Bootlace	On-grown cultured
1893							82	
1900							75	
1909							48 000	
1911					90 000		4513	
1926							2850	
1954							6000	

Local Source	Foreign Source		
1956			8000
1957			2000
1961			53 000
1962			143 000
1964			83 000
1965			114 000
1966	1 077 000		53 000
1967	3 935 000		
1968	2 803 000		4000
1969			35 000
1970			30 000
1975			38 000
1976			19 000
1977			30 000
1978	368 000		12 000
1979			75 000
1989		9700	
1990		58 840	
1991		108 515	
1992		102 450	
1993		105 000	
1994		103 500	
1995		216 600	
1996		74 580	
1997		82 200	
1998		77 550	
1999		62 500	
2000		61 015	
2001		45 500	
2002		55 000	
2004		63 500	
2005		64 000	
2006		55 000	
2007		107 000	
2008		206 000	
2009		117 500	
2010		153 000	
2011		306 000	
2012		177 000	

4 Fishing capacity

There is no exact data available but for the professional fisheries eel is of no importance. Some semi-professional fishermen may have minor income from eels mainly as a side-catch. Therefore the recreational fisheries mainly catch the eels. The number of recreational fishermen in Finland is high but only a very small portion of those catch eels as a main target (with fykenets, longlines, angling, spears, etc.). For most of the people eel is a surprising bycatch.

4.1 Glass eel

4.2 Yellow eel

4.3 Silver eel

4.4 Marine fishery

5 Fishing effort

No available data.

5.1 Glass eel

5.2 Yellow eel

5.3 Silver eel

5.4 Marine fishery

6 Catches and landings

The restockings in the late sixties and in 1970s gave a catch of 60–80 tonnes a year in the end of 1970s and the beginning of 1980s (Pursiainen and Toivonen, 1984). Introductions and restockings ceased in 1979, which caused a radical reduction in the annual eel catch (Table 2). After the year 1986 the catch was so low that the eel was not detected as a species in the official statistics, but included into the group “other species”. Pursiainen and Toivonen (1984) found out that 1000 stocked individuals/year in freshwaters in Southern Finland gave a catch of 90 kg/year about ten years later. Using the same figures the restockings after 1990 probably give nowadays a catch between 5–10 tonnes/year. Figures in the professional fisheries columns in Table 2 are based on logbook data and in the recreational fisheries data on questionnaires.

Table 2. Eel catches in Finland 1975–2010 (x1000 kg). The statistical data is collected by the FGFRI.

	Marine fisheries		Freshwater fisheries		
Year	Professional	Recreational	Professional	Recreational	Total catch
1975	0	0	0	0	0
1976	4	15	2	7	28
1977	2	14	2	45	63
1978	1	14	2	60	77
1979	2	14	2	59	77
1980	2	14	3	60	79
1981	1	8	2	28	39
1982	1	8	1	28	38
1983	1	8	1	28	38
1984	1	4	1	22	28
1985	1	4	1	22	28

	Marine fisheries		Freshwater fisheries		
1986	1	4	2	49	56
1987	0,2	?	?	?	0,2+?
1988	0,4	?	?	?	0,4+?
1988–1995	?	?	?	?	?
1996	?	1	?	21	22+?
1997–2002	?	?	?	?	?
2003	0,4	?	?	?	0,4+?
2004	1,1	?	?	?	1,1+?
2005	0,4	?	?	?	0,4+?
2006	0,2	?	0	?	0,2+?
2007	0,5	?	0	?	0,5+?
2008	1	13	0	4	17
2009	1,8	?	0	?	1,8+?
2010	2,2	1	0	9	12,2
2011	2	?	not ready	?	2+?

6.1 Glass eel

6.2 Yellow eel

6.3 Silver eel

6.4 Marine fishery

See Table 2.

7 Catch per unit of effort

No available data.

7.1 Glass eel

7.2 Yellow eel

7.3 Silver eel

7.4 Marine fishery

8 Other anthropogenic impacts

No available data.

9 Scientific surveys of the stock

9.1 Recruitment surveys, glass eel *(includes yellow eel in Scandinavia)*

No available data.

9.2 Stock surveys, yellow eel

No available data.

9.3 Silver eel

DIDSON has been used for the first time in 2011to monitor downstream migration of silver eels in the upper reaches of the Kokemäenjoki watercourse (Area 3 in the map below) above the uppermost dam. During a one month operation period in autumn 119 individuals were detected (average length 93,5 cm, variation 70–123 cm). This is the minimum estimate as the whole river bed was not covered by the DIDSON. Operations are going to be renewed this autumn and hopefully also in the future.

10 Catch composition by age and length

No data available.

11 Other biological sampling

During 1974–1994 over 2000 eels were collected in thirty lakes and in some lake outlets in southern Finland. Length, weight, eye diameter, colour of the sides and belly, sex and weight of the gonads (not always) were determined and after 1986 also swimbladders were examined for *Anguillicola*. Age and growth were also determined. The aim of the study was to evaluate the biological outcome of eel stockings made in 1960s and 1970s and to estimate the yield to fishery and the proportions of eels escaping the lakes. The results were published mainly in 1980s (Pursiainen and Toivonen, 1984; Pursiainen and Tulonen, 1986; Tulonen, 1988; Tulonen, 1990; Tulonen and Pursiainen, 1992). The concentrations of radionuclides ^{134}Cs and ^{137}Cs and PCB in eels were also investigated (Tulonen and Saxen, 1996; Tulonen and Vuorinen, 1996).

There were no routine biological sampling programmes or eel research projects during 1994–2005. Some occasional samples were taken in few lakes on the author's personal interest. Also in some small water systems silver eel escapement has been monitored since 1974 (one place), 1980 (two places) and 1989 (two places) with eel boxes in the outlets. Eels in the lakes have been re-stocked there in 1967, 1978 and 1989 respectively. One sample of "natural" elvers has been collected in 2002 in southwest Finland and on the coast of the Bothnian Bay. One third of the elvers were infected with *Anguillicola*. This was the first time *Anguillicola* ever found in Finland (Tulonen, 2002).

In 2006 a four year study on the biological and economical outcome of eel stockings made since 1989 and on the state of natural eel stocks was established in FGFRI. The main goal was to compile the facts and other biological data about eels in Finland to the Eel Management Plan. In the study some sampling was also done in ten lakes in southern Finland and in eight areas in the Baltic along the coasts of Gulf of Finland and Bothnian Bay and in the rivers running into them. Due to sparse populations the sample sizes are only in few cases big enough (>100 ind.) to make any scientific evaluations. In 2010 and 2011 there has been only casual sampling in the most interesting locations due to lack of funding.

Considering eel's low status for fisheries and low economic value in Finland, it is obvious that collecting data more effective is difficult to arrange.

11.1 Length and weight and growth (DCF)

Data not yet processed.

11.2 Parasites and pathogens

Data not yet processed.

11.3 Contaminants

11.4 Predators

12 Other sampling

No other sampling is going on.

13 Stock assessment

13.1 Local stock assessment

There is no routine assessment of local stocks. Neither there is any formal advice on fisheries management.

13.2 International stock assessment

13.2.1 Habitat

Terms used in the EMP to define natural habitats for the eel were:

- outlet of the river basin is in Finland's national territory;
- there has been natural immigration of elvers before the damming of the rivers;
- there have been considerable stockings lately;
- there has been regular eel fishery.

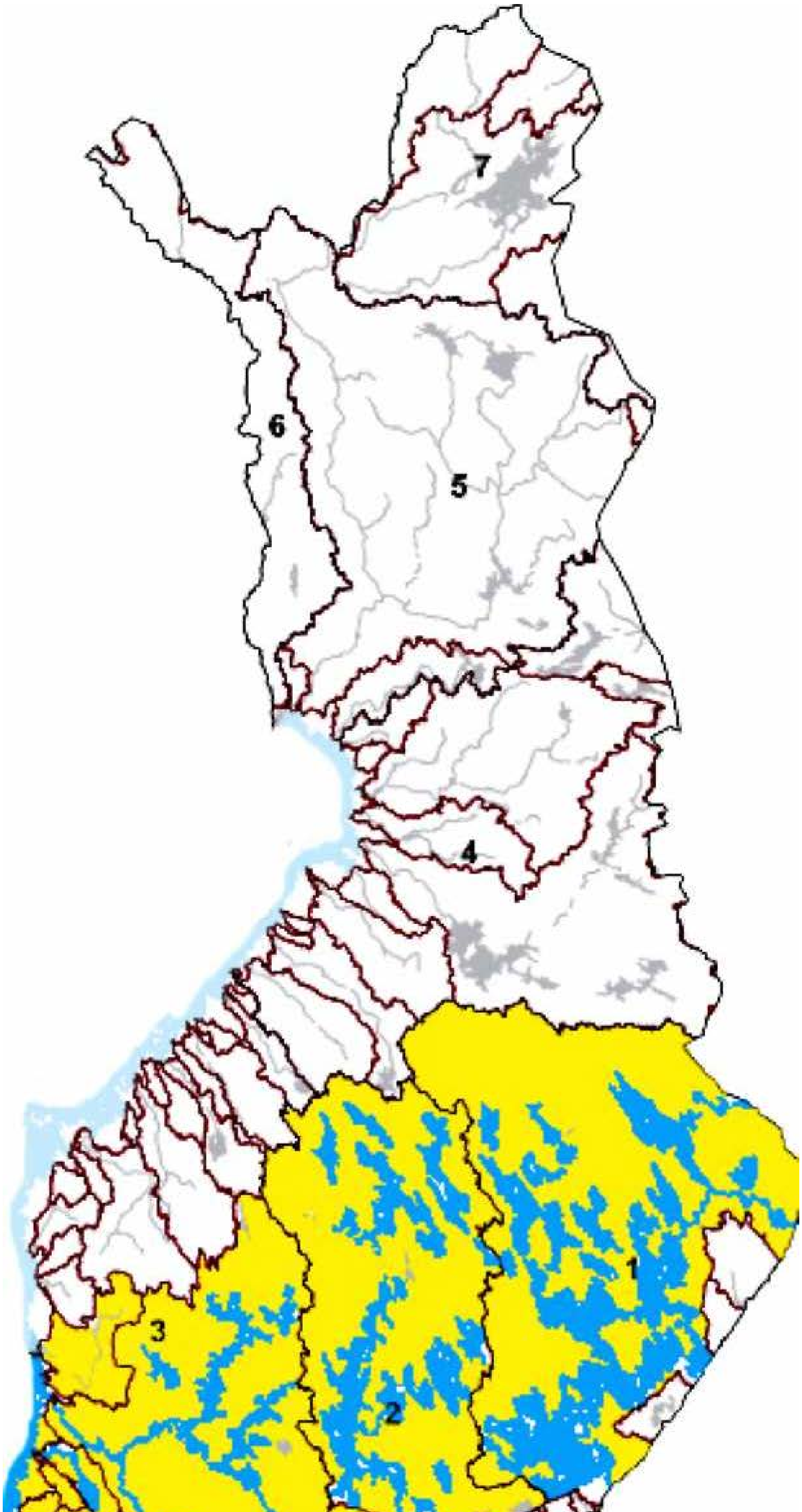
On the grounds of the terms two categories with few subcategories were defined:

a) Area of free migration includes all coastal waters of the Baltic and the inner archipelago to the depth of ten meters and the few small undammed river basins running to the Baltic. The area was subdivided into two categories:

i) Reserve area (the Bothnian Bay area) where eels exist but for climatically and geographical reasons have always been very rare. Light blue area in the map. Total area is 1783 km².

ii) Main management area for the eel (the Gulf of Finland and the small undammed river basins running to it). Deep blue coastal area in the map Total area is 4677 km² for the coastal area and 382 km² for the small river basins. According to EMP stockings in this area compensates in the long run the loss of silver eels in freshwaters.

b) Area where immigration of elvers is totally prevented because of the dams and the hydroelectric turbines in the dams have a severe negative effect on the escapement of silver eels. This area includes three major freshwater river basins; Vuoksi (number 1 in the map), Kymijoki (number 2) and Kokemäenjoki (number 3), and also some small water basins running to the Baltic. Yellow area in the map, main lakes in the area are coloured in deep blue. Total area is 20 509 km². No management actions take place in this area.


7
6
5
4
3
2
1
0
100

13.2.2 Silver eel production

13.2.2.1 Historic production

No data available.

13.2.2.2 Current production

No data available.

13.2.2.3 Current escapement

No data available.

13.2.2.4 Production values e.g. kg/ha

No data available.

13.2.2.5 Impacts

No exact data available. Impact of fishery is very low both in freshwaters and in the Baltic. Impact of hydropower in freshwaters is high.

13.2.3 Stocking requirement eels <20 cm

According to the EMP 537 000 glass eels will be stocked annually in the first years in the main management area for eel (area of free migration (A), category b). After few years the stocking volume doubles to 1 074 000 individuals. In 2011 only 200 000 individuals were stocked (37% of the amount in EMP) and in 2012 91 000 individuals (17% of the amount in EMP).

13.2.4 Summary data on glass eel

No glass eels caught in Finland. All glass eels or ongrown eels are imported and used for stockings in Finland (100%).

13.2.5 Data quality issues

14 Sampling intensity and precision

No data available yet. Only a small fraction of the data has been analysed.

15 Standardisation and harmonisation of methodology

15.1 Survey techniques

No data available.

15.2 Sampling commercial catches

No data available.

15.3 Sampling

Done by FGFRI since 1974 with longlines and fykenets in lakes and eel traps in the rivers. In 2006–2009 samples were collected in freshwaters with the help of local recreational fishermen and in the sea by few professional fishermen. Fish have been collected mainly alive from the fishermen but occasionally also as frozen. In few cases the fishermen have measured (weight and length) the fish and delivered the head and the guts together with the length–weight data to FGFRI where otolihs have been removed and swimbladder examined for *Anguillicola*.

For every fish following information has been collected:

- Catching date and killing date;
- Catching site ;
- Fishing gear;
- Length;
- Weight;
- Sex;
- Colour (sides and belly);
- Diameter of the eye;
- Weight of the gonad (only occasionally);
- *Anguillicola* (no/yes, how many, size).

15.4 Age analysis

So far when age analysis has been done grinding and polishing method has been used, Swedish style as described in ICES WKAREA Report 2009 in Bordeaux. Lately also cutting slices with otolith saw and etching using EDTA and staining using neural red has been tried out.

15.5 Life stages

Silver eel: side silver or copper, glossy, belly white and glossy.

Yellow eel: sides brown, grey, green, not glossy, belly brown, green, grey, yellow, not glossy.

15.6 Sex determinations

From macroscopic examination of the gonads, confirmed by length and colour.

16 Overview, conclusions and recommendations

In the EMP there are some recommendations for the research:

1) The natural distribution of eel in Finland and the state of this natural stock has to been examined and followed regularly;
2) Eel has to be taken as a species in the catch statistics both in recreational and professional fishery;
3) Research has to be carried out to find out the biological outcome of the stockings conducted according to the EMP. Natural and fishing mortality and especially recruitment of yellow eels to silver eels and the success of silver eel's migration have to be studied;
4) *Anguillicola* infection level should be investigated in the natural and introduced eel populations.

Only the recommendation number 2 has fulfilled and few aspects of recommendations 3 and 4.

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Report on the eel stock and fishery in France 2011/'12

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Reporting Period: This report was revised and completed in August 2012.

2 Introduction

2.1 Presentation of eel fisheries in France

The French eel fisheries occur mainly in inland waters (rivers, estuaries, ponds and lagoons) but also in coastal waters (see Figure FR 1 and Table FR a). The glass eel fisheries are more important in the Bay of Biscay region but they are also found in the Channel region. The yellow eel fisheries occur in the same areas and concern also the upper parts of the rivers of the Atlantic coast, the Rhine and tributaries. The Mediterranean lagoons produce the most part of yellow eels and bootlace eels are targeted for exportation towards Italy. Silver eel fisheries are limited to some rivers, mostly in the Loire basin and in the Mediterranean lagoons.

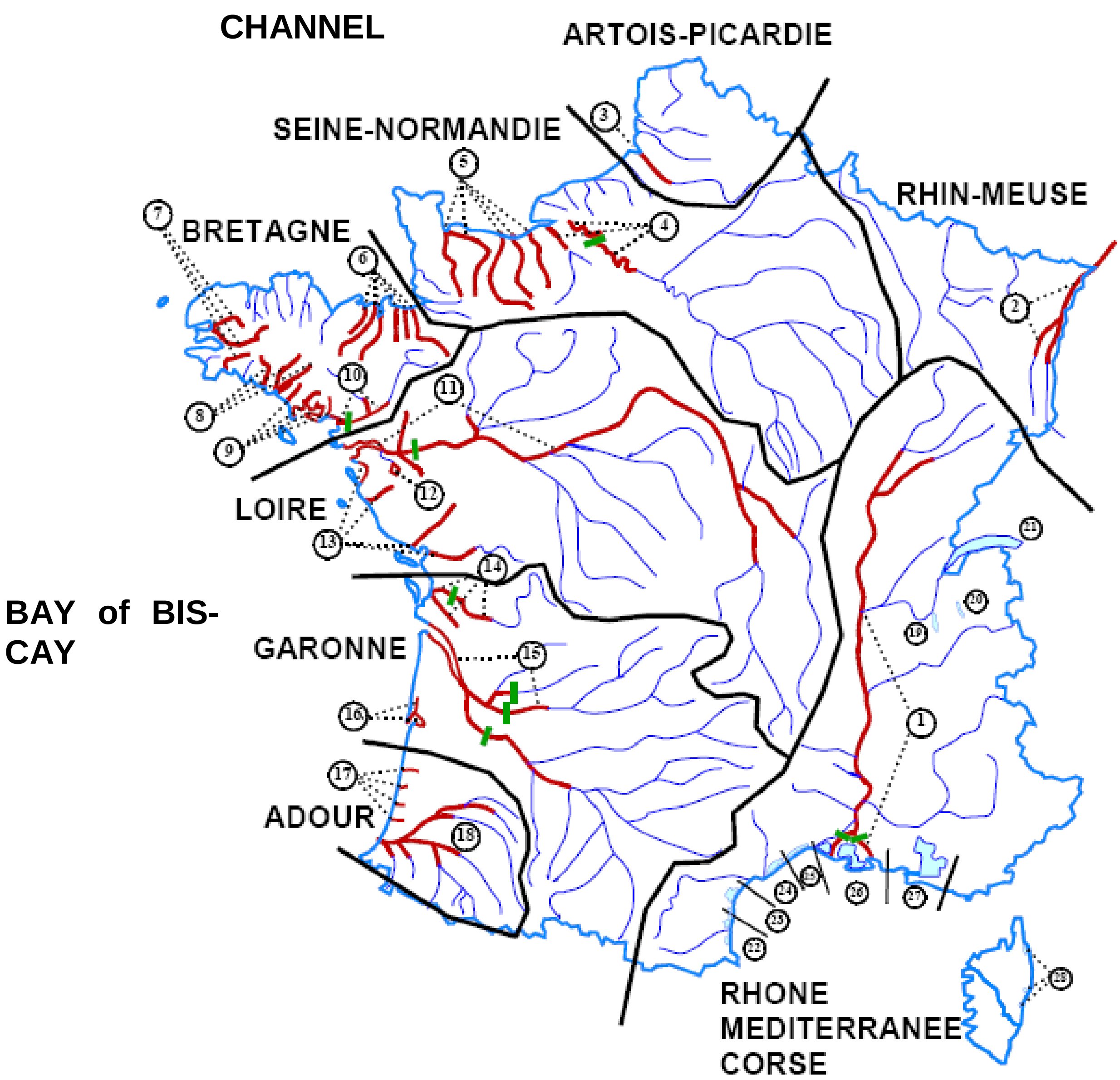


Figure FR 1. Inland waters in France (eel fisheries in red; tidal limits in green). The number correspond to the list of fishing zones in Table FR a. The management unit names and limits are in black (redrawn from CASTELNAUD, 2000).

From 1999 to 2001, the total number of professional fishermen fishing eel, seeking one or several stages, was about 1800 with an estimated total catch of 200 tons of glass eels and 900 tons of yellow or silver eels (Castelnaud and Beaulaton, unpublished data).

Illegal fishermen are targeting glass eels in the tidal parts of rivers and other stages in whole France including sometimes for commercial purpose. Their number and the amount of their catches had never been clearly quantified.

Table FR a. Fishing zones in French inland waters related to the 8 management units (COGEPOMI) (modified from CASTELNAUD *et al.*, 2000, unpublished data).

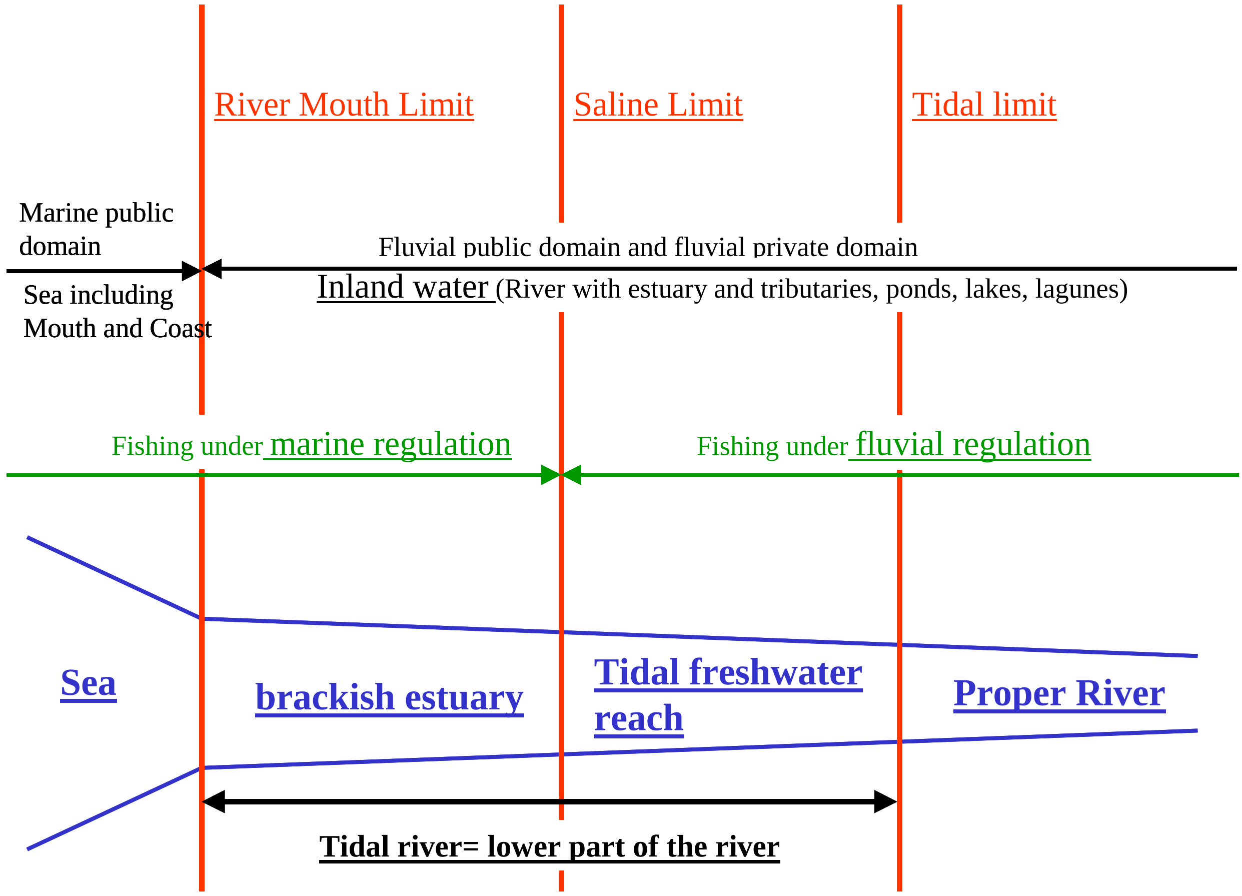
(Number from Figure FR 2) Fishing zone – Surface for lagoons	COGEPOMI
(1) Delta du Rhône	Rhône-Méditerranée Corse
(1) Fleuve Rhône aval et amont, Saône, Doubs	Rhône-Méditerranée Corse
(2) Fleuve Rhin, Ill	Rhin Meuse
(3) Estuaire Somme	Artois-Picardie
(4) Estuaire Seine, Fleuve Seine aval	Seine Normandie
(4) Fleuve Seine amont, Risle	Seine Normandie
(5) Estuaires Touques, Dives, Orne, Aure, Vire	Seine Normandie
(6) Estuaires Couesnon, Rance, Fremur, Arguenon, Gouessan, Gouet	Bretagne
(7) Estuaires Elorn, Aulne, Odet	Bretagne
(8) Estuaires Laïta, Scorf, Blavet	Bretagne
(9) Rivières d'Etel, d'Auray, de Penerf, Golfe du Morbihan	Bretagne
(10) Estuaire Vilaine aval	Bretagne
(10) Estuaire Vilaine amont, Fleuve Vilaine aval, Oust, Chere, Don	Bretagne
(11) Estuaire Loire, Loire aval, Erdre, Sèvre Nantaise	Loire
(11) Fleuve Loire amont, Maine, Mayenne, Allier	Loire
(12) Lac de Grand-Lieu	Loire
(13) Baie de Bourgneuf, Estuaires Vie, Lay, Sèvre Niortaise	Loire
(14) Estuaire Charente, Fleuve Charente aval, Estuaire Seudre	Garonne
(14) Fleuve Charente amont	Garonne
(15) Estuaire Garonne, Garonne aval, Dordogne aval, Isle	Garonne
(15) Fleuve Garonne amont, Dordogne amont	Garonne
(16) Canal de Lège	Garonne
(16) Delta d'Arcachon	Garonne
(17) Courants de Mimizan, Contis, Huchet, Vieux-Boucau	Adour
(18) Estuaire Adour, Fleuve Adour, Nive, Bidouze, Gaves de Pau et d'Oloron, Luy	Adour
(19) Lac du Bourget	Rhône-Méditerranée Corse
(20) Lac d'Annecy	Rhône-Méditerranée Corse
(21) Lac Léman	Rhône-Méditerranée Corse
(22) Etang de Canet - 480 ha	Rhône-Méditerranée Corse
(22) Etang de Salses Leucate - 5800 ha	Rhône-Méditerranée Corse
(23) Etang de Lapalme - 600 ha	Rhône-Méditerranée Corse
(23) Etang de Bages-Sigean - 3700 ha	Rhône-Méditerranée Corse
(23) Etang de Campignol – 115 ha	Rhône-Méditerranée Corse

(Number from Figure FR 2) Fishing zone – Surface for lagoons	COGEPOMI
(23) Etang de l'Ayrolle – 1320 ha	Rhône-Méditerranée Corse
(23) Etang de Gruissan – 145 ha	Rhône-Méditerranée Corse
(24) Etang de Thau – 7500 ha	Rhône-Méditerranée Corse
(25) Etang d'Ingril – 685	Rhône-Méditerranée Corse
(25) Etang de Vic – 1255 ha	Rhône-Méditerranée Corse
(25) Etang de Pierre- Blanche – 371 ha	Rhône-Méditerranée Corse
(25) Etang du Prévost – 294 ha	Rhône-Méditerranée Corse
(25) Etang de l'Arnel – 580 ha	Rhône-Méditerranée Corse
(25) Etang du Grec – 270 ha	Rhône-Méditerranée Corse
(25) Etang Latte-Méjean – 747 ha	Rhône-Méditerranée Corse
(25) Etang de l'Or – 3200 ha	Rhône-Méditerranée Corse
(26) Etang du Ponant – 200 ha	Rhône-Méditerranée Corse
(26) Petite Camargue gardoise – 1200 ha	Rhône-Méditerranée Corse
(26) Etang du Vacares et des Impériaux – 12000 ha	Rhône-Méditerranée Corse
(27) Etang de Berre – 15500 ha	Rhône-Méditerranée Corse
(28) Etang de Palo – 210 ha	Rhône-Méditerranée Corse
(28) Etang d'Urbino – 790 ha	Rhône-Méditerranée Corse
(28) Etang de Diana – 570 ha	Rhône-Méditerranée Corse

2.2 Management and monitoring system

The administrative saline limit separates two different fishery regulations: marine and fluvial (freshwater) (Figure FR 2). The marine fisheries are located in coastal water, brackish estuaries and in the Mediterranean lagoons. The freshwater fisheries are located upstream from the saline limit and comprise rivers, lakes, ponds, ditches and canals. In large estuaries there is a special zone, called the "tidal freshwater reach", located between the saline limit and the tidal limit, where some marine professional fishermen can fish along with river fishermen while these are not allowed to go downstream the saline limit.

In brackish and coastal waters within EMU, amateur fishermen do not need licences to fish with authorized fishing gears. A system of licences is set up for marine professional fishermen, for river professional and amateur fishermen in freshwaters. The glass eel fishery is limited with quotas of glass eel stamps and the silver eel fishery is limited by personal authorizations. Since EMP, professional and recreational fisher fishing with gears should have a special authorization to target eels. Anglers do not require any special authorization for eel fishing, just to have a general fishing licence. In the Mediterranean lagoons, where glass eel fishing is forbidden, there are also limitations in the number of marine professional fishermen and fishing capacities. Since the French EMP there is also a system of stamps one for yellow and one for silver eel fishing.



		Marine professional = MP
Fisher category	Marine professional = MP Marine recreational with or without boat = MA	River professional = FP River amateur with gears with or without boat in public domain = FA Angler = AN River amateur (being also angler) with gears in private domain = AG
Fishing rights	MP: quota of licence, eel specific stamps MA: no licence, gears limited by rules	MP & FP: quota of licence, eel specific stamps FA: quota of licence, eel specific stamps AN: general rod licence AG: AN licence + eel specific authorisation

Figure FR 2. Inland waters and fisheries limits, fishermen categories and fishing rights by zones (Castelnaud and Beaulaton, 2005, unpublished data).

Outside EMU, eel fishing is forbidden.

In the rivers under fluvial regulation, the fishing rights are delivered to fishermen by the local Fluvial Fisheries Administrations. The regulation systems in brackish estuaries and Mediterranean lagoons are the result of a negotiation between fishermen organizations (respectively "Commission des poissons migrateurs et des estuaires" and "Prud'homies") and Marine Fisheries Administrations.

The marine professional fisheries in Atlantic coastal areas, estuaries and tidal part of rivers in France has been monitored by the "Direction des Pêches Maritimes et de l'Aquaculture" (DPMA) of the Ministry of Agriculture and fisheries trough the Centre National de Traitement Statistiques (CNTS, ex-CRTS) from 1993 to 2008 and is now by France-Agrimer. This system is evolving and is supposed to include marine professional fishermen from Mediterranean lagoons. In this system, glass eels are distinguished from subadult eel, but yellow and silver eels cannot be separated until recently.

The river professional and amateur fishermen in rivers above marine estuaries (and in lakes) have been monitored since 1999 by the ONEMA (Office National de l'Eau et des Milieux Aquatiques, ex-CSP) in the frame of the «Suivi National de la Pêche aux Engins et aux filets» (SNPE).

These two monitoring systems are based on mandatory reports of captures and effort (logbooks) using similar fishing forms collected monthly (or daily for glass eel; Table FR b) with the help of some local data collectors.

Beside these mandatory systems, for which reliability, accuracy and availability of data are variable, local scientific monitoring have been developed in the Gironde, the Adour and the Vilaine basin for instance. Data on annual captures are also provided for some sectors by the local fishery administrations: "Directions Départementales des Affaires Maritimes" (DDAM), "Directions Départementales du Territoire/du Territoire et de la Mer" (DDT/DDTM)". At some occasions, some punctual studies made by scientific institute, local fishery administration or fishermen themselves are available.

Table FR b. Official administrative monitoring systems in France.

<table>
<tr><th></th><th colspan="2">Sea</th><th colspan="2">Inland waters</th></tr>
<tr><td></td><td>Outside EMU</td><td>Saltwater</td><td>Brackish water (including Med. Lagoons)</td><td>Freshwater</td></tr>
<tr><td>Professional</td><td rowspan="3">Eel Fishing ban</td><td>No data available</td><td>Quota of licences
Stage specific stamps
Compulsory logbook (DPMA/France-Agrimer)</td><td>Quota of licences
Stage specific stamps
Compulsory logbook (ONEMA)</td></tr>
<tr><td>Recreational with gears</td><td colspan="2" rowspan="2">No licence, no logbooks</td><td>Licences and specific yellow eel authorisation
Compulsory logbook (public domain: ONEMA / private domain: not monitored)</td></tr>
<tr><td>Anglers</td><td>Licences (not eel specific), no logbooks</td></tr>
</table>

To manage the migratory species and their fisheries all along the watershed (under marine and fluvial regulation), special organizations, called "Comités de Gestion des Poissons Migrateurs" (COGEPOMI), have been created in 1994. There are eight COGEPOMI (management units, grouping basins), one for each important group of basin: Rhine-Meuse, Artois-Picardie, Seine-Normandie, Bretagne, Loire, Garonne, Adour and Rhone-Méditerranée-Corse (see Figure FR 1 and Table FR a). They gather representatives of fishermen organizations, administrations and research centers. Each COGEPOMI propose a management plan and funding every five years and has to monitor them. The plan determines conservation and management actions, restocking operations, proposes fishing regulations for both recreational and professional fisheries.

Until 2009, these management plans did not aim at achieving a particular escapement rate for eel, and the results of management actions have not really been evaluated. While this system allows for a global approach, and tries to solve environmental problems such as migration barriers or turbine mortality, it does not give for the moment, a consistent management basis for eel at the national level by lack of central regulation and designing of practical management rules.

Since 2009, French eel management unit (EMU) as defined by the European eel regulation are more or less COGEPOMI. One should notice that Corse is a separate management unit and that EMU are extended to coastal waters (Figure FR 3). A national EMP has been build that gives national instructions that can for some measures be adapted by EMU through COGEPOMI or other local institutions.

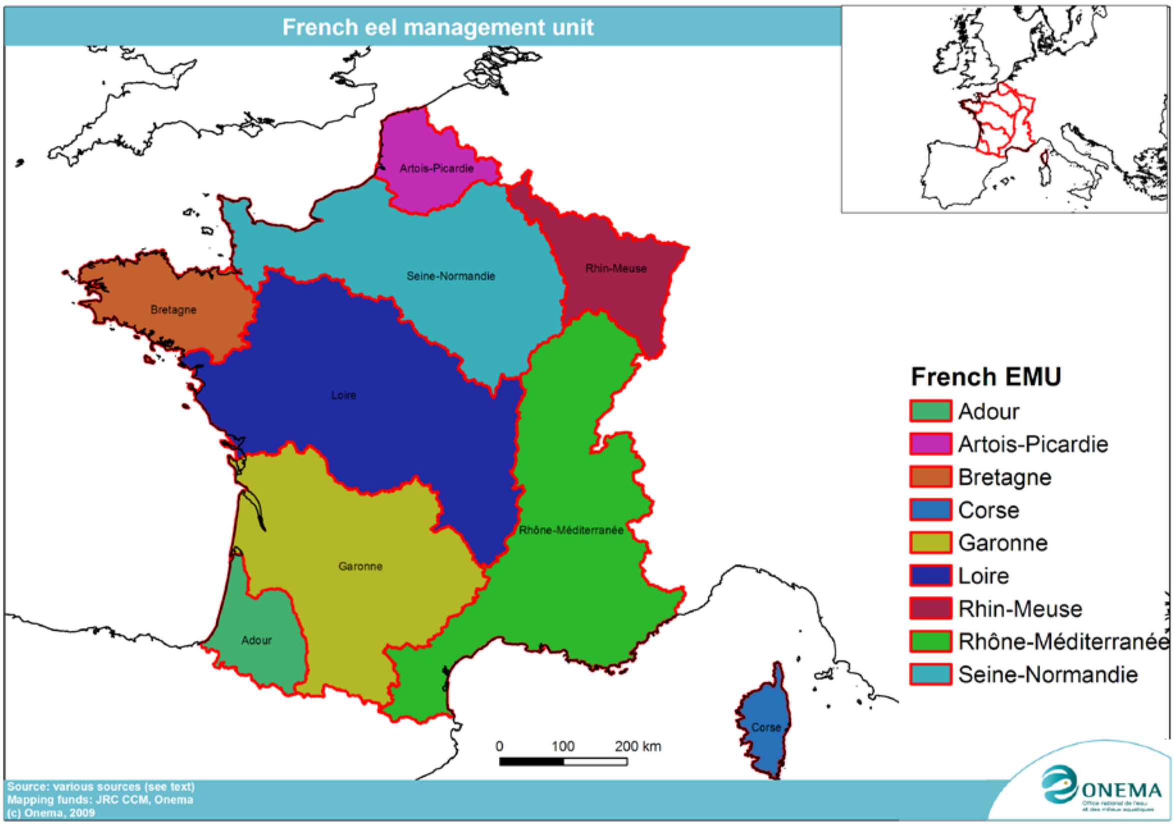


Figure FR 3. French eel management unit.

3 Time-series data

3.1 Recruitment and escapement series

3.1.1 Glass eel recruitment

As foreseen by the working group, the regulation system set in place with the management plan has disrupted the existing series of capture. The Vilaine, Loire, Gironde and Adour series which were based on total catch of glass eel can no longer be considered as giving reliable information on the trend of recruitment.

The Vilaine still provided data up until 2011 as it was considered that the quota system had not changed much the exploitation of glass eel in the Vilaine and the assessment of the total recruitment remained feasible. This year (2011–2012 season) however, the fishery was closed for a while in the middle of the season, with no simple ways of rebuilding the recruitment during that period. For the other sites, since 2008, the geographic scale at which catch information is now made available at the national level is the management unit, with no simple ways of getting back to the estuary.

3.1.1.1 Commercial

Four total landings-series commercial were provided for the Loire, Gironde, and Adour. These series are disrupted (see above).

3.1.1.2 Recreational

No “recreational” catch series is provided.

3.1.1.3 Fishery independent

One fishery independent recruitment survey is provided for the Gironde. The scientific survey (glass eel/1000 m³) is conducted by Irstea (see 9.1.1 for details). This series is the only available for 2012.

Table FR c. Recruitment-series in France. 2012 means 2011–2012 migration season.

EMU	Bretagne	Loire		Garonne-Dordogne-Charente-Seudre-Leyre			Adour - Cours d'eau cotiers	
Year	Villaine Arzal trapping all	Loire Estuary com. catch	Sevres Niortaies Estuary com. cpue	Gironde (catch) com. catch	Gironde pibalour (cpue) com. cpue	Gironde scient. Estim.	Adour Estuary (catch) com.[1] catch	Adour Estuary (cpue) com. cpue
1923				46.0				
1924		65						
1925		70						
1926		90		18.7				
1927		65		34.1				
1928		102		22.4				5
1929				22.5				5.5
1930		1		28.2				6.7
1931				26.9				18.7
1932				31.1				
1933				13.5				
1934		90		13.4				
1935		150		19.7				
1936		30						
1937		7						
1938		15						
1939		17						
1940		27						
1941		21						
1944		10						
1945		66						
1946		43						
1947		178						
1948		197						
1949		193						
1950		86						
1951		166						
1952		121						
1953		91						
1954		86						
1955		181						
1956		187						
1957		168						
1958		230						

EMU	Bretagne	Loire		Garonne-Dordogne-Charente-Seudre-Leyre			Adour - Cours d'eau cotiers	
Year	Villaine Arzal trapping all	Loire Estuary com. catch	Sevres Niortaies Estuary com. cpue	Gironde (catch) com. catch	Gironde pibalour (cpue) com. cpue	Gironde scient. Estim.	Adour Estuary (catch) com.[1] catch	Adour Estuary (cpue) com. cpue
1959		174						
1960		411						
1961		334		32.2	10.47			
1962		185	30	218	30.64			
1963		116	72	363	33.15			
1964		142						
1965		134	17	353	62.74			
1966		253	13	27.6	10.02			5.1
1967		258	8	163	25.46			6.4
1968		712	15	284	38.23			10.1
1969		225	14	36.6	18.52			5
1970		453	15	204	24.98			7.5
1971	44	330	12	47.1	9.12			4.6
1972	38	311	11	69.0	13.73			4.4
1973	78	292	8.5	20.0	29.19			4.5
1974	107	557	9	54.6	21.44			7.4
1975	44	497	8.5	44.1	12.5			5
1976	106	770	17	121	34			11
1977	52	677	15	122	25.38			
1978	106	526	18	64.7	23.17			
1979	209	642	17.5	73.2	18.74			10
1980	95	526	12	125	35.05			5
1981	57	303	9	84.9	32.41			
1982	98	274	8.5	61.0	14.55			
1983	69	260	6	66.7	14.33			
1984	36	183		45.0	13.87			
1985	41	154		27.0	7.39			2.4
1986	52.6	123		35.3	9.02		8	1.5
1987	41.2	145		44.6	9		9.5	3.3
1988	46.6	177		27.9	7.55		12	3.7
1989	36.7	87		45.9	8.9		9	4.1
1990	35.9	96		29.2	5.37		3.2	1.2
1991	15.35	36		38.4	6.78		1.5	0.7
1992	29.57	39		22.5	6.58	1.75	8	2.9
1993	31	91		42.4	8.92	2.83	5.5	2.4
1994	24	103		45.5	8.15	2.2	3	1.4
1995	29.7	133		43.5	8.49	2.92	7.5	2.6
1996	23.29	81		27.9	5.25	2.07	4.1	1.53
1997	22.85	71		49.3	9.24	3.14	4.6	1.6
1998	18.9	66		18.4	3.46	???	1.5	1.07

EMU	Bretagne	Loire		Garonne-Dordogne-Charente-Seudre-Leyre			Adour - Cours d'eau cotiers	
Year	Villaine Arzal trapping all	Loire Estuary com. catch	Sevres Niortaies Estuary com. cpue	Gironde (catch) com. catch	Gironde pibalour (cpue) com. cpue	Gironde scient. Estim.	Adour Estuary (catch) com.[1] catch	Adour Estuary (cpue) com. cpue
1999	16	87		43.1	7.41	3.49	4.3	1.82
2000	14.45	80		28.5	5.41	1	10	4.43
2001	8.46	33		8.2	1.85	0.36	2	0.49
2002	15.9	42		35.1	6.22	1.02	1.8	0.89
2003	9.37	53		9.6	2.52	0.28	0.6	0.31
2004	7.49	27		14.4	2.5	0.3	1.8	0.6
2005	7.36	17		17.3	2.7	0.53	3.2	1.13
2006	6.6	15		9.4	2.4	0.27	1.7	0.72
2007	7.7	21		7.5	2.1	0.14	1.4	0.66
2008	5.1	STOPPED	1.93	10	2.6	0.28	1.7	1.05
2009	2.2		STOPPED	3.5	1.4	0.44	STOPPED	STOPPED
2010	3.8			STOPPED	STOPPED	0.10		
2011	3.7					0.16		
2012	STOPPED					0.08		

[1] **Com.=commercial.**

3.1.2 Yellow eel recruitment

3.1.2.1 Commercial

Not relevant.

3.1.2.2 Recreational

Not relevant.

3.1.2.3 Fishery independent

3.1.2.3.1 Bresle river (Seine-Normandie EMU)

The Bresle River is the index river (see 9.1.2) from the Seine-Normandie EMU (close to the Artois-Picardie EMU). It is a 70 km long river with a mean flow of 7 m³/s. A trap (daily counting from April to December) on an eel ladder (3 km from the sea, on the second dam) allows to follow the relative evolution of the upstream migration since 1994 (Figure FR 4 and Table FR d). The proportion of eel that use the fish compared to other way of passage is under evaluation. Five marking–recapture campaigns have been made in 2009 and in 2010 using VIE. Eels are caught in the Eu ladder, marked and released 1.3 km downstream. The provisional recapture rate is 21.9% (min=2.9%; max=40.3%). We can thus estimate that since 2005 between 14 000 and 37 000 eels (150–390 eels/ha of wetted are) are recruited in the Bresle river (2 km from the sea).

The increase observed in 2003 is probably caused by an improvement of the ladder accessibility and highlights the importance of the validation of such series.

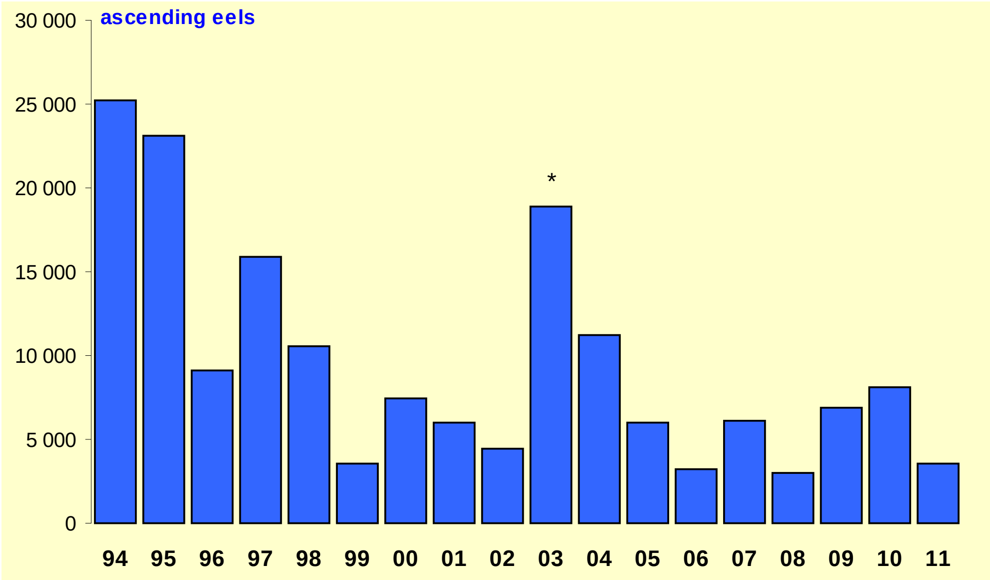


Figure FR 4. Annual evolution (1994–2011) of fish number in the eel ladder trap on the Bresle River (data: ONEMA). 2003: change in ladder device.

Table FR d. Annual evolution (1994–2010) of fish number in the eel ladder trap on the Bresle River (data: ONEMA). 2003: change in ladder device.

YEAR	ASCENDING EELS	YEAR	ASCENDING EELS	YEAR	ASCENDING EELS
1990		2000	7403	2010	8097
1		1	5980	1	3536
2		2	4394	2	
3		3	18 932	3	
4	25 277	4	11 178	4	
5	23 068	5	5976	5	
6	9140	6	3206	6	
7	15 849	7	6132	7	
8	10 547	8	3010	8	
9	3558	9	6911	9	

The migratory period starts at the end of April and ends in mid-November with the maximum being between June and August (92%) (Figure FR 5).

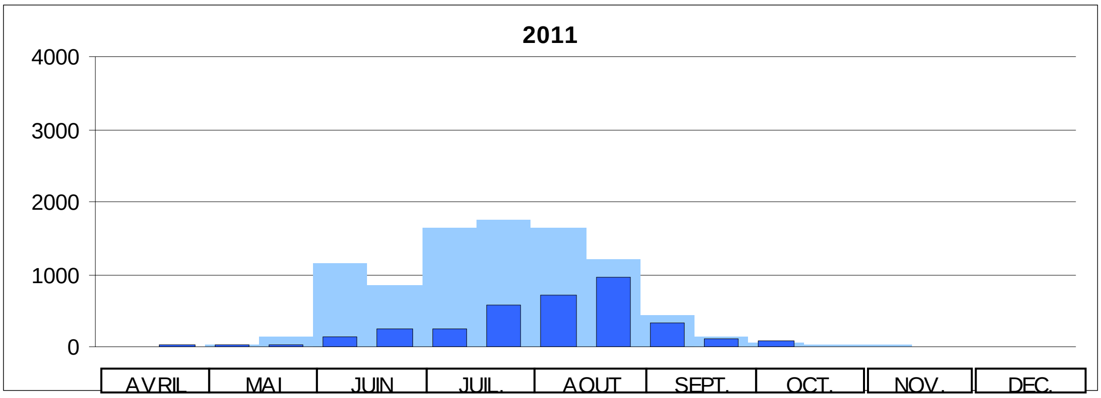


Figure FR 5. Bi-monthly migratory rythm of eels ascending the EU ladder (Bresle river ; data: ONEMA). Light blue: 1994–2010 average. Dark blue: 2011.

It is also possible to analyse the fish characteristics. For example, eel length ranges between 55 mm and 305 mm with 90% of fishes being between 75 mm and 115 mm among more than 28 000 eel measured. The mean eel length has slightly increased since 1994 (10 mm; Figure FR 6), with a decrease of the proportion of glass eels and small eels (<90 mm), the overall mean length is 96.9 mm.

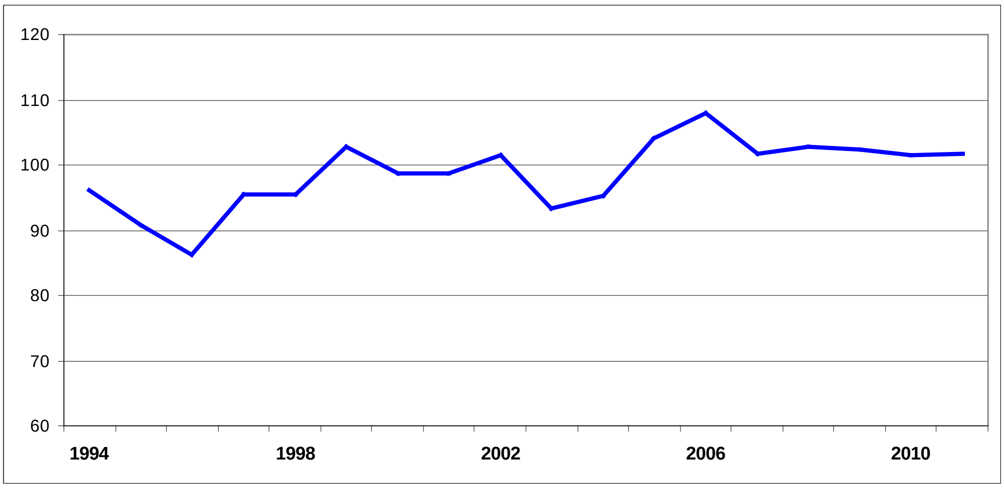


Figure FR 6. Annual evolution of mean length in the eel ladder trap on the Bresle River (data: ONEMA).

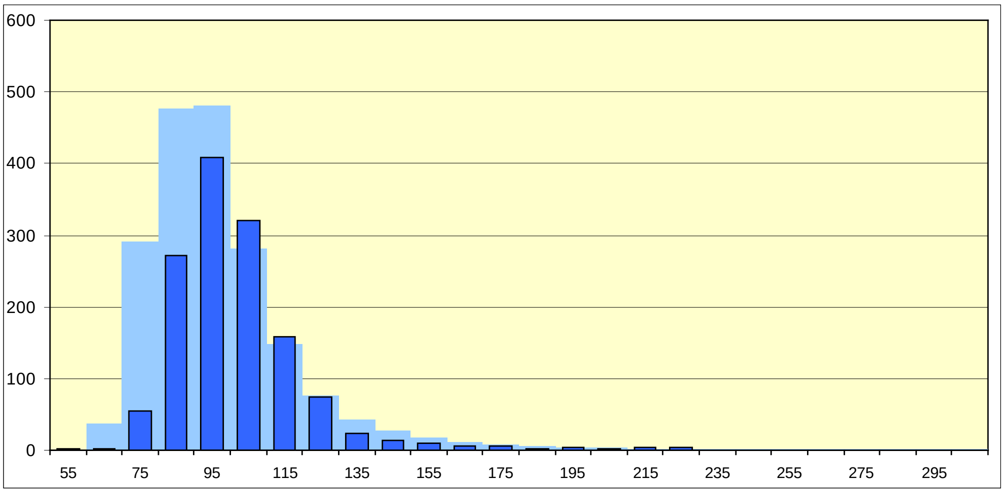


Figure FR 7. Length distribution of eels ascending the EU ladder (Bresle river ; data: ONEMA). Light blue: 1994–2010 average. Dark blue: 2011.

3.1.3 Escapement-series

3.1.3.1 Bresle river (Seine-Normandie EMU)

The Bresle river is one of the French index rivers (see Table FR bb). In 2009, for the first time the silver escapement has been survey all the year round. This survey is carried out 15 km from the sea. Even if two alternative passages are available, the station is assessed to control 74% of wetted area. Only eels longer than 350 mm can be caught by the device. Among 365 days, the trap has been operated for 309 days, but some days the traps have been overflowed (Figure FR 8). 863 eels (521 kg) have been caught in 2009. Catch have been greater than 15 eels for ten days representing 41% of the total, the rest have been caught in 137 days, all the year round. 99% of eel are identified as silver eels according to silver index (Durif *et al.*, 2005 and 2009). 98% are greater than 500 mm and thus assumed to be female. The mean length is 668 mm (sd=94 mm) for a mean weight of 604 g (sd=12 g).

A marking–recapture campaign has taken place in October with 80 eels from the trap marked and release upstream. 16% have been recaptured. A provisional estimate of the total silver eels runs above the trapping station range from 6400 to 7200 silver eels (3.86 to 4.35 t).

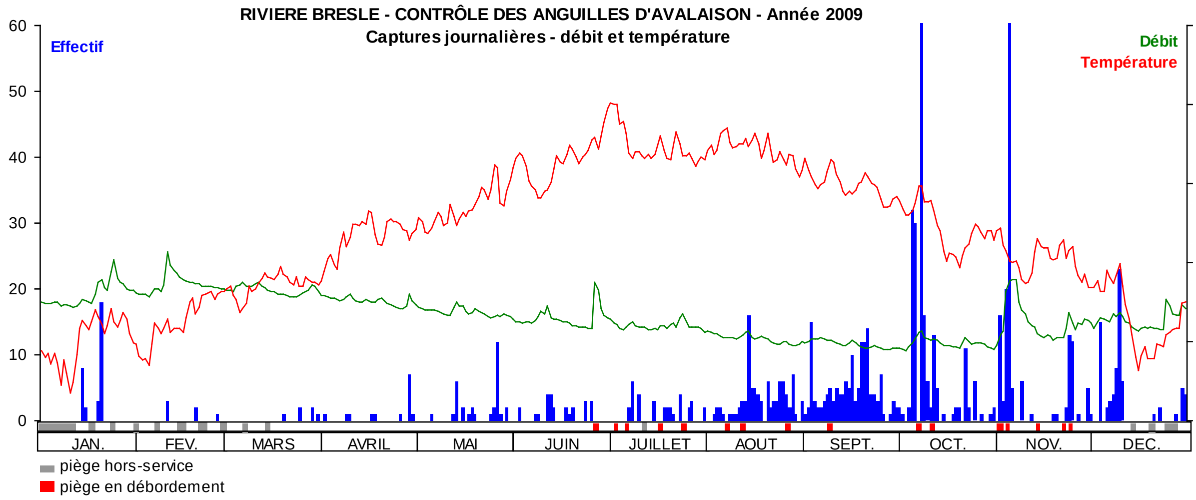


Figure FR 8. 2009 silver eel surveys in the Bresle River (data: ONEMA). Blue bar = silver eels number, red = temperature, green = discharge. Grey days = trap not operating, red days = trap operating but overflowed.

3.1.3.2 Frémur river (Britanny EMU)

The Frémur River is the main river (17 km) of a small basin (60 km²). An intensive eel monitoring program has taken place in 1995 (Charrier *et al.*, 2011). This monitoring is now part of the index river system (see 9.1.2).

The second dam (Pont es Omnès; 4.5 km from the sea) is equipped to monitor silver eel run. Except for extreme situation, the system catches any escaping silver eel. However the silver eel escapement is closely related with the water release for the dam which in use for water intake.

The series is given in Table FR e. Between 1996–1997 and 2000–2001 the mean number of silver eel is about 850, since the mean number decrease to 460. Preliminary results from 2010–2011 season seems to show a new decrease below 300 silver eels. At the same time the sex-ratio increase from 33% of female to 51% of female.

Table FR e. Silver eel escapement on the Frémur river (Charrier *et al.*, 2011).

	SILVER EEL (#)	SILVER EEL (KG)	SEX-RATIO (%F)
1996–1997	675	91.2	27%
1997–1998	828	165.1	34%
1998–1999	676	118.2	33%
1999–2000	1271	245.7	35%
2000–2001	816	141.4	38%
2001–2002	392	68.3	37%
2002–2003	372	97.2	58%
2003–2004	571	122.6	48%
2004–2005	333	72.3	46%
2005–2006	565	151.2	59%
2006–2007	602	142.9	53%
2007–2008	515	128.3	57%
2008–2009	473	118.7	49%
2009–2010	320	94.3	57%

3.2 Glass eel landings

3.2.1 The Garonne (Garonne EMU)

The Gironde series is collected by the Irstea (Girardin and Castelnaud, 2011) and was extended to the past before 1978 by Beaulaton (2008). The oldest catches (<1936) were extrapolated thanks to data that have been collected by Gandolfi in several papers, and that come from the railway statistics and San Sebastian market. In the 1980s, the catches from recreational fishermen were larger than those from commercial fishermen. The Gironde is one of the few estuaries where an estimation of recreational landings is available as a time-series. It has been extrapolated from professional landings and number of river amateur fishermen.

One should notice that landings were, until the beginning of the 1980s, dominated by the freshwater tidal reach catches ("Garonne Dordogne Isle rivers") but since then have been overtaken by brackish estuary catches ("Gironde estuary").

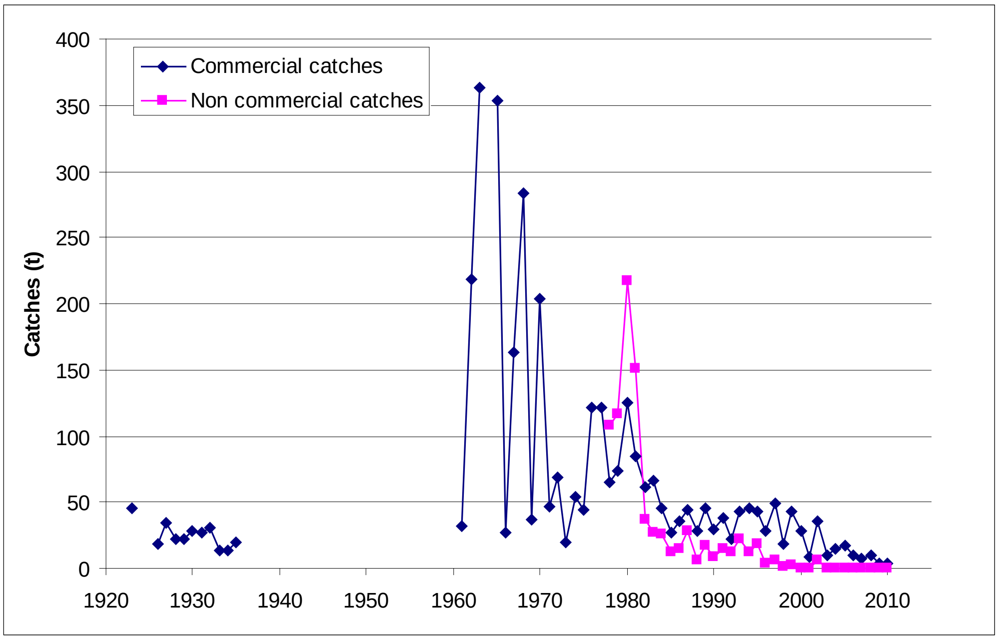


Figure FR 9. Glass eel landings in the Gironde (Garonne EMU).

3.2.2 General overview

Table FR f summarizes major French glass eel landings series from 1978 onwards. These series show clear decrease from more than 1000 t as overall before 1980 to less than 100 t as overall since 2004 and less than 50 t as overall since 2010.

Table FR f. Glass eel professional catches in the large French basins and total production in France for professional and non-professional fishers. MP: marine professional fishers, PF: river professional fishers, Non-professional: amateur fishers including poachers for Gironde; numbers in black= estimations by extrapolation; 0 t = less than 1 t. *ICES indicated a 60% drop in landings compare to 2008; ** from official data. Yellow underline = updated in 2012.

	COMMERCIAL FISHERMEN CATCH (TONS)								NON COMM; FISHERMEN CATCH (TONS)			
	Adour		Gironde		Loire		Vilaine	Total France[1]	Adour	Gironde	Loire	Total France [2]
Season	MP	FP	MP	FP	MP	FP	MP					
1978			22	43	514	12	106	1393		108		647
1979			26	47	620	22	209	1850		116		697
1980			38	87	508	18	95	1491		217		1303
1981			36	49	288	15	57	890		151		904
1982			39	22	261	13	98	866		36		219
1983			48	19	241	19	69	791		27		161
1984			32	13	168	15	36	528		26		156
1985			21	6	145	9	41	444		12		71
1986	8		27	9	113	10	53	423		14		87
1987	10		26	19	131	14	41	461		29		172
1988	12		22	6	165	12	47	504		7		40
1989	9		32	14	78	9	37	410		17		110
1990	3	4	23	6	81	16	36	325		9		54
1991	2	4	30	9	31	5	15	179		14		87
1992	8	12	15	8	32	7	30	183		13		77
1993	6	7	33	9	80	11	31	329		22		130
1994	3	7	40	5	95		24	329	18	12	0	74
1995	8	4	36	8	127	6	30	413	10	19	0	113
1996	4	3	25	3	73	8	22	262	12	4		25
1997	5		36	13	67	4	23	287	6	6		39
1998	2	7	16	2	61		18	195	7	1		6
1999	4	2	35	8	80	7	15	242	2	3	1	6
2000	10		25	3	74	6	14	206		0	1	2
2001	2		8	0	33	3	8	101		0	0	1
2002	2		25	10	42	8	16	202		6		37
2003	1		9	1	53	4	9	151		0		
2004	2	2	13	1	20	2	8	89	0	0	0	
2005	3	6	13	4	17	4	7	89	0	0	0	0
2006	2	2	8	1	15	3	7	67	0	1	0	1
2007	1	2	7	1	21	3	8	77	0	0	0	0
2008	3	2	6	2	19	3	5	79	0			
2009		0		0		1	2	43*	0			
2010		1		0		3	4	41**				
2011		1		0		2	4	31				
2012		1		1		2		34				

3.3 Yellow eel landings

3.3.1 Commercial

3.3.1.1 The Garonne (Garonne EMU)

The Gironde series has been collected by the Irstea (Girardin and Castelnaud, 2011) and concerns landings from professional fishermen in the lower part of the Garonne basin (comprising the brackish estuary and the tidal freshwater reach of the Garonne and Dordogne rivers). This series was extended in the past before 1978 by Beaulaton (2008). One should notice that 1946–1977 data are based on low number of fishermen that may explain high variability from these years (Figure FR 10). The fisheries also shifted from eel pot made of wood to plastic eel pots. Like for glass eel, the Gironde is one of the few estuaries where an estimation of recreational landings is available as a time-series. It has been extrapolated from professional landings and number of river amateur fishermen.

Yellow eel landings clearly decreased over the last twenty years from 158 t in average between 1978–1986 to less than 25 t since 2002.

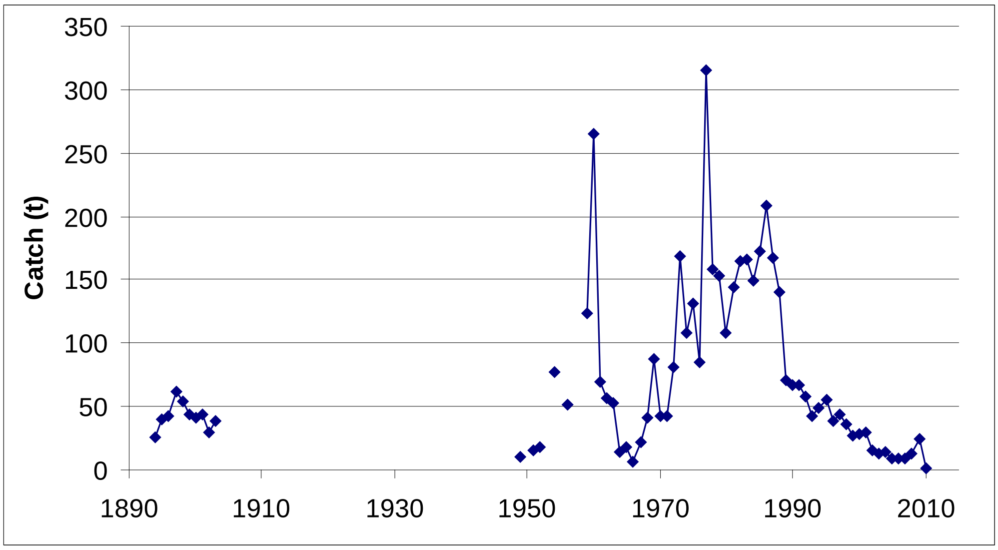


Figure FR 10. Marine and river professional yellow eel landings in the Gironde basin (brackish and freshwater estuary).

3.3.2 Recreational

No data available.

3.4 Silver eel landings

3.4.1 Commercial

3.4.1.1 Loire river (Loire EMU)

The Guideau fishery of the Loire is one of the French fishery targeting silver eels. Statistics on a sample of four fishers are available from 1987 and on the whole fishery from 2001 (Table FR g).

Table FR g. Landings (in t) of silver eel "guideau" fishery in the Loire River. In Bracket: number of fishers considered. Acou *et al.*, 2010 = Total landings from Acou *et al.* (2010) and Boisneau com. pers. *in* Beaulaton *et al.*, 2009. Official statistics = Total landings as declared to SNPE from Onema. Bodin *et al.*, 2011 = landings from a sample of four fishers from Bodin *et al.* (2011).

	Acou *et al.*, 2010	Official statistics	Bodin *et al.*, 2011
1987–1988			27.8 (4)
1988–1989			31.8 (4)
1989–1990			23.2 (4)
1990–1991			29.4 (4)
1991–1992			23.5 (4)
1992–1993			18.1 (4)
1993–1994			15.6 (4)
1994–1995			22.2 (4)
1995–1996			24.3 (4)
1996–1997			18.9 (4)
1997–1998			26 (4)
1998–1999			18.5 (4)
1999–2000			19.9 (4)
2000–2001			17.4 (4)
2001–2002	45.3 (12)		25.6 (4)
2002–2003	38.1 (10)		20.1 (4)
2003–2004	36.4 (10)		24.8 (4)
2004–2005	16.1 (8)	22.7 (7)	7.3 (4)
2005–2006	25.9 (9)	19.6 (7)	14.9 (4)
2006–2007	26.4 (7)	29.4 (8)	15.3 (4)
2007–2008	33.2 (9)	24.8 (6)	19.7 (4)
2008–2009	18.2 (7)	12.2 (7)	12.9 (4)
2009–2010		19.5 (7)	14.3 (4)
2010–2011			5.7 (4)

3.4.2 Recreational

No data available. No more relevant: the French EMP has banned silver eel recreational fishing.

3.5 Aquaculture production

3.5.1 Seed supply

No data available.

3.5.2 Production

No data available.

3.6 Stocking

3.6.1 Amount stocked

A public tender of 2 million Euros for restocking (and restocking monitoring) has been made each year since 2010.

Glass eels are all caught in the EMU in which they are restocked. Thus there is no restocking in EMU where there isn't a glass eel fishery. Glass eels have been quarantined in fish sellers' tanks for the duration of sanitary analyses (e.g. EVEX). All restocking sites are monitored to assess the efficiency of restocking (see 12.1).

In 2010, two projects representing 150 k€ (including monitoring) for 200 kg restocked have been selected. Finally no glass eel have been restocked because of the end of the glass eel season. However 209 kg (glass eel mean weight 0.233 g and thus 900 000 glass eels) have been restocked in the Loire River in July 2010. Those Glass eel were collected from a CITES seizure.

In 2011, eleven projects have been selected for a total amount of 4024 kg. Finally only 747.5 kg were really restocked, partly because of late selection process and partly because of lack of supply.

In 2012, eleven projects have been selected for a total amount of 3475 kg. Finally 3086 kg were really restocked.

Apart from this national restocking program, some local restocking may have taken place but quantity, quality (glass eel or yellow eel, …), origins and objectives are unknown. For example: they have been a long history of stocking in Lake Grand Lieu (Adam, 1997) to enhance fishery with a maximum of more than 2 t of glass eels in the 1960s and more than 1.5 t of elvers in the 1990s.

Table FR h. Quantity (in kg) of glass eels restocked in France per EMU between 2010 and 2012. * = glass eels from a CITES seizure.

EMU	2010	2011	2012
Artois-Picardie	0	45	37
Seine-Normandie	0	134	111
Britanny	0	200	333
Loire	209 *	323.5	1684
Garonne	0	45	870
Adour	0	0	51
Total	209	747.5	3086

3.6.2 Catch of eel <12 cm and proportion retained for restocking

Table FR i described the quantity of glass eels fished in France and exported or used in France for restocking.

Table FR i. Quantity exported or used in France for restocking purpose and originated from France. * = 209 kg seized in France from an unknown origin have been restocked in France in 2010.

	Quantity (kg)			
Country	2009	2010	2011	2012
Austria				
Belgium			120	160
Bulgaria				
Cyprus				
Czech Rep		671	620	520
Denmark		1050	600	2750

	Quantity (kg)			
Country	2009	2010	2011	2012
Estonia				
France		*	747.5	3086
Germany		2492	807	1761
Greece				
Finland				
Hungary				
Ireland		805		
Italy				
Latvia				
Lithuania				
Luxembourg				
Malta				
Morocco				
Netherlands		2890	370	2086
Norway				
Poland		85	85	90
Romania				
Slovakia				
Slovenia				
Spain		250	169	351.5
Sweden		870		
U.K.		240	1487	400
Hong Kong				
Unknown				
Total		9353	5005.5	11 204.5

3.6.3 Reconstructed time-series on stocking

Table FR j present a summary of known quantity of stocked eel. At present only those from the national restocking programme are fully known (3.6.1). Some local restocking may have taken place but quantity, quality (glass eel or yellow eel, …), origins and objectives are unknown. Recent findings in historical grey literature show that restocking in France has begun at soon as the mid-XIXth century and that quantity can be important: for example, in 1884, 600 kg of glass eels from the Gironde estuary have been stocked in the Cantal départment. Research is ongoing on that subject. It is impossible to give a comprehensive picture this year.

Table FR j. Reconstructed time-series on stocking. Quantity in kg. * = from a CITES seizure, unknown origin.

	Local Source				Foreign Source			
Year	Glass Eel	Quarantined Glass Eel	Wild Bootlace	On-grown cultured	Glass Eel	Quarantined Glass Eel	Wild Bootlace	On-grown cultured
2010						209*		
2011	747.5							
2012	3086							

3.7 Silver eel "restocking"

Glass eels have never been exploited on the French Mediterranean coast. Restocking measures were therefore not applicable on the Mediterranean coastline. Instead, a new approach was experienced in 2011: a part of the exploited silver eels was released to the sea. In the Rhône Mediterranée Corse EMU, eel fishing activity is principally located in lagoons and both yellow and silver stages are targeted. Fishermen working in lagoons are small scale fishers (boat <7 m, using passive gears: mostly assemblage of fykenets called capétchades), relying mostly on eel species to sustain their livelihoods. This pilot study was closely followed by the scientists and the governmental authorities. A protocol was designed by a group of scientists (Amilhat *et al.*, 2012a) to ensure the respect of good practices. Eels were released at the mouth of the lagoons with direct access to the sea (no dams or fishing gears). They were released at dawn, their natural time to migrate, shortly after they have been captured (mostly the following night). In total 16 tons of silver eels were released in 2011 (between 24th November and 29th December), over twelve releasing events on ten locations (Figure FR 11 and Table FR k).

Figure FR 11. Locations (black dots) where silver eels were released in 2011.

Table FR k. Quantity of silver eels released in November and December 2011.

#	Lagoon	Date	Released quantity (kg)
1	Bages-Sigean Nord	24-nov	1188
2	Mauguio (Or)	24-nov	1716
3	Salses-Leucate Sud	25-nov	1452
4	Vendres	26-nov	528
5	Bages-Sigean Sud	29-nov	1452
6	Ayrolle	30-nov	1974.5
7	Salses-Leucate Nord	12-déc	983.5
8	Thau 3	21-déc	3168
9	Ingril, Vic, Pierre Blanche, Arnel, Grec, Méjean, Pérols	22-déc	942
10	Ponant, Virdoule, Médard, Marette	23-déc	792
11	Thau 1	27-déc	924
12	Thau 2	29-déc	924
	Total		16 044

4 Fishing capacity

Since the enforcement of the management plan, the number of fishermen licensed for eel is reported at the national level. Data are given separately for the Mediterranean lagoons which have different regulations.

Before the entry into force of the French EMP, there was no special licence for yellow (and silver) eels fluvial fishermen.

4.1 Glass eel

The eel fishery is regulated by a licence and a local basin "stamp" is necessary to go fishing for glass eel in a given location. These "stamps" are granting access to the whole EMU but to a more local level.

The licences are delivered annually but the fishing season overlaps from one year to the next. Thus for the 2001–2012 season, the number of licence is between 573 and 500 for marine fishermen. The number of licences delivered for glass eel has been steadily diminishing from a total of 1224 in 2006 to 647 in 2012. Fishing for glass eel is not authorized in the Rhône Méditerranean, nor in the Corsica EMU.

Table FR l. Glass eel licences.

	2006	2007	2008	2009	2010	2011	2012
Marine commercial fishermen	853	862	814[1]	754	643	573	500
Fluvial Commercial fishermen	371	343	328	205	180	158	147
Amateur				|←Fishing forbidden			
Total	1224	1205	1142	959	823	731	647

4.2 Yellow eel

In addition to the diminution in the number of licences for yellow eel, several sectors have been closed for PCB contamination reasons (Seine, Rhône, Saône, Gironde estuary…).

Table FR m. Yellow eel licences.

	2009	2010	2011	2012
Marine commercial fishermen	309	268	245	236
Mediterranean and Corsica (Yellow and Silver) commercial fishermen	.	295	265[2]	269
Fluvial commercial fishermen	169	171	170	169
Fluvial amateur with gears	.	.	.	5224
Anglers[3]	.	.	1 414 017	1 321 924

[1] Note this data has been updated since national management plan and previous report.

[2] Interregional number fixed.

[3] Not eel specific license. Eel fishing report is mandatory but no statistics are available yet.

4.3 Silver eel

Since the adoption of the French eel management plan, fishing for silver eels is no longer allowed in marine waters except in the Mediterranean lagoons where a specific licence is required. However more or less all fisher with both stage (yellow and silver) and we thus give the total number of fisher (Table FR n). In fluvial part on professional fisher from certain place (mainly Loire river and Grand Lieu lake) of Loire EMU and of Rhône EMA (lower part of Rhône river) are allowed to fish silver eel. However due PCB contamination, silver eel is only really fished in Loire EMU.

Table FR n. Silver eel licences.

	2009	2010	2011	2012
Marine fishermen	Not allowed			
Mediterranean and Corsica (Yellow and Silver)		295	265	269
Fluvial fishermen	44	41	37	34
Fluvial amateur with gears	Not allowed			
Anglers	Not allowed			

5 Fishing effort

5.1 Glass eel

The trend in effort is provided by comparing (Beaulaton *et al.*, 2009) data with current fishing effort. The number of marine fishermen who have reported a catch has dropped from 827 (extrapolated number in 2009) to 528 in 2012. The actual number is consistent, because it stands between the number of licences issued for 2011 (573) and for 2012 (500). The drop in the number of fishermen having reported a catch is of 36%, a little bit larger than the drop in the number of licensees.

Table FR o. Trend in glass eel fishing effort, number of marine fishermen having reported a daily catch[4]. Source: FranceAgrimer (DPMA).

EMU	2008	2011	2012
Artois Picardie	28	12	9
Seine Normandie		34	13
Bretagne	154	74	70
Loire et Côtiers Vendéens	341	327	258
Garonne-Dordogne-Charente	212	139	124
Adour et Landes	92	92	54
France	827	678	528

The fishing trips for marine glass eel fishermen are grouped daily, each day corresponding to one or two trips. When looking at the number of daily catch, the current number of daily catch only represents 44% of 2007/2008 daily catch, while it was about half that number (48%) in 2011, so there is a steady diminution in fishing effort of about 56% from 2009 to 2011. In 2010 and 2011, this diminution is mostly the con-

[4] 2007/2008 was extrapolated and calculated for WGEEL 2009.

sequence of trade closure as the quota set at the national level was not attained, and thus was not restrictive to the fishing activity. However, in 2012 the quota was attained quite rapidly in some places, and the fishery stopped for a while in most of the sectors (Figure FR 12).

In places where many boats are competing with each other, the diminution in fishing effort might be somewhat compensated by the greater individual efficiency of boats as the overall number of boat diminishes. This decrease in fishing effort can thus be considered as an overestimation of the diminution in fishing mortality.

Table FR p. Trend in glass eel fishing effort, number of daily catch for marine fishers[5]. FranceAgrimer (DPMA).

EMU	2008	2011	2012
Artois Picardie	858	169	199
Seine Normandie		247	159
Bretagne	4954	1664	1347
Loire et Côtiers Vendéens	16 009	8739	7702
Garonne-Dordogne-Charente	7576	3085	3758
Adour et Landes	2450	1300	968
France	31 847	15 204	14 133

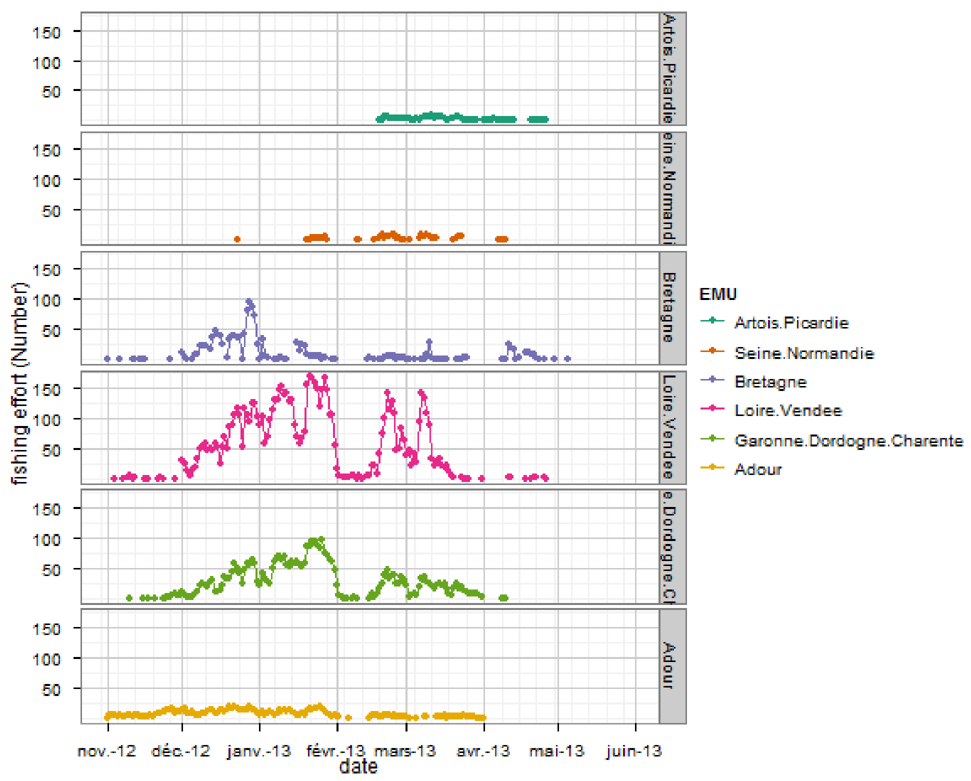


Figure FR 12. Fishing effort daily values for commercial marine fishermen in France in 2011/2012.

[5] 2007/2008 was extrapolated and calculated for WGEEL 2009.

5.2 Yellow eel

No data available.

5.3 Silver eel

No data available.

5.4 Marine fishery

No data available.

6 Catches and landings

6.1 Glass eel

For total catch of marine fisher in 2012, two sources of data are available, the catch from the national FranceAgrimer (DPMA) database and the table reporting the total quota issued officially at some time in the season, while in some places all catches might not have been inserted in the database (Table FR q). The drop in landings from 2007/2008 is about 60%, consistent with the drop in daily fishing effort estimated as 56%. Contrarily to last year's, there are clearly periods with no glass eel catch (Figure FR 12) in 2011–2012 season due to quota closure.

Table FR q. Trend in glass eel landings (kg), marine commercial fishermen, Source FranceAgrimer (DPMA) July 2012, WGEEL 2009, WGEEL 2010, WGEEL 2011.

<table>
<tr><th>EMU</th><th>2007/2008</th><th>2009/2010</th><th>2010/2011[6]</th><th>2011/2012</th></tr>
<tr><td>Artois Picardie</td><td rowspan="2">1175</td><td>460</td><td>278</td><td>468.17[7]</td></tr>
<tr><td>Seine Normandie</td><td>860</td><td>400</td><td>369</td></tr>
<tr><td>Bretagne</td><td>5864</td><td>4095</td><td>3619</td><td>3322[8]</td></tr>
<tr><td>Loire et Côtiers Vendéens</td><td>42 816</td><td>24 761</td><td>17 415</td><td>18 415[8]</td></tr>
<tr><td>Garonne-Dordogne-Charente</td><td>17 031</td><td>6423</td><td>5352</td><td>6928</td></tr>
<tr><td>Adour et Landes</td><td>4519</td><td>537</td><td>1353</td><td>949</td></tr>
<tr><td>France</td><td>71 405[8]</td><td>37 177[9]</td><td>28 417[10]</td><td>30 452[11]</td></tr>
</table>

For fluvial fishers the declared total landings are given in Table FR r. They have dropped since 2009 which may be a combination of management measure and decreasing recruitment. Despite of the objective of decreasing fishing mortality 2012 season is the best landings since the entry into force of the French EMP which may be the result of an increasing pressure (but number of fisher decrease), a better recruitment or decreasing pressure in marine estuary.

[6] Source FranceAgrimer (DPMA), WGEEL 2011.

[7] In cases where the total amount of catch is lower than the "official quota report", the official figure is used. The latter is then based on trade reports.

[8] Extrapolated, see WGEEL 2009, 31 847 in the official database.

[9] Probably quite inaccurate.

[10] Note that this value is lower than official figure (32 291), see WGEEL 2011 for explanation.

[11] Updated from national database in July 2011, this figure is slightly larger than official quota report 30 361.

Table FR r. Trend in glass eel landings (kg), Fluvial fishermen, Source ONEMA.

EMU	2007/2008	2008/2009	2009/2010	2010/2011	2011/2012
Loire et Côtiers Vendéens	3316	1270	3114	1669	2094
Garonne-Dordogne-Charente	1727	143	26	236	646
Adour et Landes	2224	217	542	936	1105
France	7267	1630	3683	2840	3845

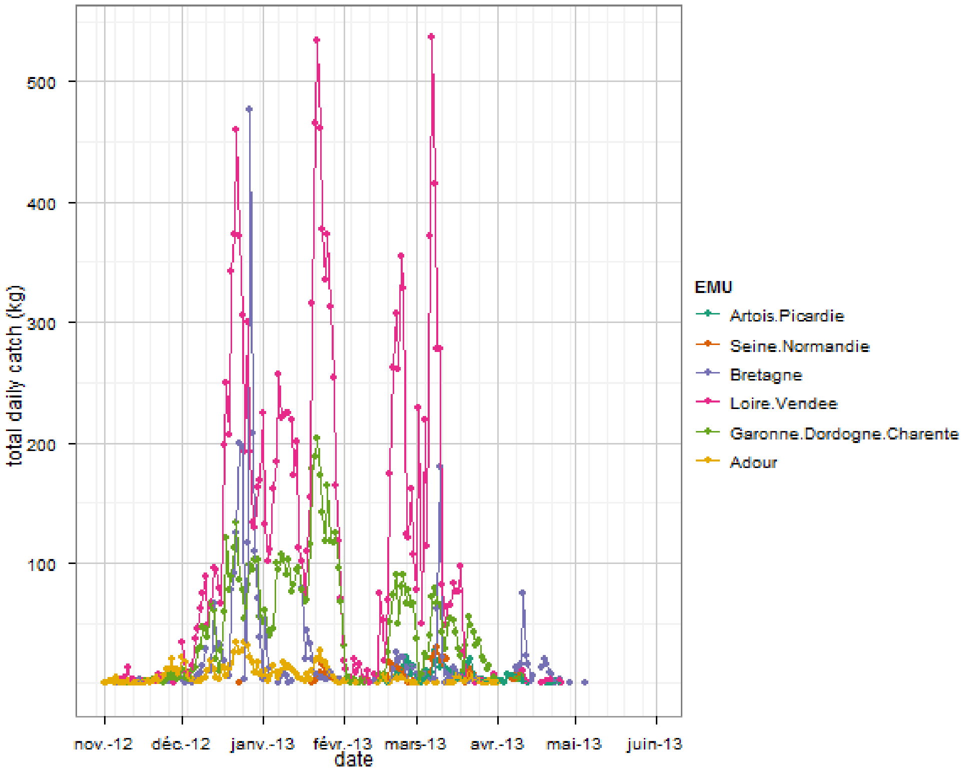


Figure FR 13. Daily total landing values for commercial marine fishermen in France in 2011/2012.

Table FR s. Comparison of different sources of glass eel landings (t) for seasons between 2007–2008 and 2012–2012.

	2007/2008	2008/2009	2009/2010	2010/2011	2011/2012
Estimated trade from eurostat (t)	51.7	25.5	41.8	33.7	24[12]
Glass eel traders (CONAPED estimate)	68–72	31–32			
Export to Hong-Kong China	39	6.9	13.7	0	0
Commercial landings (fluvial+commercial)	78,7	42.8 ?[13]	40.9	31.2[14]	34.3

[12] 24 t exported from France. 8 t reported as import from France. 3.09 t for restocking.

[13] ICES indicated a 60% drop in landings.

[14] 32.3 in official statistics.

6.2 Yellow eel

The only information available for marine commercial fishery in France in 2011 is a sum (346 222 kg) of yellow and silver eel landing (source DPMA). The origin, the date and other type of information of these landing are not available.

A recent analysis of fisher logbooks estimates that the total catch (yellow and silver eel) in the Mediterranean lagoons of the Languedoc-Roussillon region, were 260 t in 2009 and 239 t in 2010.

The declared landings of professional fluvial fishermen is given in Table FR t.

Table FR t. Declared landings of yellow eels caught by professional fluvial fisher split by EMU. Source: SNPE Onema.

	2007	2008	2009	2010
Loire	6447	11 755	12 678	10 329
Rhin	724			
Rhône	576	1		
Seine	862	230	120	214
Adour	706	515	458	552
Garonne	7572	15 185	15 073	910
Total	16 887	27 686	28 329	12 005

6.3 Silver eel

No precise statistics are available for marine fishermen (see 6.2).

Silver eel fishing for fluvial fishermen in only allowed in Loire and Rhône EMU. Due to PCB contamination silver eel fishing only take place in Loire EMU. The status of Grand Lieu Lake being particular, we only give here the statistics for Loire EMU excluding this lake (Table FR u).

Table FR u. Declared silver eel landings for professional fluvial fisher in Loire EMU (Grand lieu Lake excluded). Source: Onema.

	Loire
2005	23 488
2006	20 633
2007	30 485
2008	25 387
2009	12 851
2010	20 215
2011	11 452

6.4 Marine fishery

No data available.

7 Catch per unit of effort

7.1 Glass eel

7.1.1 Marine professional fisher

The cpue for the commercial glass eel fishery of marine fishermen is showing an upward trend when compared to last year or even 2007/2008 data, except in the Adour where it remains quite stable. This trend might indicate better recruitment, but the relation to the actual stock abundance should be considered cautiously for three reasons: (1) in some places, large diminution in overall fishing effort as well as period of closure of the fishery have led to a greater quantity of glass eel being available in the estuaries; (2) the buying of limited quantity of glass eel to reach quotas figures have resulted in some places in daily individual target set for fishermen by fish buyers, rendering commercial cpue highly biased as a stock indicator. In that case cpue would be lower than in normal fishing conditions. The comparison with 2007/2008 data is further hampered by the current aggregation of catch data per EMU. (3) The current reporting of catch per EMU is less informative than per estuary and hinders the possibility of doing local analyses. Details about the trend in cpue is given in Figure FR 13.

Table FR v. Daily cpue for the commercial glass eel fishery.

EMU		2007/2008	2010/2011	2011/2012
Artois Picardie		0.94	1.49	1.98
Seine Normandie			1.42	2.11
Bretagne		1.01	1.84	2.01
Vilaine		1.07		
Loire et Côtiers Vendéens	Loire	2.28	1.73	1.97
	Vendée	1.70		
Garonne-Dordogne-Charente	Garonne	1.50	1.58	1.69
	Charente	1.72		
Adour et Landes		0.90	0.86	0.85

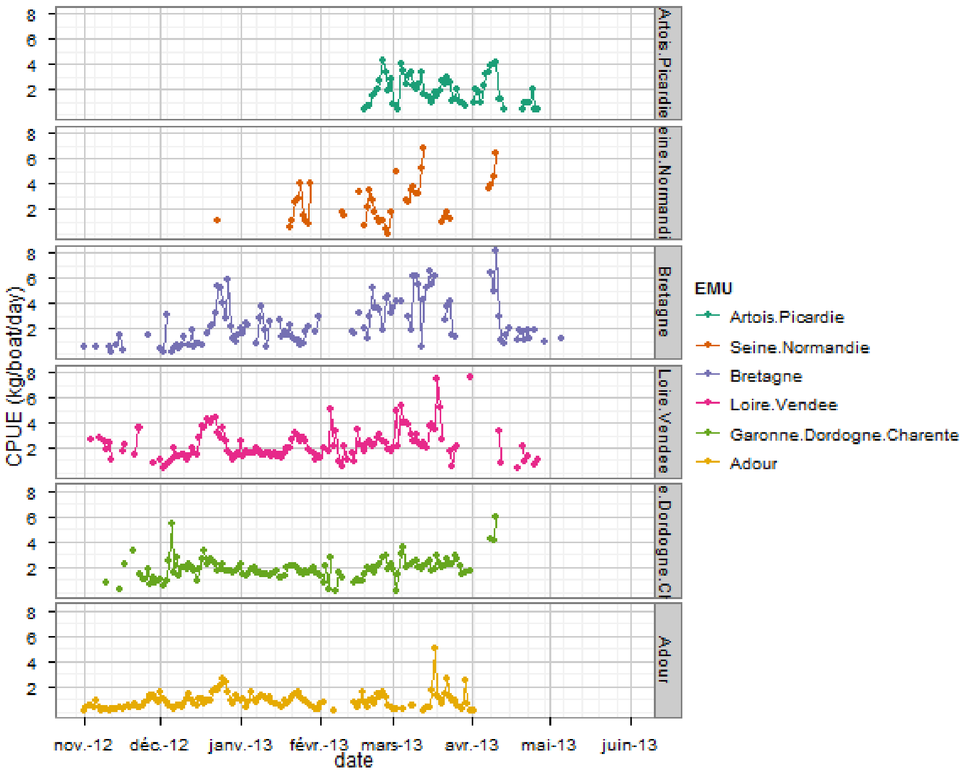


Figure FR 14. Daily cpue for commercial marine fishermen in France in 2011/2012.

7.1.2 The Garonne (Garonne EMU)

The Gironde basin is the tidal part **(**Figure FR 1 and Figure FR 2) of the Garonne basin, comprising the brackish estuary and the tidal freshwater reach of the Garonne River, Dordogne River and of its tributary, the Isle River. The results are providing by the Irstea statistical monitoring system and have been studied by Beaulaton (2008).

One of the notable features of the glass eel fishery in the Gironde is the major shift from scoopnet catches in favour of large pushnet catches (Figure FR 15 and Table FR w). The fishery is presently very largely a large pushnet fishery in the estuary, whereas formerly it was a scoopnet fishery in freshwater estuary.

After a large decrease of the glass eel abundance (cpue) in the Gironde basin between 1981 and 1985, the cpue slightly decreased to reach its lowest level in the last recorded year (2009–2010) (Figure FR 15 and Table FR w).

Table FR w. Catches of glass eel for professional large pushnet (LPN), small pushnet (SPN) and scoopnet (SN) and non-professional scoopnet fishermen, cpue on the Gironde basin for 1961–2008 (Source: Irstea). "-": gears not used that year ; "?" unevaluated.

	Total Catch (t)				CPUE (kg/day)
Year	Pro. LPN	Pro. SN	Pro. SPN	NonPro. SN	Pro. LPN
1960–1961	-	32.2	-	?	
1961–1962	-	217.8	-	?	
1962–1963	-	363	-	?	
1963–1964	-	?	-	?	
1964–1965	-	352.5	-	?	
1965–1966	-	27.6	-	?	

	Total Catch (t)				CPUE (kg/day)
Year	Pro. LPN	Pro. SN	Pro. SPN	NonPro. SN	Pro. LPN
1966–1967	-	162.8	-	?	
1967–1968	-	284.2	-	?	
1968–1969	-	36.6	-	?	
1969–1970	-	203.8	-	?	
1970–1971	-	47.1	-	?	
1971–1972	-	69	-	?	
1972–1973	-	20	-	?	
1973–1974	1.9	52.7	-	?	7.8
1974–1975	6.6	37.5	-	?	6.7
1975–1976	25.2	95.7	-	?	13.2
1976–1977	39	82.6	-	?	11.7
1977–1978	26.7	83.3	-	107.8	12.8
1978–1979	28	89.7	-	116.2	14
1979–1980	45.8	167.3	-	217.1	25.4
1980–1981	45.5	78.3	-	150.6	14.9
1981–1982	49.6	36.6	-	36.5	10.9
1982–1983	49.5	25.8	-	26.9	12.7
1983–1984	30.5	26	-	26	17.6
1984–1985	16.3	11.7	-	11.8	8.1
1985–1986	26.3	13.6	-	14.4	8.8
1986–1987	31.9	25	-	28.6	13.5
1987–1988	25.4	6.7	-	6.7	9.3
1988–1989	37.5	15.6	-	17.3	7.1
1989–1990	28.6	8.6	-	9	5.6
1990–1991	36	9.6	-	14.5	8.5
1991–1992	17	8	-	12.8	4.5
1992–1993	29.6	11.6	-	21.7	8.9
1993–1994	34.6	6.5	-	12.4	9.2
1994–1995	47.5	9.6	-	18.9	7.9
1995–1996	21.4	1.5	2.2	4.2	4.7
1996–1997	33	3.6	7.9	6.4	6.3
1997–1998	14.1	0.4	1.7	1	3.8
1998–1999	40.6	0.8	7.5	2.7	8.9
1999–2000	21.2	0.1	3.4	0.3	6.6
2000–2001	8.8	0	0.2	0.1	1.9
2001–2002	28.3	3.8	4.7	6.2	4.9
2002–2003	9.5	0.1	0.8	0.1	2.7
2003–2004	13.3	0.1	1	0.1	2.5
2004–2005	12.9	0.8	3.6	0.5	2.7
2005–2006	8.1	0	1.2	0	2.4
2006–2007	6.2	0.1	1.1	0.1	2.1
2007–2008	8.2	0.4	1.3	0.2	2.6
2008–2009	3.5	0	0	0	1.4
2009–2010	3.4	0	0	0	1.2

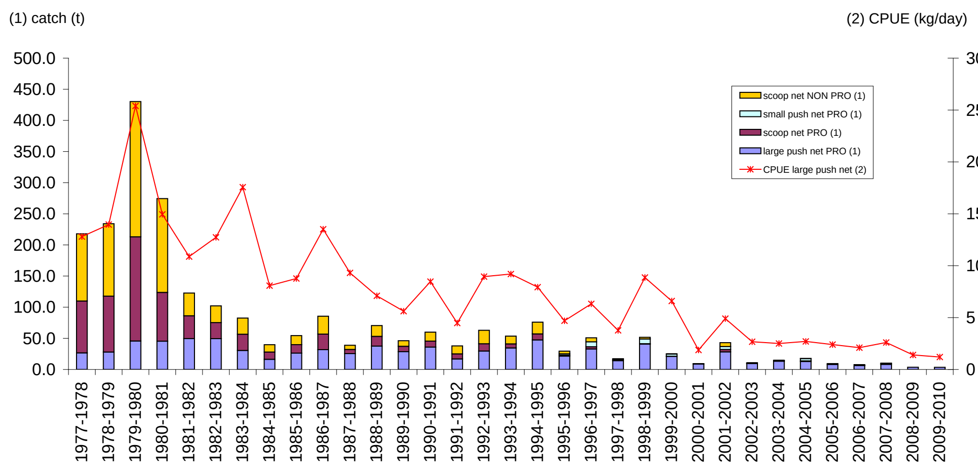


Figure FR 15. Cumulated capture of glass eel for non-professional and professional fishermen for 1978–2008, cpue of large pushnet professional fishermen on the Gironde basin for 1978–2008 (Source: Irstea).

7.2 Yellow eel

7.2.1 The Garonne (Garonne EMU)

Yellow eel cpue for the Gironde basin have been extended by Beaulaton (2008). The eel pot cpue increase in the 1970s, mainly because of change of eel pot (from wooden to plastic). Then the eelpot cpue for yellow eel has fallen since the middle of the 1980s, slightly increased until 1998 before decreasing again until 2007 (Table FR x and Figure FR 16). The total catches have decreased while the number of fishermen has also decreased. But changes in the fishing power and in the tactics have increased the real effort and our effort unit does not reflect these changes. Consequently, this cpue is not fully representative of the real current tendency of the abundance which presents certainly a more marked decrease.

Table FR x. Catches of yellow eel for professional and non-professional (from 1978 onwards only) yellow eel fishermen, cpue on the Gironde basin for 1894–2010 (Source: Irstea).

	Total Catch (t)		CPUE (kg/eelpot/month)
Year	Pro.	Non Pro.	Pro.
1894	26.2		
1895	40.5		
1896	42.1		
1897	61.6		
1898	53.7		
1899	43.5		
1900	41.8		
1901	43.9		
1902	29.1		
1903	38.1		
1949	10.7		
1950			
1951	15.4		0.5
1952	17.6		0.5

	Total Catch (t)		CPUE (kg/eelpot/month)
Year	Pro.	Non Pro.	Pro.
1953			
1954	77.5		1
1955			
1956	51.9		0.7
1957			
1958			
1959	123.8		1.4
1960	265.3		2.5
1961	69.4		0.9
1962	56.8		0.8
1963	53.1		0.9
1964	14.5		0.6
1965	18.4		0.5
1966	6.3		0.7
1967	21.5		0.9
1968	40.8		0.8
1969	87.8		3.3
1970	42.4		1.4
1971	43.1		1.7
1972	80.6		1.9
1973	168.6		1.2
1974	108.2		2.7
1975	130.8		2.3
1976	84.8		1.8
1977	314.8		2.8
1978	157.9	204.1	2.6
1979	152.5	229.5	3.7
1980	108.4	155.7	2.5
1981	143.5	148.8	1.6
1982	164.3	133.1	3.3
1983	166	76.2	2.6
1984	148.8	164.1	2.8
1985	172.4	170.3	3.4
1986	208.8	160.5	3.3
1987	167.7	134.3	1.3
1988	140	97.7	1.9
1989	70.4	40.2	1
1990	67	28.3	1
1991	67.5	15.8	1.1
1992	58.5	27.7	1.1
1993	42.2	21.4	1.5
1994	48.7	21.1	1.5
1995	55.8	18.4	1.4
1996	38.8	7.7	1.3

	Total Catch (t)		CPUE (kg/eelpot/month)
Year	Pro.	Non Pro.	Pro.
1997	43.7	9.7	1.3
1998	36.1	7.3	1.3
1999	27.3	1.5	1.2
2000	27.9	1.4	1
2001	29.4	0.6	1.1
2002	15.8	1.1	0.9
2003	12.8	0.5	0.8
2004	14.4	1.3	1.3
2005	8.6	0.6	0.8
2006	8.4	0.6	0.9
2007	8.8	0.8	1
2008	12.4	1.3	2.3
2009	24.2	1.6	2.1
2010	1.3	0	0

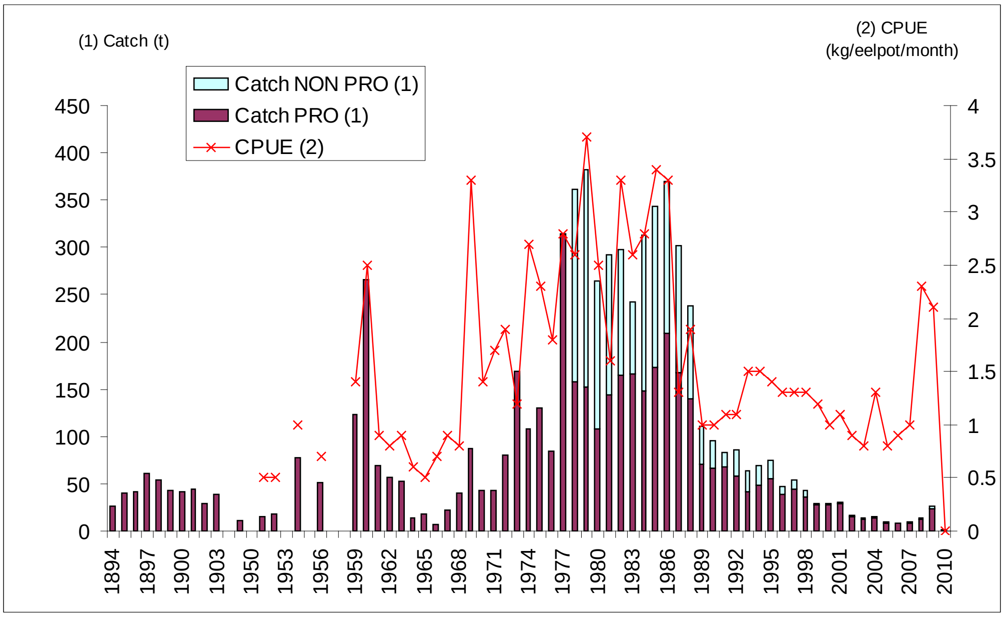


Figure FR 16. Cumulated catch of yellow eel for professional and non-professional fishermen, cpue on the Gironde basin for 1894–2010 (Source: Irstea).

7.2.2 Mediterranean lagoons

In the Mediterranean lagoons the eel catches have reached 2000 t/year during the 1980s. They have decreased progressively to 900 tons in 1998 with 200 t for the Camargue and Corsica and 700 t for the Languedoc-Roussillon (VERGNE *et al.*, 1999).

The mean average landing from 2003 to 2005 is estimated at 512 t for Languedoc-Roussillon lagoons (Cepralmar 2003, 2004, 2005). In 2007, catches in PACA lagoons are estimated at 111 t (Pôle relais lagunes méditerranéennes, 2009).

For 2008, Demenache *et al.* (2009) have estimated that the production of yellow eels in continental French Mediterranean coast has dropped further to about 294 t (precision between 211/395 t).

A recent analysis of fishermen logbooks estimated the total catch (yellow and silver eel) in Languedoc-Roussillon lagoons at 260 t in 2009 and 239 t in 2010.

7.3 Silver eel

7.3.1 Loire River (Loire EMU)

Cpue have been extracted from data of a sample of four fishers of the Guideau fishery (Bodin *et al.*, 2011; Figure FR 17). They show a significant decreasing trend.

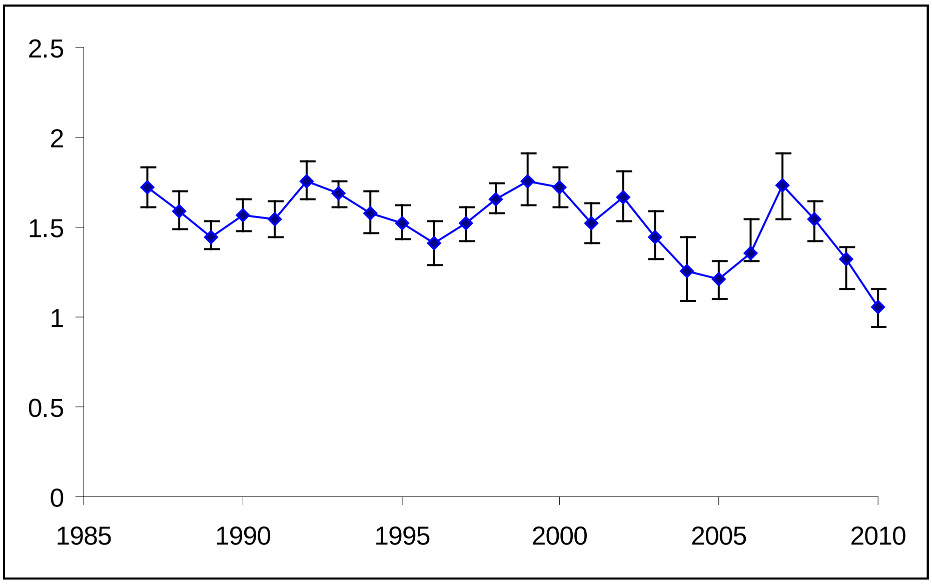


Figure FR 17. Cpue from the guideau fishery (silver eel) (Bodin *et al.*, 2011).

7.4 Marine fishery

No data available.

8 Other anthropogenic impacts

8.1 Eels and Installations R&D programme

The new insights presented here come mainly from the "Eels & Installations R&D" programme which is a partnership between Onema, Ademe and five hydroelectric companies. Over the past three years, this programme launched 18 research projects to optimise the design and management of installations to protect migrating eels. Summaries of research results and texts of the communications presented during the symposium held November 2012 the 28th and 29th are available at www.onema.fr/Programme-de-R-D-Anguilles. A synthesis document for this "Eels & Installations R&D programme" has been published in 2012 (http://www.onema.fr/IMG/EV/meetings/Les-Rencontres-15-UK.pdf).

A specific work SEAHOPE (for Silver Eels escApment from HydrOPowEr) was done during the first semester of 2012 to evaluate the turbine mortality at large scale from results of this R&D programme.

8.1.1 Upstream migration and impacts on hydropower turbines

To restore eel biomass, an essential first step is to facilitate the access of glass eels to inland waters. Even before they can reach the rivers, their travel, which depends on the tides in estuaries, is blocked by a large number of installations (tidal doors, valves, floodgates, etc.) established to control the flows of fresh and salt water between estuaries and inland waters. Through a typology of the installations the biological effectiveness of systems designed to allow, in winter, a regular inflow of limited volumes of salt water was determined (Ch. Rigaud, Irstea, Ph. Baran, Onema). Eight sampling campaigns were carried out on tidal doors, on the Charras site (the estuary of the Charente River, southwest France) that were equipped with a 10 cm chock to inhibit complete closing of the doors. The entering glass eels were collected every 20 minutes by a filter system. The campaigns confirmed the effectiveness of the system for upstream migrations. However, each installation raised specific problems. Operational management must be approached on a case-by-case basis and must notably take into account the acceptable water volumes given the upstream constraints.

Similar to the above study, efforts undertaken to assess the passage rate of an installation equipped with brush pass commonly encounter the difficulty of precisely determining the number of eels arriving at the downstream entry point of the fishway. The accessibility and the «passability» of three installations, located near the high tide line and equipped with brush passes, were evaluated with elvers (<15 cm) tagged with coloured visible implant elastomer (VIE) (Ch. Rigaud, H. Drouineau, Irstea, Ph. Baran, Onema). Tagged specimens were released at the foot of fishways (also called fish passes) or downstream of obstacles. The start of glass eel migration varies significantly between sites and even within a given site.

Once the tidal installations have been overcome, large dams constitute a second type of obstacle for upstream migration. Brush passes or passes with artificial substrates have been installed for years. A research project (L. Carry, Migado, F. Travade, EDF R&D) validated for the 20 m high dam of Golfech a new configuration including an intermediate «buffer basin» to prevent travel back downstream. The study, carried out over three migration seasons from 2008 to 2010, counted the elvers travelling through the system and monitored the progression of individuals marked with pit tags. This type of fish pass with an artificial substrate demonstrated its effectiveness for tall obstacles and a number of important improvements were made, including adding the basin in the lower section to prevent return travel, a device to facilitate exit of the eels upstream and protection against predation by birds. On the same site, a resistive counter (ELFES-ELTA) to count and calibrate elvers sliding through four tubes equipped with electrodes was developed and tested (F. Travade, EDF R&D),. The system provides precise biological information on individuals at least 125 mm in length. Adaptations to the system should make it possible to monitor glass eels and elvers smaller in size.

8.1.2 Downstream migration and impacts on hydropower turbines

During the return of silver eels to the sea, hydropower turbines represent a significant risk of mortality. Even when downstream bypasses exist, some of the adult fish go through the turbines. To improve stock management, evaluation of injury and mortality rates caused by the various types of turbines used in hydropower plants is indispensable. This type of evaluation (E. De Oliveira, EDF-LNHE, F. Pressiat, CNR) was carried out on large turbines often found along the Rhine and Rhône rivers (Kaplan turbines with four or five blades, bulb turbines). The project protocol used in Fessenheim and Ottmarsheim on the Rhine River and in Beaucaire on the Rhône River implemented a standard marking and recapture technique with HI-Z Tag inflatable tags. A group of large eels was released at different points just upstream of the turbines and then recaptured downstream of the hydropower plant. The results, shown in the table below, indicate the percentage of fish that survived after one hour and after 48 hours.

Plants	Characteristics of turbines and installations			Survival rate		Injury rate	Percentage of uninjured individuals
	Diameter	RPM	Head	1 hour	48 hour		
Fessenheim Kaplan 4 blades	6.67 m	88.2	15.7 m	93.2 %	92.4 %	11.5 %	92.6 %
Ottmarsheim Kaplan 5 blades	6.25 m	93.7	15.5 m	82.6 %	78.6 %	27.6 %	75.5 %
Beaucaire Bulb 4 blades	6.24 m	94	16 m	95.6 %	92.3 %	6.8 %	91.6 %

Table FR y. Survival rate and injury rate in large turbines (E. de Oliveira et Pressiat, unpublished data).

In addition, an analysis of experiments run on 24 sites in Europe and North America revealed highly variable mortality rates of Kaplan turbines depending on the sites (P. Gomes, M. Larinier, Onema). Mortality increased with the size of the eels and the rotational speed of the turbines, and decreased for smaller turbine diameters and lower nominal flow rates. Mortality rates ranged from 5% to 10% for large, low-head turbines and exceeded 80% for some small turbines with high rotational speeds. An *in situ* study on small Kaplan turbines must still be carried out and for the time being, the data is drawn from the literature. Following the analysis, equations were produced to predict mortality rates M (in %) as a function of eel size TL (in m), rotor diameter DR (in m), the nominal flow Q (in m^3/s) and the rotational speed N (in rotation/min) (Gomes et Larinier, 2008).

$$M(\%) = 4.67\ TL^{1.53}\ Dr^{-0.48}\ N^{0.6}$$

$$M(\%) = 6.59\ TL^{1.63}\ Q^{-0.24}\ N^{0.63}$$

$$M(\%) = 12.42\ TL^{1.36}\ Q^{-0.22}\ Dr^{-0.10}\ N^{0.49}$$

8.1.3 Understanding the effects of turbines and of the installations themselves

The data obtained on turbines are not sufficient to estimate the overall mortality caused by an installation. It is necessary to characterise the behaviour of eels when confronted with different means of overcoming installations (turbines, locks, dams, bypasses). A three-year study (F. Bau, Irstea, F. Travade, EDF) was carried out on the lower Gave de Pau river where 192 silver eels were equipped with emitters and monitored by radio over a 60-kilometre section comprising six hydropower installations. A majority of the fish passed via the spillways (68% on average) with significant discrepancies depending on the general configuration of the spillway and the spaces between the bars of the water intakes. A formula were proposed to estimate escapement rates via the spillway as a function of the ratio between flow in the spillway Qdev and the total discharge of the river Qtotal, and of the ratio between eel size L_t and space between bars (e) (Bau *et al.*, 2012).

$$P = \exp(\eta)/(1+\exp(\eta))$$

with

$$\eta = -6.89 + 4.28*(Qdev/Qtotal) + 0.273*L_t/e$$

A similar approach based on the NEDAP technology using RFID (radio-frequency identification) was implemented on the French side of the Rhine to see how eels overcame a series of six obstacles equipped with detection systems (long underwater antennas) (E. de Oliveira, EDF-LNHE). After having solved numerous technical problems the plan is to equip and release over 300 eels each year over the next four or five years. During the first two years, the experiments suffered from numerous that have since been solved.

8.1.4 Understanding the effects of installations and series of installations

This new knowledge on downstream migration rhythms and on the behaviour of the fish in and around installations has made it possible to evaluate the cumulative losses caused by a series of installations along a river. This type of evaluation is a necessary step toward integrated management of entire river basins (P. Gomes, M. Larinier, Ph. Baran, Onema). Using the results and models produced for the Gave de Pau river, a downstream-migration model was created for a series of characteristic flow rates, i.e. during the migratory period, the eels are divided equally among the flow rates considered characteristic (Q75, Q90, Q95, Q97.5 and Q99). This model was enhanced with statistical models on flow rates at turbine intakes and with the mortality equations for each type of turbine (see Figure 1). This new method provides for a given period, a percentage of escaping eels for each installation and an overall percentage of eels surviving all the installations. When applied to a river in southwest France comprising 26 installations, the model indicated an overall percentage of escaping eels between 33% and 66%, with an average of 49%.

In this context, an application (SEAHOPE) of this methodology combined with the results of "Eel Density Analysis model" (EDA) and the French database on river obstacles (ROE) was attempted to a selection of ten rivers (Figure FR 18). 398 obstacles with a use for hydroelectricity were listed in the ROE for these rivers. Among them 188 were located in the present zone of presence for eel and in functioning in 2011.

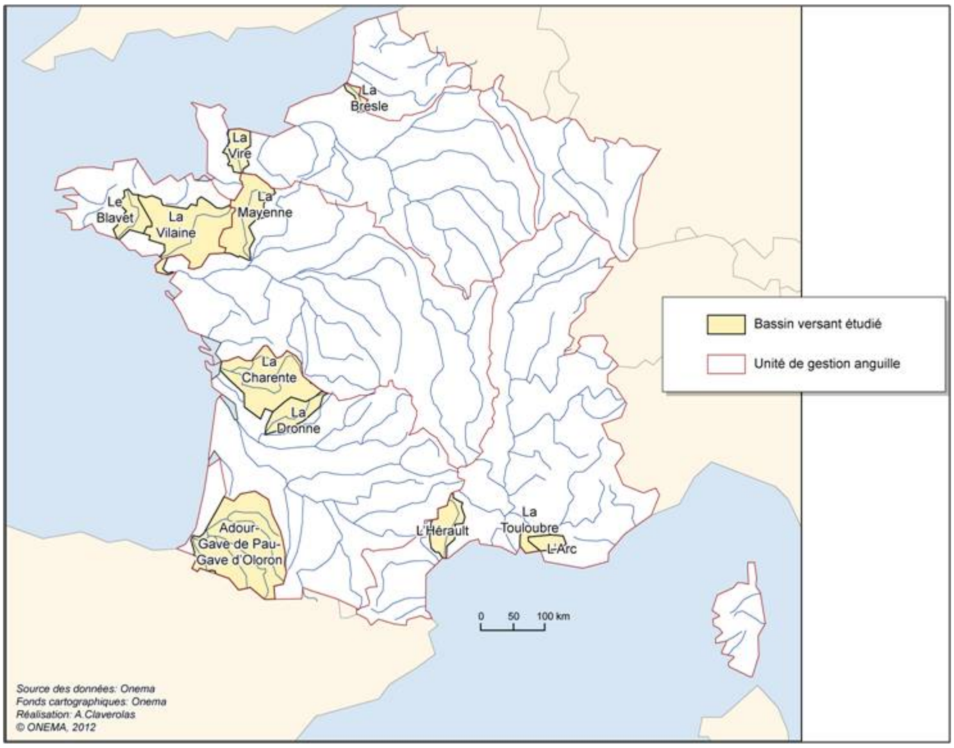


Figure FR 18. Localisation of the rivers selected for SEAHOPE application.

The methodology to calculate the mortality caused by a turbine is based on three submodels. A first one estimates the temporal distribution of dam passages within a migration season, depending on the hydrology (an equally repartition of runs between five discharges). The second submodel quantifies the proportion of eels passing or not through turbines, depending on spill flow to river flow ratio. Finally, a third model quantifies turbine-induced mortalities depending on both turbines (diameter, rotation speed and nominal discharge), and eels (length) characteristics.

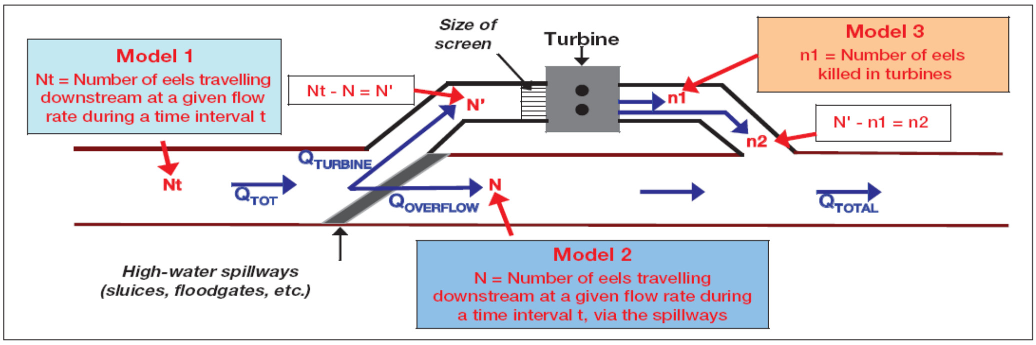


Figure FR 19. Three models for estimating mortality on a turbine.

The distribution of eel in the ten rivers was based on two hypotheses. The first one was the abundance calculated by the EDA model. The second one corresponded to a uniform distribution of eel in the river and gave an estimate of the maximum mortality due to turbines. The results are presented in the Table FR z but should be considered with caution. Half of the characteristics of the turbines were indirectly determined. There are limitations in the three submodel of turbine mortality and with the EDA density calculation. Finally, the representativeness of the ten selected rivers is not guaranteed. Nevertheless this approach gave the order of magnitude for the mortality caused by turbines at the river scale.

Table FR z. Estimated mortality due to hydropower obstacles in the ten selected basins according to EDA result or to uniform distribution of eels.

		Adour	Arc–Touloubre	Blavet	Bresle	Charnete	Dronne	Héreault	Mayenne	Vilaine–Oust	Vire
Eda	% of eels downstream the first turbine	76	78	61	57	91	25	40	67	87	80
	Cumulative Mortality (%)	3.8	11.3	9.0	2.3	1.0	12.5	9.8	5.2	2.5	2.7
Uniform dist.	% of eels downstream the first turbine	40	30	20	19	58	3	7	32	70	53
	Cumulative Mortality (%)	20.7	34.5	31.1	4.9	6.1	28.0	33.5	22.3	7.9	9.4

8.1.5 Turbine management to reduce mortality rates

One obvious solution to reduce mortality is to halt generation during peak migration periods but is very expensive in terms of energy production. To time the stops in production as best possible, the time periods when the largest numbers of fish are underway must be anticipated. The MIGROMAT® biomonitor, designed specifically for this purpose, was tested (T. Kieran McCarthy, R. McNamara, Galway University) from September 2008 to March 2010 in Killaloe on River Shannon (Ireland). The comparisons between the alarms issued by MIGROMAT® and the migratory peaks measured by a nearby fishery showed that the system, in its current form, is not very effective. The alarms generally corresponded to peaks in migratory flows, but were issued too late.

To set up true power-generation management programmes on a large scale, operational, predictive models was developed for the Loire River where a 20 year dataseries on silver eel catches is available (A. Acou *et al.*, 2009). The daily catches were linked with variations in flow rates, water turbidity, luminosity index and weather conditions. The final model predicted 80% of the peaks in downstream migration run 24 hours in advance. Simulated halts in electrical generation in the study zone confirmed better results of this model compared to methods based exclusively on threshold flow rates. Management of hydropower generation must now be approached from an economic angle to take into account rigorous cost-benefit criteria.

8.1.6 Additional approaches with «fish friendly» turbines and water intakes

A number of other technical solutions were proposed and tested. Further development work is of course needed. One solution is «fish friendly» turbines and particularly the VL (very low head) turbine designed for 1.4 to 3 metre heads. An initial prototype was tested successfully in Millau during downstream migration tests on smolts and silver eels. After a few dimensional adjustments, the new VLH turbine was put through extensive tests in Frouard on the Moselle River (M. Leclerc, MJ2/ECOGEA), where it produced a maximum of 400 kW for a net head of 2.4 metres and a flow rate of 22 cubic metres per second. The experimental results were most promising with a percentage of lethal injuries close to zero and non-lethal injuries within 48 hours of approximately 2%. *In situ* tests with a very different «fish friendly» turbine, the ALDEN turbine(Alden hydrological lab in the U.S, Voith Hydro) will be carried out for eels of sizes corresponding to those migrating downstream in 2014–2015 (F. Travade, EDF R&D). This turbine is 3.7 metres in diameter and optimised for a flow rate of 45 cubic metres per second with a head of 28 metres. However, considerable work is still required to develop low-mortality turbines for intermediate head values.

An infrasonic repulsion device (Profish Technologies) to block access of the fish to the water intakes was tested for two years, using a radio-monitoring system for 150 eels equipped with emitters, on two sites on the Gave de Pau River with very different layouts. The system failed the test because no significant differences were noted in the behaviour of the eels when sites were equipped with the system (F. Bau, Irstea).

The best solution, if economically feasible, remains screens positioned upstream of the turbine intakes, with sufficiently small distances between the bars to block access by eels. In 2008, a study established the basic parameters for the design and sizing of screens, based on feedback from experiments carried out in France and abroad (D. Courret and M. Larinier, Onema). Two systems have been developed. In the first one, the screen is at a sharp angle to the horizontal and virtually perpendicular to the flow of water. The angle guides the fish to one or more bypasses located at the top (see photo opposite). In the second, the screen is vertical and slanted with respect to the flow of water, thus guiding the fish toward a bypass on one side. Following the initial analysis, a complete study (S. Raynal and L. Châtellier, Institut P') in an experimental channel was launched to develop load-loss equations for these specific systems, taking into account their geometrical parameters. An additional study is now underway, in the framework of a partnership between Onema and the French hydroelectric companies (SHEM, CNR, EDF, FHE) and should be terminated by the first half of 2013. The results of all these studies will enable to better understand the technical modifications required in installations to help in saving the eel.

9 Scientific surveys of the stock

9.1 Recruitment survey, glass eel

9.1.1 The Gironde (Garonne EMU)

The Gironde survey consists in a monthly sampling of 24 stations (surface + deep) distributed along four transects. This monitoring uses an estuarine research vessel (Figure FR 20) and aims at evaluating the abundance variations of the juveniles of fish and crustacean and the adults of small species.

Figure FR 20. "L'Esturial" boat used for scientific survey in the Gironde (Source: Irstea).

The results (annual average from September to August) for glass eels highlight a sharp decrease for season 1999–2000 and a steady low decrease afterwards. In the main, this analysis confirms results coming from fishery data (Table FR aa and Figure FR 21) even if some little differences remain to analyse.

Table FR aa. Time-series for the Gironde glass eel recruitment data by migratory season= year (n-1)- (n). This series has been reviewed – new figures (Girardin and Castelnaud, 2011).

Season (n-1,n)	1990	2000	2010
0		1.00	0.10
1		0.36	0.16
2	1.75	1.02	0.08
3	2.83	0.28	
4	2.20	0.30	
5	2.92	0.53	
6	2.07	0.27	
7	3.14	0.14	
8		0.28	
9	3.49	0.44	

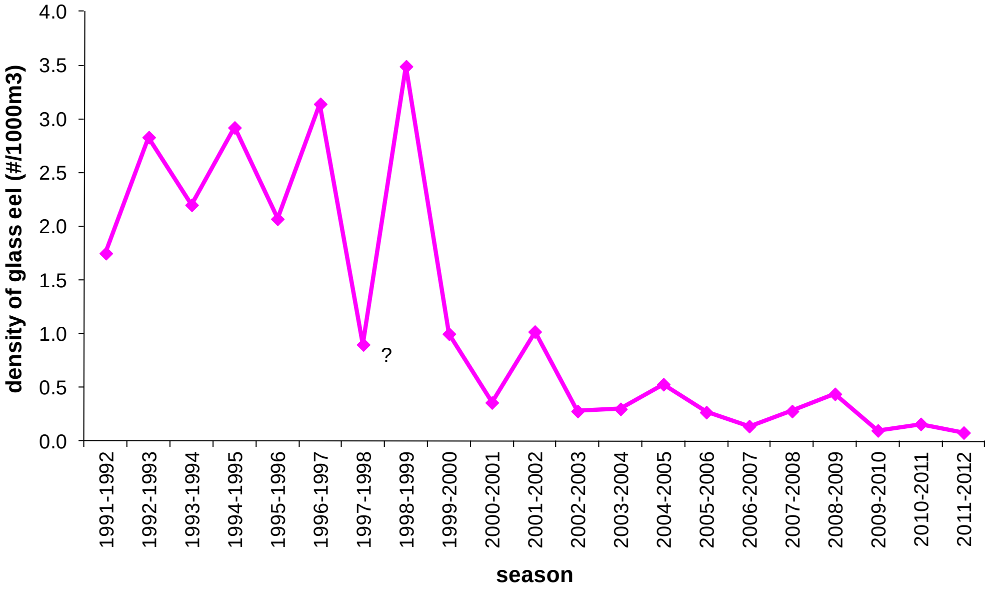


Figure FR 21. Results of the glass eel recruitment survey in the Gironde (? Indicates a suspect data from missing sampling in January).

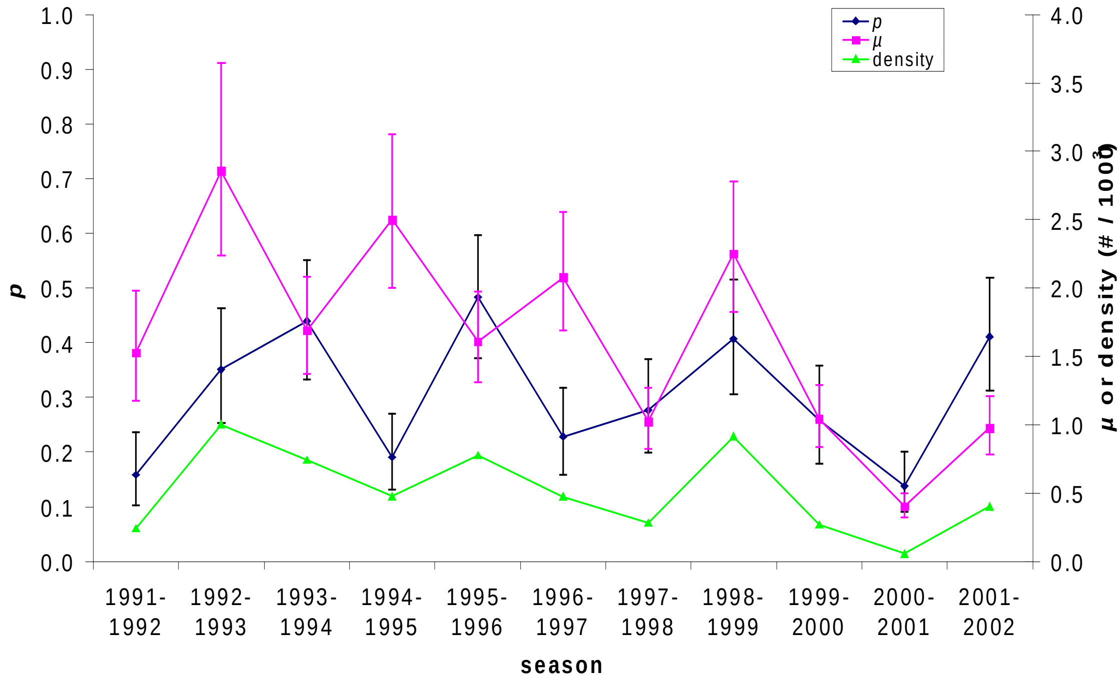


Figure FR 22. Results for glass eel of a delta-gamma analysis for season effect (p=probability of positive capture, μ=mean capture for only positive capture, density=p*μ) (extracted from Lambert, 2005).

These data were from seasons 1991–1992 to 2001–2002 were analysed by Lambert (2005) using a delta-gamma approach (Stefánsson, 1996). This method allows separate analyses of the presence probability (p) and positive capture (μ) and joint analyse through overall density. The delta and gamma approaches were performed thanks to generalized linear models (GLM; McCullagh and Nelder, 1989) with both spatial and temporal effects. Results on season effect (Figure FR 22) show some peculiar seasons like 2000–2001 for which glass eels were rarely caught (low p) and when caught, in low number (low μ), resulting in a very low density.

9.1.2 Index river system

In the framework of the French management plan, a network of index rivers (at least one for each EMU) are setting up in order to monitor ascending recruitment (glass eels or elvers) and migrating silver eels (Table FR bb). The selected rivers are presented in the Table FR bb.

Table FR bb. Selected river for a river index network.

EMU	Selected river
Adour	Courant de Soustons (fluvial basin with big lakes <1000 km²)
Gironde	Dronne (fluvial basin >1000 km²)
Loire	Sèvre Niortaise (marshes)
Bretagne	Frémur (fluvial basin <1000 km²) and Vilaine (fluvial basin >1000 km²)
Seine-Normandie	Bresle (fluvial basin <1000 km²)
Artois-Picardie	Somme (fluvial basin >1000 km²)
Rhône-Méditerranée	Rhône (fluvial basin >1000 km²) and Vaccarès lagoon
Corse	Not yet selected
Rhin-Meuse	Rhine (fluvial basin >1000 km²)

The Bresle River is part of this system and results for recruitment survey are given above (3.1.2.3.1).

9.2 Stock surveys, yellow eel

9.2.1 WFD survey

Water Framework Directive (WFD) survey is operated by Onema for fish compartment in rivers. The survey consists of electrofishing in 1500 sites in France every two years.

An example of results has been presented in previous report (Briand *et al.*, 2008a). Poulet *et al.* (2011) used these data to study time trends in fish population (including eel) over a 20 year period (1990–2009) and 590 sites in France. They show that eel is one of the most declining fish both in terms of presence and abundance. Figure FR 23 shows the extraction per site from their results of the trend in eel population. Most sites show a decreasing trend.

Furthermore WFD survey is the raw data used by EDA model to assess the biomass (see 13.2).

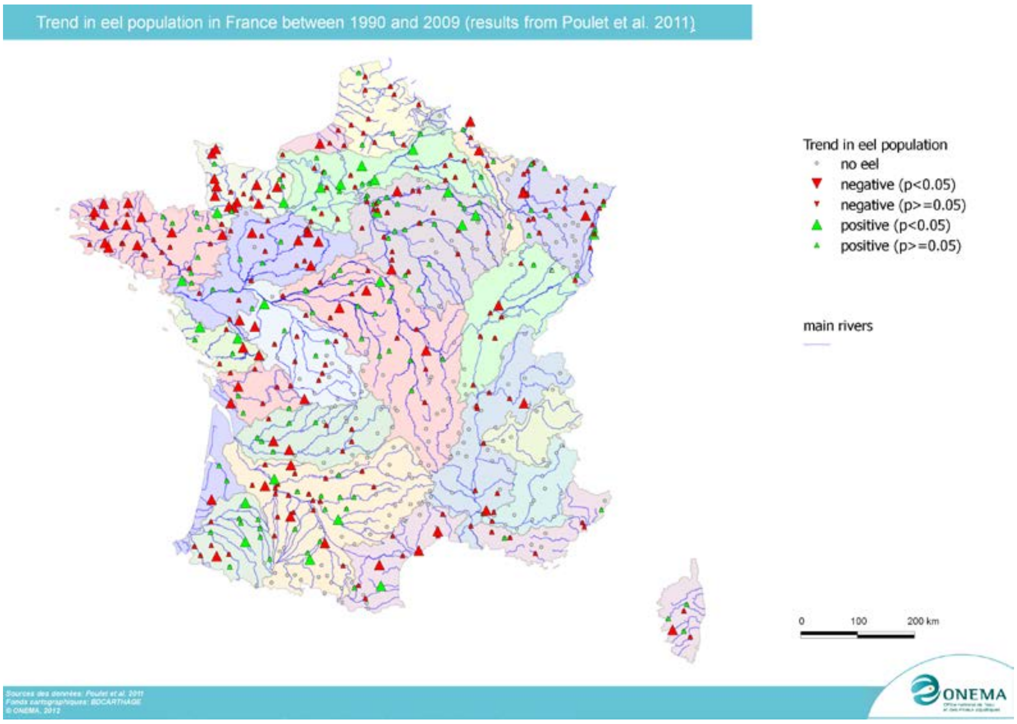


Figure FR 23. Trend in eel population in France between 1990 and 2009 according to Poulet *et al.* (2011) results.

9.2.2 Specific eel survey

To complete the WFD survey network, the French EMP established eel specific networks consisting of electrofishing network of sites close from the sea (<200 km) not covered by WFD network. There are about 300 sites that are fished in the following EMU: Artois-Picardie (62), Seine-Normandie (30), Brittany (49), Loire (27), Garonne (65), Adour (61). Results need to be analysed.

9.3 Silver eel

9.3.1 Index river system

The index river system describe above (9.1.2) also provide data on silver run. Bresle River and Frémur River results are described above (3.1.3.1 and 3.1.3.2).

10 Catch composition by age and length

See 11.1 for DCF sampling.

11 Other biological sampling

11.1 Length and weight and growth (DCF)

DCF data have been analysed in previous report (Beaulaton *et al.*, 2011).

11.2 Parasites and pathogens

Amilhat *et al.* (submitted) evaluated the level of contamination of migrant silver eels from Mediterranean habitats presenting different degrees of contamination. They considered simultaneously pathogens (*Anguillicoloides crassus*, virus Evex) and chemical contaminants (PCBs, OCs and heavy metals) concentrations. A total of 222 silver males sampled from three coastal lagoons (Canet-Saint-Nazaire, Salses-Leucate and Bages-Sigean) and a river (La Berre) were analysed. Each silver eel was contaminated by at least one type of contaminant (pathogens/PCBs/OCs/Cadmium). Most of the specimens (42%) harboured two types of contaminant, 38% three types and 10% four types. Based on available literature (providing contaminants threshold values for migration and/or reproduction success), we estimated that, depending on the site and year, 3 to 100% of the eels would probably be unable to reproduce successfully.

11.3 Contaminants

See above (11.2).

11.4 Predators

No data available.

12 Other sampling

12.1 Restocking monitoring

All restocking site from the French national restocking programme (3.6.1) are monitored to assess the efficiency of restocking.

Restocked eels are sampled six months, one year and three years after the restocking. For site where small eels can be found, a proportion of restocked eels are marked, otherwise they aren't.

Only 2011 monitoring on 2011 restocked eel is available and analysed. Six sites were finally restocked.

On Hourtin site the recapture monitoring is done by fykenets. On all other sites electrofishing is done.

12.1.1 Mortality

A mortality survey is made during 15 days after the restocking. Three batches of glass eels are held in pot *in situ* or three batches in aquaria for both unmarked and marked (oxytetracycline) eels. There is a huge variability among batches and the mortality vary between 6% and 72% (median = 30%). The analysis (logistic regression) don't show any significant difference between *in situ* and in aquaria batches but show a higher mortality for marked eels compared to unmarked eels (Table FR cc).

Table FR cc. Mean (logistic regression) mortality after 15 days of marked and unmarked eel.

	Marked eel	
	No	Yes
Hallue (Artois-Picardie)	29%	
Aure (Seine-Normandie)	50%	
Vilaine (Brittany)	23%	31%
Loire (Loire)	29%	38%
Lay (Loire)	26%	34%

12.1.2 Eel recapture

We first estimate that the maximum length of glass eel after six months is 130 mm. The analysis shows that:

- 23 eels below 130 mm were found in Hallue river;
- 44 eels below 130 mm were found in Aure river;
- three among 50 examined were marked on Vilaine sites;
- of the 51 eels examined in the Loire, none are marked;
- ten among 50 examined were marked on Lay river;
- no eel below 130 mm were found in Hourtin lake.

We recapture restocked eels in at least four among six sites. In the Loire River, the natural recruitment might have been too high to permit the recapture of a marked eels. On the Hourtin Lake the fykenets may not be adapted to catch small eels.

12.1.3 Restocked eel growth

The restocked and recaptured eels (12.1.2) allow us to analyse the growth of eel after six months (Table FR dd). The smallest recaptured eel was 66 mm long (Aure) and the largest 103 mm long (Lay) (Figure FR 24). We thus consider in the following that length of eel restocked are <110 mm after six months. The mean growth ranged from 10 mm (Aure) to 22 mm (Vilaine). Even if marked eels (Vilaine and Lay) have the largest growth, no conclusion can be drawn as the Hallue and Aure are thought to be less favourable to eel growth.

Table FR dd. Length (mm) of restocked eel during the restocking and six months after. In bracket: number of eels retrieved (see text).

	0 DAYS	6 MONTHS	MEAN GROWTH
Hallue (Artois-Picardie)	69.5	86.0 (23)	16.5
Aure (Seine-Normandie)	66.9	76.5 (44)	9.6
Vilaine (Brittany)	67.9	90.3 (3)	22.4
Lay (Loire)	68.1	87.5 (10)	18.6

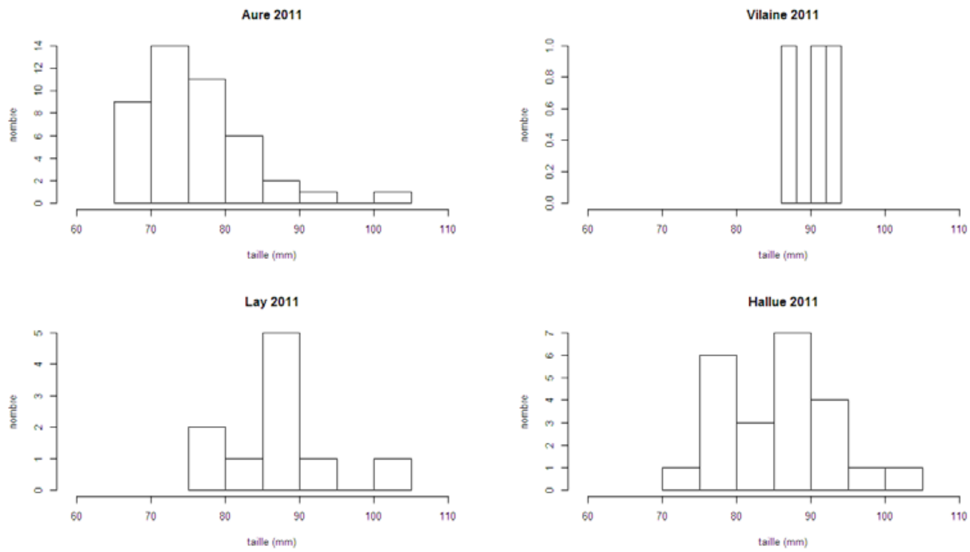


Figure FR 24. Length distribution (mm) of recapture eel.

12.1.4 Restocking efficiency

The restocking and the sampling strategies were very different from one operation to the others making the global analysis more difficult but offering a chance to test different scenarios.

12.1.4.1 Eel distribution

One of the most important hypotheses to be done is the distribution of restocked eels.

The Aure operation is the only one that has long distance survey (Figure FR 25). No eel were recaptured downstream or more than 5 km upstream from a restocking point and the density quickly decreased outside restocking point.

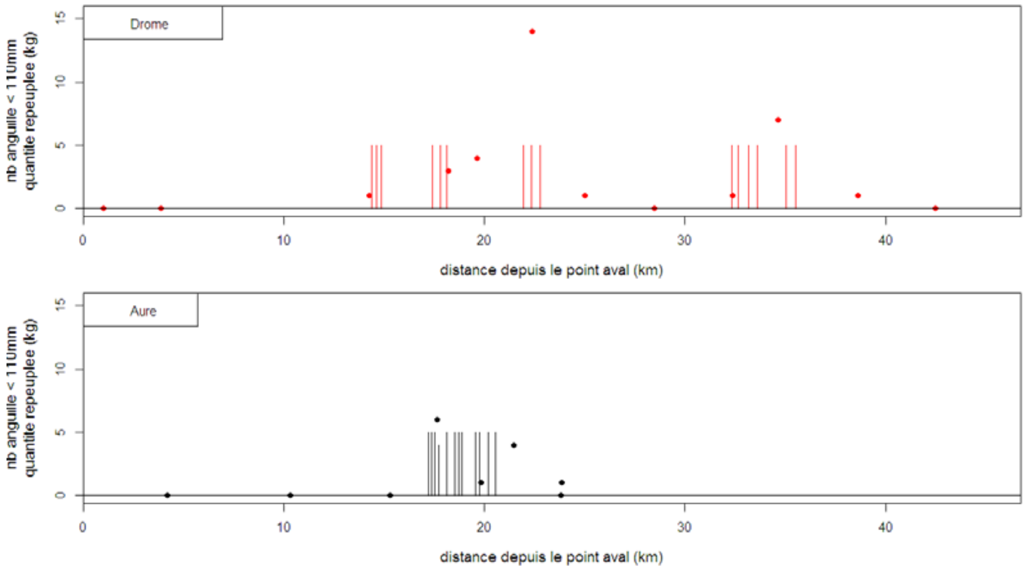


Figure FR 25. Distribution of restocking quantity (kg; bar) and recapture eel (number; point) in Aure and Drome river expressed as a distance from the Aure-Drone confluence.

For the following we thus make the assumption that restocked eel colonised the 5 km upstream the restocking point. We also make the assumption that they follow a uniform distribution within that area with a mean density equal to the mean density of our sampling station within that area.

12.1.4.2 Eel density

In the Hallue site a two pass electrofishing is made allowing stock estimate. In other sites, point sampling has been made. For this site we used Germis (2009) relationship: one eel per point is equal to 50 eels/100 m².

12.1.4.3 Restocking efficiency

Knowing the eel distribution and the density, we can estimate the number restocked after six months and compare it to the initial number of eel restocked to obtain the apparent mortality (which can be true mortality or eel moving outside the estimated colonisation area).

For sites where natural recruitment exists, we can use recapture of marked eel to refine the estimate. In this first rough estimate, we do not take into account the difference in mortality shown between marked and unmarked eel (12.1.1).

Table FR ee. Glass eel restocking efficiency.

	HALLUE	AURE	VILAINE	LOIRE	LAY	HOURTIN	TOTAL/MEAN
restocked (kg)	45	134	200	150	173.5	45	747.5
Mean weight (g)	0.273	0.257	0.340	0.280	0.300	0.252	0.291
Restocked (number)	164 835	521 401	588 235	535 714	578 333	178 571	2 567 090
Colonised length (km)	10	25	48.5	8	18	//	109.5
Mean width (m)	5	8	3	200	40		
Surface (ha)	5	20	14.95	160	72	?	271.95
Mean glass eel density (#/100 m²)	330	261	393	33	80	?	94
cpue (#/EPA) (eel <110 mm)		0.10	0.06	0.13	0.25	//	0.14
eel <110 mm six month density (#/100 m²)	4.0	4.9	3.1	6.6	12.6	0.0	5.2
nb eel six month (<110 mm)	2000	9767	3965	105 333	90 600	0	211 665
Apparent survival (%)	1.2%	1.9%	0.7%	19.7%	15.7%	0.0%	8.2%
Marking–recapture correction			100%	<20%	96%		
number eels six month corr.	2000	9767	3965	<20 654	87 328	0	<123 714
App. survival Corrected (%)	1.2%	1.9%	0.7%	<4%	15.1%	0.0%	<4.8%

After six months, under our hypotheses, the apparent survival is less than 5% in all sites but Lay. In the latter, the apparent survival is 15%. Except the Loire, this is the site restocked with the lower initial density. A negative correlation between initial density and apparent survival seems to appear.

This survival seems to be low compared to Berg and Jorgensen (1994) experiments that stocked quarantined glass eels and obtained apparent survival of 20% 100 days after stocking.

12.1.4.4 Critical analysis

The relationship used to convert point sampling to eel density may not be adapted to all sites.

In some site sampling are made along the bank and we extrapolate this value to the all river.

The length of the colonized zone is a crucial parameter based only on Aure experiment: 5 km may be to long for small rivers (tributaries of the Vilaine for example) or too small for large rivers (Loire).

Within a restocking zone, we take the mean density value, while sampling point may not be well spread inside it.

The width of the river is estimated by satellite image or taken from RHT. This doesn't give a precise figure or it can be erroneous.

Finally, monitoring one year and three years after will be done and will give more data to improve this analysis. A more complex model (using knowledge on eel behaviour for example) may also improve the analysis.

12.2 Silver eel transfer in Mediterranean lagoons

In 2011 a pilot study of transport to the sea of silver eel has been done in autumn 2011 (3.7). This measure has allowed gathering a lot of new data concerning the biological characteristics of silver eels (Table FR ff, Figure FR 26 and Figure FR 27) in the Mediterranean lagoon, such as the repartition of sex ratio along the coastline. (Amilhat *et al.*, 2012b).

Table FR ff. Biological characteristics of migrant silver eels (IO>=6.5). Males and females are separated according to their size, <45 cm for male and >45 cm for females. See Figure FR 11 for locations.

		MALES			FEMALES			%FEMALES
#		N	MEAN LENGTH. ± E.T (MIN–MAX) IN CM	MEAN WEIGHT. ± E.T (MIN–MAX) IN G	N	MEAN SIZE.± E.T (MIN–MAX) IN CM	MEAN WEIGHT ± S.D (MIN–MAX) IN G	
7	Salses-Leucate Nord	56	35.3±2.8	45±11	4	58.9±10.0	226±143	7
			(27.6–41.0)	(19–77)		(50.3–73.0)	(106–430)	
3	Salses-Leucate Sud	50	36.2±2.2	79±16	10	57.6±9.9	378±288	17
			(31.0–41.0)	(43–115)		(51.0–84.0)	(219–1167)	
1	BagesSigean	46	38.8 ± 2.1	100 ± 17	10	65.5 ± 12.4	589 ± 402	17

		MALES			FEMALES			%FEMALES
#		N	Mean length. ± E.T (min–max) in cm	Mean weight. ± E.T (min–max) in g	N	Mean size.± E.T (min–max) in cm	Mean weight ± S.D (min–max) in g	
	Nord		(34.5–43.0)	(68–138)		(45.5–91.0)	(148–1580)	
5	Bages-Sigean Sud	48	39.3 ± 2.6	70±11	12	57.7±10.3	262±167	20
			(33.0–44.8)	(49–96)		(45.3–81.0)	(108–651)	
6	Ayrolle	44	36.9±2.3	83±16	6	67.8±12.0	636±289	12
			(31.2–41)	(56–118)		(46.5–79.4)	(180–939)	
4	Vendres	7	40.7±2.5	94±7	45	63.6±5.0	426±131	85
			(37.0–44.1)	(87–104)		(53.6–78.4)	(220–748)	
11	Thau 1	18	41.2±2.1	117±22	40	64.0±10.3	535±258	43
			(37.4–44.2)	(81–165)		(45.2–85.8)	(131–1139)	
12	Thau 2	34	37.7±3.4	85±29	25	54.2±5.0	290±95	47
			(32.8–44.0)	(50–148)		(45.5–67.3)	(139–550)	
8	Thau 3	32	38.9±2.6	91±21	27	56.4±5.4	322±109	62
			(33.0–43.0)	(49–137)		(50.4–69.0)	(222–591)	
9	Ingril, Vic …	23	39.1±1.9	96±16	37	56.3±5.9	318±112	68
			(36.8–44.0)	(70–140)		(47.1–74.5)	(171–706)	
2	Mauguio	2	38.9±3.9	163±123	54	68.3±7.7	NA	97
			(36.1–41.6)	(76–250)		(45.5–90.9)	(177–3000)	
10	Ponant, Virdoule…	25	36.8±2.5	81±19	34	63.4±9.2	502±233	58
			(32.4–41.5)	(57–118)		(45.0–84.1)	(159–1154)	
	Total	385	37.7±3.0	81±27	304	61.9±9.1	539±417	44
			(27.6–44.8)	(19–250)		(45–91)	(106–3000)	

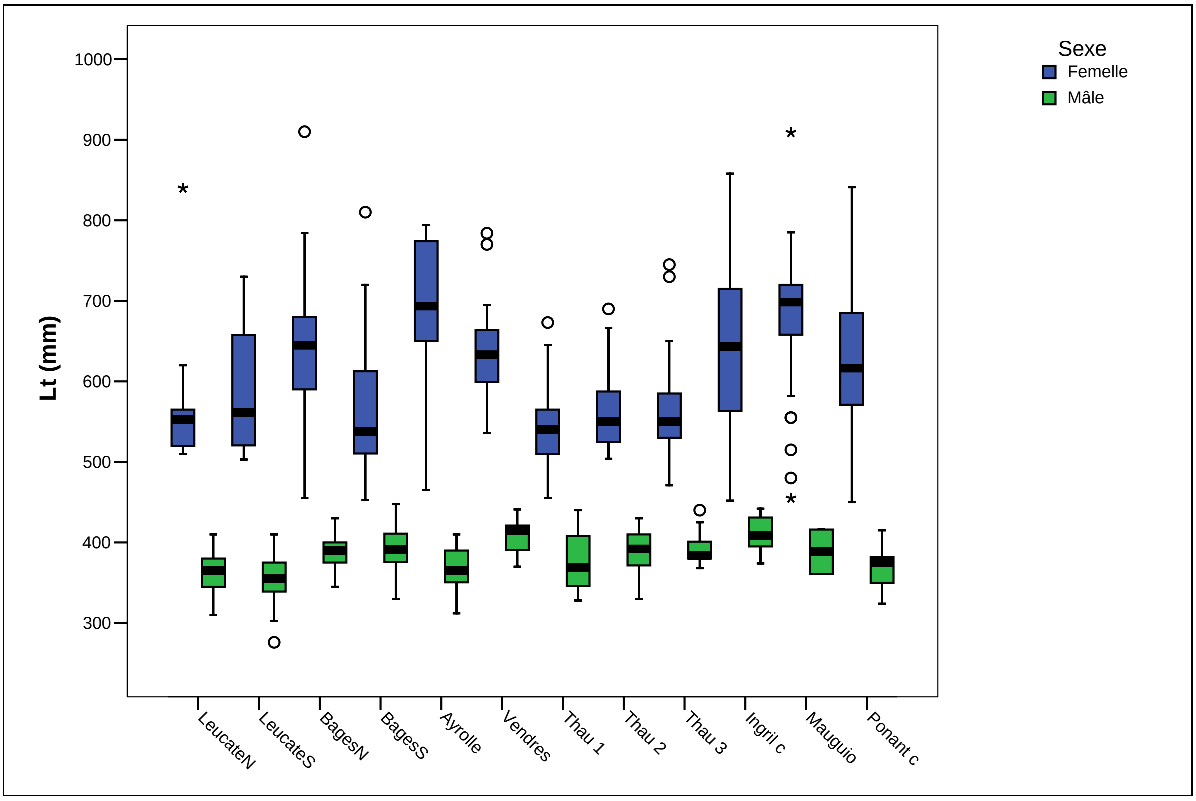


Figure FR 26. Box plot showing the size of silver eels caught for each release according to the sex.

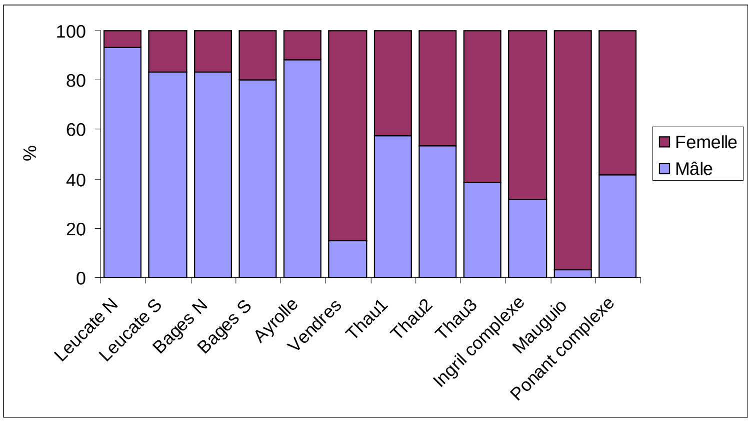


Figure FR 27. Percentage of male and female caught at each site. Male/female distinction according to the size at 45 cm.

13 Stock assessment

13.1 Local stock assessment

See Table FR kk and 13.2.3.1

13.2 International stock assessment

13.2.1 Habitat

Table FR gg summarizes wetted area by EMU as used for escapement evaluation by EDA 2.1 (2114 km²; Jouanin *et al.*, 2012) and some big areas not taken into account by

EDA: the brackish part of the Gironde estuary (461 km² according to DCF reporting); the lagoons' area are estimated to 1300 km² including associated wetland and 803 km² without by Barral *et al.* (2007) using Corine Land Cover and 748 km² according to WFD reporting.

The 478 Lakes reported for WFD represent 1623 km². Lake Geneva alone is 577 km². Figure FR 28 gives the cumulated area in function of their altitude and gives 1582 km² below an altitude of 1000 m. Among those below the altitude of 1000 m, some can have a depth of hundred or more meters (mean Lake Geneva depth is 153 m) which is not suitable for eel. However some others like Lake Grand Lieu (51 km²) are famous for their eel population and fisheries. Some of them may not be naturally related to the sea (Alpine Lakes). Parts of these lakes are in fact included in RHT, as they are part of the hydrographic network. The total area of lakes below an altitude of 1000 m and with an average depth below 10 m (or unknown) is 596 km².

Rigaud (2011) evaluated the area of salted marshes to 150 km².

Thus the total of inland habitat is around 4000 km².

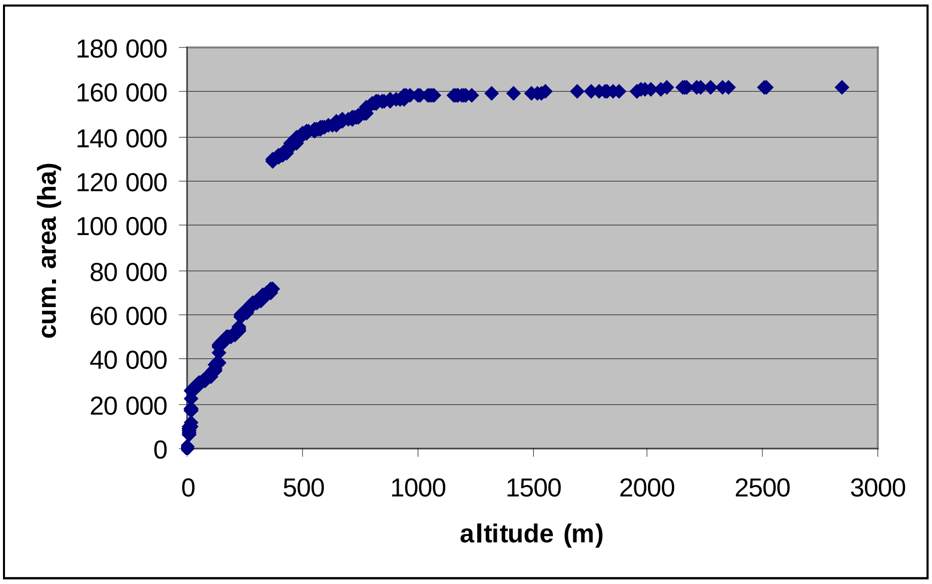


Figure FR 28. Cumulated area of lake in function of their altitude (WFD data).

The Coastal eel habitat remains unknown. Coastal water bodies *sensu* WFD have a total area of 20 518 km².

For memory, the previous version of EDA 1.3 estimated wetted area to 6727 km². The difference is explained by the new river network used for the reporting in France (RHT; Pella *et al.*, in press; instead of BDCarthage).

Table FR gg. Wetted Area (in km²) of different type of eel habitat by EMU.

EEL HABITAT	RIVER-INE+ ESTUARY AS USED BY EDA	LAKES (WFD,;ALT<1000 M; DEPTH<10 M)	SALTED MARSHES	TRANSITIONAL & LAGOON NOT INCL. IN EDA	TOTAL IN-LAND	COASTAL	TOTAL
Rhin	87			0	87	0	87
Meuse	42			0	42	0	42
Artois Picardie	47			0	47	505	552
Seine Normandie	347			0	347	1964	2311
Bretagne	83			0	83	8773	8856
Loire	474			0	474	3112	3586
Garonne Dordogne Charente Seudre Leyre	402			461	863	1167	2030
Adour	85			0	85	365	450
Rhône-Méditerranéee	532			775	1307	2523	3830
Corse	15			28	43	2109	2152
Total	2114	576	150	1264	4104	20 518	24 622

13.2.2 Silver eel production estimated by EDA

All technical details are given in Jouanin *et al.* (2012). EDA estimates cover rivers including estuaries but Gironde (brackish part). This doesn't include lakes, marshes, lagoons and coastal areas and is thus an underestimation of the total production in France. Since the June reporting, some minor corrections have been done that explains some differences between this report and the June report to the EU Commission. This doesn't bring about any substantial change in the results.

13.2.2.1 Biological parameters

Some biological parameters (mean weight, age and natural mortalities per stage) are needed to convert number in biomass (or biomass in number), or glass eel and yellow eel in silver eel. We simplify the parameters proposed by Grisam group (Briand *et al.*, 2008b) by using the same figures in every EMU (Table FR hh) and for the different categories of fishermen (Table FR ii).

Table FR hh. Mean weight and age of silver eel per EMU.

EMU	MEAN WEIGHT OF A SILVER EEL (G)	MEAN AGE OF A SILVER EEL (YEAR)
Rhin-Meuse	800	12
Artois-Picardie	800	12
Seine-Normandie	800	12
Bretagne	800	12
Loire	800	12
Garonne	800	12
Adour	800	12
Rhône-Méditerranée	800	12
Corse	800	12

Table FR ii. Natural survival rate, mean weight and age of eels per stage and by fisheries.

<table>
<tr><th colspan="2"></th><th>SURVIVAL TO SILVER EEL STAGE</th><th>MEAN WEIGHT (G)</th><th>MEAN AGE</th></tr>
<tr><td colspan="2">glass eel caught</td><td>3.8%</td><td>0.33</td><td>0</td></tr>
<tr><td rowspan="3">yellow eel caught by a</td><td>non pro.fisher</td><td rowspan="3">43.5%</td><td rowspan="3">125</td><td rowspan="3">6</td></tr>
<tr><td>pro. fisher in Atl. EMUs</td></tr>
<tr><td>pro. fisher in Med. EMUs</td></tr>
</table>

13.2.2.2 Potential silver eel escapement ($B_{potential}$)

In France silver eel escapement was estimated at the EMU scale but all together in the same model. The method is firstly based on an estimation of yellow eel density. This estimation is calculated using the EDA2.1 model calibrated on 9556 electrofishing operations (3946 stations) between 1984 and 2009. Secondly an estimate proportion of yellow eel that silver every year (5%[15]) allows calculating the escapement before sil-

[15] (Acou, 1999 ; Robinet *et al.*, 2007 ; Feunteun *et al.*, 2000). Durif *et al.* (2009) silver index applied to 2009 and 2010 WFD electrofishing gives an estimate of 4.2% (Beaulaton, unpublished data).

ver eel anthropogenic mortalities. This potential escapement per year was equal to 3.2 million silver eels during the period 2006–2009 for the whole France (Table FR kk).

13.2.2.3 Current escapement ($B_{current}$)

The silver eel mortalities (e.g. fisheries, turbines, …) should be deduced to this potential to evaluate the current escapement. At the moment, silver eel fisheries (Loire EMU) and turbine mortality can be assessed (Table FR ll and 13.2.2.8.2). This should thus be considered as a maximum $B_{current}$. For whole France, we estimate current escapement (2006–2009 mean) to 3.0 million silver eels which corresponds to 2395 t or 11.3 kg/ha (Table FR kk).

Table FR jj shows a comparison for some rivers between EDA 2.1 results and escapement estimate derived from field data. Field data are silver eel counts that can be associated with mark-recapture experiment (Bresle only), except Loire which is silver eel fishery associated with mark-recapture experiment. It covers a variety of basin from the Northern part of France:

- the Loire basin covers nearly 20% of the total area of France;
- Bresle (750 km²) and Somme (6550 km², but only upper part of the basin is monitored) are medium basin;
- Oir (86 km²) and Frémur (60 km²) are very small basin.

EDA gives results very close from field data. This should however be confirmed (or infirmed) with coming results from index rivers (9.1.2). The ratio between EDA and field data ranges between 36% and 167%. Using this ratio EDA estimate could be comprised between 1.8 and 8.3 million silver eels. However this is not a true estimate of the confidence interval.

Table FR jj. Comparison between EDA results and escapement estimate from field data on silver eels run.

		EDA2.1		Escapement estimate from field data of silver eel			
EMU	River	Year of estimate	Npotential	Npotential	Year of estimate	Reference	Ratio EDA / estimate
Artois-Picardie	Somme		1510	905	2010–2011	Pawar (2011)	167%
Seine-normandie	Bresle	2009	2580	6400–7200	2009	This report (Bresle river (Seine-Normandie EMU)3.1.3.1)	36%–40%
	Oir		527	473	2000–2002	Acou *et al.* (2009)	111%
Bretagne	Frémur		310	320	2009–2010	Charrier *et al.* (2011)	97%
Loire	Loire		135 049	150 000	2008–2009	Acou *et al.* (2010)	90%

13.2.2.4 Best achievable biomass (B_{best})

We calculate B_{best} by adding to $B_{current}$, the number of equivalent silver eels that are removed by anthropogenic mortalities at glass and yellow eel stage. These equivalent silver eels are calculated from biological parameters (13.2.2.1). For instance, from 1000 glass eels (yellow eels), we assume that 38 (respectively 435) would become silver eels. This analysis should only be considered as a minimum estimate of anthropogenic impact, as only glass eel, yellow eel and silver eel fisheries mortalities are known (Table FR ll). N_{best} and B_{best} are calculated for the 2006–2009 period at 50 million silver eels which corresponds to 40 000 t (188 kg/ha) (Table FR kk).

13.2.2.5 Pristine biomass (B_0)

The pristine biomass can be assessed from the maximum of B_{best} i.e. 331 million for 265 000 t (1250 kg/ha). It can also be assessed by taking the maximum of $B_{current}$ as 40% of B_0 i.e. 19 million silver eels for 15 000 t (71 kg/ha). Past data on fisheries shows that the second value is too low. The first one seems at the contrary quite large. Beaulaton *et al.* (2010) estimate pristine biomass to 175 million (140 000 t using a mean weight of 800 g) base on biomass and recruitment decline. We thus consider in the following this last value as the best available pristine biomass estimate bearing in mind that there might still be density dependent effect unaccounted for in this estimate.

13.2.2.6 Production values e.g. kg/ha

Productions for area assessed by EDA are given in Table FR kk. They are calculated assuming a mean weight of silver of 800 g. They decrease from nearly 30 kg/ha to 10 kg/ha.

Table FR kk. Summary of EDA results. N = escapement in number; B = biomass in t; P = production in kg/ha. Habitat area = 2114 km²; N0 = 175 million; mean silver eel weight = 800 g.

	NPOTENTIAL	BPOTENTIAL	NCURRENT	BCURRENT	PCURRENT	NBEST	BBEST	%CUR/BEST	%CUR/PRIST	%BEST/PRIST
1990	6 978 714	5 582 971	6 494 194	5195	24.6	247 056 165	197 645	2.6%	3.7%	141%
1991	7 541 323	6 033 058	7 036 284	5629	26.6	306 383 525	245 107	2.3%	4.0%	175%
1992	5 046 064	4 036 851	4 702 810	3762	17.8	330 969 579	264 776	1.4%	2.7%	189%
1993	5 012 320	4 009 856	4 676 671	3741	17.7	215 893 168	172 715	2.2%	2.7%	123%
1994	4 373 046	3 498 437	4 060 959	3249	15.4	134 570 945	107 657	3.0%	2.3%	77%
1995	3 959 429	3 167 543	3 667 746	2934	13.9	117 808 986	94 247	3.1%	2.1%	67%
1996	3 300 311	2 640 249	3 059 985	2448	11.6	86 335 955	69 069	3.5%	1.7%	49%
1997	3 712 803	2 970 242	3 432 024	2746	13.0	67 372 994	53 898	5.1%	2.0%	38%
1998	2 965 458	2 372 366	2 746 261	2197	10.4	65 237 687	52 190	4.2%	1.6%	37%
1999	2 772 946	2 218 357	2 562 186	2050	9.7	79 100 004	63 280	3.2%	1.5%	45%
2000	3 985 304	3 188 243	3 707 253	2966	14.0	69 688 725	55 751	5.3%	2.1%	40%
2001	4 207 246	3 365 797	3 896 023	3117	14.7	67 693 773	54 155	5.8%	2.2%	39%
2002	4 448 619	3 558 895	4 132 257	3306	15.6	51 335 526	41 068	8.0%	2.4%	29%
2003	4 411 791	3 529 433	4 099 845	3280	15.5	38 135 947	30 509	10.8%	2.3%	22%
2004	3 978 813	3 183 050	3 710 624	2968	14.0	36 675 666	29 341	10.1%	2.1%	21%
2005	3 756 755	3 005 404	3 497 738	2798	13.2	58 504 020	46 803	6.0%	2.0%	33%
2006	3 564 090	2 851 272	3 312 090	2650	12.5	51 939 108	41 551	6.4%	1.9%	30%
2007	3 178 063	2 542 450	2 944 293	2355	11.1	65 701 362	52 561	4.5%	1.7%	38%
2008	3 345 180	2 676 144	3 120 850	2497	11.8	38 366 792	30 693	8.1%	1.8%	22%
2009	2 792 400	2 233 920	2 599 550	2080	9.8	42 328 154	33 863	6.1%	1.5%	24%
2006–2009 mean	3 219 933	2 575 947	2 994 196	2395	11.3	49 583 854	39 667	6.3%	1.7%	28%

13.2.2.7 Precautionary diagram

Results of EDA (Table FR kk) are plotted on the precautionary diagram (ICES, 2011; Figure FR 29). It shows a decreasing escaping biomass despite a decrease in %SPR. However the location of these points in the graph is highly dependent of pristine biomass and the best achievable biomass figures. If the pristine biomass is under- (over) estimated, all points will move to the left (to the right). For example a very unlikely pristine biomass of 19 million (13.2.2.5) will move all points around a %SSB of 20%. If the best achievable biomasses are under-(over-)estimated, all points will move up (down). For example if we take the very unlikely hypothesis that B_{best} should by divided by 10, points will move around a %SPR of 50% and even some above 100% which is impossible in the absence of massive restocking.

The combination of this very large and unlikely overestimation of both the pristine biomass and the best achievable biomass move points around %SPR of 50% and %SSB of 20% with most points in the red zone.

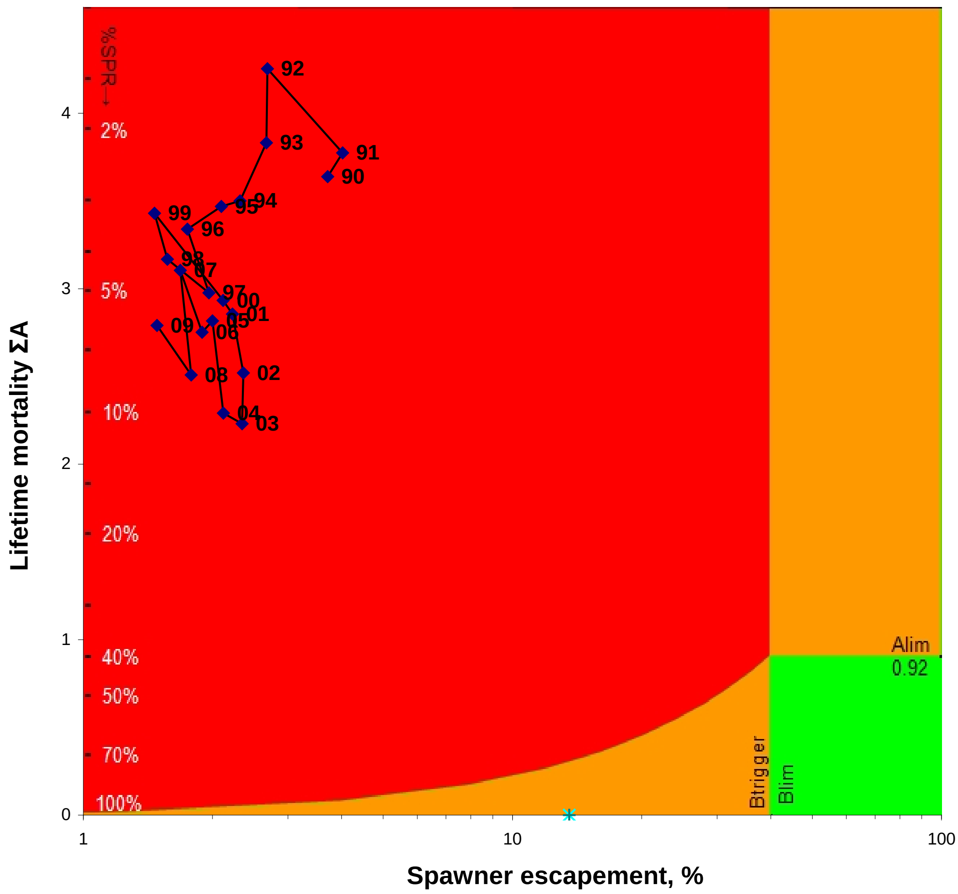


Figure FR 29. Trajectory of escapement for France using EDA between 1990 and 2009. Habitat area = 2114 km²; N0 = 175 million; mean silver eel weight = 800 g.

13.2.2.8 Impacts

13.2.2.8.1 Fisheries

Fisheries time-series have been reconstructed from available data in order to be used to derive the 3Bs from EDA results (Table FR ll). Glass eels data are those from Table

FR f. Professional yellow eel series are built with data from Beaulaton *et al.* (2009) for the whole France and Grand Lieu Lake, from this report for Gironde series (Table FR x) and from Adam (1997) for Grand Lieu Lake. Recreational yellow eel series is built with estimates from Briand *et al.* (2008b) and using yellow eel abundance series from French EMP for extrapolation. Silver eel series only consider professional fishers from the Loire EMU and is a combination of data from Table FR g and Table FR u. This doesn't take into account former silver eel fisheries in watermill operated by either commercial or recreational fishers everywhere in France. Poaching is also not taken into account at any stage. Glass eel fisheries totally dominate catches in silver eel equivalent especially if considering the time lag needed to reach this stage (13.2.2.1).

Table FR ll. Reconstructed (professional and recreational) fisheries series in EDA areas and conversion in silver eel equivalent using biological parameters (13.2.2.1).

	Catch (in t)			Catch (silver eel equivalent in number)		
	Glass	Yellow	Silver	Glass	Yellow	Silver
1978	2040			234 329 864		
1979	2547			292 567 728		
1980	2794			320 940 020		
1981	1794			206 072 439		
1982	1085			124 631 325		
1983	952	1989		109 353 937	7 425 931	
1984	684	1540		78 569 425	5 747 587	
1985	515	1681		59 156 804	6 274 475	
1986	510	1335		58 582 466	4 983 496	
1987	633	1288	50	72 711 178	4 808 408	62 033
1988	544	1491	57	62 487 964	5 566 574	71 118
1989	520	1204	42	59 731 142	4 495 621	51 911
1990	379	1197	53	43 534 813	4 466 219	65 797
1991	266	1206	42	30 554 776	4 503 388	52 560
1992	260	988	32	29 865 571	3 689 764	40 490
1993	459	969	28	52 724 219	3 615 880	34 910
1994	403	861	40	46 291 635	3 215 458	49 704
1995	526	1006	43	60 420 347	3 755 385	54 117
1996	287	898	34	32 966 996	3 352 095	42 307
1997	326	849	46	37 446 831	3 169 379	58 010
1998	201	759	33	23 088 384	2 831 283	41 269
1999	248	542	36	28 487 160	2 023 045	44 384
2000	208	558	31	23 892 457	2 083 383	38 933
2001	102	563	47	11 716 493	2 102 953	58 789
2002	239	550	40	27 453 352	2 054 616	49 445
2003	151	560	38	17 345 005	2 088 923	47 239
2004	89	533	24	10 223 215	1 988 177	29 459
2005	91	529	27	10 452 950	1 973 122	33 612
2006	68	436	31	7 810 995	1 628 198	38 154
2007	77	326	34	8 844 804	1 217 706	43 086
2008	79		19	9 074 539		23 619
2009	43		20	4 916 332		25 306
2010	41		10	4 709 571		12 588
2011	31			3 560 895		
2012	34			3 905 498		

13.2.2.8.2 Non-fisheries mortalities

Turbines' impact can be assessed thanks to SEAHOPE preliminary work on selected basin (8.1.4). Based on those rivers the mean cumulative turbines' mortality on escaping silver eel is 6% according to EDA distribution and 20% according to a uniform distribution. We here only consider the EDA distribution to be consistent. Based on potential escapement (13.2.2.2 and Table FR kk), the mortality due to turbines ranges from 160 000 (130 t in 2009) to 450 000 (360 t in 1991) silver eels. This is however very rough estimates that don't take into account for example the difference in eel characteristics (size) within a basin or the impact of turbines as an upstream migration obstacle.

There isn't enough precise data that allows giving estimates of mortality for any other of non-fishery mortalities despite that upstream migration obstacles and land cover are included in EDA 2.1 model.

13.2.2.9 Critical analysis of EDA

As already said, EDA 2.1 uses the RHT hydrographical network that doesn't include Gironde Estuary, lakes, marshes and lagoons. It has the advantage of being well chained and this allowed running calculations on silver eel migration and turbine mortality. On the other hand, other hydrographical networks would have been more suited to represent the true surface of water habitats.

EDA uses WFD (or WFD-like) data for eel density. They are multispecific electrofishing which may under-estimate eel density. We only use multipass electrofishing in waddable zone excluding thus large (>9 m) and/or deep (>0.7 m) river.

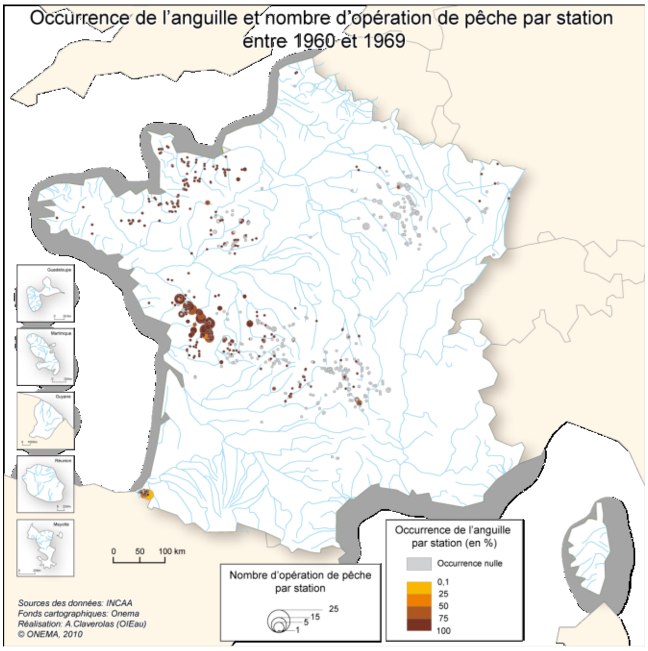
Some areas (Est of France for example) are not well cover by electrofishing data used and therefore possibly biased.

The riverine area used to quantify the habitat may not be the appropriate descriptor, especially for deepest zone.

The number of obstacles is used to describe the effect of upstream migration barrier while knowing the height or height combined with other characteristic of the obstacle is more appropriate (Leprevost, 2007; Hoffmann, 2008). But that kind of data were not available at the national level at the time the analysis was done.

Despite all these criticisms EDA provides reasonably good results on the area covered when compared to silver eel filed data (Table FR jj). Even if it is not a definitive proof, it gives a certain level of confidence in EDA results. The best achievable biomass and particularly the pristine biomasses should however be considered with caution. Historical data have been gathered (Figure FR 30) to be able to check pristine biomass. However the comparison has not yet been done.

Only fisheries and turbines mortalities are used for anthropogenic mortalities because they are the only data available. Those data are sometimes extrapolation (particularly yellow eel fisheries and turbines data) which may have caused bias. However the comparison between the glass eel catches in equivalent silver eel (Table FR ll) and the silver eel escapement calculated by EDA (Table FR kk) leads to a mean exploitation rate of this fishery of 90% (and a maximum at 97%). This value is highly unlikely. It is probably not due to an underestimation of EDA result since results are not so far from field evaluations (Table FR jj). It is difficult to believe that fisher have voluntarily overdeclared their catches. We cannot exclude that a density-dependence regulates the elver stock but this mechanism should be limited in the present situation of scarcity. Therefore the most acceptable explanation for this bias is to consider a massive anthropogenic extra mortality during the first years of the continental life. This hypothesis should be verified and an original experimental design should be specifically designed to this goal.



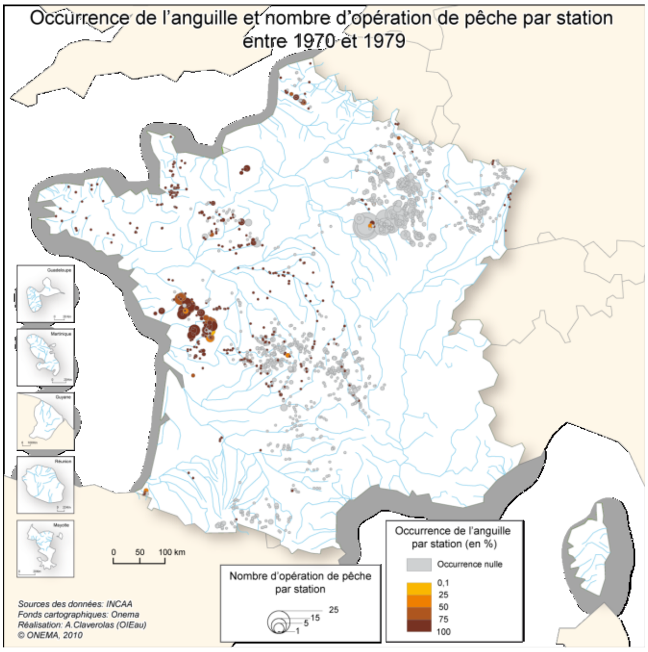


Figure FR 30. Example of historical data gathered: Occurrence (colour) of eel in electrofishing. The size of bubble describes the number of electrofishing operations. INCAA database – Onema.

13.2.3 Silver eel production in Mediterranean lagoons

The following estimates are not part from French reporting. It is a preliminary attempt for WGEEL use.

13.2.3.1 Available data and methods

Some recent estimates of silver eel escapement are available from literature.

Bevacqua *et al.* (2007) use a demographic model on Camargue lagoons to test the effect of management scenarios on silver eel escapement. On the system Imperiaux (4600 ha) + Vaccarès (6400 ha), they estimate a current escapement of about 14 t (1.3 kg/ha), whereas the best achievable escapement is 65 t (5.9 kg/ha).

Amilhat *et al.* (2008) used mark–recapture on a silver eel fishery in Bages-Sigean Lagoon (3770 ha) in 2007. They found an exploitation rate of 18% according to ML Darroch estimator and of 20.3% according pooled Petersen estimator. The mean weight of silver eel was 102 g and 97% were male (<45 cm). Silver catch corrected for the return rate is respectively for year 2006 to 2010: 4.9 t, 40.7 t, 16.2 t, 9.0 t, 10.1 t (Anonymous, 2011b). From those data the current escapement ranges between 20.8 t (200 000 silver eels; 5.5 kg/ha) and 172.4 t (1 690 000 silver eels; 45.7 kg/ha). The average of those five years is 68.5 t (670 000 silver eels; 18.2 kg/ha). Anonymous (2011b) also gives yellow eel catch for the same period that can be corrected for return rate. Considering this mortality as the only source of mortality before the silver eel stage (which may not be appropriate) and making the assumption that growth and mortality compensate each other (1 kg of yellow eel should give 1 kg of silver eel), the best achievable biomass can be evaluated to 125.7 t (33.3 kg/ha) on average. The ratio between $B_{current}$ and B_{best} is 55%.

Charrier *et al.* (2012) used mark–recapture on a silver eel fishery in the Or Lagoon (3170 ha) in 2009. They found a silver eel biomass before exploitation of 43 t (13.6 kg/ha; 185 000 eels) for a real escapement (given silver eel fishery) of 34 t (10.7 kg/ha; 146 000 eels). The mean weight of silver eel was 232 g and 67% were male (<45 cm). Total landings for Or lagoon are 69.1 t in 2009 and 55 t in 2010. Assuming a 75% of yellow eel and taking the same assumption than above, the best achievable biomass can be evaluated to 89 t (28.0 kg/ha). The ratio between $B_{current}$ and B_{best} is 38%.

13.2.3.2 Assessing $B_{current}$ and B_{best} for Mediterranean lagoons

The data available (13.2.3.2) are too scarce to provide an evaluation of $B_{current}$ or B_{best}, even if they are a good starting point.

13.2.3.3 Pristine biomass (B_0)

Bonnet (1973) shows that landings according to official statistics have peaked in 1971 in Thau lagoons at 1340 t (179 kg/ha) and in Berre lagoons at 2100 t (135 kg/ha). According to fishers the total landings for these two lagoons was in fact 5000 t (200 kg/ha).

Aranda (1991) shows that the mean landings in Thau lagoon in 1980s was 230 t (61 kg/ha) with a maximum of 390 t (103 kg/ha).

Quignard *et al.* (1983) show that landings in Or lagoon increased from 75 t in 1897 to between 250 t (78 kg/ha) and 1000 t (315 kg/ha) in the 1960s and 1970s.

Ximenes *et al.* (1990) gives production in the 1980s for different lagoons. It ranges between 17 kg/ha to 60 kg/ha.

This can be a good basis for having an evaluation of pristine biomass.

13.2.4 Overall comments on silver eel production

While the above data are based on our best estimates they remain very rough and should be consider as preliminary. Not evaluated compartment can have an escapement of the same order of magnitude than the one evaluated by EDA.

13.2.5 Stocking requirement eels <20 cm

France has declared in the EMP that between 5% and 10% of its own glass eel catch should be stocked every year. Given the current level of landings, it means a stocking requirement between 1 t and 4 t. The stocking is operated through a public tender (see 3.6.1).

13.2.6 Data quality issues

A national plan against PCBs including eel sampling have been set up since 2008. All details and data can be found here (http://www.pollutions.eaufrance.fr/pcb/). Some samples have also been analyzed for mercury. Data can be accessed through http://www.pollutions.eaufrance.fr/pcb/resultats-xls.html and http://pollutions.eaufrance.fr/Demo/Resultats_hydro.aspx. Following those analyses some fisheries bans have been taken that sometimes only concerns eels above a given size (Figure FR 31).

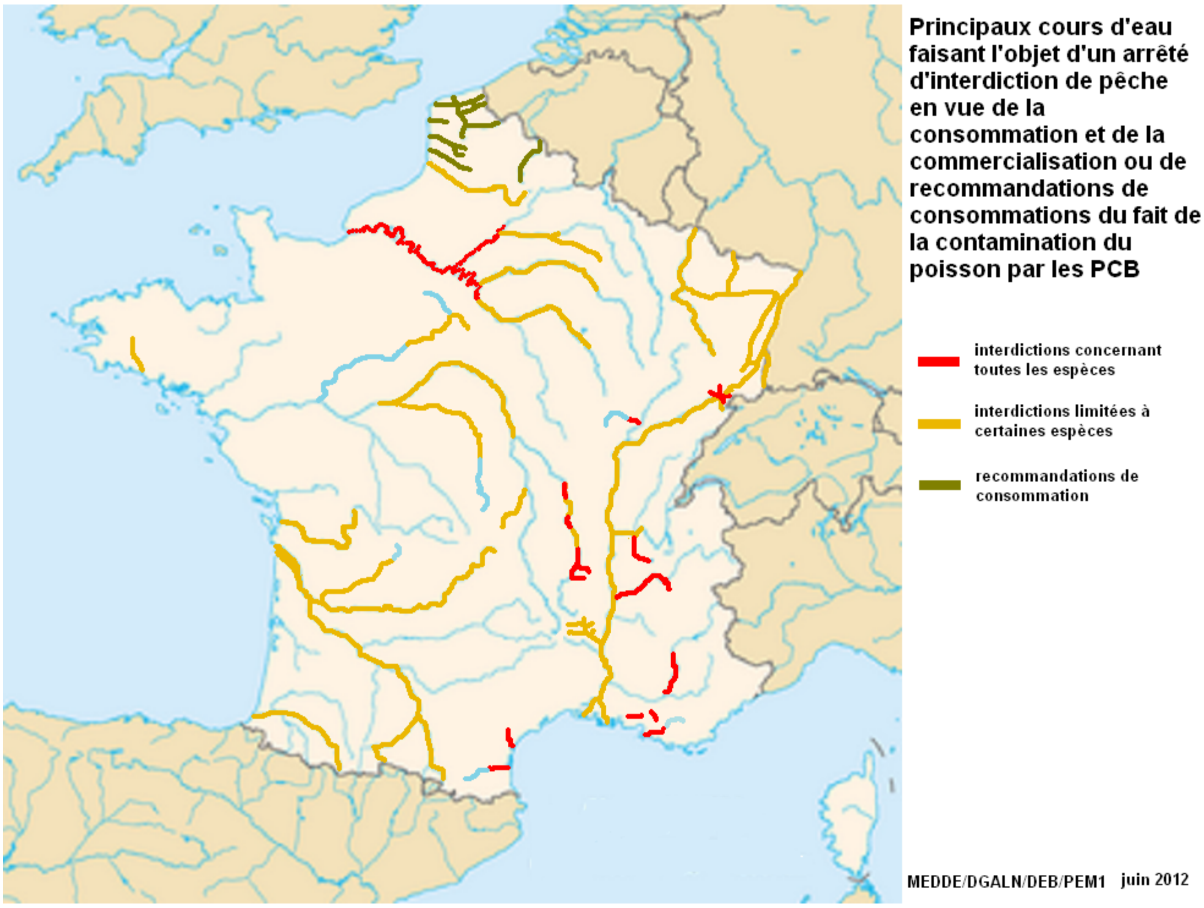


Figure FR 31. Fisheries bans due to PCB in France in June 2012. (source French report to EU Commission). Red: ban for all species; orange: ban for some species (including eel); green: consumption advertising. Sometimes it only concerns eel above a given size.

14 Sampling intensity and precision

In the context of the coming post-evaluation of national eel management plans, the estimation the reliability of stock assessment models becomes a crucial step. In France, the EDA (Eel Density Analysis) model was used to extrapolate yellow eel densities from electrofishing sites to the whole river network. From this extrapolation, a fixed silvering rate was used to calculate the potential silver eel escapement.

There are currently very few field studies where surveys on both yellow eel and silver eel would allow a proper validation of the modelling approach. For this reason, an individual-based model, named CREPE (Constructed Reality for Eel Population Exploration) was developed to apply EDA in a fully data-rich situation. CREPE uses the best knowledge available on eel ecology during the continental phase. It is thus biologically meaningful and acceptable to both eel ecologists and managers. CREPE also provides the opportunity to test the application of assessment models in various contexts, where potentially all can be known. By being able to provide any data, and simulate various contexts, it avoids the pitfall of field data with too many regional particularities.

The difference between CREPE-simulated and EDA-evaluated yellow eel stock abundance has been analysed. The strategy was to considerer several alternatives in the four main biological processes: 1) three levels of diffusivity in the dispersal process, 2) four alternative anthropogenic mortalities corresponding to the combination of with or without fisheries and of with or without obstacles, 3) two biological hypotheses in the sex determinism: density-dependant determinism or fixed 50% sex ratio and 4) three levels of intrinsic growth rate.

This plan led to seventy two scenarios which were repeated one hundred and fifty times to take into account the stochasticity effect. For each scenario we had also considered ten different sets of electrofishing stations randomly chosen in reaches where electrofishing is possible. For each scenario and each station location CREPE produced a virtual dataset of eel density which is used by EDA to estimate the yellow eel stock.

The first step of the analysis was to consider the probability to have a realistic EDA estimate of the yellow eel stock, defined as a density less to two thousand and five hundred eels per hectare of wetted area. More realistic estimates were obtained when diffusivity increased, in situation with fishery or with medium and high growth rates. But the major factor was the station location with some datasets lead systematically to unrealistic values when others systematically to realistic values.

We then considered the probability to have a positive bias. Overestimations were more frequent with low and medium diffusivity, in situation with fishery, with low growth rate or with genetic sex determinism. But again station location is the major factor with half of the datasets that most of the time overestimated the yellow eel density.

Finally we analysed the bias in absolute value. This analysis led to similar conclusions with a high influence of the electrofishing station location. High diffusivity, presence of fishery, medium or high growth rate were associated with to lower bias.

As a conclusion, this work showed the interest of building an operating model like CREPE to test the reliability of an assessment model. This kind of tool allows defining cautious application of an assessment model. In future CREPE could be used to explore proposals of improvement for EDA. This exploration of EDA highlights the mains strength and main weakness of EDA It is easy to apply EDA in a large number of EMUs (or in our case in a large number of datasets from one EMU). But blind application is still risky since extrapolation from electro-fishing station to all the reaches of river networks can lead to unrealistic or biased results.

The next step will be to understand when or why a dataset gives unsatisfactory results and to adapt field survey or statistical methodology to avoid such situations.

15 Standardisation and harmonisation of methodology

No data available.

16 Glass eel trade (EuroStat data)

The EuroStat database was queried to assess the trade of eel for the working group. For this reason the trade analysis does not only include France, though mostly "French" results are reported below. The analysis done below might be updated by the expertise of the working group. The categories selected were 03019210, 03019230, 03019290, 03026600, 03027400, 03032600, 03037600, 03054410, 03054950, 03019200, which correspond to live, fresh, frozen, smoked (two subcategories there, one including offal, the other not), and also for live eel three new categories >12 cm, 12 to 20 cm and larger than 20 cm.

The reporter countries selected were the three major glass eel fishing countries, i.e. France, UK and Spain.

The partners selected were:

Inside EU

BELGIUM (and LUXBG -> 1998), CZECH REPUBLIC (CS->1992), GERMANY (incl. DD from 1991), ESTONIA, FRANCE, UNITED KINGDOM, GREECE, IRELAND, ITALY, LITHUANIA, LATVIA, NETHERLANDS, POLAND, ROMANIA, SWEDEN, SLOVENIA, SLOVAKIA..

Outside EU

HONG KONG, KOREA (REPUBLIC OF (SOUTH KOREA), MOROCCO, CHINA JAPAN.

Additional sum of countries

EU27_EXTRA, EU27_INTRA.

The database was queried in August 2012 for data on glass eel trade from September to June, but clearly the latest trade data from April or May might have been missing.

The data have then been included in a database of glass eel trade containing data tracing back to 1961. The prices have been corrected for inflation using the French harmonised price for consumption series of INSEE.

A quick check of the data has shown that despite the new categories included to account for glass eel trade, some shipment of eel with high mean price (larger than €100 per kg) were deemed to be made of glass eels.

Some monthly trade values, made of fresh, live or frozen eels were identified as a possible mixture of glass eel and yellow eel and the quantity of glass eel was calculated according to the mean price of glass eel and yellow eel calculated for that year, by a glm analysis (Figure FR 32 and Figure FR 33). A lot of the grouped trade values (for instance EU intra, EU extra, or trade for all of 2011) fall into that category of being made of a mixture of yellow eel and glass eel.

The analysis of glass eel trade data shows that despite the enforcement of the regulation and the ban by CITES on glass eel trade, the prices have remained high, attaining the value of €445/kg in France for the 2011/2012 glass eel fishing season (Table FR mm).

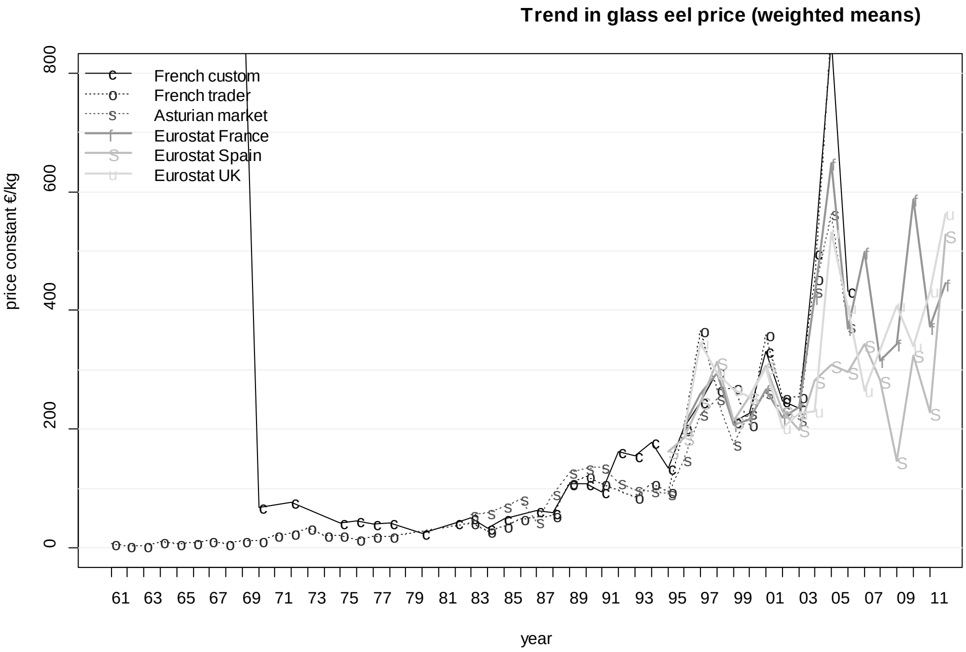


Figure FR 32. Trend in glass eel prices, values extracted from French custom, and after 2006 from EuroStat. Weighted means of annual glass price per countries. Data corrected from inflation. 1969 corresponds to the first appearance of Japanese buyers on the French glass eel market.

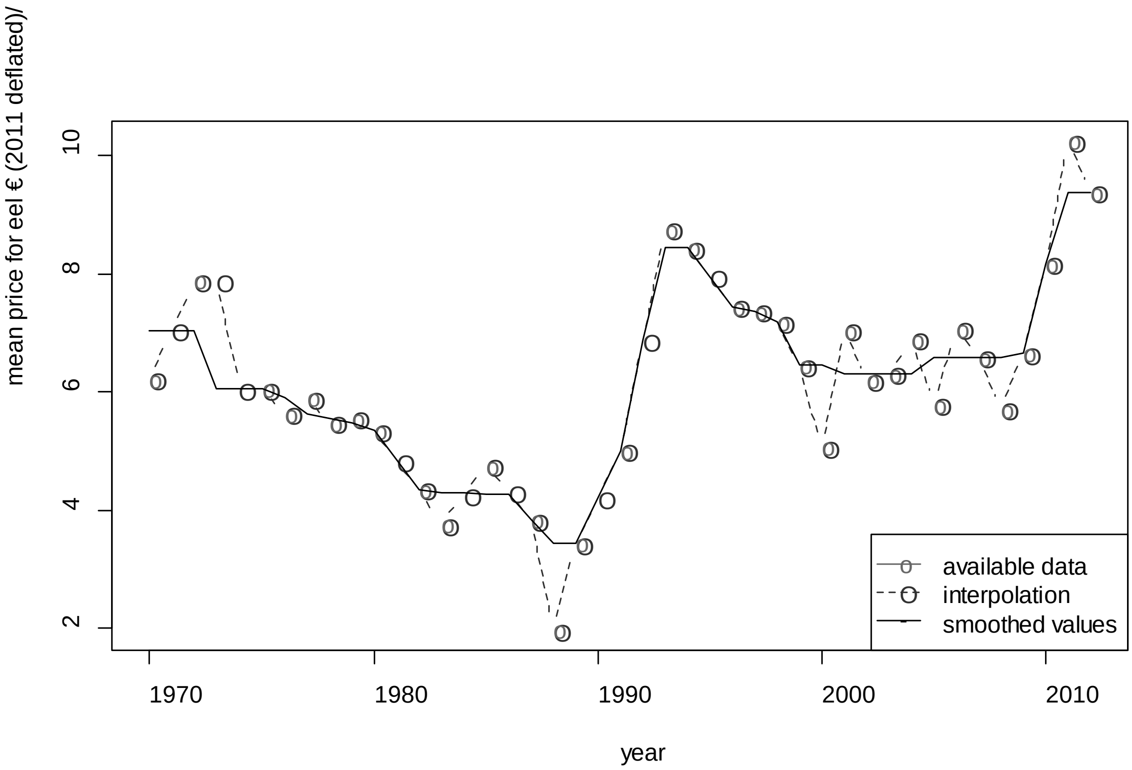


Figure FR 33. Trend yellow eel price, used to calculate the quantity of glass eel in shipment of intermediate mixed price identified as mixture of yellow and glass eels.

Table FR mm. Mean price of glass eel in France.

year	Mean price glass eel
1961	7
1962	4
1963	3
1964	10
1965	7
1966	9
1967	12
1968	8
1969	534
1970	41
1971	21
1972	51
1973	33
1974	20
1975	32
1976	30
1977	30
1978	31
1979	31
1980	24
1981	24
1982	43
1983	47
1984	31
1985	43
1986	49
1987	63
1988	57
1989	109
1990	114
1991	101
1992	162
1993	121
1994	143
1995	114
1996	202
1997	291
1998	286
1999	230
2000	216
2001	319
2002	240
2003	242
2004	457
2005	792
2006	401
2007	499
2008	316
2009	344
2010	588
2011	373
2012	445

Japanese traders first come to France and discover that there are glass eels there (1969)

Historical peak in glass eel price (2005)

Last year of outside EU export quotas by CITES (2010)

When checking the import export trade data, one has to bear in mind that only enterprises working within a country report trade to the EuroStat. So an English enterprise buying glass eel in France will appear as importer in the UK trade statistics but not as exporter elsewhere. The main export destinations for France are Denmark, Germany and the Netherlands (Figure FR 34).

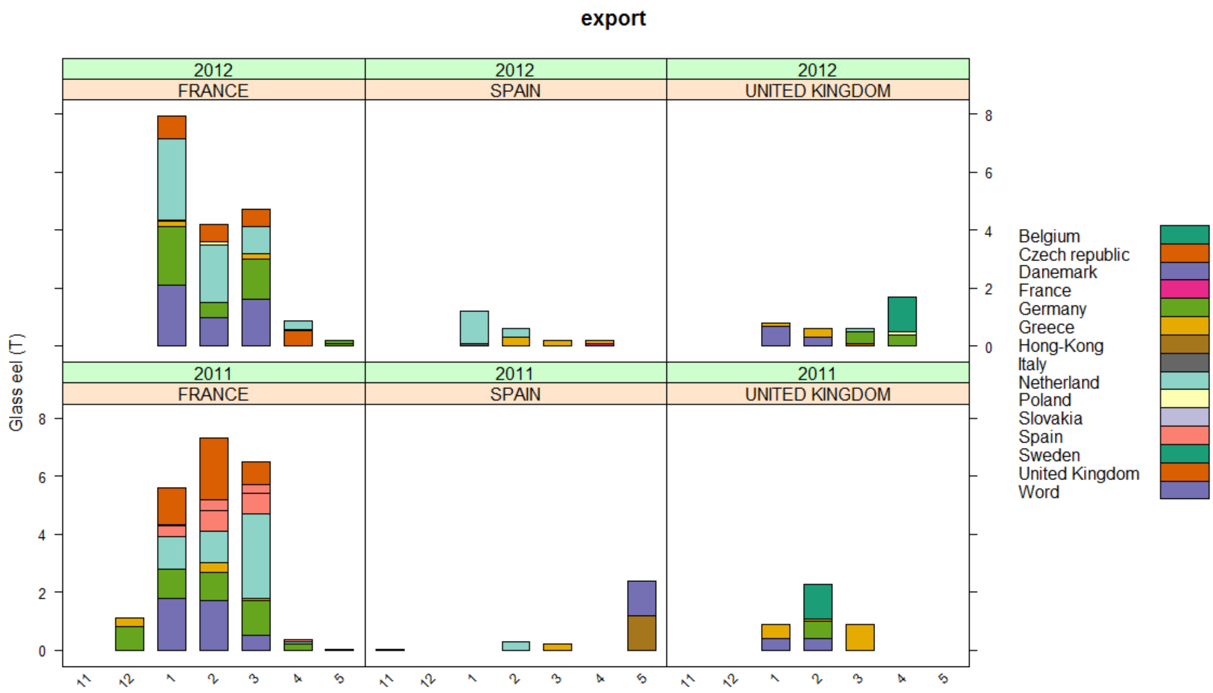


Figure FR 34. Quantity of glass eel exported from France Spain and the UK for the fishing season 2010–2011 and 2011–2012. Data extracted in August 2012 and July 2011.

17 Overview, conclusions and recommendations

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Report on the eel stock and fishery in Germany 2011

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Reporting Period: This report was completed in August 2012, and contains data up to 2011.

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2 Introduction

This report provides the most recent information about eel stocks, eel fishery and eel surveys in Germany. The recent years were characterised by the implementation of the Eel Management Plans for nine German River Basin Districts. During that period, the legal frameworks had to be adapted in some States, structures for documentation of catch, efforts and re-stocking had to be established and, of course, many direct management measures had to be conducted. At the end of June 2012, the first report about the implementation of the German Eel Management Plans and the recent development of the eel stocks was submitted to the European Commission. It covers the period 2008 to 2010 and hence, many data here in this country report also refer to this period. If new data for 2011 were already available, they were, of course, included in the report. For practical reasons, the relevant authorities and institutions in the States mainly focus on the requirements of the reports to the EU Commission and not on providing detailed data on an annual basis. Therefore, there is no permanent new calculation of escapement, production and other population parameters for each year. These data are now provided for the period 2008–2010.

The report also gives data from some scientific surveys, but most parameters on production, wetted areas, silver eel escapement, etc. have not been calculated new. For the purpose of practicability, in these cases the information from last year (i.e. from the Eel Management Plans, EMP) is repeated in the relevant chapters.

2.1 Eel Management Plans

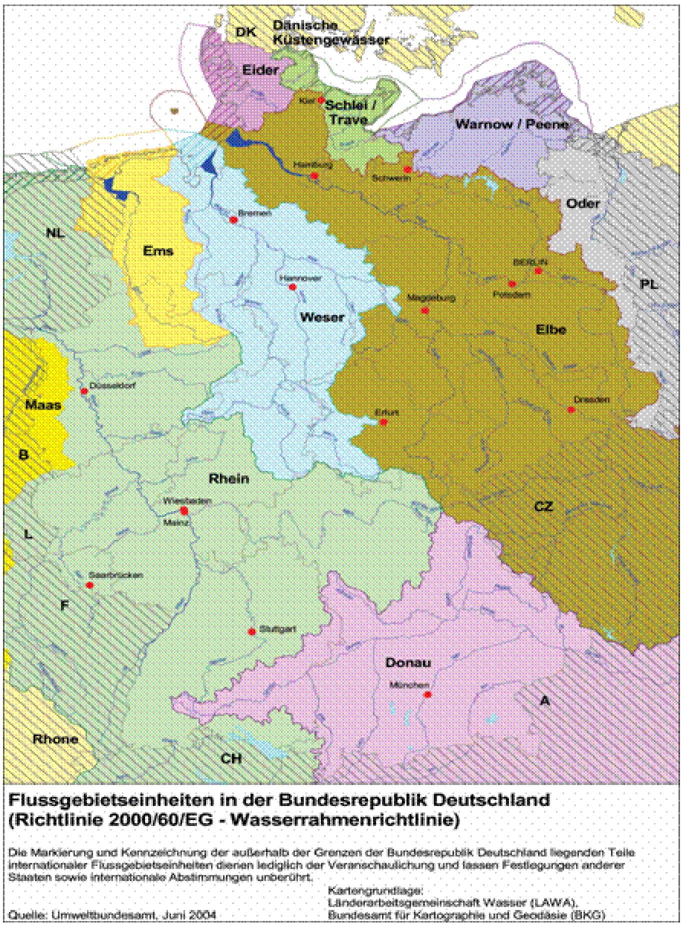

Figure 1. River Basin Districts (RBD) in the Federal Republic of Germany: Eider, Schlei/Trave, Elbe, Warnow/Peene, Oder, Weser, Ems, Rhine, Meuse and Danube.

In December 2008, Germany had submitted Eel Management Plans for its RBD's as required by the EU Council Regulation 1100/2007. The plans had been prepared for nine RBD's (Eider, Elbe, Ems, Meuse, Oder, Rhine, Schlei/Trave, Warnow/Peene and Weser). No plan was prepared for the river Danube, since according to a decision of the European Commission the Danube does not constitute a natural distribution area for eel in the sense of the Council Regulation 1100/2007.

The main measures proposed in the EMP's are:

- increase minimum size limits to 45 cm or 50 cm (different between the "*Bundesländer*");
- maintain and, if possible, increase restocking of eels (not all RBD's), see details in Chapter 13.2.2.6;
- closed seasons (different periods);
- attempts to reduce mortality at turbines, etc. (a position paper of the union of the bigger hydropower companies (BDEW) exists, in which they declare their willingness to cooperate in this question), e. g. by catch-and-carry projects or innovative technical solutions;
- actions to reduce mortality by cormorants (depending on the conditions in the respective RBD/Bundesland).

Meanwhile, some further restrictions have been established, e. g. in parts of the river Rhine commercial fishing for eel is forbidden due to contaminant concentrations. Additionally in some RBD's there are special restrictions, which are limited to one or two states, e. g. removal of stationary eel traps, if possible. These were not included into the list of "main measures".

In April 2010, the German EMP's have been approved by the European Commission. Following this approval, the states started the implementation of the plans. However, the states do this by different ways. Some establish special eel regulations, whereas others only change some aspects of existing legal frameworks.

In the 2012 report to the European Commission about the implementation of the EMP's and about the recent development of the eel stocks, the status of the implementation has been documented. Most of the planned measures have been started but some are in delay and some targets could not be achieved completely. The report also lists measures and their implementation, which had originally not been included in the EMP's and may hence be seen as additional measures. For more details see Fladung *et al*. (2012).

2.2 Eel data collection under the DCF

Sampling of European Eel data in freshwaters is now mandatory under the DCR. In Germany, sampling has started in spring 2009 and the first DCR-report has been submitted to the EU. The results of the biological sampling of eels in the freshwaters have also been presented as an Annex to the Country Report in 2010 and 2011. The most recent data are now included in an Annex to this Country Report. The first two years of sampling have been considered as a "pilot" phase. So far, sampling is focused on biological parameters of eel in commercial catches of the inland fishery. From each river basin district (according to WFD), about 200 eels (100 yellow and silver eels, respectively) have been sampled and investigated. Since 2011 the sampling scheme has slightly changed, but is still focused on biological parameters. Analyses include length, weight, age, sex. Some additional parameters are and will be also be analysed, such as *Anguillicoloides crassus* infestation and also concentration of some contaminants. However, these additional investigations are not mandatory under the DCF.

At present, no data on the fishery itself are sampled within the DCR. This was decided, because a lot of these data have to be obtained in the frame of the Eel Management Plans and the formal and administrative requirements of the EU Council Regulation 1100/2007. Yet, at present the future strategy of the DCF-sampling is under discussion and possibly may change (e. g. inclusion of detailed data about fishing effort in direct relation to catches).

3 Time-series data

3.1 Recruitment-series and associated effort

3.1.1 Glass eel

3.1.1.1 Commercial

There is no glass eel fishery in Germany.

3.1.1.2 Recreational

There is no recreational fishery for glass eel in Germany.

3.1.1.3 Fishery independent

There is no regular and long-term glass eel monitoring in Germany. A monitoring for immigrating elvers/young yellow eels is performed in Mecklenburg-Pomerania (see 3.1.2.3).

3.1.2 Yellow eel recruitment

3.1.2.1 Commercial

There is no data time-series on yellow eel recruitment available based on commercial catches.

3.1.2.2 Recreational

There is no data time-series on yellow eel recruitment available based on recreational catches.

3.1.2.3 Fishery independent

Immigration and upstream migration of young eels have been monitored on some locations in Mecklenburg-Pomerania. The monitoring stations were established in waters of the RBD's Warnow/Peene (both Baltic Sea) and Elbe (North Sea). Recruitment to the rivers of the Baltic Sea is considerably lower than in the rivers draining into the North Sea (Ubl and Dorow, 2010; 2011; pers. comm. Malte Dorow for the 2011 data.).

The few data available indicate that the numbers of glass eels arriving are very low if compared to former data but there was no clear trend in the recent years (Lemcke, 2003; Schaarschmidt, 2005; Schaarschmidt *et al*., 2007; Ubl *et al*., 2007; Table 1). At least in the North Sea catchment (Elbe system) there seemed to be no further decline.

Table 1. Comparison of standardised catches of upstream migrating eels (2002–2011) in several rivers in Mecklenburg-Pomerania (number of eels per fishing gear between May and October; Ubl, 2009; Ubl and Dorow, 2010; 2011; data for 2011; Dorow, pers. comm.).

River	Station	Distance to coast	Gear/Relation	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Baltic Sea													
Warnow	Bützow	53 km	per eel ladder	230	73	56	76	40	35	Not sampled	Not sampled	Not sampled	Not sampled
Hellbach	Mühle	7 km	per eel ladder	25	33	not sampled	not sampled	not sampled	Not sampled	Not sampled	Not sampled	Not sampled	Not sampled
Wallenstein-graben	Wismar (Mühlenteich)	2 km	per eel ladder	not sampled	not sampled	173	153	123	296	509	238	614	113
Mühlengrube	Wismar (Ziegenmarkt)	0.1 km	per eel ladder	not sampled	not sampled	not sampled	not sampled	17	19	81	4	0	0
Uecker	Torgelow (Wehr)	52 km (Oder estuary) or 83 km (Peene estuary)	per eel ladder	70	33	---	---	53	32	25	37	37	51
Plastbach (or Farpener Bach)	Alt Farpen (Stausee/Speicher)	4.8	per eel ladder	not sampled	not sampled	not sampled	not sampled	---	101	67	25	29	84
North Sea													
Müritz-Elde-Wasserstraße	Dömitz (Fischpass)	224 km	per fyke net	5934	2365	3145	2861	3124	2440	1395	Not sampled	2659	3236
			per eel collector	not sampled	not sampled	not sampled	not sampled	9	---	Not sampled	Not sampled	Not sampled	Not sampled
Dove Elbe	Dömitz (Wehr)	224 km	per eel ladder	not sampled	1981	676	721	1035	890	542	Not sampled	62	2024
			per eel collector	not sampled	not sampled	not sampled	not sampled	11	---	Not sampled	Not sampled	Not sampled	Not sampled

3.2 Yellow eel landings

3.2.1 Commercial

There are no time-series on commercial catches of yellow eels available, which could serve as an index. Therefore, data on total landings of yellow eels are presented in Chapter 6.

3.2.2 Recreational

There are no time-series on recreational catches of yellow eel available.

3.3 Silver eel landings

3.3.1 Commercial

There are no time-series on commercial catches of silver eels available, which could serve as an index. Therefore, data on total landings of yellow eels represented in Chapter 6.

3.3.2 Recreational

There are no time-series on recreational catches of silver eel available.

3.4 Aquaculture production

3.4.1 Seed supply

According to data of the German Federal Statistical Office (Statistisches Bundesamt) **5.4 tons** of glass eel were brought to German eel aquaculture companies in 2011. However, information about the sources of the glass eels was not provided. In general, the legal situation regarding the availability of the data (sources) appears to be a bit unclear (data protection, etc.)

3.4.2 Production

Table 2. Production of eel in recirculation systems.

YEAR	PRODUCTION (T)
2003	372
2004	328
2005	329
2006	567
2007	740 (440 t for human consumption and 300 t stocking size eel)
2008	749 (447 t for human consumption and 302 t stocking size eel)
2009	667 (385 t for human consumption and 282 t stocking size eel)
2010	681 (398 t for human consumption and 283 t stocking size eel)
2011	660 t Data not yet available separately for consumption/stocking

3.5 Stocking

3.5.1 Amount stocked

Table 3. Eel restocking in German inland waters from 2008–2010 (Mio. individuals). Data were taken from the 2012 report to the European Commission about the implementation of the German Eel Management Plans (Fladung *et al.*, 2012). Bootlace eel are wild caught eels with lengths of roughly 20–30 cm.

RBD	Glass eel	Ongrown eel	Bootlace eel
Eider	0	0	0
Elbe	4.345	15.872	0.267
Ems	0.328	0.665	0.036
Maas	0.015	0.004	0.002
Oder	0	0.220	0.192
Rhine	1.011	3.349	0.079
Schlei/Trave	0	0.539	0.279
Warnow/Peene	0.062	1.125	0.217
Weser	0.310	1.772	0.432
Total	6.1	23.5	1.5

3.5.2 Catch of eel <12 cm and proportion retained for restocking

There is no glass eel fishery in Germany.

3.5.3 Reconstructed time-series on stocking

A document with detailed information about re-stocking with different types (age groups) of eel during the period 1990–2010 has been provided to the WGEEL subgroup on restocking (contact: Uwe Brämick, Håkan Wickström).

4 Fishing capacity

4.1 Glass eel

There is no glass eel fishery in Germany.

4.2 Yellow eel

Fisheries in Germany usually are mixed fisheries, which catch different species and also both stages of eel, yellow and silver eel (even though some gears are more specialized for one of the stages). Furthermore, so far there was no obligation to report catches separately for yellow and silver eel, respectively. Therefore, fishing capacity is given combined for yellow and silver eels. The data were taken from the EMP's (for 2007, commercial fishery) and from the 2012 report to the European Commission about the implementation of the EMP's (anglers). There are no new data for commercial fisheries available (but now data on fishing effort are provided in the relevant section). Yet, the data have probably not changed very strong since 2007. For anglers, new data are included, but it should be noted that these are only numbers of valid licences, which does not necessarily mean that these anglers fish for eel.

RBD Eider

- 69 full-time (68 coastal, one inland water), 146 part-time, 300 hobby fishermen (1200 fykenets allowed);
- about 20 000 anglers (in 2010).

RBD Elbe

- 413 full- and part-time fishermen/fishing enterprises, (11 102 fykenets, 31 stownets, 24 electrofishing gears, 38 stationary eel traps allowed in 2007);
- 323 181 anglers (in 2010).

RBD Ems

- four full-time and five part-time fishermen (using fykenets and stownets);
- 48 660 anglers (in 2010).

RBD Maas

- 6821 anglers (in 2010).

RBD Oder

- 89 full- and part-time fishermen/fishing enterprises (using 2116 fykenets, seven stownets, 23 electrofishing gears, five stationary eel traps);
- 30 080 anglers (in 2010).

RBD Rhein

- approximately 288 (full-) and part-time fishermen (fykenets and a few stownets);
- 178 845 anglers (in 2010).

RBD Schlei/Trave

- coastal fishery: 142 cutters (124 full-time, 18 part-time), 107 boats (full-time) and 379 boats (part-time fishermen); in total 628 fishing vessels of different size; 808 hobby fishermen (allowed to use 3232 fykenets and 80 800 hooks on longlines);
- inland fishery: 16 fishing enterprises;
- about 20 000 anglers (in 2010).

RBD Warnow/Peene

- coastal fishery: 345 full-time fishermen, 138 part-time fishermen, 261 hobby-fishermen (in total 846 fishing vessels <12 m and 34 vessels >12 m);
- inland fishery: 41 fishing enterprises with 125 vessels (using ca. 1800 fykenets or eeltrap chains, ten seines, seven electrofishing gears, four stationary eeltraps, longlines with 25 000 hooks);
- 134 655 anglers (in 2010).

Weser

- 17 full-time fishermen, four cooperatives, 99 part-time fishermen (using stownets, fykenets, traps);
- 105 755 anglers (in 2010).

In 2010, the total number of valid fishing licences in the RBD's relevant for eel was 867 996. This is a reduction of 2% compared to 2008 (the first year of the implementation of the EMP's). Yet, it is not known, how many anglers actually fish for eel.

4.3 Silver eel

See 4.2.

4.4 Marine fishery

These data are included in the previous section (4.2).

5 Fishing effort

In the frame of the implementation of the EMP's, data on fishing effort became available due to documentation requirements in the Regulation 1100/2007 (the "Eel-Regulation"). The data are taken from the first report to the EU Commission on the implementation of the EMP's in Germany.

5.1 Glass eel

There is no glass eel fishery in Germany.

5.2 Yellow eel

Fisheries in Germany usually are mixed fisheries, which catch different species and also both stages of eel, yellow and silver eel (even though some gears are more specialized for one of the stages). Therefore, fishing effort cannot be presented separately for yellow and silver eel. Hence, Table 4 gives the data on total fishing effort on both stages. Except for large fykenets, a decreasing tendency in fishing effort is documented for the period 2008 to 2010.

Table 4. Fishing effort with the most relevant eel fishing gears of commercial and semicommercial fisheries in German waters in 2010 and change (%) in relation to the 2008-data. Data are presented as *gear * days used*.

RBD	Small fykes	Large fykes	Longlines (eel line 100 at hooks)	Aalpuppen ("Hook buoy"?)	Stow nets	Stationary eel traps	Electro fishing
Eider	25,379	---	0	0	197	0	0
Elbe	403,531	309,032	301	10,965	4,130	872	69
Ems	3,410	16,892	0	0	5,209	0	0
Maas	0	0	0	0	0	30	0
Oder	373,285	60,838	83,478	12,300	1,599	0	30
Rhein	112,860	6,214	6	0	167	0	290
Schlei/Trave	623,181	---	3,027	0	0	0	8
Warnow/Peene	3,429,488	53,625	430,663	2,250	0	197	21
Weser	155,621	3,540	0	0	844	18	0
Total	5,126,755	450,141	517,475	25,215	12,146	1,117	418
Change from 2008 to 2010 (%)*	-12	+16	0	-73	-26	-44	-30

***Without the State of Brandenburg, because no data from this State were available for 2008.**

5.3 Silver eel

See 5.2.

5.4 Marine fishery

The data for the marine coastal fishery, which are conducted in the frame of the EMP's, are included in Table 4.

6 Catches and landings

At present, it is not possible to provide temporally structured information (e. g. on a monthly basis or so). Although the fishermen (will) have to deliver the information at least on a monthly basis to the authorities (at least in some States), but it is not clear, if the authorities will have the capacities to analyse or summarise the data, at least in a regular scheme. However, the new documentation requirements have been established and most States document catches separately for yellow and silver eel, respectively.

6.1 Glass eel

There is no glass eel fishery in Germany.

6.2 Yellow eel

The separate documentation of yellow and silver eel catches has improved, but is not complete in all cases. Therefore, combined data for yellow and silver eels are given in some cases.

Table 5. Combined catches of yellow and silver eels (t) by the German inland fishery in 2011.

„Bundesland“ (State)	Commercial fishery			Recreational fishery
	Yellow eel	Silver eel	Undifferentiated)	
Baden-Württemberg	6.1	2.5		5.0
Bayern	0.4	0.4		16.0
Berlin	8.0	6.1		6.2
Brandenburg	93.0	23.0		35.0
Bremen			2.9	4.5
Hamburg	No data	No data	No data	No data
Hessen			0.8	No data
Mecklenburg-Vorpommern	80.5	25.3		61.2
Niedersachsen	No data	No data	No data	No data
Nordrhein-Westfalen	0.5	0.6		20.0
Rheinland-Pfalz	No data	No data	No data	No data
Saarland	0	0	0	<1
Sachsen	1.1	0.7		5.1
Sachsen-Anhalt	2.0	1.5		9.8
Schleswig-Holstein	24.1	11.3		64.1
Thüringen	0.1	0		3.1
Total*	215.8	71.4	3.7	230

***Data missing for the States Niedersachsen, Hamburg and Rheinland-Pfalz.**

6.3 Silver eel

Silver eels are included in Section 6.2.

In addition to the catches, information can be provided about some trap & truck-activities. The projects already mentioned in the last years report (Mosel, Main, Neckar, Schlei/Trave) have been continued, or in case of the RBD Schlei/Trave started. In Table 6, available information about the downstream transported eels is provided.

At the River Mosel, a trap & truck initiative of the State Rheinland-Pfalz (Rhineland-Palatinate) and the RWE Power AG has been active since 1995. About ten fishermen catch silver eels, which are transported downstream to the lower Rhine. (Lothar Kroll, State Agency for Environment, Water Supply and Trade Supervision of Rhineland-Palatinate; Karin Schindehütte; Ministry for Climate Protection, Environment, Agriculture, Nature Conservation and Consumer Protection of the State of North Rhine-Westphalia).

In Bavaria, a project has been started in the river Main (RBD Rhine). Eels are caught by "Schokkers". (Jan Baer, Fisheries Research Station Baden-Württemberg; Michael Schubert, Bavarian State Research Centre for Agriculture, pers. comm.).

In the river Neckar (RBD Rhine, State Baden-Württemberg) a project has been initiated in 2009. The fish are caught by electrofishing and determined as yellow or silver eels by measuring eye diameter, etc. Only silver eels are transported downstream to avoid that the fish migrate upstream again. It should be noted that this is an area quite upstream, above plenty of hydropower plants; so the low biomass of transported eels from this area is not surprising. The project is planned for five years (Jan Baer, Fisheries Research Station Baden-Württemberg).

A new project was initiated in autumn 2011 in Schleswig-Holstein, a coastal state. Silver eels will be caught from inland fisheries of the RBD Schlei/Trave and released into the estuary of the river Eider (North Sea). The project has started on a quite low level but possibly the numbers of transported eels will increase in 2012. (Siegfried Spratte, State Agency for Agriculture, Environment and Rural Areas Schleswig-Holstein, pers. comm).

Table 6. Biomass of downstream transported silver eels (kg) in Trap & truck projects in several German rivers.

YEAR	MOSEL	NECKAR	MAIN	SCHLEI/TRAVE
1997	1474			
1998	1923			
1999	3418			
2000	4600			
2001	5803			
2002	4735			
2003	3939			
2004	3584			
2005	5286			
2006	5434			
2007	7357			
2008	5783			
2009	4030	320	5703	
2010	3850	261	4731	
2011	5139	350	6636	102

6.4 Marine fishery

Table 7. Eel landings from the coastal fishery in North and Baltic Sea by quantities and value.

	North Sea						Baltic Sea		
Year	Lower Saxony (incl. stocking size eel)		Schleswig-Holstein		Schleswig-Holstein Stocking size eel		Schleswig-Holstein		Mecklenburg-Pomerania
	t	€	t	€	t	€	t	€	t
1961	47.8	76,854							
1962	66.8	108,019							
1963	55.3	111,128							
1964	56.1	124,742							
1965	56.3	135,596							
1966	67.8	143,672							
1967	92.3	199,788							
1968	102.5	245,202							
1969	85.3	194,871	97.4	313,213			204.5	909.189	
1970	130.3	324,193	94.1	349,148			143.8	682.162	
1971	113.9	375,358	130.6	550,216			124.5	679.720	
1972	77.2	71,785	92.3	453,610			146.8	749.918	
1973	77.5	393,541	105.5	510,202			151.2	825.524	
1974	85.9	392,953	113.8	661,990			109.8	679.307	
1975	94.7	509,196	102.6	592,191			123.7	762.290	
1976	104.5	540,277	102.4	599,191			102.6	660.139	
1977	99.3	540,192	135.9	793,559			77.6	546.213	
1978	69.0	432,263	100.7	682,567			62.6	465.377	
1979	81.4	486,924	76.1	569,022			81.6	596.672	
1980	108.9	658,220	73.5	548,177			66.0	474.395	
1981	119.4	787,696	55.4	405,403			75.1	575.250	
1982	107.3	766,437	67.3	502,455			98.3	746.875	
1983	102.9	684,057	72.6	531,814			82.6	636.962	
1984	95.4	617,621	62.2	483,898			51.3	420.048	
1985	65.4	449,844	57.1	442,299			50.4	411.762	
1986	91.7	662,076	39.6	324,351			65.6	564.750	
1987	69.0	485,298	21.0	171,292			57.1	478.490	
1988	45.6	349,384	42.2	363,694			70.1	590.345	
1989	29.3	220,463	31.4	265,244			86.9	751.143	
1990	35.9	283,640	14.7	125,732			82.4	741.405	
1991	24.5	202,558	11.8	94,525			83.5	773.621	
1992	25.7	223,031	6.1	57,957			78.7	701.902	
1993	30.1	227,157	12.8	115,980	1.9	9,690	66.5	624.781	
1994	64.5	492,489	13.3	68,891	10.4	44,146	63.7	567.412	
1995	42.5	322,316	7.7	60,244	3.6	18,496	60.2	542.434	
1996	15.7	135,320	6.3	43,984	3.5	17,850	27.7	267.152	
1997	30.0	238,911	12.0	84,278	3.7	22,452	44.5	417.479	

	North Sea						Baltic Sea		
Year	Lower Saxony (incl. stocking size eel)		Schleswig-Holstein		Schleswig-Holstein Stocking size eel		Schleswig-Holstein		Mecklenburg-Pomerania
1998	13.8	114,715	8.5	62,714	3.7	22,289	19.1	186.149	
1999	19.9	161,782	10.5	75,144	6.1	33,233	27.0	254.386	
2000	16.3	141,990	5.7	39,266	5.0	27,756	30.1	284.963	
2001	21.1	186,200	4.7	37,764	4.7	26,266	28.6	278.228	108
2002	35.3	292,198	4.4	38,850	4.0	21,547	28.0	218.217	98
2003	29.8	233,986	4.8	36,067	3.4	19,548	27.4	251.862	93
2004	31.7	246,038	5.4	39,745	4.1		17.3	136.337	94
2005	22.2	198,872	5.0	38,400			17.0	130,560	86
2006	19.1	165,340	4.1	29,247			21.1	141,178	91
2007	23.6	191,278	0.05	388			11.3	67,806	76
2008	14.3*		0.1				13.2		71
2009	13.2*		0.1				8.5		64
2010	13.5*		0				13.4	87,529	61
2011	14.8*		0				9.5	59,987	42

*** These catches do not reflect real "marine" fishery. Instead, they represent catches from the lower reaches and estuaries of rivers draining into the North Sea. They come from transitional waters according to the WFD, but in the fisheries legislation they are counted as "coastal fishery".**

7 Catch per unit of effort

According to the EU Regulation 1100/2007, catches as well as effort have to be reported by the fishermen. In the frame of the implementation of the EMP's, the documentation of the catches has been improved and that of effort has been established. (See relevant sections in this report.). However, so far the catches are not directly related to the efforts, because this analysis would mean a substantial and additional effort for the responsible authorities. In the moment it is not clear, if, when or how such analyses will become available in the future.

7.1 Glass eel

There exists no glass eel fishery in Germany.

7.2 Yellow eel

There are no data on cpue available.

7.3 Silver eel

There are no data on cpue available.

7.4 Marine fishery

There are no data on cpue available.

8 Other anthropogenic impacts

Estimates for mortalities due to other anthropogenic impacts are given in Chapter 13.2.2.5.

9 Scientific surveys of the stock

9.1 Recruitment surveys, glass eel (includes yellow eel in Scandinavia)

See information/data on elver monitoring in Mecklenburg-Pomerania in Chapter 3.1.2.3.

9.2 Stock surveys, yellow eel

Information on stock assessment (yellow eel monitoring) in coastal waters of the Baltic Sea is provided in Chapter 13.1.

9.3 Silver eel

No new information available.

10 Catch composition by age and length

Data obtained during the DCF-sampling are reported in a separate Annex to this report.

Since the Regulation 1100/2007 requires a substantial documentation of fishing capacities, efforts and yields, it was decided in Germany to focus on the biological sampling in the frame of the DCR/DCF. In a pilot phase in 2009 and 2010 all relevant RBD's were sampled. Results were presented in the last years report. In 2011, the sampling scheme was slightly changed.

11 Other biological sampling

11.1 Length, weight and growth (DCF)

Results of the sampling in the frame of the DCF are presented in a separate Annex. There are no other data for length, weight and growth available.

11.2 Parasites and pathogens

Thieser *et al*. (2012) studied infestation of European and American eel with the swim bladder nematode *Anguillicoloides crassus* in two north German Lakes. The background of this study is the unintended stocking of *A. rostrata* in several lakes in Mecklenburg-Pomerania in the period 1998–2002. This stocking of the wrong eel species is of course negative under the aspect of nature conservation. (However, since meanwhile the stocking material is routinely tested genetically (for *A. anguilla* vs. *A. rostrata*) the temporal disturbance will probably disappear within the next ten years.) But on the other hand, this special situation offers the possibility top study infestation of the two Atlantic Anguilla-species, which naturally would not occur in the same waters with *A. crassus*. In both lakes, the eel stocks result almost exclusively from restocking. In total, the authors analyzed 91 eels (48 European, 43 American). Infection with *A. crassus* was found in both species and there was no clear difference in prevalence. Prevalence of *A. crassus* larvae was between 24% and 53% in *A. anguilla* and between 48% and 50% in *A. rostrata*. For adult nematodes, prevalence was 48% to 68% in *A. anguilla* and 43–80% in *A. rostrata*. A heterogeneous picture without noteworthy differences between the two species was found for the swimbladder Degenerative Index (Lefebvre, 2002). The authors did not find a significant effect of *A. crassus* infection on Condition Factor and Spleen-Somatic Index.

In a study at Lake Constance, Bernies *et al*. (2011) documented establishment and development of the *A. crassus* over a 21 year period (1988–2009). After an initial phase, prevalence was stable for about fifteen years at 60–70% but in the last two years of the study, the value decreased significantly to 48%. The authors also recorded a drastic initial increase in infection intensity, which peaked at 16 nematodes per swimbladder four years after the first occurrence of the parasite in the lake. Yet, rather short after this peak, infection intensity started to decrease. This trend continued until the end of the study when the mean infection intensity was 3.3 nematodes per swimbladder.

11.3 Contaminants

Nagel *et al*. (2012) demonstrated the impact of silvering on biliary PAH (polycyclic aromatic hydrocarbons) metabolite concentrations and used normalization procedures to overcome silvering related accumulation effects of PAH-metabolites in eel bile. The authors investigated the hydroxyl-metabolites of pyrene (1-OH Pyr) and phenantrene (1-OH Phen) in the bile of different maturation stages of eels (silvering index I–V) from nine German rivers. They detected increasing absolute PAH metabolite levels in bile during the silvering process. They highest rise was observed at the transition from pre-migration stage III to the migrating stage IV, suggesting the cessation of feeding at this stage. A cessation bias in PAH metabolite measurement could be diminished by normalization of absolute values against bile pigments (A_{380}, biliverdin). For future eel monitoring, the authors recommend 1) to regularly monitor PAH-metabolites in bile, 2) to determine silvering index of eel and 3) to normalize PAH-metabolite values in bile based on silvering status.

Eel samples of monitoring programmes in North Rhine-Westphalia showed high values in the range of or above the maximum level for dioxins and dioxin-like PCBs. 137 samples were examined, originating from the rivers Weser, Rhine, six Rhine tributaries, three Meuse tributaries, and one reservoir. Due to the results the "Landesamt für Natur, Umwelt und Verbraucherschutz" (LANUV NRW) recommended in July 2012 to avoid consumption of wild eels caught in North Rhine-Westphalian waters (www.lanuv.nrw.de).

11.4 Predators

Estimates for predation by cormorants are included in Chapter 13.2.2.5.

12 Other sampling

A study on silver eel migration and fisheries mortality in the River Havel (RBD Elbe) was conducted by Simon *et al*. (2011). By using acoustic telemetry (VEMCO), the authors studied the migration behaviour and fishery mortality of silver eels during the early phase of the spawning migration through the River Havel downstream to the River Elbe. A total of 99 female silver eels were implanted with acoustic transmitters and released at two locations in the Havel river system in autumn 2007. Tag recaptures by fisheries were used to assess fishery mortality. Most eels continued their downstream migration immediately after release during October–November in the year of release. However, some eels continued their migration the following spring or autumn. Only a few eels migrated during winter and summer. Tagged eels reached the River Elbe from two days to more than one year after tagging. Fishing efficiency was very high, and by the end of December 2008, only 8% of the tagged eels had reached the river Elbe, whereas 25% were reported caught by commercial fishermen and 2% by recreational fishermen. The remaining 65% of the tagged eels were unaccounted for at the end of the study period.

Another acoustic telemetry study (VEMCO) on the migration behaviour of female silver eels was conducted by Dorow *et al*. (in press) in the river Warnow. 148 female silver eels with a mean length of 74.6 cm and a mean weight of 826.2 g were tagged and released in the river Warnow between June and November 2011. Until May 2012, 91 had already passed the lower Warnow towards the Baltic Sea. Three of these 91 eels were later caught around the island Fehmarn. However, two other tagged eels were caught in a lake rather far upstream of the release position. The authors noted a considerable variation in the migration behaviour of the eels (timing, speed). E. g. the fastest eel migrated the distance Vorbeck to Warnemünde (about 40 km) in 2.3 days, whereas the slowest (migrating) individual needed 193 days for the same distance.

Oeberst and Fladung (2012) described the improved version of the model used to estimate population development and escapement in the German EMP's (GEM II). This new version was recently used to do the calculations for the 2012 report to the European Commission about the implementation of the German EMP's and the development of the eel stocks in the German waters. The model had also been part of the POSE-project, were it, in general, yielded reasonable results (Erik Fladung, pers. comm.). First comparisons of the modelling results for escapement with tagging studies on silver eels in the Havel/Elbe system showed that the model at least delivers results in the right order of magnitude (Erik Fladung, pers. comm.).

In 2004, a study on the success of eel restocking with different type of stocked fish (glass eel *vs.* ongrown eels) was started in the State of Brandenburg. Recently, Simon (2012) provided first and preliminary results of this study. The study was conducted in seven closed eutrophic lakes with less than 20 ha area and 10 m depth. The authors stocked glass eels (mean 7.2 cm) and ongrown eels (mean 15.3 cm) in a standardized combined way (50 g glass eel per ha and 500 g ongrown eel per ha) every second year. The glass eels were marked with Oxytetracyclin and Alizarin Red, whereas the ongrown eels were tagged with coded wire tags (CWT). Growth and condition were studied by regular sampling during the study period. In all lakes, the fish stocked as glass eels had higher growth rates, and after three to five years they had outweighed the previous advantage in size of the fish stocked as ongrown eels. Whereas condition of the glass eels increased slightly in the first years after stocking, condition of the ongrown eels decreased during that period. Obviously, eels adapted to artificial food in the fish farms have some problems to switch to a natural diet in the lakes. Survival rates do not seem to differ between the stocking groups, which is also in contrast to former assumptions. Yet, the authors state that the results have to be interpreted very carefully and cannot be generalized, because the study was done under certain conditions, which may not be given everywhere (glass eels of very good quality were stocked at a very favourable time; this may not be possible for large restocking programmes for logistical reasons, etc.).

13 Stock assessment

13.1 Local stock assessment

Stock assessment in coastal waters

In the last years report, a monitoring system for coastal waters of the Baltic Sea was described, which had been developed and tested by the Institute for Fisheries of the State Research Centre Mecklenburg-Vorpommern for Agriculture and Fishery (Dorow and Ubl, 2011). The transportable fykenet system consists of a square external leader net weir with a fykenet chamber in each corner. The net square encloses a total fished area of 1 ha. Additionally, six chains of eel traps are deployed in the fished area to increase the likelihood of catching all eel above a certain size (defined by the used mesh size) that are within the net weir. The results of the first tests had been described by Dorow and Ubl (2011) and were included into last year's country report. Dorow and Ubl (2011) also considered temperature effects and size selectivity of the system. Recently, the first results of the regular monitoring with this fyke system have been published by Dorow *et al*. (2012). From 2008 to 2011, the system was used for 200 samplings. The standardized fishing time for the system is 48 hours. 124 were conducted in inner coastal waters and 76 in outer coastal waters. In total 1157 eel were caught. 97% of the eel were classified as yellow eels. The overall eel density (eels >36 cm, for reasons of size selectivity of the system) was 4.7 yellow eels per ha, what relates to a biomass of 1.3 kg/ha. The authors noted a high variability in the densities found. There were highly significant differences between the inner and outer coastal waters with higher eel densities in the outer coastal waters. Mean yellow eel density in the outer coastal waters was 8.7 ind./ha (2.3 kg/ha). In contrast, mean biomass in the inner coastal waters was only 0.6 kg/ha. Some differences were also found between single stations within the sampling areas. As a consequence of the significant differences between inner and outer coastal waters, the authors estimated the stock numbers separately for inner and outer coastal waters. In the inner and outer coastal waters, numbers of 400 000 and 1 500 000 eels >36 cm was estimated, respectively. The mean age of the eels in the outer coastal waters (8.2 ± 1.9 years) was significantly higher than in the inner coastal waters (7.4 ± 1.9 years). Based on eel densities and age distribution the authors also tried a rough estimate of recruitment to the coastal waters. According to their results, with about 31 ind. (1+)/ha * year recruitment to the outer coastal waters was considerably higher than in the inner coastal waters (5 ind./ha * year). In total this would result in a recruitment of approximately 7 mio. individuals per year to the coastal waters. (All information in this paragraph was taken from Dorow *et al*., 2012).

13.2 International stock assessment

13.2.1 Habitat

These data were taken from the EMP's and have been given also in the last year's report. They have not changed but for the reason of practical working with the report, they are given here again.

Table 8. Habitat types (ha) per RBD.

HABITAT TYPE	LACUSTRINE	RIVERINE	TRANSITIONAL & LAGOON	COASTAL	TOTAL
RBD					
Eider	4978	2899	1662	459 244	468 783
Elbe	136 662	18 097	46 260	Not included	201 019
Ems	1194	6633	36 164	Not included	43 991
Maas	0	892	Not included	Not included	892
Oder	49 205	2654	28 507	Not included	80 366
Rhein	14 400	44 531	Not included	Not included	58 931
Schlei/Trave	20 546	2483	0	310 761	333 790
Warnow/Peene	30 175	4647	0	310 080	344 902
Weser	4962	15 096	34 650	Not included	54 708

13.2.2 Silver eel production

13.2.2.1 Historic production

In the previous report, these data had been taken from the EMP's. In the frame of the work on the 2012 report to the European Commission on the implementation of the EMP's, the original German Eel Model (GEM) has been further developed (GEM II, see Oeberst and Fladung, 2012; Fladung *et al*., 2012) and the population parameters have been recalculated with the new model. Here the new data are given. For some RBD's, higher values of B_0 have now been calculated, but for other RBD's the new value is lower. In total, however, the reference value has clearly increased. Note that the model was not used for the RBD's Eider and Schlei/Trave and, hence, the data for these RBD's have not changed.

Table 9. "Historic" spawner escapement by RBD. Data were taken from the 2012 report to the European Commission on the implementation of the German EMP's (Fladung *et al*., 2012).

RBD		Detail	Total production of silver eel (t) – B_0
Eider	North Sea	Inland and coastal waters	240
Elbe	North Sea	Inland and transitional waters	1450
Ems	North Sea	Inland and transitional waters	711
Maas	North Sea	Inland waters	4
Oder	Baltic Sea	Inland and transitional waters	118
Rhein	North Sea	Inland waters	288
Schlei/Trave	Baltic Sea	Inland and coastal waters	641
Warnow/Peene	Baltic Sea	Inland and coastal waters	1395
Weser	North Sea	Inland and transitional waters	605
Total			5453

13.2.2.2 Current production

The German eel model does not distinguish between production and escapement. Hence, these values are not available in the moment.

13.2.2.3 Current escapement

The current escapement has also been calculated with the improved model. Changes in relation to the former reports may therefore be due to a) real changes in escapement but also due to b) a new calculation basis. In Table 10 the new data are given.

Table 10. Present spawner escapement by RBD. Data were taken from the 2012 report to the European Commission on the implementation of the German EMP's (Fladung *et al.*, 2012) RBD's. The data are results of modelling, taking into account recruitment estimates for the relevant periods and also estimates or data for all anthropogenic impacts.

RBD		DETAIL	TOTAL PRODUCTION OF SILVER EEL (T) (ESCAPEMENT)
Eider	North Sea	Inland and coastal waters	109
Elbe	North Sea	Inland and transitional waters	186
Ems	North Sea	Inland and transitional waters	390
Maas	North Sea	Inland waters	<1
Oder	Baltic Sea	Inland and transitional waters	19
Rhein	North Sea	Inland waters	154
Schlei/Trave	Baltic Sea	Inland and coastal waters	290
Warnow/Peene	Baltic Sea	Inland and coastal waters	539
Weser	North Sea	Inland and transitional waters	357
Total			2045

13.2.2.4 Production values e.g. kg/ha

See Table 10 (Section 13.2.2.3).

In addition to the estimates of historic and current escapement, some additional estimates were available for the best achievable escapement (B_{best}) under present recruitment and without any anthropogenic impacts (i. e. present recruitment levels, no restocking, full accessibility of habitats, no fishery, no turbine mortality, etc.). They were also estimated with the improved model used for the calculation of current and historic escapement in the respective RBD's/EMU's, by setting the anthropogenic impacts as zero.

Table 11. Estimates for the best achievable escapement (B_{best}) under present recruitment and without any anthropogenic impacts. Data were taken from the 2012 report to the European Commission on the implementation of the German EMP's (Fladung *et al.*, 2012) RBD's.

RBD		Detail	Best achievable escapement (Bbest) under present recruitment without any anthropogenic impacts (t)
Eider	North Sea	Inland and coastal waters	146
Elbe	North Sea	Inland and transitional waters	118
Ems	North Sea	Inland and transitional waters	235
Maas	North Sea	Inland waters	1
Oder	Baltic Sea	Inland and transitional waters	9
Rhein	North Sea	Inland waters	17
Schlei/Trave	Baltic Sea	Inland and coastal waters	384
Warnow/Peene	Baltic Sea	Inland and coastal waters	614
Weser	North Sea	Inland and transitional waters	163
Total			1687

According to the calculations, actual escapement is lower than B_{best} in only three of the RBD's, whereas in five RBD's current escapement is higher than B_{best}. Accordingly, the total escapement from all RBD's is also higher than B_{best}. This is obviously a result of the considerable restocking in the past. Of course, the data and model assumptions will have to be assessed and further improved in the future to put the calculations, and the discussion of the data on a more solid ground and to achieve a higher reliability.

13.2.2.5 Impacts

Information about the impacts on the eel stocks in the RBD's were also new calculated for the 2012 report to the European Commission. Data for 2010 are given in Table 12.

Table 12. Impacts on the eel stocks per RBD (2010). Data were taken from the 2012 report to the European Commission on the implementation of the German EMP's (Fladung *et al.*, 2012).

RBD	IMPACT (MORTALITY IN TONS)		
	Commercial and recreational fishery (inland and coastal)	Mortality at technical constructions (turbines, pumping stations, etc.)	Predation by cormorants
Eider	23	12	28
Elbe	296	43	75
Ems	20	5	2
Maas	<1	<1	<1
Oder	23	<1	19
Rhein	64	129	12
Schlei/Trave	59	23	79
Warnow/Peene	112	<1	6
Weser	50	70	9
Total	647	283	231

13.2.3 Stocking requirement eels <20 cm

From the nine EMP's for the relevant German RBD's, the following stocking requirements could be extracted.

Table 13. Stocking requirements in Germany according to the Eel Management Plans.

RBD/EMU	GLASS EEL	ELVERS (FARMED, PRE-GROWN)	BOOTLACE EELS (WILD CATCHES)
Elbe	---	5 250 000 to 9 000 000	300 000
Eider	---	---	---
Ems	150 000	500 000	---
Maas	10 000	10 000	---
Oder	---	75 000	45 000
Rhein	750 000	1 100 000	---
Schlei/Trave *	3 000 000–3 750 000	---	---
Warnow/Peene	---	1 000 000	100 000
Weser	50 000	1 000 000	---
Total	3 960 000–4 710 000**	8 935 000–12 685 000	445 000

*** 1 t glass eel equivalents increasing to 1.25 t.**

**** In the future, and depending on availability and price of glass eels, alone in the RBD Weser, stocking of 6 mio glass eels is intended.**

Since there have no changes been made to the EMP's, the data are still valid. In the 2012 report to the Commission it is shown that in the first period, the planned stocking targets have not been achieved completely. However, especially for the ongrown eels, the target was nearly achieved (23.5 mio ind. (2008–2010) *vs.* planned 26.8 mio. ind.).

From the data in Table 13, a rough estimate of the required amount of glass eels could be made. Since bootlace eels are wild catches of small eels up to 30 cm, which are caught in the lower reaches of the rivers and transported to other rivers in Germany, they are not included.

For the calculation of glass eel numbers from elver numbers (pre-grown in farms) a mortality rate of 33% was assumed. This means that from three glass eels two elvers would be obtained, thus leading to a ratio of "1 elver = 1.5 glass eels". Hence, to achieve the required numbers of elvers, 13 402 500–19 027 500 glass eels would be needed. If the mortality rate in the farms is lower, the numbers would decrease accordingly.

Overall, the German stocking requirements sum up to at least 13 mio eels of different size, increasing to about 18 mio (4 mio glass eels + 9 mio elvers; increasing to 5 mio glass eels + 13 mio elvers). Expressed as glass eel equivalents and by using the ratio "1 elver = 1.5 glass eels", it would be 17 362 500 (3 9600 000 + 13 402 500) increasing to 23 737 500 (4 710 000 + 19 027 500) glass eel (equivalents).

This would be a biomass of 5.8 to 7.9 t glass eels.

If these targets can be achieved, largely depends on the availability and the price of glass eels.

13.2.4 Summary data on glass eel

There is only a very limited amount of information available. According to data of the German Federal Statistical Office (Statistisches Bundesamt) **5.4 tons** of glass eel were brought to German eel aquaculture companies in 2011.

13.2.5 Data quality issues

The quality of the available data is not easy to assess. There is no long history of eel stock assessment in Germany and hence the results are based on catch statistics, estimates and model calculations. The reliability of the catch statistics has not been evaluated so far. The model assumptions (in the EMP's and in the 2012 report to the European Commission (Fladung *et al*., 2012)) will have to be evaluated continuously in the future, but in the absence of better data, these assumptions were necessary to estimate the parameters required by the EU Regulation 1100/2007. The model used to calculate the different population parameters of eel in German waters has been further developed and has also been tested in the frame of the POSE project. Yet, the results will of course have to be compared to results obtained directly from the respective rivers, e. g. by mark–recapture studies. First data from tagging studies in the Havel/Elbe system seem to indicate that at least the order of magnitude is well met with the model (Erik Fladung, pers. comm.).

14 Sampling intensity and precision

A regular sampling is conducted in the frame of the Data Collection Framework (DCF). Information on the sampling design is provided in a special Annex to this report.

There are no data available from other studies.

15 Standardisation and harmonisation of methodology

15.1 Survey techniques

So far, there is no standardized survey technique for eel monitoring. However, at least for the coastal waters, a monitoring system has been developed, which could allow a standardized monitoring in these waters in the future and which potentially could be used in other Baltic countries as well. For details see Chapter 13.1.

15.2 Sampling commercial catches

Commercial catches are sampled in the frame of the DCF. Details are given in a special Annex to this report.

15.3 Sampling

15.4 Age analysis

15.5 Life stages

15.6 Sex determinations

16 Overview, conclusions and recommendations

In Germany, the relevant authorities and institutions have prepared their first report to the European Commission about the implementation of the EMP'S and the recent development of the eel stocks. This report formed another milestone in the development of eel management in Germany. For most of the measures planned in the EMP's the implementation has been started or already achieved. However, some targets could not be achieved completely and some of the measures are in some delay, which can be partly explained by the late approval of the German EMP's by the European Commission. The structures of new documentation rules have been developed and established (statistics for effort, separate catch statistics for yellow and silver eels and so on). The Regulation 1100/2007 requires a much more detailed documentation of the eel fishery from fishermen and Member States. However, the capacities of the fisheries authorities are limited and it appears still not clear, if and how the big amount of data that could be expected, will be analysed and used in the future.

In the course of the preparation of the 2012 report to the Commission, the modelling tools were further developed and improved (Oeberst and Fladung, 2012) and it can be expected that a better and more detailed assessment of the stock and of the effects of the management measures will be possible in the future. These efforts will be supported by the new data, which become available continuously through the sampling of eel under the DCF.

In Germany, in the last years, several projects and studies have been conducted, which improved the availability of data on important population parameters (and will continue to do so in future). The results of the biological sampling in the frame of the DCF will also help to improve the population model used for the calculation of escapement.

The eel is still an important species for the German fisheries sector, especially for inland and coastal fishery, even though the importance of this sector itself is rather small. After a clear decrease during the last decades, due to considerable efforts spent on restocking, the eel catches now appear to be on a low but rather stable level. The population model used in the 2012 report to the European Commission predicts that, if all measures planned in the EMP's will be implemented, including considerable restocking, the eel stocks in German waters will increase again in the coming years.

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Annex: German National Data Collection of European eel (*Anguilla anguilla*) 2010–2011

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Introduction

Following the „pilot" project in 2009/2010 (EIFAC/ICES WGEEL Report 2010), sampling of the European eel (*Anguilla anguilla*) in German River Basin Districts (RBD) is continued as part of the DCF. Data will be collected and reports will be provided on an annual basis ((EC) No 199/2008), starting in 2011.

Materials and methods

Sampling in 2011 started in April and ended in December 2011. Sampling locations are given in Figure 1, sample sizes, fishing gear and time of sampling are summarized in Table 1.

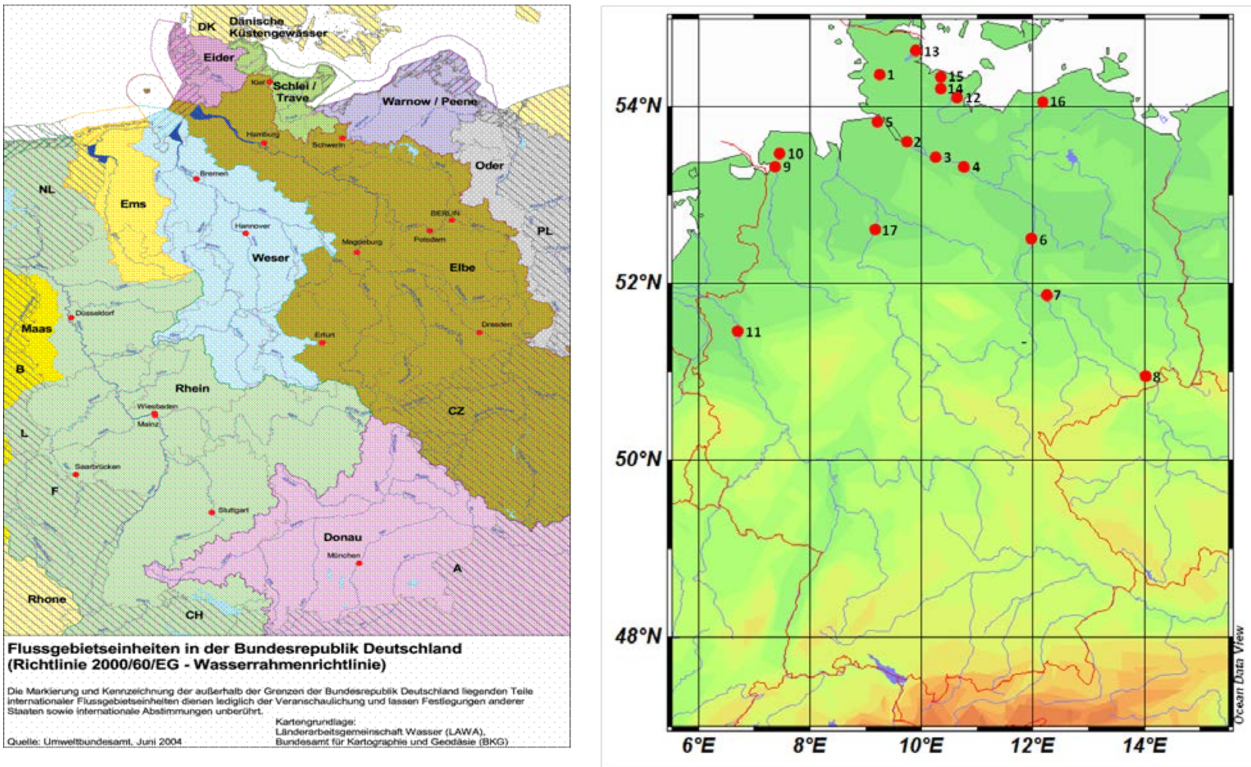

Figure 1. (left) German River Basin Districts; (right): Numbers indicate sampling locations within the RBD's. 1: Eider, 2–8: Elbe, 9–10: Ems, 11: Rhine, 12–15: Schlei/Trave, 16: Warnow /Peene, 17: Weser.

Table 1. Numbers of sampled eels, fishing gear and time of sampling according to German RBD'S (as of 06.09.2011). Eel life stages are indicated by S (Silver) and Y (Yellow). Characteristics of eel samples according to each location in RBD's in 2011.

No	RBD	Time of sampling	Sample Size/Stage* (n)			Fishing Gear
			S	Y	Total	
1	Eider	August 2011	19	34	53	fykenet
	Eider	October 2011	80	2	82	fykenet
2	Elbe	June 2011	1	25	26	fykenet
	Elbe	July 2011	4	25	29	fykenet
3	Elbe	June 2011		35	35	fykenet
		October 2011	21	4	25	stownet
4	Elbe	June 2011	1	23	24	stownet
5	Elbe	July 2011	17	31	48	fyke et
6	Elbe	July 2011	17	22	39	fykenet/stownet
7	Elbe	August 2011		7	7	electrofishing
8	Elbe	August 2011	1	2	3	electrofishing
9	Ems	April 2011		49	49	fykenet
		October 2011	65	2	67	fykenet
10	Ems	April 2011	1	48	49	fykenet
11	Rhine	October 2011	131	2	133	stownet
		Oct/Nov 2011	50	2	52	stownet
12	Schlei/Trave	July 2011	4	17	21	fykenet
		September 2011	7	16	23	fykenet
13	Schlei/Trave	August 2011	15		15	fykenet
14	Schlei/Trave	August 2011	24	13	37	fykenet
		November 2011	1		1	fykenet
		December 2011	2	4	6	fykenet
15	Schlei/Trave	December 2011	8	9	17	fykenet
16	Warnow/Peene	November 2011	50	2	52	stownet
		December 2011	20		20	stownet
17	Weser	September 2011	86	2	88	stownet

***:S=Silver Eel; Y=Yellow Eel.**

Methods and analyzed parameters are similar to those described in the "EIFAC/ICES WGEEL Report 2010" (Annex to last year's Country Report) with few exceptions:

a) River Elbe was sampled at eight locations all along the German part of the river from the Czech border to the estuary;

b) Eels were staged into yellow eels (stage 1–3) and silver eels (stage 4–6) according to Durif *et al*., 2005.

Since at this point no or little data is available on infestation with *Anguillicoloides crassus* (e.g. Hartmann, 1994) they are not included in the results.

Results

A total of 1001 eels were sampled from seven different RBD's. Mean length in the RBD'S was 53,53 cm (SD: 12,3 cm) for Eider, 56,88 cm (SD: 11,7 cm) for Elbe, 51,87 cm (SD: 11,4 cm) for Ems, 74,98 cm (SD: 9,4 cm) for Rhine, 65,24 cm (SD: 10,0 cm) for

Schlei/Trave, 50,69 cm (SD: 11,2 cm) for Warnow/Peene and 75,49 cm (SD: 7,7 cm) for the RBD Weser.

Length distributions fort the different RBD's (pooled Y&S, male&female) are given in Figures 2a–g. Note that length distributions are biased by e.g. the selectivity of the respective fishing gear or differences in minimum size limits between locations. Especially in the rivers Elbe and Eider, a relatively high proportion of eels <40 cm were caught since the respective fishermen were allowed to catch fish below the minimum size limit, e.g. for restocking purposes.

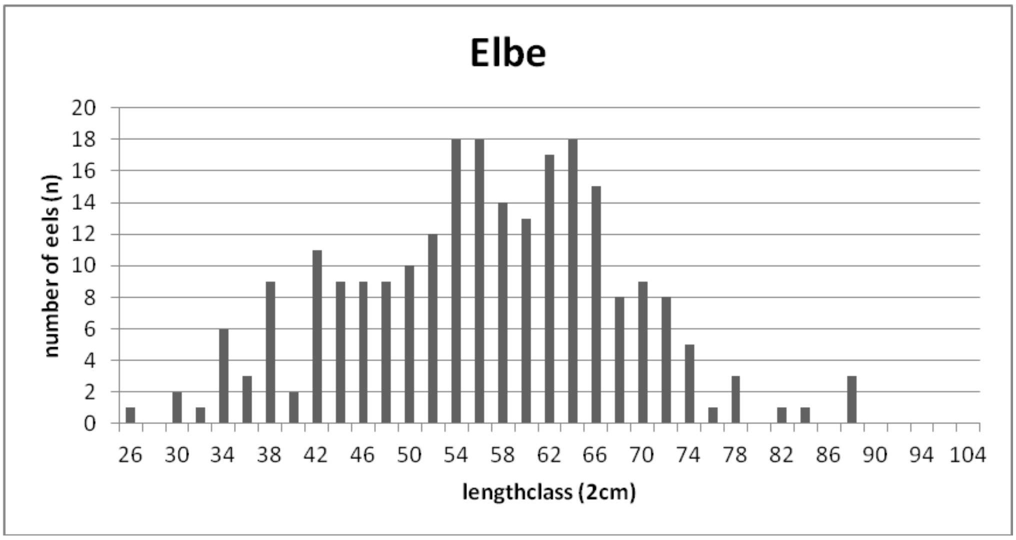

Figure 2a. Length distribution of eel samples from the RBD Elbe (n=236).

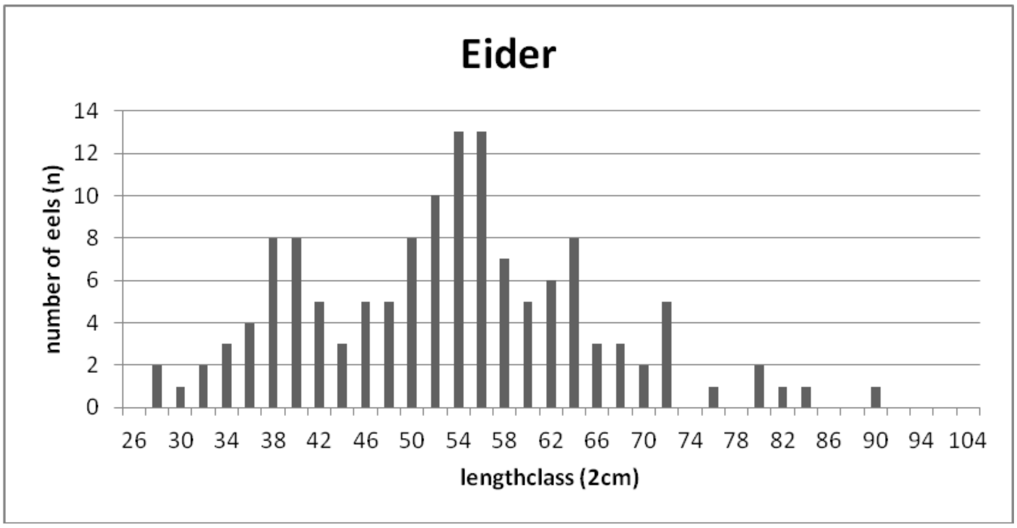

Figure 2b. Length distribution of eel samples from the RBD Eider (n=135).

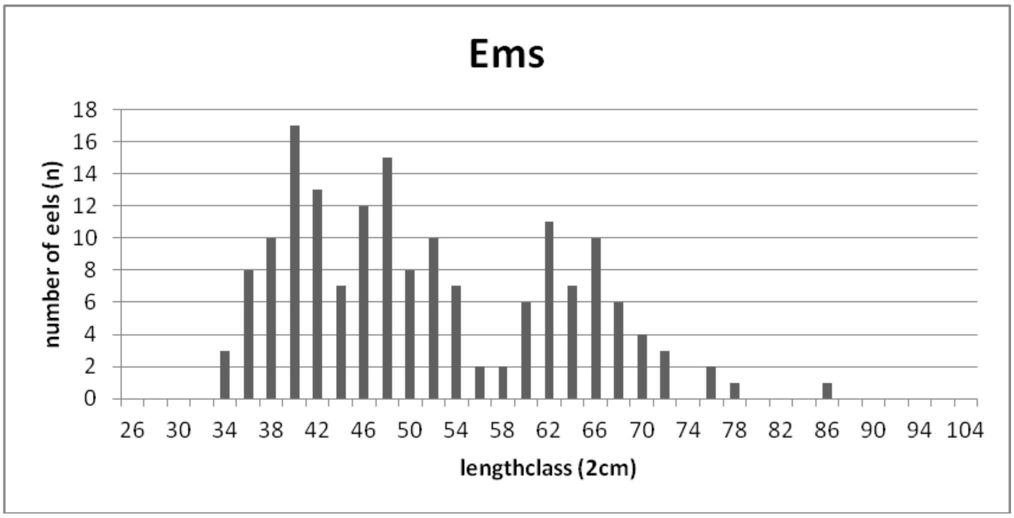

Figure 2c. Length distribution of eel samples from the RBD Ems (n=165).

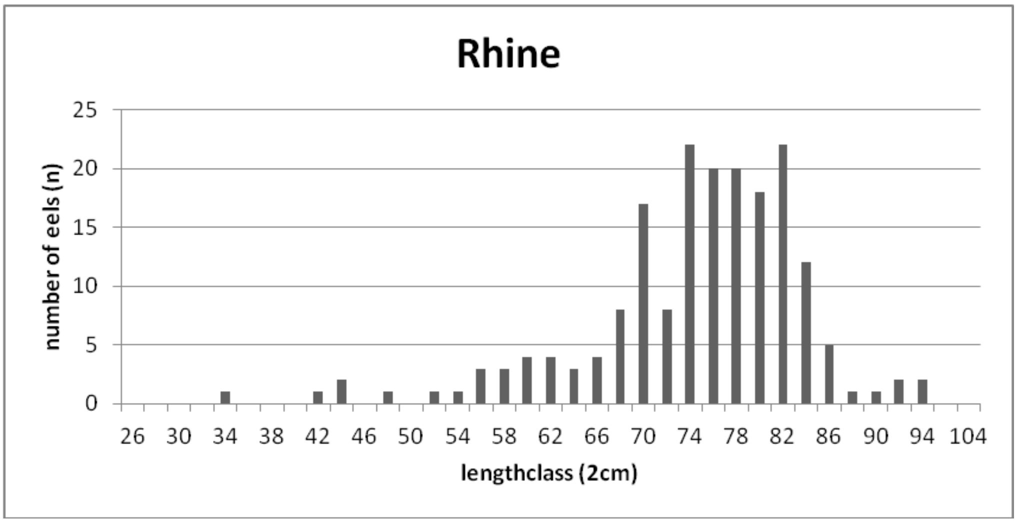

Figure 2d. Length distribution of eel samples from the RBD Rhine (n=186).

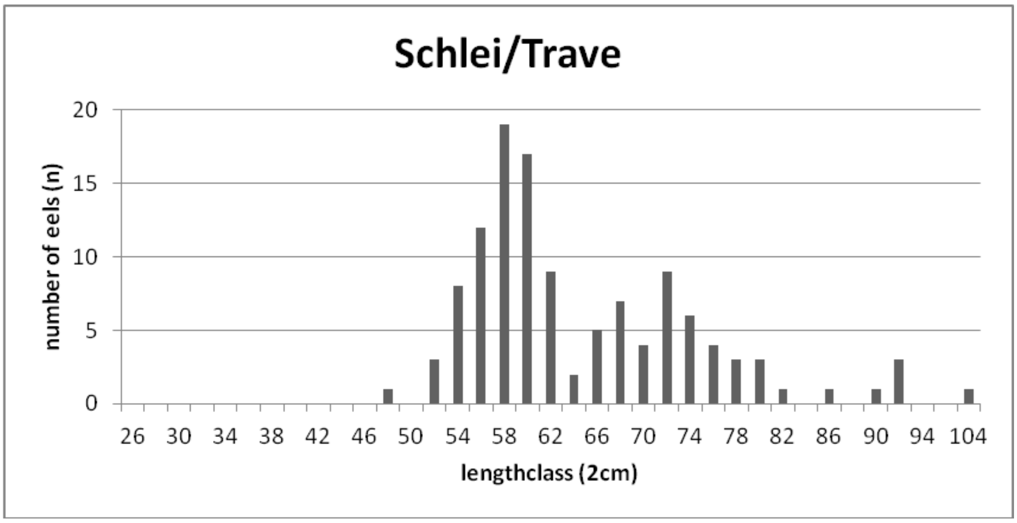

Figure 2e. Length distribution of eel samples from the RBD Schlei/Trave (n=119).

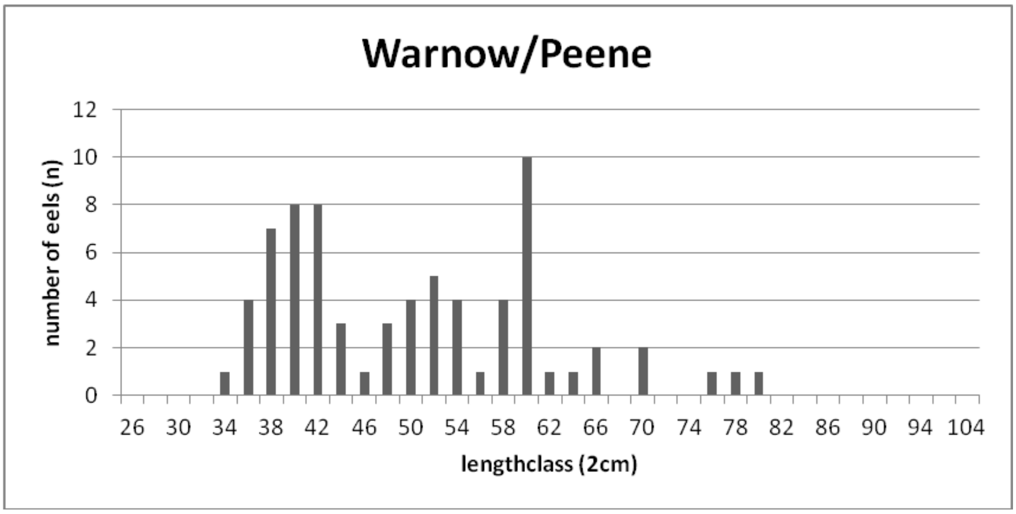

Figure 2f. Length distribution of eel samples from the RBD Warnow/Peene (n=72).

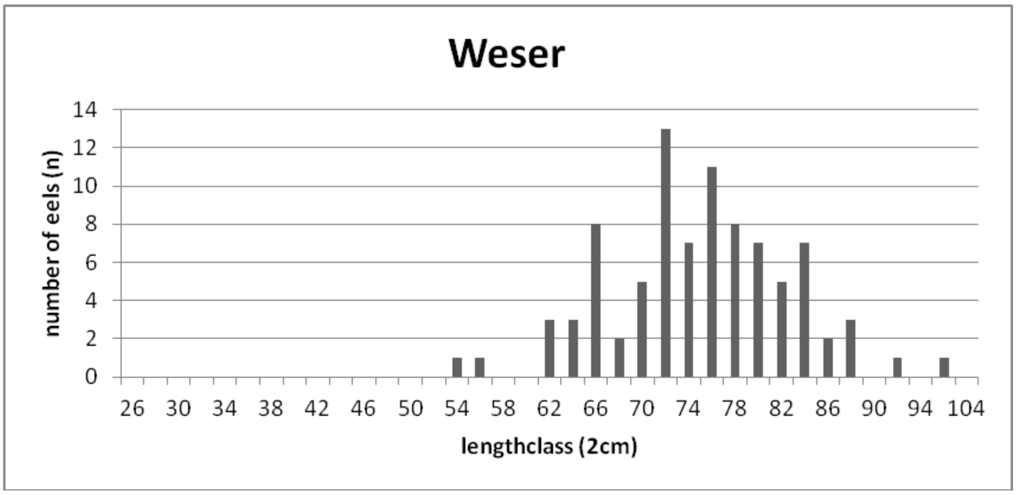

Figure 2g. Length distribution of eel samples from the RBD Weser (n=88).

Figures 3a–g summarise the length–weight relationship in the different RBD's.

All available samples within one RBD were pooled. Female and male eels were discriminated by colour (red (female) and black (male). The relationship was well described by a power function ($L = aW^b$) for all RBD's and ranged from near isometric (Warnow/Peene: b=2.92) to positive allometric growth (Ems: b=3.48).

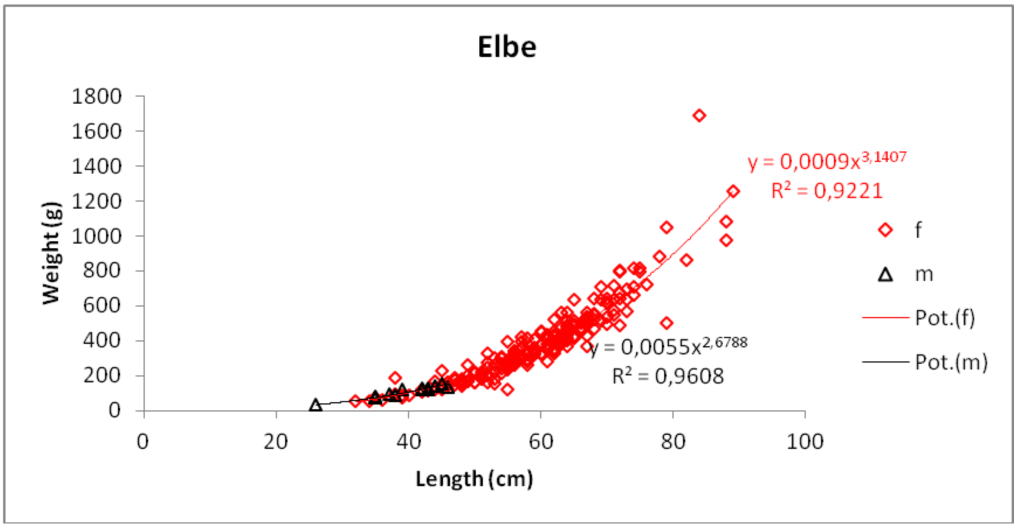

Figure 3a. Length–weight relationship of eel samples from the RBD Elbe (n=236).

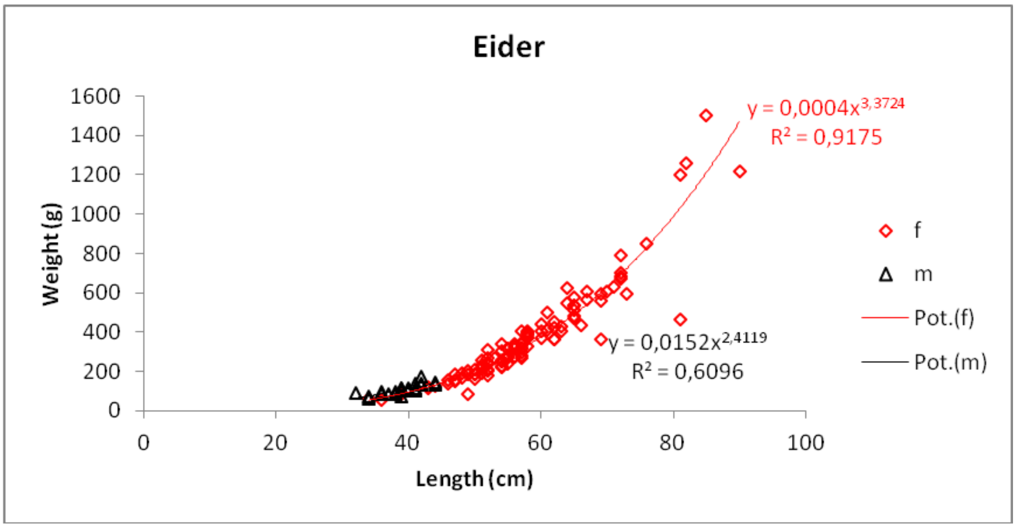

Figure 3b. Length–weight relationship of eel samples from the RBD Eider (n=135).

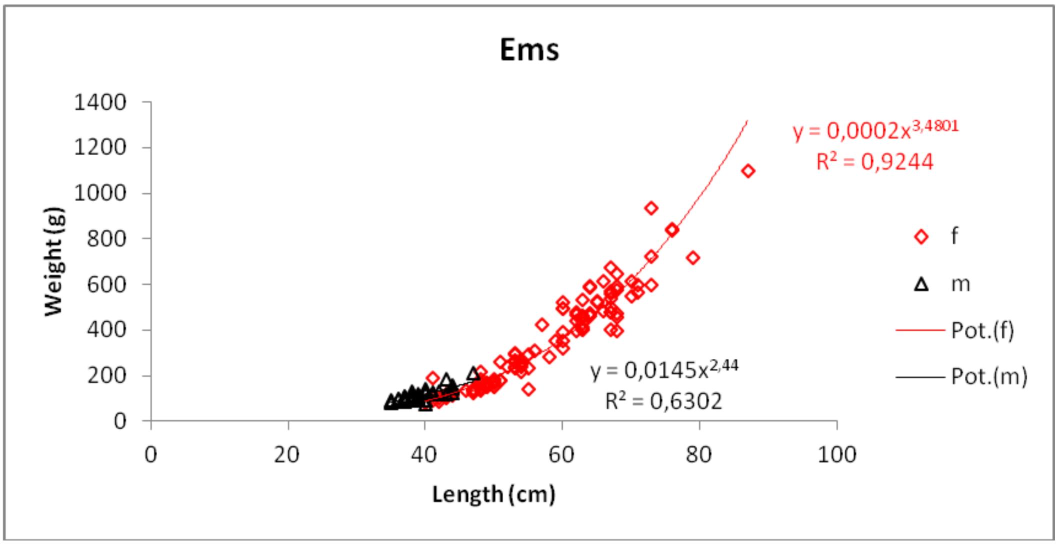

Figure 3c. Length–weight relationship of eel samples from the RBD Ems (n=165).

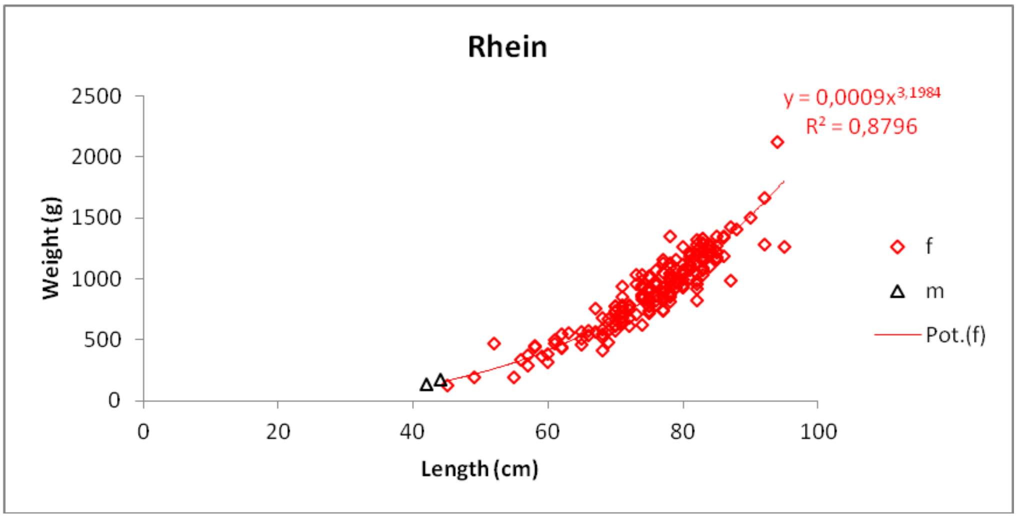

Figure 3d. Length–weight relationship of eel samples from the RBD Rhine (n=186).

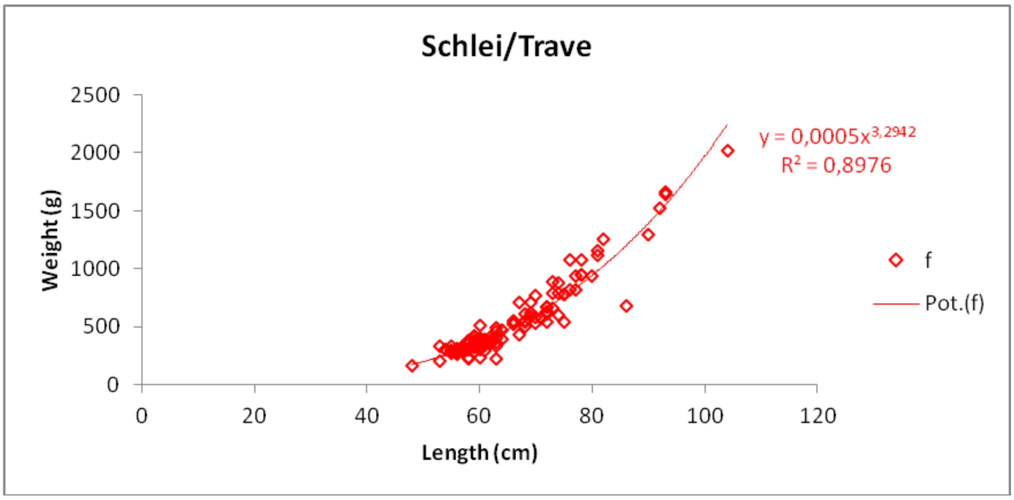

Figure 3e. Length–weight relationship of eel samples from the RBD Schlei/Trave (n=119).

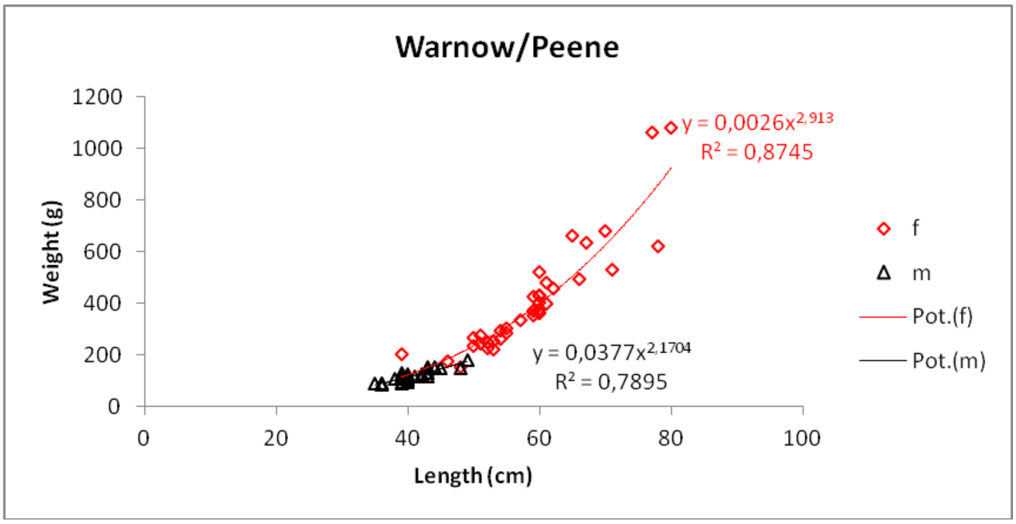

Figure 3f. Length–weight relationship of eel samples from the RBD Warnow/Peene (n=72).

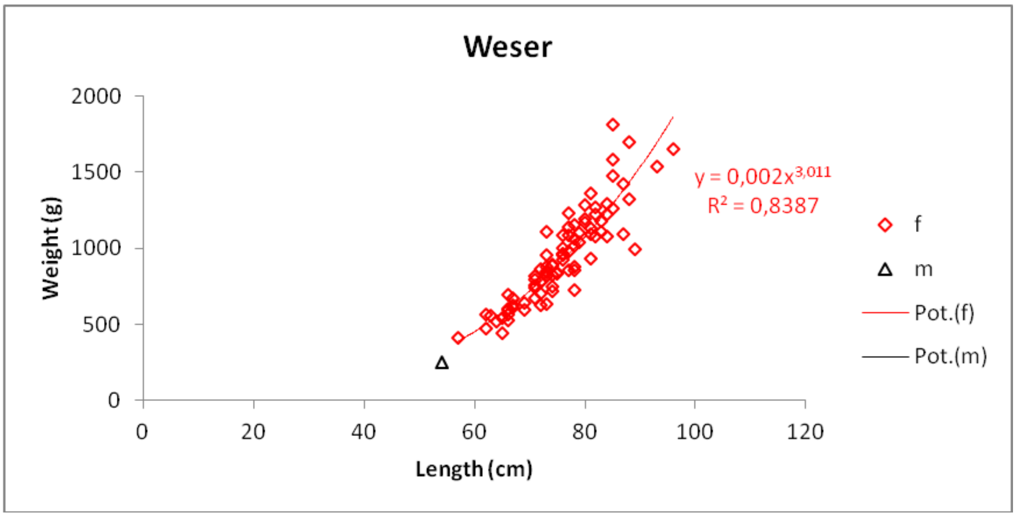

Figure 3g. Length–weight relationship of eel samples from the RBD Weser (n=88).

Figures 4a–g summarize the age–length relationship in the different RBD's.

Different silvering stages (1–6) are displayed by respective coloured symbols. Yellow eels of stages 1–3 are illustrated by diamonds, silver eels 4–5 by circles and male silver eels by triangles. The trendline and its respective coefficient of determination represent the age–length relationship of all (pooled) samples.

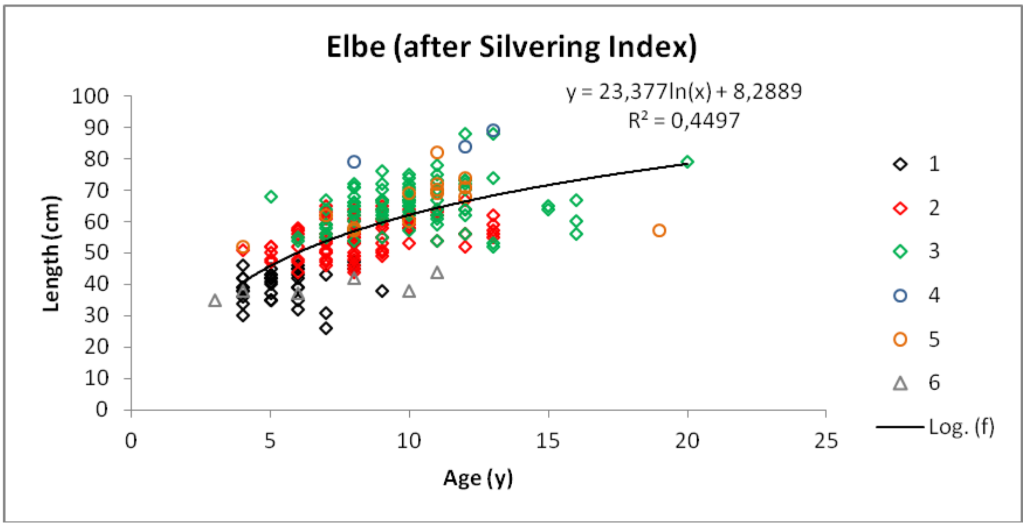

Figure 4a. Length–age relationship of eel samples from the RBD Elbe (n=236).

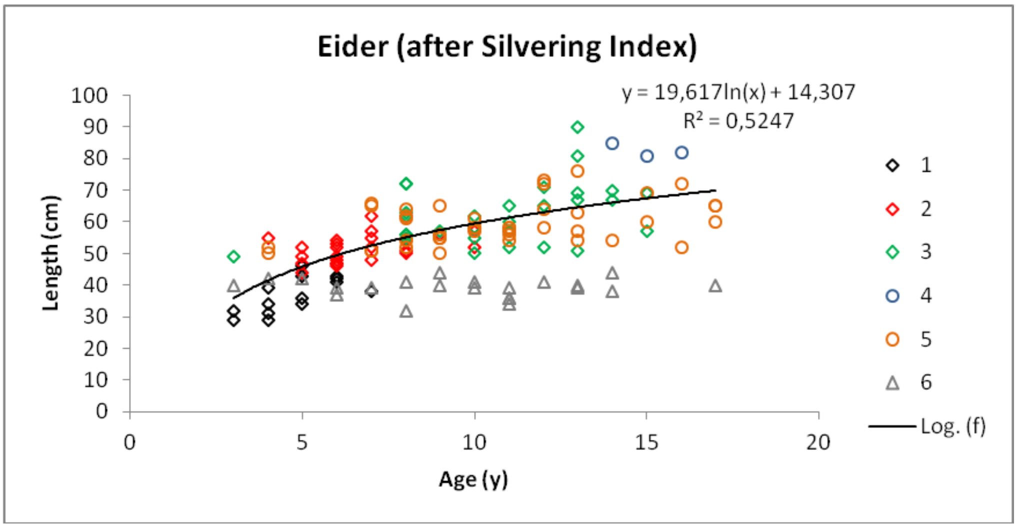

Figure 4b. Length–age relationship of eel samples from the RBD Eider (n=135).

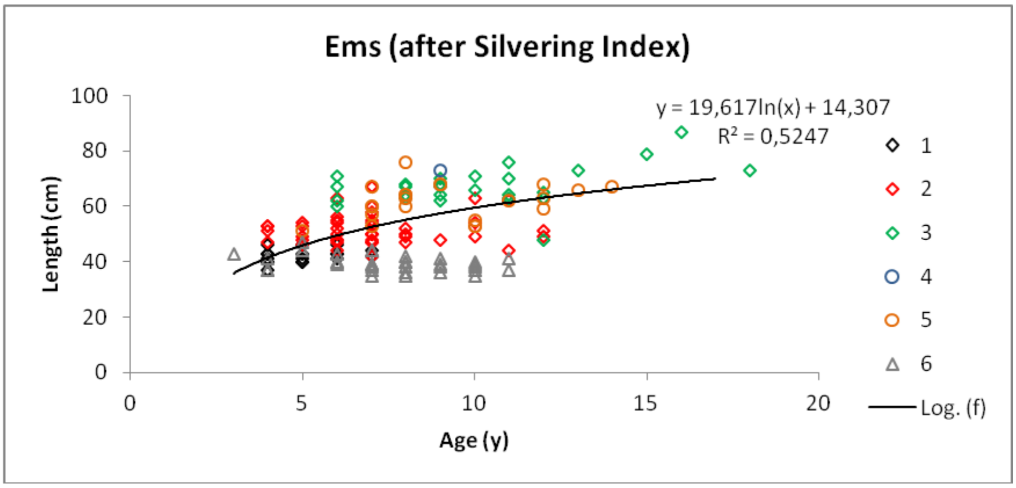

Figure 4c. Length–age relationship of eel samples from the RBD Ems (n=165).

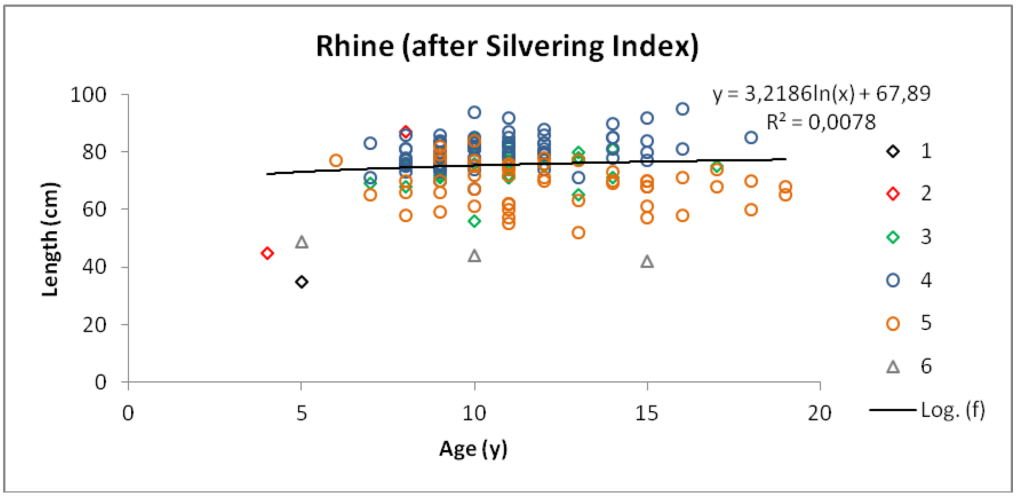

Figure 4d. Length–age relationship of eel samples from the RBD Rhine (n=186).

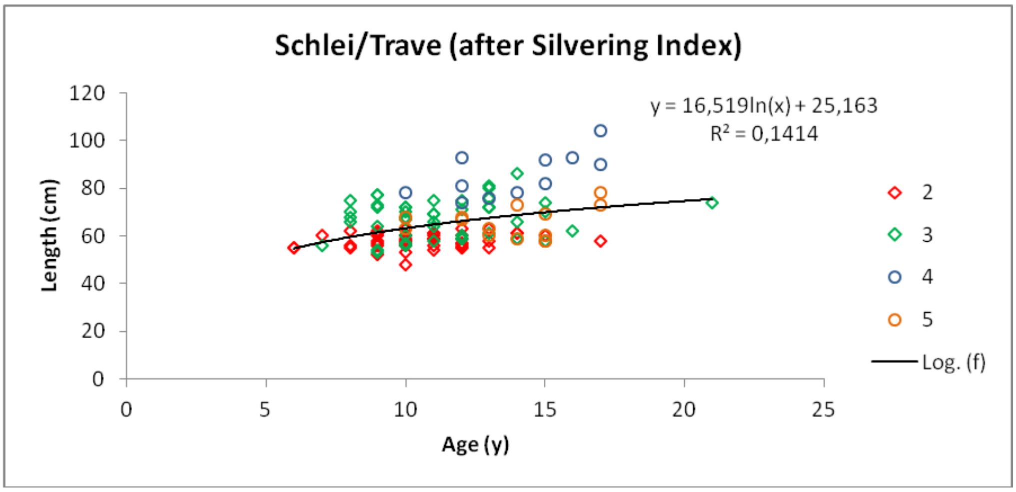

Figure 4e. Length–age relationship of eel samples from the RBD Schlei/Trave (n=119).

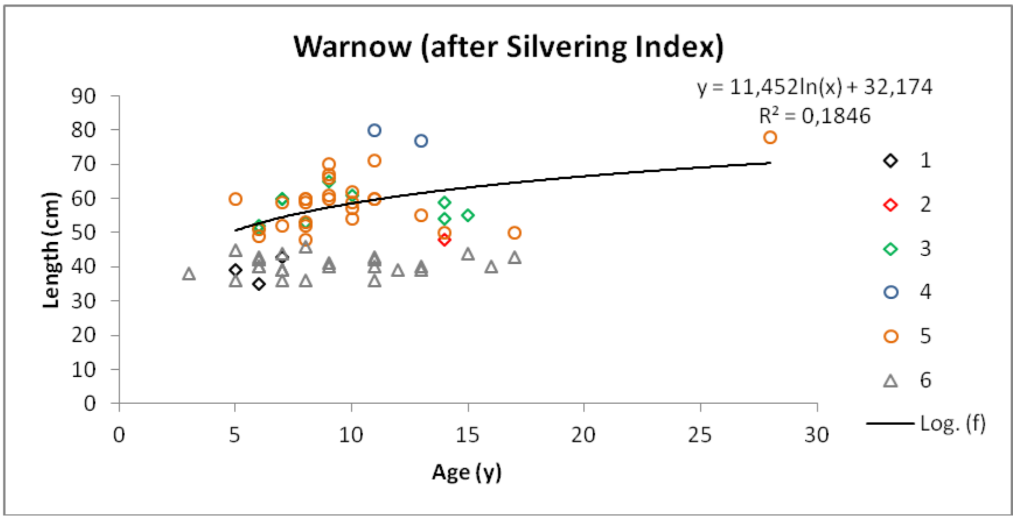

Figure 4f. Length–age relationship of eel samples from the RBD Warnow/Peene (n=72).

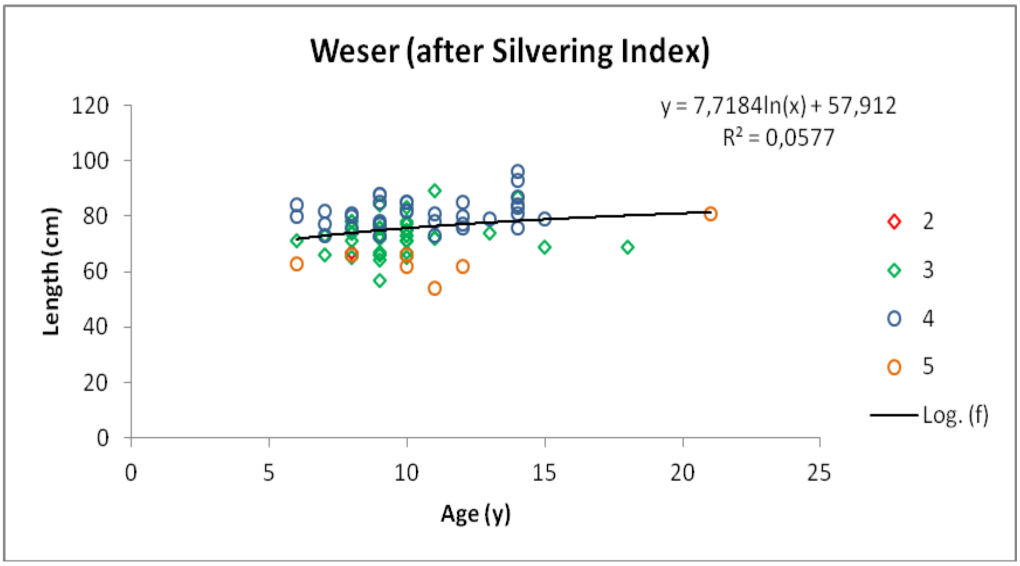

Figure 4g. Length–age relationship of eel samples from the RBD Weser (n=88).

Discussion

It is striking that the exponent in the length–weight relationship shows considerable variation between the different RBD's. This however might very well be a result of the different sample sizes and size ranges covered at the different locations. Especially in the Rhine and Schlei/Trave system no eels below 45 cm were sampled, while at the same time some of the largest specimens were caught. Generally, eel sampling in the RBD's suffers from a methodical weakness which imposes considerable restrictions on their informative value. Especially due to the migratory behaviour and restocking programs it is difficult to link eels to their sampling location. These problems are further enhanced by the above mentioned sources of error like e.g. different selectivity of sampling gears between locations.

However, if these problems are appropriately accounted for when interpreting the data, long-term sampling of eels in freshwaters can significantly contribute to improvements in European eel management.

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Report on the eel stock and fishery in Ireland 2011/'12

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Reporting Period: This report was completed on 1st September 2012, and contains data up to 2011 and some provisional data for 2012.

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The data presented in this report has been drawn from various sources including the Irish Standing Scientific Committee on Eel Report to IFI/DCENR 2012, the annual IFI Eel Monitoring Programme Annual Reports (O'Leary *et al*., 2009–2011), annual reports to the ESB and the SSCE by NUIG on Silver Eel Research and trap and transport monitoring (McCarthy *et al*., 2009–2011), Marine Institute annual stock assessments for the Burrishoole (2009–2011) and the annual Country Report to the joint EIFAAC/ICES Working Group on Eel. More complete presentation and analysis of these data are available from the sources of these reports.

2 Introduction

This report continues the sequence of reporting annual national eel data to the ICES/EIFAAC Eel Working Group. In line with the requirements of the EU Eel Recovery Plan (Action Plan; COM 2003, 573: Regulation; COM (2005) 472) and the EU Data Collection Regulation for fisheries (Council Regulation 1543/2000 and Commission Regulations 1639/2001, 1581/2004) the National Eel Reports were restructured under the standard headings of the DCR. The EU requires under the Regulation (COM (2005) 472) that Eel Management Plans be established and implemented.

2.1 The Irish National Programme

The Irish National Programme is conducted in close co-operation between the following organisations, although the details in relation eel and inland fisheries have yet to be established.

Department of Communications Energy and Natural Resources (DCENR)

DCENR is the main governmental department with responsibility for inland fisheries policy, management, control and enforcement.

Department of Environment, Heritage and Local Government (DEHLG)

DEHLG is the main governmental department with responsibility for core functional areas of environment, water and natural heritage, built heritage and planning, housing, local government and meteorological services and implementation of the Habitats and Waterframework Directives. DEHLG is responsible for CITES.

The Marine Institute (MI)

The MI is a semi-state marine research organisation with national responsibility for the provision of scientific advice on eel and the collection of scientific data on the fisheries sector and the implementation of the module on evaluation of inputs, fishing capacities and fishing effort and the module of evaluation of catches and landings as defined in the Application regulation of EU Council Regulation 1543/2000.

Inland Fisheries Ireland

Inland Fisheries Ireland (IFI) was formed in 2010 following the amalgamation of the Central Fisheries Board and the seven former Regional Fisheries Boards into a single agency. Inland Fisheries Ireland is responsible for the protection, management and conservation of the inland fisheries resource across the country, including implementation and monitoring of the Irish eel Management Plans. Ireland has over 70 000 kilometres of rivers and streams and 144 000 hectares of lakes all of which fall under the jurisdiction of IFI. The agency is also responsible for sea angling in Ireland.

Electricity Supply Board (ESB)

ESB has a statutory role in preserving and developing the Shannon fishery, since the establishment of a hydroelectric scheme on the river when the government handed over all fishing rights to the company in 1935. The ESB is responsible for implementing the silver eel trap and transport schemes on the Shannon, Erne and Lee.

The Loughs Agency

The Loughs Agency aims to provide sustainable social, economic and environmental benefits through the effective conservation, protection, management, promotion and development of the fisheries and marine resources of the Foyle and Carlingford Areas.

Standing Scientific Committee on Eel

The Standing Scientific Committee on Eel (SSCE) was established under Section 7.5 (a) of the 2010 Inland Fisheries Act. The purpose of the committee is to provide independent scientific advice to guide IFI in making the management and policy decisions required to ensure the conservation and sustainable exploitation of the Ireland's eel stocks. The SSCE is comprised of representatives from the relevant State Agencies, and its ToR is to define and oversee a programme of monitoring, stock assessment and post-evaluation of management measures and to provide advice on eel.

2.2 Eel Management Plans–Ireland

Eel management plans were submitted to the EU in early January 2009 and these were accepted by the EU in early July 2009. The following is the Executive Summary from the National Report (Irish EMPs) to the EU.

2.2.1 Introduction

The latest scientific advice from the International Council for the Exploration of the Sea (ICES) concerning European eel is that the stock is outside safe biological limits and that current fisheries are not sustainable. ICES have recommended that a recovery plan be developed for the whole stock of European eel as a matter of urgency and that exploitation and other human activities affecting the stock be reduced to as close to zero as possible. Ireland established a National Working Group on eel management in 2006, in advance of the agreement of the Regulation (EC) No. 1100/2007, in order to begin the preparatory work required and Irish scientists participated in Working Groups and EU projects (i.e. EU SLIME) in developing methodologies and data collection and modelling for eel stock assessment.

2.2.2 Organisation of the Eel Management Units

The Eel Management Plans were established and implemented for River Basin Districts as defined in Directive 2000/60/EC and in accordance with Article 2 of the Eel Regulation. Ireland submitted a National Report encompassing five River Basin EMPs and one transboundary EMP. These are the Eastern EMP, South Eastern RBD EMP, South Western RBD EMP, Shannon IRBD EMP, Western RBD EMP and the transboundary North Western RBD EMP (Figure 2.1). Figure 2.1 also shows the transboundary agreement for the Eastern RBD and Neagh Bann RBDs.

Inland and estuarine eel fisheries in Ireland were managed by seven Regional Fisheries Boards, divided into Fisheries Districts, and the Loughs Agency. Fisheries District boundaries largely conformed to the arrangement of river catchments. Fisheries management is now undertaken by Inland Fisheries Ireland using the WFD boundaries.

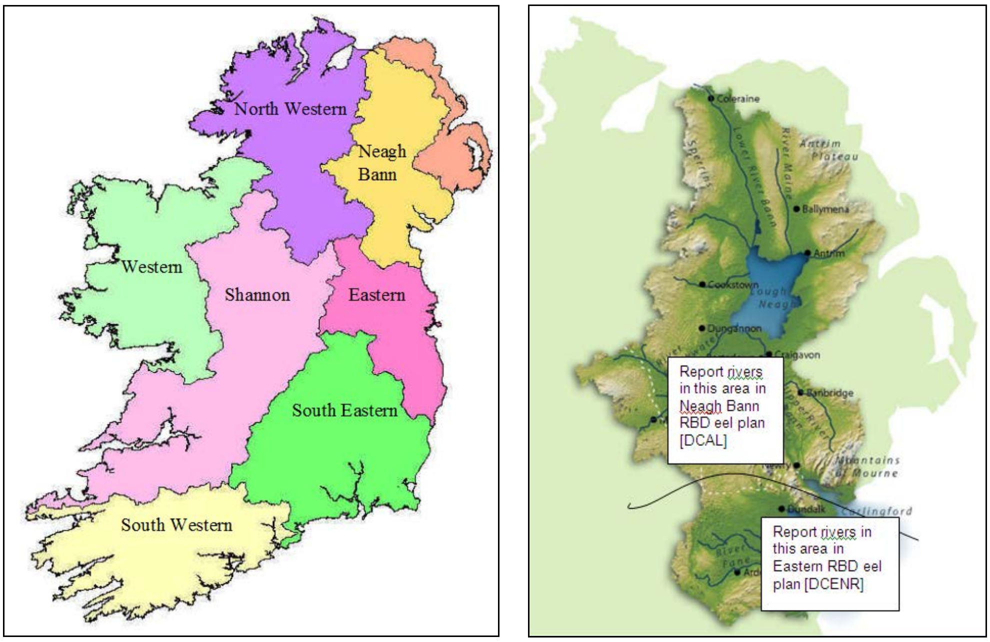

Figure 2-1. Map (left) showing the River basin Districts and the map (right) showing the transboundary agreement between the Neagh/Bann RBD and the Eastern RBD.

2.2.3 Description of the Eel Management Units

Current management of migratory species in Ireland, salmon and sea trout, has been at the catchment level and it is therefore logical to expand this to encompass the management of eel. A G1S based data model was established for the quantification of the freshwater salmon habitat asset and for the determination of the quantity of habitat available to migratory salmonids. 261 discrete migratory salmonid 'Fishery Systems' were identified. Four Northern Ireland catchments have now been included in this quantification in support of the NWIRBD transboundary management plan. It is likely that eels are present in the majority or all of these systems. Commercial fishing probably only takes place in 4.6% of the catchments, although this accounts for some 71% of the total wetted area.

The estimated total wetted area of the 265 lake, river and stream habitat accessible to migratory fish (including 1st order streams) in Ireland (including the Northern Ireland part of the Erne and the Loughs Agency Rivers in the Foyle and Carlingford areas) is 153 881ha. The 265 "migratory" systems were estimated to contain 132 275 ha of lake habitat and 21 606 ha of fluvial habitat, of which 2826 ha is estimated to be 1st order stream. The ShIRBD, WRBD and NWIRBD are dominated by lacustrine habitat.

The catchments have been characterised on the basis of their underlying geology, specifically in terms of the proportion of the surface area comprising calcareous and non-calcareous types. This catchment characterisation led to a continuous summary variable for catchment freshwaters, i.e. the proportion of wetted area comprising non-calcareous geology. Lacustrine habitat dominates Ireland's freshwaters, comprising more than 85% of the wetted area. Similarly, calcareous habitat heavily dominates overall.

Water quality in Ireland is generally good and compares favourably with other Member States. The main challenge for water quality is to deal with eutrophication arising from excess inputs of nutrients from all sources. The extent of eutrophication has been increasing persistently since the 1970s and is probably the most serious environmental pollution problem in Ireland. Poor water quality impacts on the potential of rivers to produce salmon. It is unknown whether similar poor water quality levels have an effect on eel. Nationally (RoI), the current water quality in 82.7% of the habitat available for salmon production is unpolluted, a further 12.8% is considered slightly polluted and the remaining 4.5% is considered to be moderately or seriously polluted. In general, persistent organic pollutants were relatively low in the Irish eels sampled to date.

Preliminary analysis of information available on the presence of *Anguillicola* in different catchments would indicate that approximately 50% of the wetted area is now potentially infected by the parasite and that it continues to spread.

Six catchments in Ireland have major hydropower installations in the lower catchments. 46% of the available wetted habitat is upstream of major barriers, although there is a greater proportion (53%) of the potential silver eel production when the differences in relative productivity are taken into account. An average mortality of 28.5% per turbine installation (ICES 2003) was used in assessing the impact of hydropower. It is intended that immediate measures will be put in place to mitigate against turbine mortality, including trap and transport on the Erne, Shannon and Lee. These are outlined in the management actions section. It is also recommended that all new hydropower turbines and potential barriers to upstream migration should be evaluated in Environmental Impact Assessments for potential impacts on eel.

Natural mortality of eels is a major, but relatively unknown, factor in the population dynamics of eels and mortality caused by predation is one of the factors contributing to natural mortality. There are few data on the level of predation on eel in Ireland or on the impact on the eel stock. The most recent census of cormorants in Ireland (Seabird 2000 breeding survey) reports that the Irish coastal population has remained stable since the previous census (1985–1988). Other legislation must be complied with when considering possible actions against predators.

2.2.4 The eel fishery

Glass eel and elver fishing in Ireland is prohibited by law (1959 Fisheries Act). The commercial eel fishery involved harvesting both yellow and silver eel in freshwater and in estuarine or tidal waters. Yellow eel were fished using a variety of techniques, the most common of which are baited longline, fykenets and baited pots. When silver eel were migrating downstream are caught in fykenets and stocking-shaped nets called "coghill nets" which are attached to fixed structures in the river flow, often at "eel weirs". The declared commercial eel catch in the Irish Republic, 2001–2007, ranged from 86 t to 120 t involving about 150–200 part-time fishermen, but inadequate reporting and illegal fishing makes this difficult to quantify accurately and it maybe a substantial underestimate. A total maximum of 278 licences were issued in 2006 and a maximum of 182 of these were actively fished in 2005. The value of the reported catch was therefore in the order of €0.5 million to €0.75 million.

In May 2008, a byelaw was introduced (Conservation of Eel Fishing (Annual Close Season) Bye-law No. C.S. 297, 2008) restricting the fishing season for both yellow and silver eel. Analysis of the impact of implementing a Yellow eel fishing season from 1st June to 31st August and a Silver eel season from the 1st of October to 31st December showed the impact of the reduced fishing season would have been different in each Region with the level of reduction ranging from 7 to 42% in yellow eel catch and 0–40% in silver eel catch.

Recreational eel fishing is only carried out by a minority of rod anglers and there is no legal, or voluntary, declaration of catch which is probably relatively small. There is no legislation protecting eels from angling. All other fishing engines, including, fykenet and baited pots, are authorized under the commercial legislation.

There is no eel culture in Ireland at the present time and none is envisaged in the near future.

NOTE: the commercial eel fishery was closed in Ireland in 2009 and possession of eel caught in the State was deemed illegal. Eel captured in the recreational fishery should be released.

2.2.5 Escapement-local stock modelling

The Irish Management Plans will include a time period for detailed data collection and a parallel program of stock assessment, including silver eel escapement estimates, and model development. In the interim, the three options proposed in the Eel Regulation were used to make preliminary estimates of pristine production and current escapement. The approach outlined in Article 2 of the Eel Regulation (EC No. 1100/2007) was followed to calculate pristine and current escapement and a simple model was proposed to project the impact of management actions on escapement from freshwaters.

No estimates of truly pristine escapement exist for Irish eel freshwater catchments. Recruitment of juvenile eel to Irish catchments (2003–2007) has declined to between 4% (Shannon) and 23% (Erne) of historical values (1979–1984) and has been particularly poor in 2008. Historical production of silver eels was calculated (for freshwaters only) using catch-series for four catchments (where the fishery efficiency was estimated) for periods prior to 1980. These data were calibrated using eel growth rates for 17 catchments and a regression model was developed relating production to catchment geology, a proxy for productivity. This gave historic production rates of 0.9 kg/ha (Burrishoole-unproductive) to 5.5 kg/ha (Moy-productive) and total historic silver eel potential production (without anthropogenic mortality) of 586 t per annum.

Current (2008) silver eel production from freshwaters was estimated using a similar approach with rates of 1.3 kg/ha (Burrishoole-unproductive) to 2.7 kg/ha (Ennell-productive) and total current silver eel escapement of 143 t. Current (2008) Irish escapement expressed as a percent of historic production (EU target = 40%) range from 10% in the ShIRBD to 68% in the SWRBD. The national percent escapement is 24.3%.

Current (2009–2011 average) silver eel production from freshwaters was estimated using a similar approach with rates of 1.0 kg/ha (Burrishoole) to 1.64 kg/ha (Shannon) and total current silver eel escapement of 216 t. Current (2009–2011 average) Irish escapement expressed as a percent of historic production (EU target = 40%) range from 34.2% in the ShIRBD to 46% in the EEMU and SWRBD. The national percent escapement is 36.9%.

Due to the last 18+ years of low and declining recruitment, regardless of which management actions are taken, achieving the 40% EU target in the long term will require a recovery of recruitment arising from concerted international action and cannot be achieved in Ireland alone. It was difficult to assess a timeframe for recovering the predicted downward trend in escapement in the absence of knowing what the European recruitment levels will be in the future and in the absence of a clear timeframe from the EU. To facilitate setting a timescale to recovery it was decided to adopt the approach used by Astrom and Dekker (2007) in predicting the recovery time for recruitment under different reduced levels of mortality. Two assumptions were made: the first that Europe responds in a similar fashion to reducing mortality and the second, that as recruitment recovers towards historical, the Spawning–Stock Biomass is recovering towards the target. Therefore, recruitment recovery is used as an alternative target towards the escapement target. It is also possible that the EU biomass escapement target may be reached in a shorter timescale than full historical recruitment.

2.2.6 Stocking

Purchase of glass eel for stocking from outside the state does not currently take place. Assisted migration of upstream migrating pigmented elvers takes place in the Shannon (Ardnacrusha) and Erne (Cathaleen's Fall) and of pigmented young eel (bootlace) on the Shannon (Parteen Regulating Weir). Prior to 2009, small amounts of glass eel and elver were taken in the Shannon estuary and in neighbouring catchments and these were stocked into the Shannon above Ardnacrusha and Parteen HPSs. Given the widespread presence of *Anguillicoloides* and the move towards risk averse management strategies at low recruitment levels, this practice was **discontinued**.

2.2.7 Monitoring and post-evaluation

The national plan describes a comprehensive programme of monitoring and evaluation of management actions and their implementation, and also a programme of eel stock assessment to establish a stock baseline, estimate silver eel escapement and monitor the impact of the management actions on the local stocks.

Ireland is committed to compliance with the Data Collection Regulation. Given the cessation of the fishery there was no obligation to undertake sampling under the DCR in 2009–2011.

Ireland has submitted the 2012 Report to the EU and an annexed science report on the status of the eel stock in Ireland.

2.2.8 Management actions

There are four main management actions aimed at reducing eel mortality and increasing silver eel escapement in Irish waters. These are a cessation of the commercial eel fishery and closure of the market, mitigation of the impact of hydropower, including a comprehensive silver eel trap and transport plan, ensure upstream migration of juvenile eel at barriers and improve water quality including fish health and biosecurity issues.

2.2.9 Summary

In 2008, Irish silver eel escapement from freshwaters expressed as a percent of historic production (EU target = 40%) ranged from 10% in the ShIRBD to 68% in the SWRBD. The national percent escapement is 24%.

In 2009–2011, Irish silver eel escapement from freshwaters expressed as a percent of historic production (EU target = 40%) ranged from 34.2% in the ShIRBD to 46% in the EEMU and SWRBD. The national percent escapement is 36.9%.

In general, we have demonstrated an increase in biomass of silver eel escaping and the reduction in mortality caused by fishing and hydropower. While further reduction in mortality is unlikely, it possible that additional biomass will feed through in the coming years from the closure of the yellow eel fishery.

However, it is unclear how the collapse in recent recruitment will impact on silver eel biomass and whether density-dependent effects (change from small males to higher proportions of larger females) will buffer the collapse in recruitment by temporarily increasing biomass of silver eels, even with falling numbers.

The projected indications, given past recruitment patterns, yellow eel surveys and the closure of the yellow eel fishery, are that production of silver eels will remain at current levels, or may even increase until circa 2018, after which it is anticipated that a marked reduction will take place. Recruitment in the Erne, in particular, was relatively high between 1994 and 2001 and it is anticipated that this will have a positive effect on silver eel production in the coming 5–6 years. Some RBDs (e.g. SERBD and SWRBD) may already be showing the impact of declining recruitment.

It is therefore unlikely that the EU target and recovery of recruitment to historic levels will be achieved within the projected 90 years outlined in the Irish EMP. While management measures (i.e. cessation of fishing, trap and transport around hydropower stations) implemented in Ireland have led to considerable improvements in silver eel escapement, equivalent EU-wide actions have not, to the best of our knowledge, taken place. Further improvement in silver eel production is contingent on increased recruitment of juveniles to Irish waters. Conclusion of the EU 2012 reporting and evaluation process will provide the opportunity to evaluate whether the initial implementation of the Regulation is likely to lead to an improvement in recruitment.

3 Time-series data

3.1 Recruitment Monitoring

Figure 3.1 gives the locations of the recruitment time-series. Recruitment monitoring of 0+ age glass eel (elvers) takes place on the Shannon at Ardnacrusha and the Erne at Cathaleen's Fall (Ballyshannon) and of >0+ age recruits at Parteen Regulating weir on the Shannon. Additional monitoring takes place at a number of Stations, mostly in the Shannon Region. New stations have been put in place on the Lee (south coast) and the Liffey (east coast).

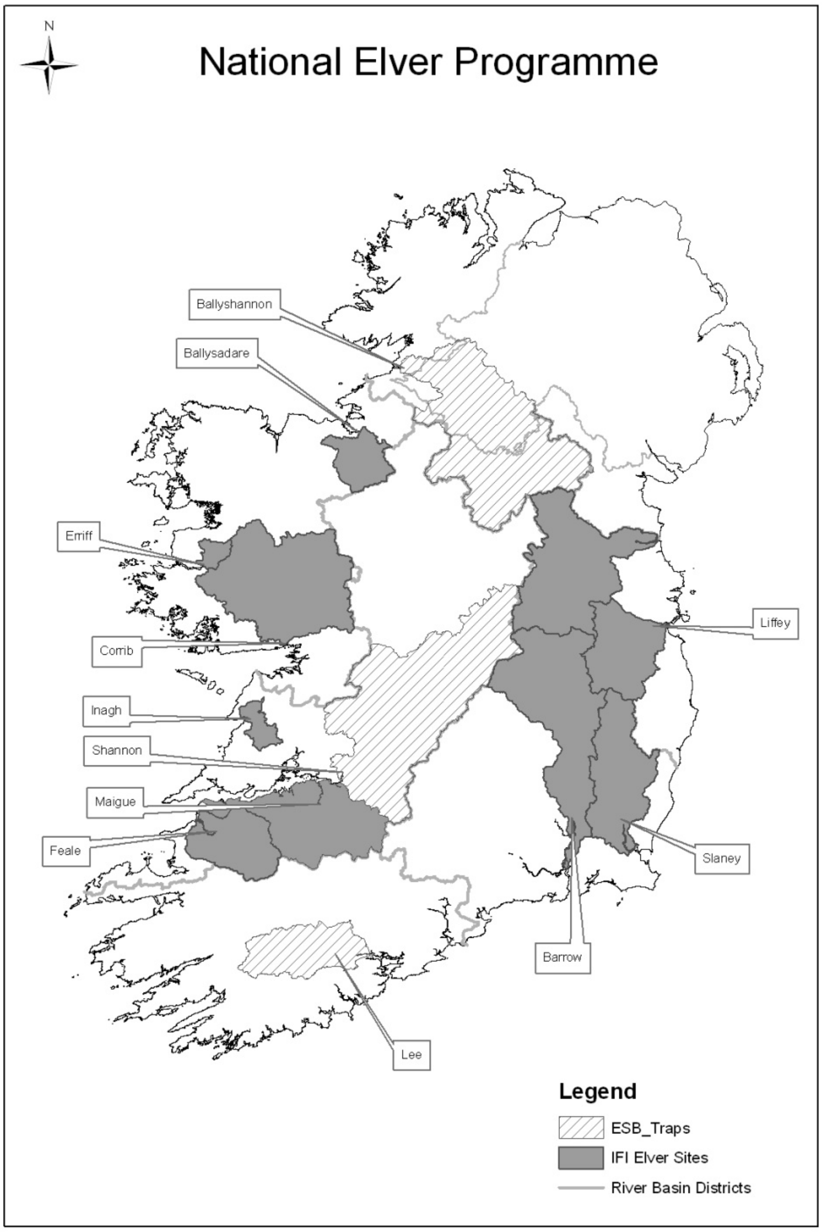

Figure 3-1. Locations of recruitment monitoring.

3.1.1 Glass eel

3.1.1.1 Commercial

There is no authorised commercial catch of juvenile eel in Ireland as glass eel and elver fishing in Ireland is prohibited by law (1959 Fisheries Act, Sec. 173).

3.1.1.2 Recreational

There is no recreational catch of juvenile eel in Ireland as glass eel and elver fishing in Ireland is prohibited by law (1959 Fisheries Act, Sec. 173).

3.1.1.3 Fishery independent

There is no authorised commercial catch of juvenile eel in Ireland, but some fishing has been authorised in the past under Sec. 18 of the Fisheries Act for enhancement of the fisheries. Catches are made at impassable barriers and this is reported in the relevant Regional Eel Management Plans. Monitoring of elver migrating at Ardnacrusha (Shannon) and Cathaleen's Fall (Erne) is undertaken by the ESB (Figure 3.2). Indications are that recruitment remains low. Catches in 2004 for both Erne and Shannon were the second lowest recorded. Numbers in 2005 were more unpredictable, with good catches of elvers recorded in the Erne (45% of the 1979–1984 mean) and a poor catch in Ardnacrusha (1.4% of the 1979–1984 mean). Recruitment remained low in 2010.

Full trapping of elvers on the Erne commenced in 1980. Some discrepancies in the time-series came to light in 2009. The Erne elver dataset has now been double checked and the presented data has been agreed by DCAL and AFBINI, the ESB, NRFB and MI. Any discrepancies were not major and the data trend and pattern has not changed.

Monitoring of elver migrating takes place at Ardnacrusha (Shannon), Cathaleen's Fall (Erne), the Feale, Inagh and Maigue Rivers and fishing is also undertaken by IFI in the Shannon Estuary for glass eels (Tables 3.1–3.2). Indications are that recruitment remains low. Catches in 2004 for both Erne and Shannon were the second lowest recorded and while there is no effort data available, the total catch for all stations in 2004 was the lowest yet recorded. Elver catches in 2005 were much more unpredictable, with good catches of elvers recorded in the Erne (45% of the 1979–1984 mean) and a poor catch in Ardnacrusha (1.4% of the 1979–1984 mean). Elver numbers reported for 2008 to 2010 were poor and there was little or no improvement in 2011. There was an increase in elver catch in both the Erne and the Shannon in 2012.

All catches reported in Tables 3.1–3.2 are transported upstream and restocked and have been included in Tables 3.6 and 3.7.

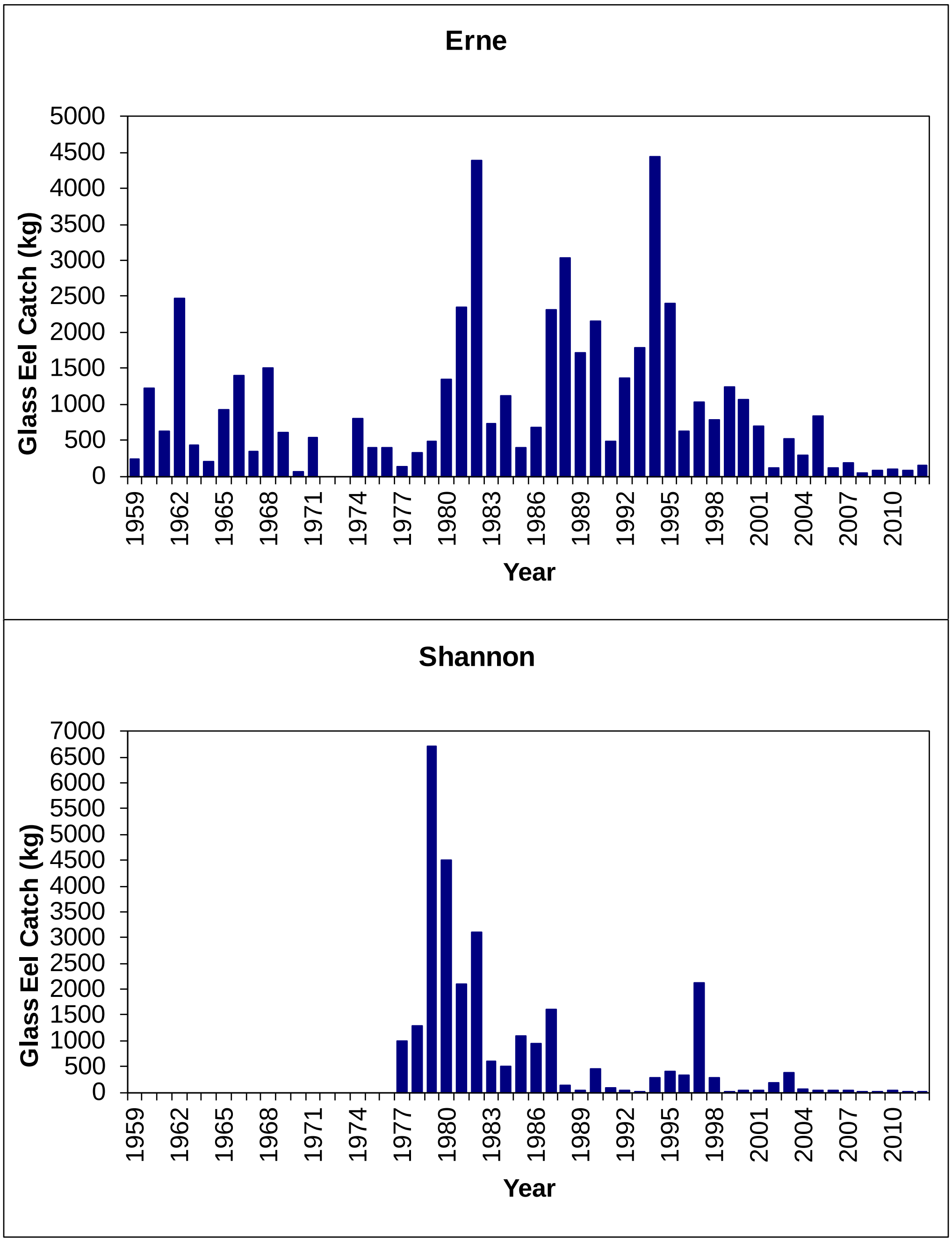

Figure 3-2. Annual elver catches (t) in the traps at Ardnacrusha (Shannon) and Cathaleen's Fall (Erne) – data from ESB. Full trapping of elvers took place on the Erne from 1980 onwards.

Table 3-1. Annual elver catches (kg) in the traps at Ardnacrusha (Shannon) and Cathaleen's Fall (Erne).

Year	Erne (kg)	Shannon (kg)	Year	Erne (kg)	Shannon (kg)
1952			1983	728	600
1953			1984	1121	500
1954			1985	394	1093
1955			1986	684	948
1956			1987	2322	1610
1957			1988	3033	145
1958			1989	1718	27
1959	244		1990	2152	467
1960	1229		1991	482	90
1961	625		1992	1371	32
1962	2469		1993	1785	24
1963	426		1994	4450	287
1964	208		1995	2400	398
1965	932		1996	618	332
1966	1394		1997	1038	2120
1967	345		1998	782	275
1968	1512		1999	1245	18
1969	600		2000	1062	39
1970	60		2001	699	27
1971	540		2002	113	178
1972			2003	525	378
1973			2004	290	58.1
1974	794		2005	838	41.4
1975	392		2006	118	42
1976	394		2007	189	45
1977	131	1000	2008	39	7
1978	320	1300	2009	88.3	7.8
1979	488	6700	2010	96.6	49.7
1980	1352	4500	2011	74.3	7.2
1981	2346	2100	2012	145.7	22.5
1982	4385	3100			

A number of additional trapping stations were fished with fixed traps in the Shannon Region; the Feale, the Maigue and the Inagh. The Maigue and Inagh were not fished in 2009 (Table 3.2). The numbers of glass eels and yellow eels in the Feale have decreased since 2009. Glass eel numbers in the Maigue increased from 3 kgs in 2010 to 5 kgs in 2011. The Inagh also recorded an increase in glass eel catch, increasing from 1.5 kgs in 2010 to 8 kgs in 2011. Recruitment compared to historical levels, remains low at all these stations.

Table 3-2. Glass eel catches (kg), 1985 to 2012 (blanks = not fished).

Year	Erne Estuary	Moy Estuary	R Feale	R Maigue	Inagh R	Sh. Estuary Glass Eels
1985			503			
1986						
1987						
1988						
1989						
1990						
1991						
1992						
1993						
1994			70	14		
1995			0	194		
1996			0	34	140	
1997			407	467	188	616
1998	46		81	8	11	484
1999	441		135	0	0	416
2000	188		174	0	120	43
2001		13	58	2	18	1
2002		21	116	5		37
2003		36	36	72	111	147
2004		0	0	0	24	1
2005		14	0	1	0	41
2006		0	1	0	4	3
2007		0	0	0	39	12
2008		0	0	0	82.5	2
2009		1	42			
2010		7	20	3	1.3	3
2011		0	5	5	8	
2012			55			

3.1.2 Yellow eel recruitment

3.1.2.1 Commercial

There is no authorised commercial catch of juvenile eel in Ireland as glass eel and elver fishing in Ireland is prohibited by law (1959 Fisheries Act, Sec. 173). Fishing for juvenile eel is also prohibited under the conservation byelaws.

3.1.2.2 Recreational

There is no authorised recreational catch of juvenile eel in Ireland as glass eel and elver fishing in Ireland is prohibited by law (1959 Fisheries Act, Sec. 173).

3.1.2.3 Fishery independent

Monitoring of juvenile yellow eel migrating at Parteen Dam (Shannon) and Inniscarra on the R. Lee takes place using a fixed brushtrap.

The data for Parteen is presented in Figure 3.3 and Table 3.3. In 2009 and 2010, due to maintenance work by ESB at the Parteen regulating weir the discharge patterns were less favourable than in 2008. This may partly account for the poor catches recorded in 2009 and 2010. However, catches in the Parteen trap continued to decline in 2011 and 2012.

A new trap was installed in 2012 on the Shannon at Parteen, on the opposite bank. The catch was 6.6 kg.

In 2010, less than one kg was recorded in the Inniscarra trap on the Lee and in 2011, 48 kg were recorded. There was no trapping in 2012.

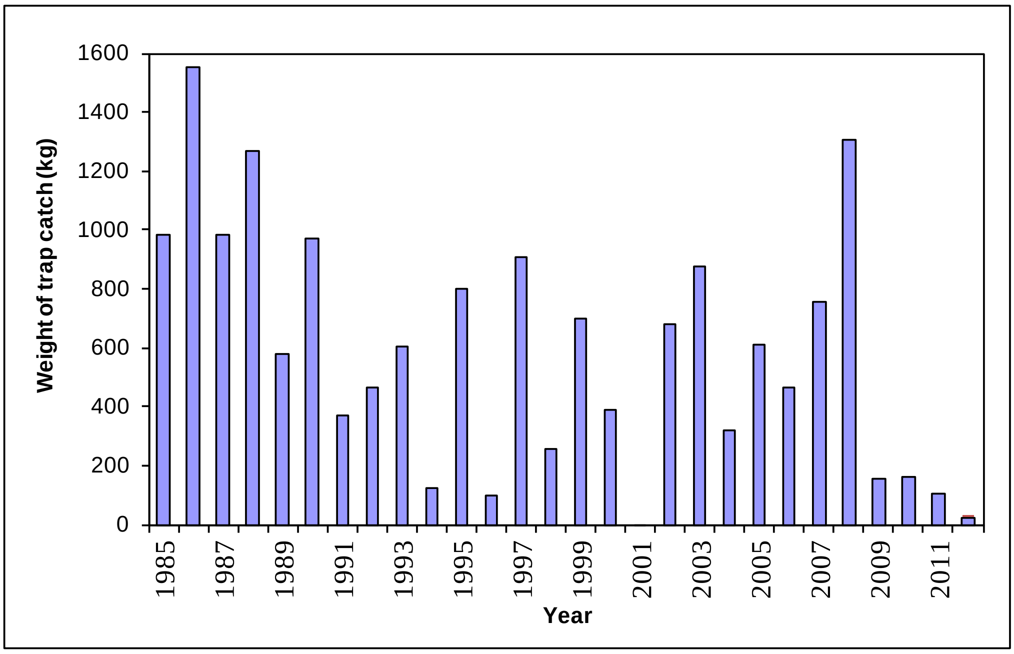

Figure 3-3. Juvenile yellow eel catches (kg) at Parteen Weir, 1985 to 2012. From 2012, a second trap was installed on the opposite bank.

Table 3-3. Juvenile yellow eel catches (kg), 1985 to 2012.

	Shannon	Shannon	Lee
Year	Parteen hatchery	Parteen New trap	Inniscarra
1985	984		
1986	1555		
1987	984		
1988	1265		
1989	581		
1990	970		
1991	372		
1992	464		
1993	602		
1994	125		
1995	799		
1996	95		
1997	906		
1998	255		
1999	701		
2000	389		
2001	3		
2002	677		
2003	873		
2004	320		
2005	612		
2006	467		
2007	757		
2008	1303		
2009	153		
2010	159.5		1
2011	104.5		48
2012	23.4	6.6	

3.2 Yellow eel landings

There are no true index series for yellow eel landings. Most of the data is aggregated by RBD.

3.2.1 Commercial

There is no new data for 2009–2011 as the commercial fisheries were closed.

3.2.2 Recreational

There is no data available for yellow eel caught by recreational fishermen; mostly rod anglers.

3.3 Silver eel landings

Commercial Fisheries were closed in 2009, 2010 and 2011.

3.3.1 Commercial

3.3.1.1 Shannon

The annual downriver migrations of silver eels have traditionally been exploited in the River Shannon and the three commercial eel weirs, owned by ESB since 1937, have continued this practice with varying success (Figure 3.4; Table 3.4). In many respects the overall pattern of change, with steadily declining silver eel catches at Killaloe/Clonlara, but relatively steady catches at Athlone, mirrors the results obtained by monitoring the Lough Derg fykenet cpue yellow eel catches versus those in upper catchment lakes.

The silver eel run was fished at a limited number of stations in 2009/10 as a conservation fishery for trap and transport around the barriers at Parteen and Ardnacrusha. The silver eel catch in 2009/10 in Killaloe was 12.020 t, upstream of Killaloe it was 12.999 t, giving a total silver eel catch for the river of 25.019 t, of which 23.73 t were released downstream of the turbine. 1.17 t was lost in a flood back into the river and the remainder was taken as samples.

The silver eel run was fished at a limited number of stations in 2010/11 as a conservation fishery for trap and transport around the barriers at Parteen and Ardnacrusha. The silver eel catch in 2010/11 in Killaloe was 12.722 t, upstream of Killaloe it were 15.536 t, giving a total silver eel catch for the river of 28.258 t, of which 27.768 t was released downstream of the turbine. The remainder was taken as samples and 490 kg were returned to the river for tracking studies.

The silver eel run was again fished at a limited number of stations in 2011/12 as a conservation fishery for trap and transport around the barriers at Parteen and Ardnacrusha. The silver eel catch in 2011/12 in Killaloe was 10.402 t, upstream of Killaloe it was 15.550 t, giving a total silver eel catch for the river of 26.952 t, of which 25.680 t were released downstream of the turbine. The remaining 272 kg were returned to the river for tracking studies.

Note: while the effort in Killaloe has probably remained similar in recent years, the catch and cpue may now be influenced by changes in management and effort further upstream in the Shannon.

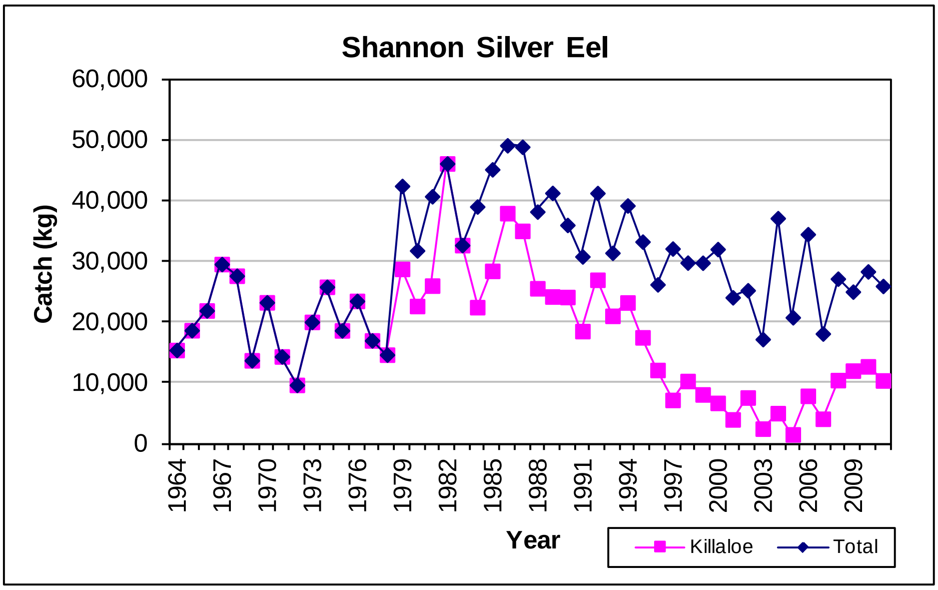

Figure 3-4. Silver eel catches from the Killaloe eel weir and the total Shannon system, for 1964 to 2011. Note that the totals in 2009, 2010 and 2011 are for a conservation fishery with reduced effort: Killaloe effort remains comparable.

3.3.1.2 Corrib

The Galway Fishery comprises a weir with 14 coghill nets. These are fished throughout the dark moon phases and may be lifted during periods of very high water. The fishery was purchased by the state in 1978 and has been fished consistently since then. Fishing effort may have increased in later years. The downward trend in silver eel catch (Figure 3.5; Table 3.4) therefore probably reflects the decreasing stock in the greater Corrib catchment and falling silver eel escapement. The catch in 2007 was 9.3 t, in 2008 it was 5.2 t and in 2009 it was 12.65 t. Table 3.4 gives the data for the Galway Fishery and Shannon silver eel trends. The data in 1976 and 1977 for the Galway Fishery are estimates.

The Galway Fishery was not fished in 2010 and 2011 due to structural safety issues with the fishing weir.

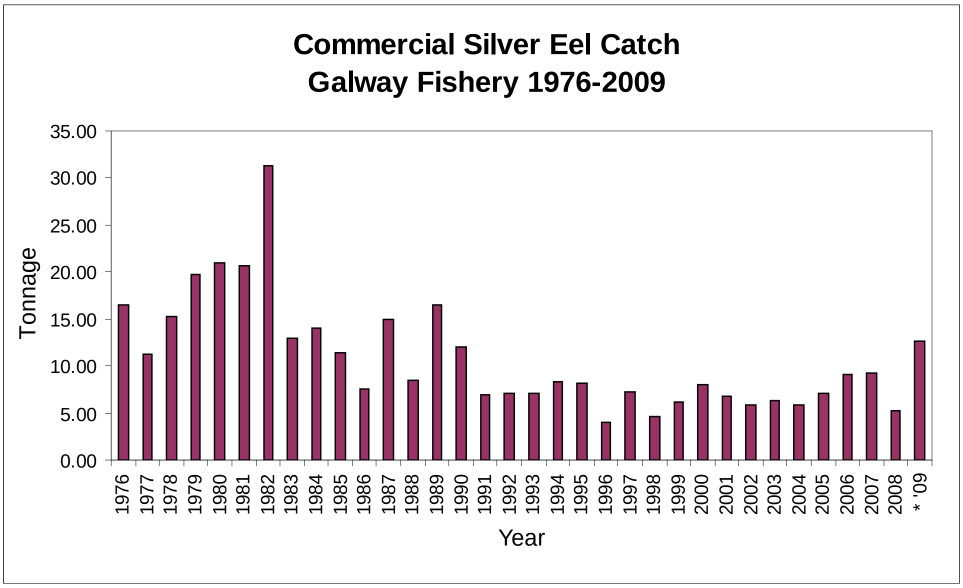

Figure 3-5. Annual silver eel catch (t) in the commercial Galway Fishery, Corrib System, for 1976 to 2009. *Note the fishery was operated as a research catch & release fishery in 2009 and was closed in 2010.

Table 3-4. Annual silver eel catch (t) in the commercial Galway Fishery, Corrib System and for the Killaloe Fishery and total Shannon catch. Note: 2009–2011 was a non-commercial fishery. nf = not fished.

Season	Year	Galway Fishery	Shannon Killaloe	Shannon Total
1964/65	1964		15.4	15.4
1965/66	1965		18.7	18.7
1966/67	1966		21.9	21.9
1967/68	1967		29.6	29.6
1968/69	1968		27.6	27.6
1969/70	1969		13.7	13.7
1970/71	1970		23.3	23.3
1971/72	1971		14.4	14.4
1972/73	1972		9.7	9.7
1973/74	1973		20.0	20.0
1974/75	1974		25.8	25.8
1975/76	1975		18.6	18.6
1976/77	1976	16.50	23.5	23.5
1977/78	1977	11.30	17.0	17.0
1978/79	1978	15.30	14.6	14.6
1979/80	1979	19.70	28.8	42.4
1980/81	1980	20.90	22.7	31.8
1981/82	1981	20.60	26.0	40.7
1982/83	1982	31.30	46.1	46.1
1983/84	1983	13.00	32.7	32.7
1884/85	1984	14.00	22.5	39.0
1985/86	1985	11.40	28.4	45.1

Season	Year	Galway Fishery	Shannon Killaloe	Shannon Total
1986/87	1986	7.50	37.9	49.1
1987/88	1987	15.00	35.0	48.9
1988/89	1988	8.50	25.6	38.2
1989/90	1989	16.54	24.2	41.3
1990/91	1990	12.05	24.1	36.0
1991/92	1991	7.00	18.5	30.8
1992/93	1992	7.15	27.0	41.2
1993/94	1993	7.14	21.0	31.4
1994/95	1994	8.32	23.2	39.2
1995/96	1995	8.16	17.5	33.3
1996/97	1996	4.07	12.1	26.2
1997/98	1997	7.29	7.2	32.1
1998/99	1998	4.62	10.3	29.8
1999/00	1999	6.10	8.1	29.8
2000/01	2000	7.95	6.7	32.0
2001/02	2001	6.84	4.0	24.1
2002/03	2002	5.81	7.6	25.2
2003/04	2003	6.27	2.5	17.2
2004/05	2004	5.83	5.0	37.1
2005/06	2005	7.15	1.5	20.8
2006/07	2006	9.16	7.9	34.5
2007/08	2007	9.32	4.1	18.1
2008/09	2008	5.24	10.5	27.2
2009/10	2009	12.65	12.0	25.0
2010/11	2010	nf	12.7	28.3
2011/12	2011	nf	10.4	26.0

3.3.2 Recreational

There is no recreational silver eel fishing in Ireland. All silver eel fishing was authorised and recorded under the commercial effort. Silver eel fishing is currently closed.

3.3.3 Fishery independent silver

The Burrishoole System in the West of Ireland is a relatively oligotrophic river and lake system with a catchment area of 8379 ha. The eel population is unexploited and the total freshwater silver eel production is trapped in downstream Wolf type traps. The silver eel catch is <u>not</u> included in the National commercial catch as the entire catch is released downstream. The Burrishoole silver eel migration is equivalent to approximately 1% of the National silver catch, by weight, but is indicative of eel production from a considerable number of low productivity Irish river systems where eel densities are relatively low and growth rates are slow, often <2 $cm.yr^{-1}$. The Burrishoole silver eel data, summarised in Table 3.5, has indicated an average pre-1980 production rate of silvers of 0.9 $kg.ha^{-1}$ (post-1980-1.3 $kg.ha^{-1}$) with possible density-dependent changes to female number (sex ratio) and size.

Total catches of silver eel in the trap between the years 1971 (when records began) and 1982 averaged 4400 individuals, fell to 2200 between 1983 and 1989 and increased again to above 3000 in the 1990s (Figure 3.6). The catch in 2003 of 3927 eel was the second highest recorded since 1982. The catch in 2005 was 2594 and in 2006 it was 2168 individual eels. Unusually high water levels in 2006 made trapping particularly difficult and some losses may have occurred.

Catches in 2009–2011 averaged 2328 eels with 2011 having the lowest count since 1986.

Table 3-5. Summary statistics for the Burrishoole silver eel census showing pre-1980 and post-2001 silver eel numbers, biomass and production figures.

Silver Eel	1971-1980	2001-2007	2009-2011
Average count	4440	2983	2328
Biomass (kg)	440	649	455
Production (kg/ha)	0.93	1.37	0.96
%SR	60.4	32.9	36.8
Av Lt Fem (cm)	48.9	52.9	50.7
Av Lt Males (cm)	37.0	35.8	35.7

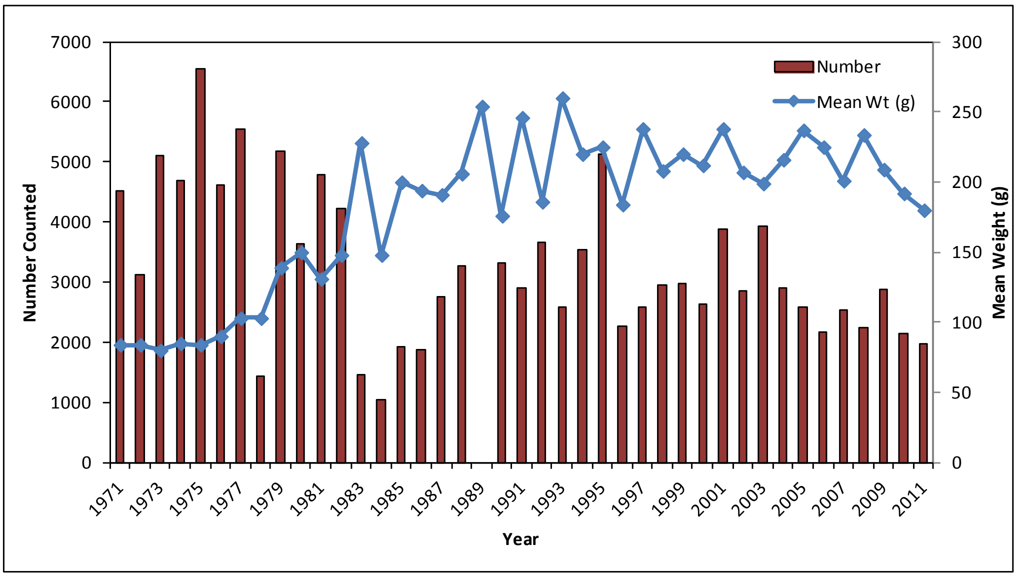

Figure 3-6. Annual silver eel catch, and mean weight (gm) in the Burrishoole System for 1971 to 2011.

3.4 Aquaculture production

Not applicable; no culture in Ireland.

3.4.1 Seed supply

Not relevant.

3.4.2 Production

Not applicable; no culture in Ireland.

3.5 Stocking

3.5.1 Amount stocked

No stocking of imported eel takes place in Ireland. The only stocking that takes place is an assisted upstream migration around the barriers on the Shannon, Erne and Lee. All recruits reported in Tables 3.1–3.3 are moved upstream.

3.5.2 Catch of eel <12 cm and proportion retained for restocking

There is no catch of eel <12 cm and therefore no proportion retained.

3.5.3 Reconstructed time–series on stocking

Table 3.6 shows the total amount of eel stocked (mostly in assisted upstream migration) in Ireland since 1959. The glass eel series in Table 3.6 has been split by RBD in Table 3.7. No eel were foreign sourced. All eel were locally caught and in most cases the capture, transport and stocking all took place in the one River Basin to aid upstream migration at barriers. This was primarily on the Erne and the Shannon but some upstream stocking also took place on the Moy and Corrib. All eels reported in Tables 3.1, 3.2 and 3.3 were stocked upstream and are reported in Table 3.6 along with some additional amounts on the Moy and Corrib.

In most cases, the majority of eels are zero age glass eel/elver, although some older bootlace eel are mixed in.

Care should be taken not to 'double bank' the Erne stockings (included in Table 3.6 and 3.7) with the UK Northern Ireland.

Table 3-6. Time-series on the total amount of eel stocked in Ireland, including transboundary Erne. The glass eel series has been split by RBD in Table 3.7. The bootlace series is from Parteen, ShRBD.

	Local Source				Foreign Source			
Year	Glass Eel	Quarantined Glass Eel	Wild Bootlace	On-grown cultured	Glass Eel	Quarantined Glass Eel	Wild Bootlace	On-grown cultured
1959	244	0	0	0	0	0	0	0
1960	1229	0	0	0	0	0	0	0
1961	625	0	0	0	0	0	0	0
1962	2469	0	0	0	0	0	0	0
1963	426	0	0	0	0	0	0	0
1964	208	0	0	0	0	0	0	0
1965	932	0	0	0	0	0	0	0
1966	1394	0	0	0	0	0	0	0
1967	345	0	0	0	0	0	0	0
1968	1512	0	0	0	0	0	0	0
1969	600	0	0	0	0	0	0	0
1970	60	0	0	0	0	0	0	0
1971	540	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0
1974	794	0	0	0	0	0	0	0

	Local Source				Foreign Source			
Year	Glass Eel	Quarantined Glass Eel	Wild Bootlace	On-grown cultured	Glass Eel	Quarantined Glass Eel	Wild Bootlace	On-grown cultured
1975	392	0	0	0	0	0	0	0
1976	394	0	0	0	0	0	0	0
1977	1131	0	0	0	0	0	0	0
1978	1720	0	0	0	0	0	0	0
1979	7188	0	0	0	0	0	0	0
1980	5852	0	0	0	0	0	0	0
1981	4446	0	0	0	0	0	0	0
1982	7485	0	0	0	0	0	0	0
1983	1328	0	0	0	0	0	0	0
1984	1696	0	0	0	0	0	0	0
1985	1990	0	984	0	0	0	0	0
1986	1632	0	1555	0	0	0	0	0
1987	3942	0	984	0	0	0	0	0
1988	3178	0	1265	0	0	0	0	0
1989	1745	0	581	0	0	0	0	0
1990	2619	0	970	0	0	0	0	0
1991	572	0	372	0	0	0	0	0
1992	1403	0	464	0	0	0	0	0
1993	1809	0	602	0	0	0	0	0
1994	4821	0	125	0	0	0	0	0
1995	2992	0	799	0	0	0	0	0
1996	1134	0	95	0	0	0	0	0
1997	4848	0	906	0	0	0	0	0
1998	1689	0	255	0	0	0	0	0
1999	2255	0	701	0	0	0	0	0
2000	1626	0	389	0	0	0	0	0
2001	818	0	3	0	0	0	0	0
2002	470	0	677	0	0	0	0	0
2003	1304	0	873	0	0	0	0	0
2004	373	0	320	0	0	0	0	0
2005	977	0	612	0	0	0	0	0
2006	168	0	467	0	0	0	0	0
2007	284	0	757	0	0	0	0	0
2008	131	0	1303	0	0	0	0	0
2009	139	0	153	0	0	0	0	0
2010	149	0	161	0	0	0	0	0
2011	148	0	153	0	0	0	0	0
2012	230	0	30	0	0	0	0	0

Table 3-7. Time-series from Table 3.6 on the total amount of glass eel stocked in Ireland, including transboundary Erne, split by RBD.

Year	Total NWIRBD	Total WRBD	Total ShIRBD
1959	244	0	0
1960	1229	0	0
1961	625	0	0
1962	2469	0	0
1963	426	0	0
1964	208	0	0
1965	932	0	0
1966	1394	0	0
1967	345	0	0
1968	1512	0	0
1969	600	0	0
1970	60	0	0
1971	540	0	0
1972	0	0	0
1973	0	0	0
1974	794	0	0
1975	392	0	0
1976	394	0	0
1977	131	0	1000
1978	320	100	1300
1979	488	0	6700
1980	1352	0	4500
1981	2346	0	2100
1982	4385	0	3100
1983	728	0	600
1984	1121	75	500
1985	394	0	1596
1986	684	0	948
1987	2322	10	1610
1988	3033	0	145
1989	1718	0	27
1990	2152	0	467
1991	482	0	90
1992	1371	0	32
1993	1785	0	24
1994	4450	0	371
1995	2400	0	592
1996	618	70	506
1997	1038	12	3798
1998	828	2	859
1999	1686	0	569
2000	1250	0	376

Year	Total NWIRBD	Total WRBD	Total ShIRBD
2001	699	13	106
2002	113	21	336
2003	525	36	743
2004	290	0	83
2005	838	14	125
2006	118	0	50
2007	189	0	95
2008	39	0	92
2009	88	1	50
2010	97	7	44
2011	74	0	25
2012	146	0	84

4 Fishing capacity

Prior to 2009

Byelaw No. C.S. 297

In May 2008, the Minister for Communications, Energy and Natural Resources introduced a byelaw (Conservation of Eel Fishing (Annual Close Season) Bye-law No. C.S. 297, 2008). This Byelaw prohibited the taking or fishing for yellow eel under 30 cm in length. The Byelaw also provided for a close season for yellow eel, from 1 September to 31 May of the following year. The Bye-law also provided for a close season for silver eel from 1 January to 30 September in any year.

ByeLaw No. 838, 2008

In May 2008, the Minister for Communications, Energy and Natural Resources introduced a byelaw (Conservation of Eel Fishing (Restriction on Issue of Licences) Bye-Law No. 838, 2008). This Byelaw capped the number of eel fishing licences which may be issued in each Fishery District in 2008 or any year thereafter.

The Management of Eel Fishing Byelaw No.752, 1998 capped the number of longline licences that a Regional Fisheries Board may issue for longline fishing for eels in any district. In addition, the Fisheries (Amendment) Act 1999 delegated authority to the Regional Fisheries Boards to issue authorisations for the use any fishing engine for the capture of eels including any long-line, as it sees fit.

Each Regional Fisheries Board had a policy on the number of fykenets permitted for each licence and in some cases the locations where they are permitted to fish. It was difficult to convert the number of licensed nets into an actual fishing effort, as many licensed fisherman either didn't fish at all or only fished for a limited period of the year. In some areas for example, such as in the southeast, fykenets were used during the weaker tides and baited pots were used when the tides were too strong for fykenets.

4.1 2009–2012 Byelaws

Conservation of Eel Fishing Byelaw No. C.S. 303, 2009

In May 2009, the Minister for Communications, Energy and Natural Resources introduced a byelaw (Conservation of Eel Fishing Byelaw No. C.S. 303, 2009). This Byelaw prohibits fishing for eel, or possessing or selling eel caught in a river in the State.

Conservation of eel fishing (prohibition on issue of licences) byelaw No. 858, 2009

In May 2009, the Minister for Communications, Energy and Natural Resources introduced a byelaw (Conservation of Eel Fishing (Prohibition on Issue of Licences) Byelaw No. 858, 2009). This Byelaw prohibits the issue of any licences for fishing for eels of the species Anguilla anguilla by any fishing method in any fishery district.

These two byelaws revoke the previous bye-laws enacted in 2008 and close all fisheries for 2009–2012.

4.2 Glass eel

There was no authorised commercial fishing of juvenile eel in Ireland as glass eel and elver fishing in Ireland is prohibited by law (1959 Fisheries Act, Sec. 173).

4.3 Yellow eel

There was no authorised commercial fishing of yellow eel in Ireland for 2009–2012. No licences were issued from 2009 to 2012.

4.4 Silver eel

There was no authorised commercial fishing of silver eel in Ireland for 2009–2012. No licences were issued from 2009 to 2012.

4.5 Marine fishery

There was no authorised commercial fishing of any eel in marine waters in Ireland for 2009–2012. No licences were issued from 2009 to 2012.

5 Fishing effort

In May 2008, the Minister for Communications, Energy and Natural Resources introduced a byelaw (Conservation of Eel Fishing (Annual Close Season) Byelaw No. C.S. 297, 2008) restricting the fishing season for both yellow and silver eel as follows:

a) to take or to attempt to take, or to fish for or to attempt to fish for, or to aid or assist in the taking or fishing for or the attempting to take or fish for, or to be in possession of brown eel during the period-

- i) from 16 May 2008 to 31 May 2008, and
- ii) in any year from 1 September to 31 May in the next following year.

b) to take or to attempt to take, or to fish for or to attempt to fish for, or to aid or assist in the taking or fishing for or the attempting to take or fish for, or to be in possession of silver eel during the period-

- i) from 16 May 2008 to 30 September 2008, and
- ii) in any year from 1 January to 30 September.

Fishing effort was not monitored in the Irish eel fishery. There was no logbook or compulsory recording system for fishermen and there is no eel dealer register or regular monitoring of eel dealers. There is also no registration of fishing boats in the eel fishery. Efforts were made to improve on the data collection by circulating an agreed catch reporting form which may lead to data discontinuity.

In May 2009, the Minister for Communications, Energy and Natural Resources introduced byelaws prohibiting fishing for eel, or possessing or selling eel caught in a river in Ireland and prohibiting the issue of any licences for fishing for eels of the species *Anguilla anguilla* by any fishing method in any fishery district (Chapter 4).

5.1 Glass eel

There is no authorised commercial effort for juvenile eel in Ireland as glass eel and elver fishing in Ireland is prohibited by law (1959 Fisheries Act, Sec. 173).

No licences were issued from 2009 to 2012.

5.2 Yellow eel

No licences were issued from 2009 to 2012.

5.3 Silver eel

No licences were issued from 2009 to 2012.

5.4 Marine fishery

There was no authorised marine fishery in Ireland. Fishing took place in transitional estuaries and lagoons and this effort was licensed and managed along with the inland fisheries.

No licences were issued from 2009 to 2012.

6 Catches and landings

Until 2008 there was no compulsory declaration of eel catch in Ireland and in many Regions, declarations of catches are not complete and under-reporting is probably widespread. Reported catches were available on an annual basis at the Fisheries Regional Level with most RFBs reporting on a District basis. The introduction of a new catch reporting form led to considerable improvement in the system after 2005.

For the Eel Management Plans, catches (RoI) of yellow and silver eel have been collated from the District returns and are presented in the 2010 Country Report for Ireland. Also included were the catches for the N. Ireland part of the NWIRBD on the Erne supplied by DCAL and AFBINI.

It would appear from the declared catch data that the conservation byelaws implemented in 2008 had little impact on the catch. This may be due to a number of factors, including greater effort in a shorter season, better data reporting and recording since 2005 and changes in reporting practices by fishermen.

With the introduction of the Conservation of Eel Fishing byelaws in 2009, all regions confirmed a closure of the eel fishery for the 2009 to 2012 seasons with no licences issued. In the transboundary areas 'The Foyle Area and Carlingford Area (Conservation of Eels) Regulations 2009' was created which prohibits the taking or killing of eels within the FCILC area. Some illegal fishing was reported and there were concerns about the traceability of eels in dealer trucks passing through some areas. Overall, illegal activity was thought to be relatively low (Ireland 2012).

6.1 Glass eel

There is no authorised commercial catch of juvenile eel in Ireland as glass eel and elver fishing in Ireland is prohibited by law (1959 Fisheries Act, Sec. 173).

6.2 Yellow eel

No official catch 2009–2012.

6.3 Silver eel

No official catch 2009–2012.

6.4 Marine fishery

No official catch 2009–2012.

7 Catch per unit of effort

There was no authorised commercial catch of juvenile eel in Ireland as glass eel and elver fishing in Ireland is prohibited by law (1959 Fisheries Act, Sec. 173).

7.1 Glass eel

No new data-refer to 2009 Country Report.

7.2 Yellow eel

No new data-refer to 2009 Country Report.

7.3 Silver eel

No new data-refer to 2009 Country Report.

7.4 Marine fishery

No new data-refer to 2009 Country Report.

8 Other anthropogenic impacts

Six catchments in Ireland have major hydropower installations in the lower catchments (Figure 8.1). The Shannon also has flow regulation throughout the catchment. These are as follows:

The Shannon	(ShRBD)
The Erne	(NWIRBD)
The Liffey	(EEMP)
The Lee	(SWRBD)
The Clady/Crolly	(NWIRBD)
The Ballysadare	(WRBD)

Table 8.1 gives the wetted areas in each catchment with major hydropower. Almost 50% of the available wetted habitat is above major barriers (Figure 8.2), although there will be a greater proportion of the potential silver eel production when the dif-

ferences in relative productivity are taken into account. This is included in the Regional EMPs and in the estimates of pristine and current escapement.

Table 8-1. Wetted areas (ha) for lakes and fluvial area above major hydropower installations.

	Lake area (ha)	Fluvial area (ha)		Total wetted area	Pristine escapement
		>1st order	1st order	ha	kg/ha
Total wetted area	132 275	18 780	2826	153 881	594 408
Total impacted	66 844	5203	959	73 006	265 427
Shannon	38 771	3304	391	42 466	200 839
Erne	24 848	1098	251	26 197	116 633
Ballisodare	1556	29	227	1812	8239
Liffey	-	424	39	464	2012
Clady/Crolly	391	20	5	416	505
Lee	1278	327	46	1651	753

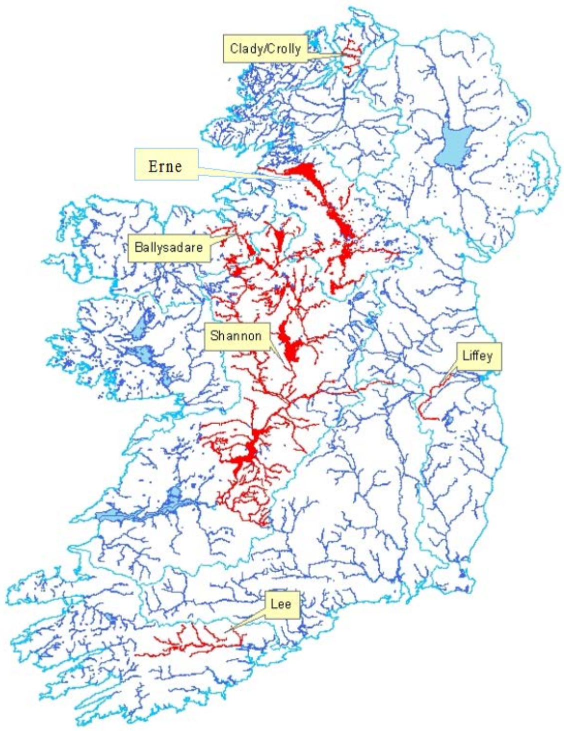

Figure 8-1. Map showing location of catchments where major hydropower installations occur. Waterbodies upstream of hydropower stations are shown in red.

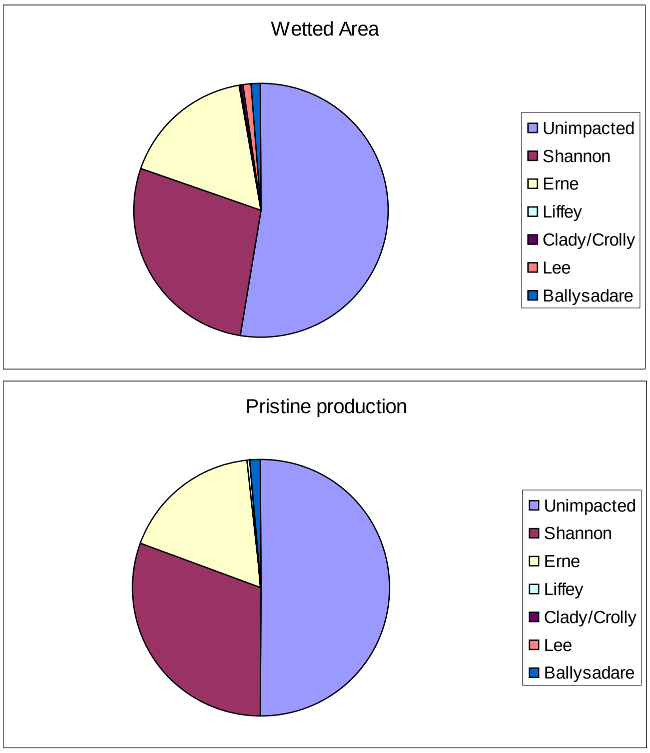

Figure 8-2. Proportions of wetted area and estimated pristine production for the catchments above major hydropower installations.

8.1 Hydropower impact

8.1.1 From Eel Management Plan

Hydropower impacts on approximately 46% of the wetted area accounted for in the six EMPs (Section 8.1). At the time of writing the Eel Management Plans no direct measurement of hydropower mortality or morbidity was available for Ireland. However, there have been a number of studies carried out elsewhere that suggested an average mortality rate of 28.5% across all length classes per hydropower installation (ICES, 2003). Therefore, the probability of surviving passage through 'n' number of hydropower installations is $(0.715)^n$. Where bypass estimates exist (i.e. 30% on the Shannon) these were incorporated in the model in 2008.

New mortality data has become available throughout the 2009–2011 period and is reported in the Ireland Report to the EU (2012). This data has been incorporated into the Irish model for assessing silver eel escapement and the escapement for 2008 has been recalculated.

Full details of both the trap and transport programme and the mortality rates for hydropower are presented in the Ireland Report to the EU (2012) in the annexed science report.

8.2 Trap and transport

The target set for the trap and transport system in the Irish Eel Management Plan was as follows:

Shannon: Trap and transport 30% of the annual run.

	catch target (t)	% of expected silver eel run	Proportion of EU H achieved – fishery closed	Approx. timeframe to recovery (y)
2009	not defined	30	0.045	95
2010	not defined	30	0.045	95
2011	not defined	30	0.045	95

Erne: Trap and transport the following. *

	catch target (t)	% of expected silver eel run	Proportion of EU H achieved – fishery closed	Approx. timeframe to recovery (y)
2009	22	36	0.092	200
2010	34	54	0.075	140
2011	39	63	0.05	100

***Erne Fishery not closed in N. Ireland in 2009.**

Lee: Trap and transport 500kg of the annual escapement.

	catch target (t)	% of expected silver eel run	Proportion of EU H achieved – fishery closed	Approx. timeframe to recovery (y)
2009	0.5	34	0.007	80
2010	0.5	34	0.007	80
2011	0.5	34	0.007	80

The total amounts of silver eel trapped and transported in each of the three rivers in 2009, 2010 and 2011 are presented in Table 8.2. The target was achieved in the R. Shannon is all three years. The target was not achieved in the Erne and was achieved in one of the three years in the Lee.

In the R. Shannon, the existing structures and experience in silver eel fishing contributed to the success of the programme. Combining the upstream fisheries with the fishery in Killaloe ensured that the 30% of the run target was achieved and also ensured a better spread of capture dates and high quality of eel.

In the R. Erne, the target was set as a fixed amount per annum based on the estimate of the run for 2001–2007 and an expectation that the silver eel production would remain high due to the history of recruitment in the 1990s. Both the experience and level of fishing effort increased on the Erne between 2009 and 2011 and this led to improved catches of eels for transport in 2010 and 2011.

In the River Lee where there was no history of silver eel fishing, the trap and transport programme was undertaken with a view to capturing potential spawners in the areas above the hydropower facilities and releasing them downstream. The fishing in 2009 was hampered by unusually high floods and in 2010 by very low water levels. A different approach was employed in 2011 with fishing taking place by fykenet in July where a catch of 731 kg was taken and transported. Analysis of the silvering characteristics indicated that it was reasonable to assume that at least 68% (500 kg) of the transported eels were silver.

Table 8-2. Total amounts (t) of silver eel trapped and transported in the Shannon, Erne and Lee, 2009-2011, and the success relative to the target set in the EMPs.

Catchment	Year	Target	Amount Transported (t)	Relation to target	Status
R. Shannon	2009	30% of run	23.730	32–35%	Achieved
R. Shannon	2010	30% of run	27.768	40%	Achieved
R. Shannon	2011	30% of run	25.680	39%	Achieved
R. Erne	2009	22t	9.383	43%	Not achieved
R. Erne	2010	34t	19.334	57%	Not achieved
R. Erne	2011	39t	25.252	65%	Not achieved
R. Lee	2009	0.5t	0.079	16%	Not achieved
R. Lee	2010	0.5t	0.278	56%	Not achieved
R. Lee	2011	0.5t	0.731	146%	Achieved
Total	2009		33.192		
Total	2010		47.380		
Total	2011		51.663		

8.2.1 Action 2b: Quantify turbine mortality

Monitoring migrating silver eel, using acoustic tag telemetry, to determine migration routes and mortality at the hydropower stations has taken place on the Shannon between 2006 and 2011 and on the Erne in 2010 and 2011 (Table 8.3). The following is extracted from the Ireland Report to the EU (2012).

Shannon: Summarising the annual data gives mortality ranges of 16.6% to 25% and an overall average mortality of 21.15 ± 8% for 104 tagged eel arriving at Ardnacrusha HPS.

In the Eel Management Plan, a figure of 30% was used to account for the amount of eel potentially using the bypass route down the old river channel and around Ardnacrusha HPS. For 2009–2011, the actual amount of eels estimated to bypass were used in determining the escapement (59%, 4.4% and 12.5% respectively). A general figure for eels estimated to use the bypass in recent years is 17.8%.

Erne: Summarising the data from 2009 to 2011 gives mortality ranges for Cliff HPS of between 6.9% and 8.5% and an average of 7.8% ± 5% and mortality for Cathaleens Fall of 22% (nine tags) in 2009. In 2010 and 2011, one turbine was removed for renovation and therefore the mortalities were lower at 6.1% and 7.7%. It is likely that these will at least double when both turbines are operational and this should be assessed in the next three years.

Currently there is no solid information about the proportions of eel that migrate via spillways compared to via the turbine passages. There may be selective migration towards the spillways, especially at Cliff, and this may be indicative of safe passage and help to explain the low HPS mortality levels observed on the Erne. The HPS mortality and bypass needs additional work on the Erne to clarify.

Table 8-3. Summary mortality data % for acoustic telemetry on the Shannon and Erne.

	Year	Number of tagged eel	Mortality % *	Number of tagged Eel	Mortality % **	
Shannon	2006					
	2007					
Average	2008–2011	104	21.15			
			Cliff		Cathaleens Fall	
Erne	2009	13	7.7	9	22*	*Low no. of tags
	2010	29	6.9	26	7.7	one turbine
	2011	60	8.5	49	6.1	one turbine
Average			7.8		16.5	estimate for two turbines.

*** Ardnacrusha on the Shannon; Cliff on the Erne.**

**** Cathaleens Fall on the Erne.**

9 Scientific surveys of the stock

9.1 Introduction

A close link between the management actions and eel stock targets will be established by implementing a comprehensive monitoring and stock assessment programme. This will allow for a direct feedback to management based on the response of the stock to implemented management actions and changes in recruitment. The results of the monitoring programme for 2009 to 2011 are now available in the Ireland Report to the EU 2012. The following chapter only summarises this.

9.2 Silver eel assessment

The Council Regulation (EC) No 1100/2007 sets a target for silver eel escapement to be achieved in the long term. Ireland is therefore required to provide an estimate of contemporary silver eel escapement. The Regulation also requires post-evaluation of management actions by their impact directly on silver eel escapement. Quantitative estimates of silver eel escapement are required both to establish current escapement and to monitor changes in escapement relative to this benchmark. Quantifying migrating silver eel each year is a difficult and expensive process but it is the only way of ultimately calibrating the outputs of the assessments.

Silver eels are being assessed by annual fishing of index stations on the Corrib, Erne, Shannon, Fane and Burrishoole catchments, all of which have a long-term history of eel catch and data collection. Trials are also being carried out at other locations identified in the EMP using coghill nets, mark** Cathaleens Fall on the Erne recapture and technology options such as electronic counters or DIDSON technology.

9.2.1 Corrib

The Galway Fishery comprises a weir with 14 coghill nets. These were fished throughout the dark moon phases and may be lifted during periods of very high water. The fishery was purchased by the state in 1978 and has been fished continually since then. The weir was operated as a scientific silver eel fishery by IFI in 2009 but was not fished in 2010 or 2011 due to structural issues with the weir.

9.2.2 Shannon

Eels have been fished on the Shannon in both historic and more recent times. Commercial fishing was initially established by the ESB in 1937. The ESB control the fishing rights as a result of the Shannon Fisheries Acts of 1935 and 1938. In 2009–2011, commercial silver eel fishing was ceased on the Shannon. The pre-EMP pilot trap and transport system of fishing at Killaloe has been continued as part of the EMP and the catch, along with that of the four contracted fishermen was transported downstream of Ardnacrusha HEP.

In the Shannon Catchment (ShIRBD), historical (pristine) silver eel production was estimated by NUIG/ESB to be in the order of 189 t, falling to an average production of 86 t for the 2001–2007 period, or an escapement of 12 t (6.4% of pristine), after exploitation and using 17.8% as an average bypass at Parteen and 21.1% turbine mortality (average 2009–2011). Following the cessation of the fishery in 2009 and implementation of the trap and transport programme, escapement increased to 66.8 t, 60.2 t and 57.9 t in 2009, 2010 and 2011 respectively, or an average of 61.6 t (32.6% of pristine).

9.2.3 Burrishoole

In the Burrishoole (WRBD), historical silver eel production was estimated by the Marine Institute to be in the order of 0.5 t, increasing to an average of 0.7 t for the 2001–2007 period, or 140% of pristine. The yellow eel stock in Burrishoole has never been commercially exploited and the stock has shown evidence of sex ratio changes from a male dominated silver eel run to a higher proportion of larger females. The number of eels has decreased while the biomass increased until about 2005. Similar observations of increasing average size/female sex ratio have been made on the Corrib and the Shannon. Production and escapement in Burrishoole for the 2009–2011 period were 0.6 t, 0.4 t and 0.4 t with an average of 0.5 t (103% of pristine) and 2010 and 2011 were the lowest observed since 1986.

9.2.4 Erne

In the Erne (NWIRBD), historical silver eel production was estimated by NUIG/ESB to be in the order of 107.5 t, falling to an average of 85 t for the 2001–2007 period, or an escapement of 32.5 t (30.3% of pristine), after exploitation and using 22.9% turbine mortality (average 2009–2011 for both Cliff and Cathaleens Fall). Following the cessation of the fishery in Ireland in 2009 and N. Ireland in 2010 and implementation of the trap and transport programme, estimated escapement increased to 37.9 t and 39.9 t in 2010 and 2011, or an average of 38.9 t (36.2% of pristine). Given the relatively high level of recruitment in the mid-1990s to the early 2000s in the Erne system (~235 recruits/ha yielding 1.6 kg/ha silver eel), comparisons with other river systems (e.g. Shannon ~64 recruits/ha yielding 1.7 kg/ha silver eel), and the relatively high yellow eel stocks in much of the Erne system compared to previous surveys, the estimates of current silver eel production in the Erne were lower than expected. This may be due to unexplained differences in productivity and recruitment, higher than previously thought commercial yellow eel catch, an underestimate of current production or a combination of these factors. Further work is required to clarify the lower than expected production estimate.

9.2.5 Fane

A preliminary assessment by IFI of the Fane in Dundalk (Eastern EMU) in October/November indicated a potential production in 2011 of approximately 2 t. The migration appeared to be dominated by male silver eel. Further surveys will conducted at this important site as it is currently the only east coast site with potential to be an index for silver eel production.

9.3 Yellow eel assessment

Yellow eel stock monitoring is integral to gaining an understanding of the current status of local stocks and for informing models of escapement, particularly within transitional waters where silver eel escapement is extremely difficult to measure directly. Yellow eel monitoring also provides a means of evaluating post-management changes and forecasting the effects of these changes on silver eel escapement. These data are held by IFI and are available to the WG on request. The monitoring strategy aims to determine, at a local scale, an estimate of relative stock density, the stock's length, age and sex profiles, and the proportion of each length class that migrate as silvers each year. A second objective of the yellow eel study was to carry out an indirect estimation of silver eel escapement. A long-term tagging programme was initiated in three lakes in 2009. All yellow eels captured in the fykenets in Lower Lough Corrib, Lower Lough Derg and Lough Feeagh were tagged using PIT tags. The detection of these tagged eels in the silver eel run over subsequent years will provide information regarding the maturation rate of the yellow eel population.

9.3.1 Fykenet survey

9.3.1.1 Lakes

Over the course of the last three years an extensive yellow eel fykenet survey was carried out in key Irish lakes. This programme addressed a number of the monitoring objectives in the EMP, such as creating a baseline dataset for monitoring changes to the yellow eel population over time, comparison with historical surveys and inter-calibration with Water Framework Directive surveys. In the Corrib, Shannon, Erne and Burrishoole catchments, yellow eels (>30 cm) were tagged with passive integrated transponders (TROVAN PIT tags). Silver eel catches from these catchments were scanned in order to detect the maturing tagged yellow eels. A number of transitional waters and lagoons were surveyed by the EMP, namely the Suir, Barrow/Nore and Slaney transitional waters and the South Sloblands (a brackish lagoon). The aim of these surveys was to investigate the importance of transitional waters to the Irish eel population. Where data were available, the current surveys were compared with previous surveys in the 1970s, 1980s and 1990s.

The general picture from the comparisons made between previous and current surveys is one of similar cpues but with a shift to larger eels. This shift to larger average size is a combination of relatively low numbers of small eels (e.g. in L. Conn, Inchiquin, and Corrib), indicative of poor recruitment, and shifting sex ratios to a higher proportion of larger females (e.g. in Corrib, Shannon and Burrishoole). The surveys of the Erne catchment still show relatively good numbers of eel compared to previous surveys, but in some cases there was evidence of previous commercial exploitation with large size classes absent in the current survey (i.e. L. Oughter, Up, L. Erne). The stocks of yellow eel in the Erne may be a reflection of the good recruitment of the 1990s and early 2000s still resident within the catchment.

9.3.1.2 Transboundary

Lough Erne is a transboundary catchment in the Northwestern River Basin District. Upper Lough Erne has a surface area of 1552 ha. It is a particularly shallow lake with a mean depth of 1.87 m across the sampling sites. Upper Lough Erne was sampled over six nights in June and August 2010 (three nights per session). A total of 493 eels were caught during sampling, with a cpue of 1.64. The eels ranged in length from 28.9 cm to 78.7 cm and in weight from 0.035 to 0.950 kgs. In total, 90 eels were sacrificed from upper Lough Erne. Of these, 99% were female. There was a 67% prevalence rate for *A. crassus* and a mean infection intensity of three parasites per eel.

In 2010, four transboundary lakes were sampled by the Water Framework Directive; Lough Lattone, MacNean Upper and Lower and Upper Lough Erne. The surveys were carried out in collaboration with IFI Swords and Ballyshannon, DCAL and AFBI.

9.3.1.3 Transitional waters

Surveys of the transitional waters showed differences between each water and between the transitional waters and the lakes. The transitional waters contained significantly smaller eels that the lakes. The highest cpues were recorded in the transitional waters of the Barrow/Nore and Suir. The Slaney and South Sloblands had comparatively lower cpues. Low mark-recapture rates indicated probable high levels of movement within these waters and made population estimation difficult. Due to the difficulties in obtaining density estimates for eels in large waterbodies and the migratory habits of eels moving upstream into the rivers and/or leaving the transitional water as silver eel, it is still not possible to estimate silver eel escapement/production for transitional waters.

9.3.1.4 Comparison with previous surveys

Extensive eel survey work was carried out on eels throughout Ireland from 1968 until the late 1990s. These surveys covered all waterbody types (rivers, lakes and transitional waters) and valuable time-series were created. The raw data were available to the Marine Institute and the Inland Fisheries Ireland and a large section of this historical data was collated into a national eel database under the NDP 'Eel Plan' Project, (Compilation of Habitat bases catchment information and historical eel data in support of eel management plans, 2010). Objective 5 of the National Eel Management Plan is to compare current and historic yellow eel stocks and the FRC datasets will be used in these comparisons.

The historical data available for analysis spans a number of important time periods. The pre-1980s data is representative of the population of eels in Ireland before the recruitment collapsed after 1980. The data from the period 1980–present represents the period of change that is occurring as a result of this collapse. The average lifespan of male and female eels in Ireland is between 10 and 20+ years, or older, depending on the productivity of the catchment, and therefore the collapse in recruitment should be reflected in the data from the mid-1990s onwards. The eel population structure was also influenced by the effects of the commercial fishery (up to 2008).

The general picture from the comparisons is one of similar cpue but an increasing size of eels in the later years. The lack of small eels in the fykenet catches in the 2009–2011, with some exceptions (i.e. transitional waters), is an indication of poor recruitment. The increasing size is largely a function of low numbers of small eels, but may also be a reflection of reduced competition and improved growth as a result of the reduced population density. A short period of relatively good recruitment in many catchments in the mid-1990s to early 2000s may have maintained the yellow eel stock giving to comparative cpues with previous studies, but the low recruitment in the last decade is now leading to lower densities of small yellow eel. From modelling exercises it seems likely that silver eel production will be at least maintained at least in some catchments, and may even increase for a short time, but this is anticipated to be short lived and a serious decline in silver eel production is expected to follow.

9.3.2 Water Framework Directive surveys

A key step in the WFD process is for EU Member States to assess the health of their surface waters through national monitoring programmes. Monitoring of all biological elements including fish is the main tool used to classify the status (high, good, moderate, poor and bad) of each waterbody. The responsibility for monitoring fish has been assigned to Inland Fisheries Ireland and AFBI in N. Ireland. A national fish stock surveillance monitoring programme has been initiated at specified locations in a three year rolling cycle (Kelly *et al.*, 2012).

Under the Eel Management Plan, monitoring Objective 4 relates to an intercalibration study between the Water Framework Directive Sampling and the Eel Monitoring Programme. This study was undertaken successfully in 2010 in Lough Ree and Upper Lough Erne. The WFD monitoring programme also addresses EMP Objectives 6 (eel stock status baseline), 7 (extent of upstream colonisation) and 8 (spread of *A. crassus*).

Initial indications from this intercalibration are that the size structure of the local eel populations and the cpue of the two surveys are generally comparable and it is intended to investigate this further. However, a low net effort and small number of sites lends itself to a wide variation in catch and therefore the higher net effort will be required to identify relative changes in eel stock structures and densities with any precision.

Approximately 81 lakes were surveyed by the WFD team in the three year cycle (2008–2010) compared with 13 lakes by the Eel monitoring programme. The WFD national programme gives a good representation of the state of the eel stocks in selected Irish lakes and will be repeated in each location every three years. Further analysis after the second three year cycle will give a clearer indication of how to use the WFD data for stock analysis. If the EMP surveys are restricted to less than 15 m depth, then the data between the two surveys should be interchangeable.

Harley *et al.* (2001) recommended that if using cpue to estimate abundance, surveys must be carried out multiple times or that the survey represents a good coverage of the stocked area. O'Neill *et al.* (2009) indicated that a high level of effort is needed to achieve good precision in the cpue estimates. The effort intensive eel specific fykenet surveys for the EMP are required in order to set a robust benchmark for the assessment of future changes in the stocks with a reasonable chance of detecting changes (O'Neill *et al.*, 2009). The intensive surveys have also resulted in a large dataset of morphological measurements. It is through these measurements that the maturation of the yellow eels into silvers will be assessed, a requirement for determining silver eel escapement. To determine the quality of eels in a lake such as age, growth and parasite prevalence, a large sample size is required. This requirement is not met under the WFD methodology with a maximum of 66 eels captured for a lake. Therefore, intensive fykenetting surveys, while time consuming, are required when assessment of the eel stock structure and detecting changes in same is the aim.

The use of fykenets to assess the population of eels in a lake must take into account the gear dependent fraction of the catch. Fykenetting samples a length class >30 cm (Naismith and Knights, 1990). Both mesh size and length of leader of the fykenets have been identified as introducing bias to the catch. Therefore the cpue used in this analysis refers to the population of eels >30–40 cm (Moriarty, 1972). However, generally the mesh size and leader length are standardised between the different surveys and are similar to those used in historical Irish surveys making it easier to compare the different results. Further analysis of how to relate cpue to population abundance is currently on-going through the EMP mark–recapture surveys.

9.4 Status of *Anguillicoloides crassus*

Monitoring Objective 8

In Chapter 3.4.2.3 of the National Eel Management Plan report, it was indicated that approximately 73% of the wetted area was infected by *Anguillicoloides*. In the interest of maintaining good eel quality, it was hoped that the further spread of the parasite might be reduced.

The eels captured during both the EMP surveys and the WFD surveys are checked for the presence of *A. crassus.* Prevalence and intensity rates vary from east to west, but the northwest and southwest of the country show little to no infection by *A. crassus*. A number of catchments, such as the Munster Blackwater, the Laune and the Fergus, have shown very low infection rates and patchy distribution which probably indicates recent introductions. Further monitoring and management will be necessary to maintain the parasite free status of catchments in these areas.

It should be noted that any transfer of water or fish, not only eels, can act as a vector for the spread of *A. crassus*. Therefore, any movements of fish or water between catchments should be undertaken with caution. This includes stocking programmes from hatcheries, transfers of coarse fish between waterbodies and bilge water in boats.

10 Catch composition by age and length

With the closure of the fisheries in 2009, there was no sampling of commercial catches in Ireland between 2009 and 2011.

The national monitoring programme described in Chapter 9 includes sampling length and age and these data are available to the WGEEL if required. All eels captured in the eel specific fykenet surveys and in the WFD surveys will be measured for length and samples of otoliths will be taken every three years from waters surveyed.

Age intercalibration is taking place annually and the guidelines reported by the ICES WKAREA are being used for age determination.

11 Other biological sampling

With the closure of the fisheries, there was no sampling of commercial catches in Ireland between 2009 and 2011.

All eels captured in the eel specific fykenet surveys and in the WFD surveys that are sacrificed for age determination will also be sexed and examined for parasites.

11.1 Length and weight and growth (DCF)

Sampling does not currently take place for DCF. Eels captured in the scientific surveys are measured for length and weight and growth will be determined from the otoliths.

11.2 Parasites and pathogens

All eels captured in the eel specific fykenet surveys and in the WFD surveys that are sacrificed for age determination will also be sexed and examined for parasites.

Parasite data will be supplied to the EEQD.

11.3 Contaminants

No new data in 2011.

11.4 Predators

No new data in 2011.

12 Other sampling

All eels captured in the national surveys were measured for determining their silvering status. Measurements taken include eye diameter and pectoral fin length.

13 Stock assessment

13.1 Local stock assessment

A national database is in the process of being compiled and this contains local stock assessment data. The main assessments included in the database are, single pass electrofishing surveys, multispecies 3 fishing depletion electrofishing surveys, boat electrofishing multispecies surveys, fykenet and electrofishing surveys under the Water Framework Directive and eel specific fykenet surveys.

A national programme of stock assessment and monitoring is outlined in the Eel Management Plan and in the Irish report to the EU. Index catchment have been intensively studied (Shannon, Erne, Corrib, Burrishoole) and these have been used to calibrate a wider assessment of data poor catchments. The stock surveys are all reported in the Irish Science Report to the EU 2012.

13.2 International stock assessment

The following sections are drawn from the National Eel Management Report which accompanied the EMPs submitted to the EU in 2008/2009. It was updated in the Ireland Report to the EU (2012).

13.2.1 Habitat

13.2.1.1 Introduction

A G1S based data model was established for the quantification of the freshwater salmon habitat asset and for the determination of the quantity of habitat available to migratory salmonids. 261 discrete migratory salmonid 'Fishery Systems' were identified nationally (McGinnity *et al.*, 2003; 2012). An additional four Northern Ireland catchments have been included in the quantification in support of the NWIRBD transboundary management plan. It is likely that eels are present in the majority or all of these systems although commercial fishing probably only takes place in 4.6% of them accounting for 71% of the total wetted area. It is also possible that this number of 265 catchments may change in the future as more information becomes available.

The river and lake network held in the EPA and CFB GIS and used for Water Framework Directive and other applications is derived from original 1:50 000 scale Ordnance Survey of Ireland mapping. The original OSI data has been subject to a thorough examination, removal of errors and addition of extra descriptor values so that the GIS version now contains:

- All component lines are 'with flow' in direction;
- Spurious breaks in the linework have been removed;
- Each "reach" or section between an upstream confluence and downstream confluence comprises a single line;
- Lines have been inserted through lakes to connect inflowing tributaries with the lake outflow point to enable linear network analysis in the GIS;
- Each reach is provided with a unique code identification number;
- Additional variables (including reach length, reach gradient, Strahler stream order number (Strahler, 1952), Shreve link magnitude number (Shreve, 1967), EPA river code have been added.

The number of lakes in the 1:50 000 scale GIS dataset comprises >12 000 units. Many are small and many are not connected to the river network by mapped channels. Each contains a unique identification number and measurement of surface area.

The national river network and lakes have been assigned to River and Lake Waterbodies for implementation of the Water Framework Directive. Rivers with a catchment area >=10 km^2 are included. In most instances the derived river waterbodies comprise a series of original 'reach' segments merged into longer waterbodies using Stahler stream order values to group connected reaches. Some 4500 waterbodies are identified.

The logic for the derivation of Lake Waterbodies from the national lake dataset requires that >=1 of the following three criteria is applicable:

- Lake surface area >50 ha;
- Lake is used for water abstraction;
- Lake occurs within a Protected Area designation.

Some 805 lake waterbodies are identified on this basis.

13.2.1.2 Wetted area

The wetted area model (2007) has its origin in a CFB methodology (Quantification of the Freshwater Salmon Habitat Asset in Ireland, 2003). It predicts the likely river width along rivers based on a statistical model built from information derived in a GIS (McGinnity *et al*., 2012).

The core GIS datasets used in the development of the model include the river and lake network at 1:50 000 scale (EPA WFD GIS); estimates of the catchment area u/s of each reach; the total length of river channel u/s of each reach, the gradient of each reach and the stream order value (Strahler, 1952). These factors were related to field survey measurement of the river width at some 277 sites to allow derivation of a statistical formula that predicts the width at any reach where these GIS variables are known.

* *a 'reach' is defined in the GIS as the river line between an upstream confluence and a downstream confluence - typically of the order of ½–1 km in length.*

An exercise to derive an improved model for river width prediction was undertaken in 2006/2007 (McGinnity *et al.*, 2012). A new series of field measurements of width were obtained with a more complete distribution across the national river network (in the 2003 study the surveyed rivers were concentrated in the Northwest and excluded the larger rivers from the sample). Arising from exploratory statistical analysis it was determined that the most appropriate model to estimate river width would be based on two predictive variables - the catchment area u/s of each reach and the stream link magnitude (Shreve, 1967) which is a less conservative form of hierarchical numbering of streams in a network than the Strahler stream order. Comparisons in Irish and Scottish rivers between modelled and measured widths were highly correlated and suggest that the model may be transferable to neighbouring geographic areas.

The estimated total freshwater wetted area* of the 265 lake, river and stream habitat accessible to migratory fish (including 1st order streams) in Ireland (including the Northern Ireland part of the Erne and the Loughs Agency Rivers in the Foyle and Carlingford areas) is 153 881 ha (Table 13.1). The 265 "migratory" systems were estimated to contain 132 275 ha of lake habitat, 21 606 ha of fluvial habitat, of which 2826 ha is estimated to be 1st order stream (calculated at a nominal width of 0.8 m). The ShRBD, WRBD and NWIRBD are clearly dominated by lacustrine habitat (Figure 13.1).

It is intended to refine this database in the future, adding in additional information such as obstacles to migration and natural barriers and groundtruthing the potentially productive area with the presence/absence of eels.

Habitat quality data using the Amiro (Amiro, 1993) and Rosgen (Rosgen, 1994) gradient classification systems are available. For example, in the Kerry Fisheries District 48% of the potential salmon producing habitat has a gradient of <0.5% (Amiro Class 1) (McGinnity *et al.*, 2003).

The area of transitional and coastal waters is summarised in Table 13.2 for each RBD. These areas were not considered in the productivity modelling for silver eel due to lack of eel data on these areas and a lack of a suitable methodology for estimating eel quantities.

Table 13-1. Total freshwater wetted areas (ha) for lake, first order fluvial and greater than first order fluvial habitat for each River Basin District, including Northern Ireland* (Erne, Drowes, Foyle, Roe and Faughan). *Data supplied by Inland Fisheries Ireland, Compass Informatics, the Loughs Agency and EHS Water Management Unit, Northern Ireland.

	Lake	>1st order fluvial	1st order fluvial	Total Wetted Area
EEMU	4861	1920	262	7043
SERBD	178	3626	412	4216
ShRBD	40 241	4487	590	45 317
SWRBD	7534	2714	419	10 666
WRBD	46 602	2869	473	49 944
NWIRBD	32 859	3165	670	36 694
Total	132 275	18 780	2826	153 881

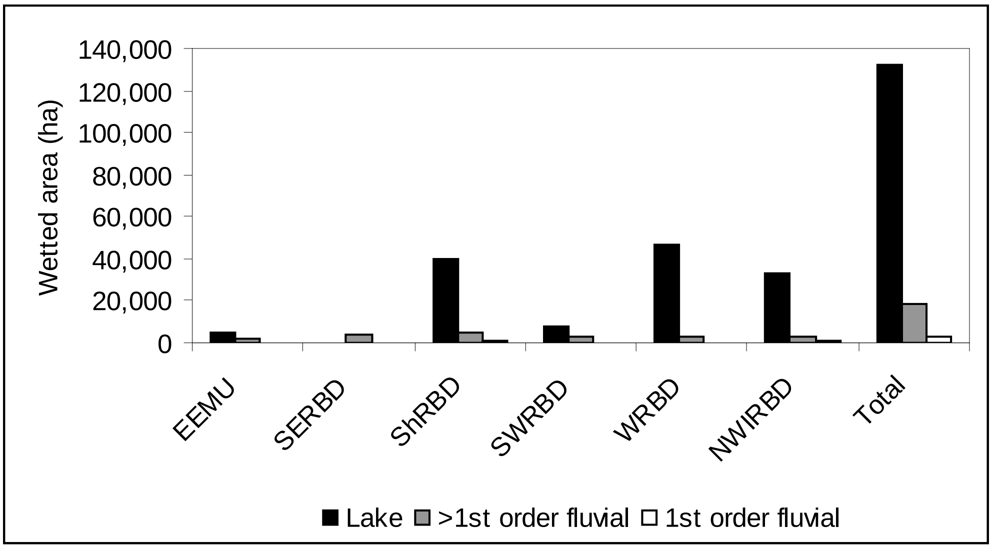

Figure 13-1. Total freshwater wetted areas (ha) for lake, first order fluvial and greater than first order fluvial habitat for each River Basin District, including Northern Ireland (Erne, Drowes, Foyle, Roe and Faughan).

Table 13-2. Total wetted areas (km²) for transitional and coastal waters for each River Basin District, including Northern Ireland (NWIRBD), but excluding the RoI part of the NBIRBD in the EEMU.

	Transitional Waters	Coastal Waters	Total Tidal Area
EEMU*	23	359	383
SERBD	90	1024	1114
ShRBD	250	1220	1470
SWRBD	166	3576	3743
WRBD	133	4574	4707
NWIRBD	131	2230	2361
Total (km²)	795	12 984	13 780

***excludes the RoI part of NBIRBD.**

13.2.2 Silver eel production

Ireland used a system of extrapolating from index data rich catchments to data poor catchments for calculating estimates of pristine and current biomass as described in the Irish Eel Management Plan (Chapter 5) and the WGEEL report (ICES, 2008).

Note: tidal and transitional waters were not included in the production and escapement analysis.

As set out in the EU template for the National Report 2012, the following definitions are adhered to:

B_0	The amount of silver eel biomass that would have existed if no anthropogenic influences had impacted the stock.
$B_{current}$	The amount of silver eel biomass that currently escapes to the sea to spawn.
B_{best}	The amount of silver eel biomass that would have existed if no anthropogenic influences had impacted the current stock.
ΣF	The fishing mortality rate, summed over the age groups in the stock, and the reduction effected.
ΣH	The anthropogenic mortality rate outside the fishery, summed over the age groups in the stock, and the reduction effected.
R	The amount of glass eel used for restocking within the country.
ΣA	The sum of anthropogenic mortalities, i.e. ΣA = ΣF + ΣH.

13.2.2.1 Introduction

The estimation of pristine and current (2008 based on the average of 2001–2007) silver eel biomass being produced and escaping was fully described in the National Eel Plan (2008, Chapter 5) and in ICES (2008, page 47). The calculation of pristine productivity for exploited catchments requires estimates of silver eel escapement along with historic silver and yellow eel catches, raised to account for unreported and also illegal catches. Historical catch records for silver eel fisheries were available for the five catchments of the Corrib, Moy, Garavogue, Burrishoole and Erne. The efficiencies of the fisheries had been previously estimated for the Shannon, Corrib and Erne silver eel fisheries. Where fishery efficiency was not measured an approximately average value of 33% was used to calculate escapement. In addition to the catch at the recording station and escapement past the recording station the yellow eel and silver eel catches made upstream were included to estimate pristine productivity. In the absence of historic data for these latter parameters (yellow and silver eel catches upstream of the recording station) it was assumed that the yields were equal to those currently observed (2001–2007). A similar process was used to calculate the 2008 production, based on the average of 2001–2007, and escapement using data from four catchments, the Shannon, Corrib, Burrishoole and Lough Ennell (estimate based on depletion fishing surveys by NUIG).

For those catchments with hydropower at the lower end of the catchment (Shannon, Erne, Liffey and Lee), an estimate of the impact was derived by imposing a 28.5% mortality per turbine passage (ICES, 2003). Therefore, the probability of surviving passage through 'n' number of hydropower installations is $(0.715)^n$. In this report, we have recalculated these estimates using the newly available hydropower mortality data.

Silver eel production was then determined for the other catchments by using a habitat based approach. The method involved determining the relationship between productivity and the geological characteristics of the catchment.

Growth rate of eel were available for 17 catchments (Moriarty, 1988; Poole, pers. com.; WFD). The wetted area within each catchment was quantified using a geographical information system and classified according to the proportion of the catchment area comprising non-calcareous geology. For 17 catchments growth rate was found to be closely negatively related to the proportion of the catchments comprising non-calcareous geology. This allowed the estimation of silver eel production to be made on the basis of geology (natural productivity) and growth rate.

Note: tidal and transitional waters were not included in the production and escapement analysis.

13.2.2.2 Historic production

Estimates of historic biomass were presented for each Eel Management Unit (EMU). During the course of 2009–2011 and the review for this report two errors were identified in the calculations, one in the Corrib historic escapement and one in the Erne historic escapement. This changed the estimated production in the Corrib from 3.38 kg/ha to 3.57 kg/ha and in the Erne from 4.50 kg/ha to 4.14 kg/ha. The corrected data for the two catchments are given in Table 13.3.

When the corrected data were inserted into the model for determining historic production for all the catchments, it made only a small difference in the overall silver eel production biomass estimate for each EMU and for the % escapement. Both datasets are presented in Table 13.4 and only the new historic biomass estimates will be used from this point forward.

13.2.2.3 Current production and escapement 2008

The production (B_{best}) and escapement ($B_{2001\text{-}2007}$) estimates presented in the EMPs are shown in Tables 13.4 and 13.5. The escapement was determined by subtracting the fisheries catch, raised to account for illegal and unreported, and then the remaining silver eel production was subjected to hydropower mortality at 28.5% per hydropower station where these occurred.

The escapements in 2008 were recalculated using the estimates of HPS mortality determined between 2009 and 2011, on the Shannon (21% and 17.8% bypass) and the Erne (cumulative 23%) and both datasets are included in Tables 13.4 and 13.5.

13.2.2.4 Production and escapement 2009–2011

The silver eel biomass produced and escaping during 2009 to 2011 in the monitored index catchments are given in Table 13.3.

These index data were then used to calibrate the IMESE model. The existing growth data was reused and it is hoped in the coming three year period to have new growth data to refresh the model. Figure 13.2 shows the relationship between the index data, the growth rate data and the geology (% non-calcareous).

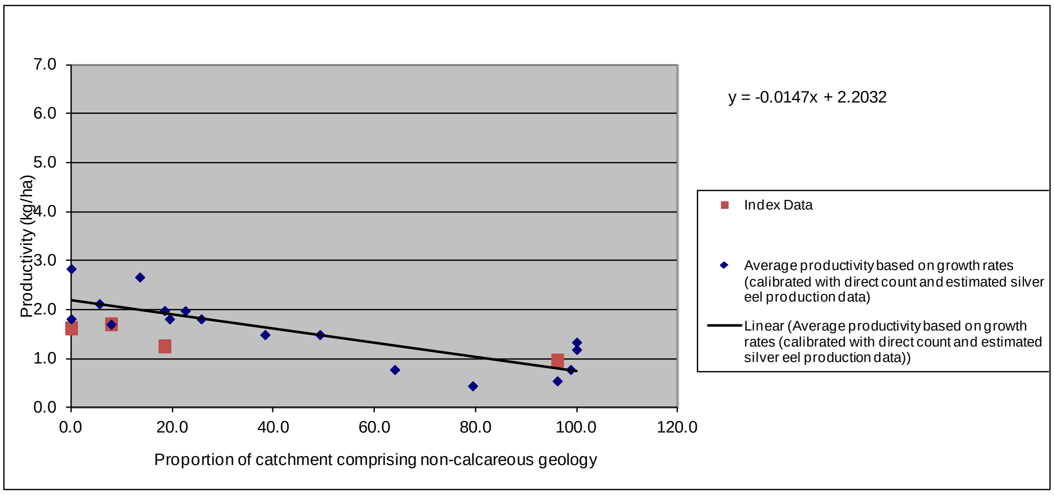

Figure 13-2. Average current (2009–2011) silver eel productivity based on growth rates calibrated with direct silver eel counts and estimated silver eel production indices for the same period.

The estimates of historic (B_o), 2008 and current silver production and escapement are given in Table 13.5 as calculated using the IMESE and summated by individual catchments for each RBD and current escapement was then estimated taking into account the HPS mortalities.. Where direct estimates were available for individual catchments, these were used instead of a modelled figure. It should be noted that the silver eel index locations were all on the west coast in 2009–2011. This may lead to inconsistencies when extrapolating to the East and south coast catchments. While a similar scenario existed for setting up the EMP, it is hoped to include at least one silver index on the east coast in the next three year period.

Current escapements are presented in Table 13.5 expressed as a percentage of the historic production. These are given for 2008 and for the 2009–2011 period as an average. The positive effect of the implemented management measures (fishery closure and silver eel trap and transport) can be clearly seen by the %SSB increasing from 24.4% (2008) to 36.8% (2009–2011).

13.2.2.5 Production values e.g. kg/ha

Production values (kg/ha) are shown in Table 13.3 for the index catchments.

13.2.2.6 Biomass and mortality overview

The diagrams below (Figures 13.4 and 13.5) plot the most recent stock assessment (2009–2011), and those presented in the Eel Management Plan (2008).

The data for each EMU and for the total are presented on the modified ICES precautionary diagram, as developed by the WGEEL using the EU management target (40% SSB) as the reference point and a calculated mortality reference point based on the EU management target (A_{lim} 0.92). The revised B_o and a recalculated 2008 figure using the turbine mortality estimates determined for Ardnacrusha between 2006 and 2011 and for the Erne 2010 and 2011 were used in these diagrams. The arrows in the diagrams indicate what effect the implementation of the management actions were expected to have.

In the EEMU, the ShIRBD, WRBD and NWIRBD, the mortality was clearly reduced as indicated by the downward direction of the bubbles and this led to increased escapement shown by right hand horizontal movement towards the 40% target. In some cases the bubbles did not respond as expected, by not moving as much to the right. This may due to some yellow eel still to feed through increasing the %SSB and moving the bubbles to the right in coming years. Or the negative impact of falling recruitment may now be leading to lower silver eel production, or there may be problems with some of the estimates as mentioned previously. Extrapolation to the east and south RBDs may need to be reviewed in the light of future additional data and for the NWIRBD diagram, either the 2008 bubble is too far to the right, due to an over-estimate of 2008 escapement, or the 2009–2011 bubble is too far to the left due to an underestimate of the current escapement or a combination of both. There is some evidence to suggest higher than previously thought yellow eel exploitation, especially in the Erne, which would increase mortality and reduce escapement of the 2008 bubble in the NWIRBD (See Ireland Report to EU 2012).

In general, we have demonstrated the increase in biomass of silver eel escaping and the reduction in mortality caused by fishing and hydropower. While further reduction in mortality is unlikely, it possible that additional biomass will feed through in the coming years from the closure of the yellow eel fishery. However, it is unclear how the collapse in recent recruitment will impact on silver eel biomass and whether density dependent effects (change from small males to higher proportions of larger females) will buffer the collapse in recruitment by temporarily increasing biomass of silver eels, even with falling numbers.

13.2.2.7 Timeframe to recovery

International scientific advice was to reduce the level of anthropogenic mortality to as close to zero as possible to achieve recovery of the stock (ICES 2008). An 85% reduction of anthropogenic mortality was estimated to be required to prevent continued decline from the current extremely low level of recruitment without achieving any long-term recovery (Åström and Dekker, 2007). The lower the anthropogenic pressure the greater the likelihood of recovery and the quicker the recovery will occur (See Chapters 5.3.1 and 5.3.2 of the National EMP 2008).

The Irish management actions implemented in the EMP resulted in no fishing mortality and markedly lower turbine mortality. According to the stock assessment of Åström and Dekker (2007), this should result in recovery of recruitment within approximately 90 years and achievement of the EU escapement biomass target in a similar or shorter timeframe, assuming the average European anthropogenic mortality is reduced to a comparable level.

Until the Member States report to the EU in July 2012, it will not be possible to reassess the timeframe to recovery. From anecdotal information, it seems that comparable actions were not implemented across Europe and therefore the timeframe will probably be longer.

In Ireland, current recruitment of glass eel from the ocean is at 1–13% of the historical level. This low recruitment leads to a low adult yellow eel stock and consequently a low stock of silver eel returning to the ocean to spawn. Under these circumstances, it is unlikely that that the 40% target SSB can be maintained. Recruitment has now become the limiting factor for recovery.

13.2.2.8 Impacts

The Eel Regulation sets a limit for the escapement of (maturing) silver eels, at 40% of the natural pristine escapement B_0 (that is: in the absence of any anthropogenic impacts and at historic recruitment). The EU Regulation thus sets a clear limit for the spawning–stock biomass, B_{lim}, as a percentage of B_0. However, no explicit limit on anthropogenic impacts A_{lim} is specified. A value for A_{lim} of 0.92 has been proposed (ICES, 2011a,b), i.e. the sum of all anthropogenic impacts over the entire continental life span should not exceed 0.92. Below B_{lim} ($B_{MSY\text{-}trigger}$), the mortality target should be reduced correspondingly (ICES, 2011b).

The Eel Regulation specifies a limit reference point (40% of pristine biomass B_0) for the size of the spawning stock in terms of biomass. For longlived species (such as the eel) with a low fecundity (unlike the eel), biological reference points are often formulated in terms of numbers, rather than biomass. For reference points based on biomass rather than on numbers, the relationship between relative spawner escapement (%SPR) and mortality (ΣA) is much more complex, but numerical simulation indicates that the relationship comes close to a reference point based on numbers (ICES, 2011b).

In the Irish EMP (2008), the silver eel production (B_{best}) and escapement ($B_{current}$) were converted from biomass to numbers in order to calculate mortality and a timeframe to recovery. Commercial catch–weight frequency distributions for yellow and silver eels (n >2300) were investigated for a number of catchments in 2008 (Corrib, Mask, Conn, Oughter, Erne, Waterford Estuary, Slaney Estuary, Shannon) (EMP, 2008). These size frequencies were used to convert the catch weights within those catchments to numbers of eels. The data were pooled to provide a national average weight distribution which was used to calculate numbers from the catches in all other catchments. Because the model was now based on numbers rather than weight, natural mortality was imposed on the yellow eel catch in order to determine the number of potential silver eels removed by the fishery. The yellow eel catch was assigned a maturation rate distribution, on the basis that if it was released or not caught, would therefore mature as silver eels, on average, over the following 0–10 years range (Irish EMP Section 5.2.4.3; Figure 13.3). Natural survival was estimated at 86% per annum. This level of survival was derived from a lifetime estimate for the non-Biscay stock as a whole spread over the residence time of Irish eels (Dekker, 2004).

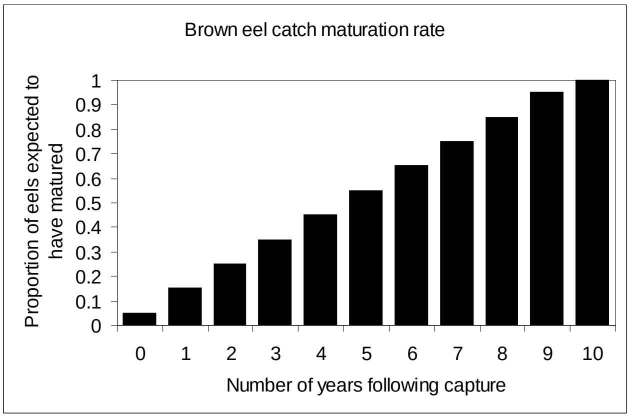

Figure 13-3. The approximated proportion of yellow eels expected to have matured to silver eel if the catch had not been killed.

Calculations of the instantaneous rates of fishing and turbine mortality were calculated based on silver eels alone, i.e. yellow eels caught by the fishery were converted to potential silver eels in order to quantify the pressure of the fishery on the stock.

$$\Psi = C_s + E + \Psi_b$$

(Ψ) potential silver eels, (C_s): silver eel catch, (E): escapement, (Ψ_b): potential silver eels from yellow eel catch.

$$\Psi_b = \sum_1^n (C_b).(P_n).(e^{-M})^n$$

(C_b): yellow eel catch, (P_n): proportion of yellow eel catch maturing in (n) years, (M): natural mortality.

$$F = -\ln((\Psi - C_s - \Psi_b) / \Psi)$$
$$H = -\ln(((\Psi - C_s - \Psi_b)*\partial) / \Psi - (\Psi - C_s - \Psi_b))$$
$$A = F + H$$

(A): anthropogenic mortality, (F): fishing mortality, (H): turbine mortality, (∂): proportion of run surviving turbine.

Table 13.6 presents the mortality data calculated using biomass ($-\ln(B_{current}/B_{best})$) and using numbers as described above. In Figures 13.4 and 13.5, the mortality data is calculated using biomass as follows:

F = - ln (what comes out / what goes in) or = $-\ln(B_{best}\text{-catch})/B_{best}$

H = idem, but B_{best} is not what goes into hydropower. (B_{best}-catch) is what goes in, and (B_{best}-catch-hydrokill) is what comes out, or $H = -\ln(B_{best}\text{-catch})\text{-hydrokill}/(B_{best}\text{-catch})$

Note that the past mortality on yellow eel has not been taken into account in the estimates of ΣF and ΣA for the 2009–2011 period due to lack of detailed catch data.

13.2.3 Stocking requirement eels <20 cm

A stocking requirement hasn't been calculated for Ireland and is not included in the first three years of the eel management plan.

13.2.4 Summary data on glass eel

No glass eel were captured, traded or consumed in Ireland between 2009 and 2012.

Table 13-3. Historic production (B_o), current production (B_{best}), current escapement, fisheries catch and estimates of turbine mortality for the Burrishoole, Corrib, Shannon and Erne. The top table presents the data as rates (kg/ha), the bottom table as total quantities (kg). ND = no data.

Catchment	Historic production (Bo) kg/ha	Best possible production (Bbest) kg/ha					Escapement (Bcurrent) kg/ha					Fishery Catch (kg/ha). *including unreported & illegal					Turbine Mortality (kg) ** 2001–2007 recalculated using '09–'11 estimates				
		2001–2007	2009	2010	2011	Average 2009–2011	2001–2007	2009	2010	2011	Average 2009–2011	2001–2007*	2009	2010	2011	Average 2009–2011	2001–2007**	2009	2010	2011	Average 2009-2011
Burrishoole	0.928	1.37	1.27	0.87	0.75	0.96	1.37	1.27	0.87	0.75	0.96	0	0	0	0	0					
Corrib	3.57	1.68	1.25	ND	ND	ND	0.46	1.25	ND	ND	ND	1.22	0	0	0	0					
Shannon	4.45	2.02	1.75	1.62	1.54	1.64	0.29	1.57	1.42	1.36	1.45	1.76	0	0	0	0					
Erne	4.14	3.28	ND	1.59	1.64	1.62	1.25	ND	1.46	1.54	1.50	1.70	ND	0	0	ND					
Burrishoole	440	649	602	410	354	455	649	602	410	354	455	0	0	0	0	0	0	0	0	0	0
Corrib	103,062	48,455	36,100	ND	ND	ND	13,371	36,100	ND	ND	ND	35,084	0	0	0	0	0	0	0	0	0
Shannon	188,849	85,700	74,382	68,920	65,558	69,620	12,163	66,788	60,170	57,885	61,614	74,600	0	0	0	0	5,969	4,095	8,210	7,673	6,659
Erne	107474	85,140	ND	41,232	42,702	41,967	32,542	-	37,942	39,858	38,900	44,239	ND	0	0	ND	9,403	ND	3,047	2394	2,721

Table 13-4. Historic (B_o) and current (B_{best} - 2008) silver eel production (t) and escapement ($B_{current}$) (t) and the percent escapement of historic production calculated using the IMESE model and inserting actual catchment data where they exist. The data for historic production were reworked and the recalculated data are presented along with those as presented in the EMP (2008). The current 2008 escapements are presented as in the EMP, with 28.5% average turbine mortality*(28.5% for hydropower and 30% Shannon bypass), and recalculated using the turbine mortalities determined during 2009–2011 (Erne (23%) and Shannon (21.1% and 17.8% bypass).**

The shaded columns are the definitive columns of biomass data with the most recent data.

	Historic Production (EMP) (kg)	Historic Production Recalculated (kg)	Current 2008 Production (kg)	Current 2008 Escapement (kg)	Current 2008 Escapement Recalculated (kg)	Current 2008 Escapement as % of Historic Production (EMP)	Current 2008 Escapement as % of Historic Production Recalculated Bo	Current 2008 Escapement as % of Historic Production Recalculated Bo & **
EMU	B_o	B_o	B_{best}	$B_{current}$ - 2008*	$B_{current}$ - 2008**	%	%	%
EEMU	21785	20490	14186	7008	7008	32.2	34.2	34.2
SERBD	15723	14813	10069	8707	8707	55.4	58.8	58.8
SWRBD	25925	24526	17390	16603	16603	64.0	67.7	67.7
ShIRBD	214048	201156	94231	19599	19,902	9.2	9.7	9.9
WRBD	170403	189167	96924	41578	41578	24.4	22.0	22.0
NWIRBD	146536	135760	103511	38014	48759	25.9	28.0	35.9
National	594420	585912	336311	131509	142847	22.1	22.4	24.3

Table 13-5. Freshwater wetted area, historic (B_o), current (B_{best} - 2008) and current (B_{best} 2009–2011) silver eel production (kg) and escapement ($B_{current}$) (kg) and the percent escapement of historic production. The escapements for 2008 are presented as in the EMP, with 28.5% average turbine mortality, and recalculated using the turbine mortalities determined during 2009–2011. Mortalities are calculated on biomass. The shaded columns are the definitive columns of biomass data with the most recent data.

	Freshwater Wetted Area ha	Bo Historic	Bbest 2008 Prod	2008 Escap at 28.5% HPS*	2008 Escap at new % HPS**	Bbest 2009–2011 Prod	Bcurrent 2009–2011 Escap	2008 EU%	New % HPS 2008 EU%**	2009–2011 EU %
EEMU	7,043	20,490	14,186	7,008	7,008	9,555	9,430	34.2	34.2	46.0
SERBD	4,216	14,813	10,069	8,707	8,707	6,754	6,754	58.8	58.8	45.6
SWRBD	45,317	24,526	17,390	16,603	16,603	11,637	11,282	67.7	67.7	46.0
ShIRBD	10,666	201,156	94,231	19,599	19,902	75,377	68,718	9.7	9.9	34.2
WRBD	49,944	189,167	96,924	41,578	41,578	68,650	68,650	22.0	22.0	36.3
NWIRBD	36,694	135,760	103,511	38,014	48,759	54,256	51,545	28.0	35.9	38.0
Total	153,881	585,912	336,311	131,509	142,847	226,239	216,379	22.4	24.3	36.9

*** escapement calculated using 28.5% for hydropower and 30% Shannon bypass.**

**** escapement recalculated for 2001–2007 using current estimates of mortality for Hydropower in the Erne (23%) and Shannon (21.1% and 17.8% bypass).**

Table 13-6. Mortality rate table of fishing mortality (ΣF), anthropogenic mortality outside the fishery (ΣH) and the sum of anthropogenic mortalities, (ΣA = ΣF + ΣH) using the most recent data updates. Mortality rates are calculated using biomass and also converting to numbers. Fishing mortality includes raising factors for illegal and unreported catches. *F* in 2009–2011 does not take into account yellow eel fishing mortality on the stock prior to 2009.

	biomass						numbers					
	ΣF* 2008	ΣH 2008	ΣA 2008	ΣF 2009–2011	ΣH 2009–2011	ΣA 2009–2011	ΣF* 2008	ΣH 2008	ΣA 2008	ΣF 2009–2011	ΣH 2009–2011	ΣA 2009–2011
EEMU	0.68	0.03	0.71	0.00	0.01	0.01	0.45	0.02	0.47	0.00	0.01	0.01
SERBD	0.15	0.00	0.15	0.00	0.00	0.00	0.15	0.00	0.15	0.00	0.00	0.00
SWRBD	0.01	0.04	0.05	0.00	0.03	0.03	0.01	0.03	0.04	0.00	0.02	0.02
ShIRBD	1.29	0.26	1.55	0.00	0.09	0.09	0.72	0.14	0.86	0.00	0.1	0.1
WRBD	0.85	0.00	0.85	0.00	0.00	0.00	0.62	0.00	0.62	0.00	0.00	0.00
NWIRBD	0.58	0.18	0.75	0.00	0.05	0.05	0.36	0.19	0.55	0.00	0.05	0.05
Total	0.75	0.11	0.86	0.00	0.04	0.04	0.49	0.10	0.59	0.00	0.04	0.04

ΣF **The fishing mortality rate, summed over the age-groups in the stock, and the reduction effected.**

ΣH **The anthropogenic mortality rate outside the fishery, summed over the age-groups in the stock, and the reduction effected.**

ΣA **The sum of anthropogenic mortalities, i.e. ΣA = ΣF + ΣH.**

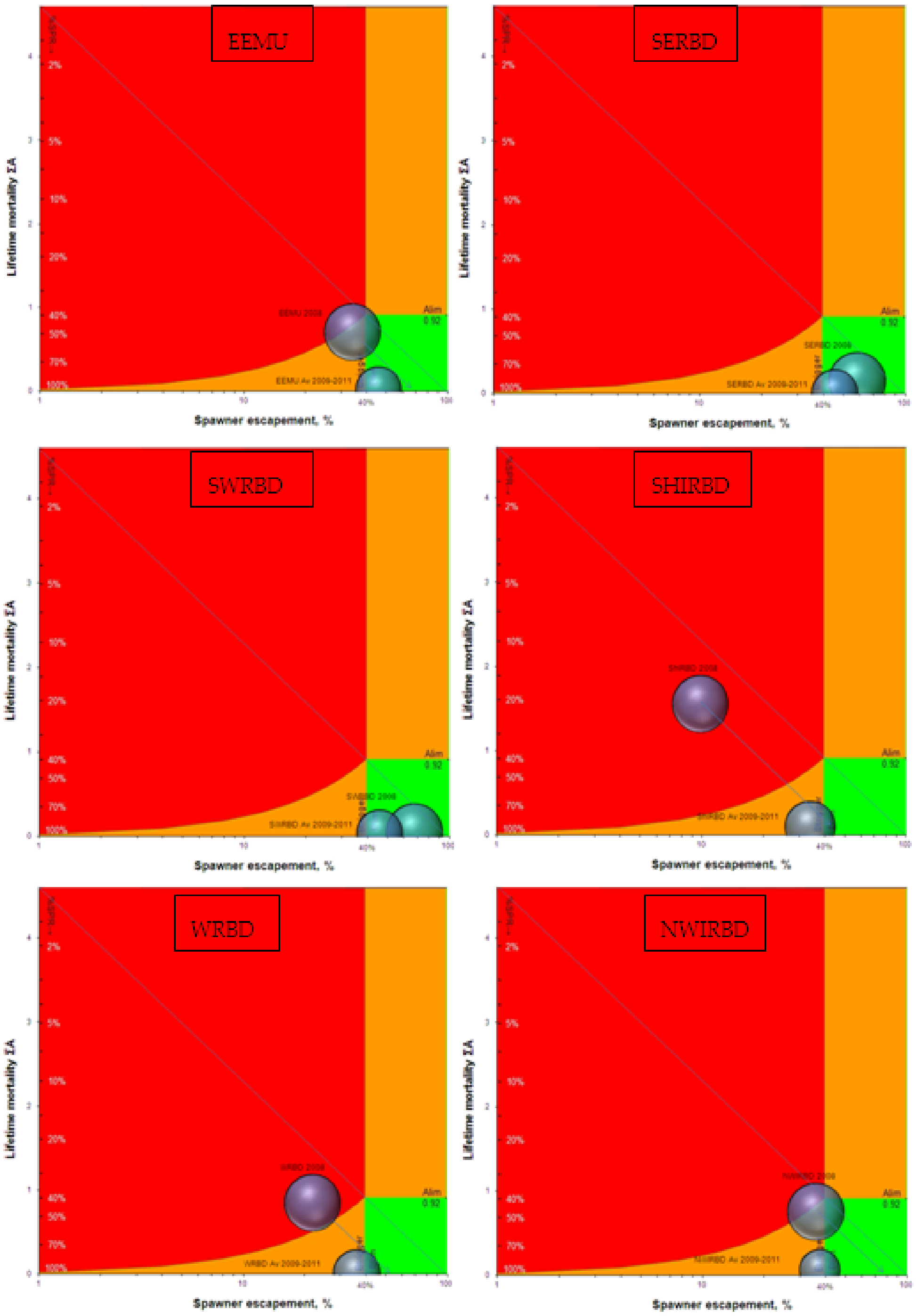

Figure 13-4. Status of the stock and the anthropogenic impacts, for each EMU in 2008 (average 2001–2007) and for the 2009–2011 period. For each, the size of the bubble is proportional to B_{best}, the best achievable escapement given recent recruitment, while the centre of the bubble gives the stock status relative to the targets/limits. The horizontal axis represents the stock status related to pristine conditions while the vertical axis represents anthropogenic mortality.

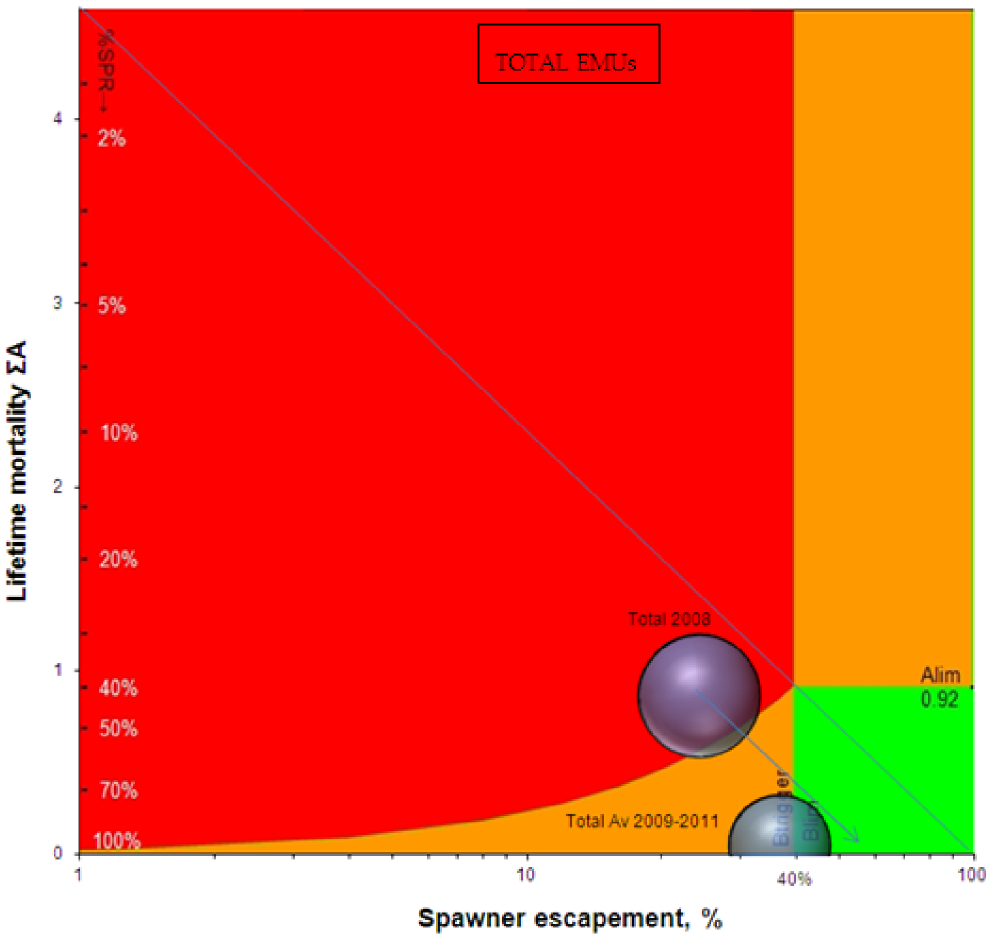

Figure 13-5. Status of the stock and the anthropogenic impacts, for total EMUs in 2008 (average 2001–2007) and for the 2009–2011 period. For each, the size of the bubble is proportional to B_{best}, the best achievable escapement given recent recruitment, while the centre of the bubble gives the stock status relative to the targets/limits. The horizontal axis represents the stock status related to pristine conditions while the vertical axis represents anthropogenic mortality.

14 Sampling intensity and precision

14.1 Fykenet surveys – extracted from SGAESAW 2009

Fykenets are a common gear for capturing anguillid eels in both commercial and research fisheries. Researchers may use fykenet catches for estimating biological parameters of local populations, for tracking abundance trends, or for mark–recapture population estimates. Size selectivity of fykenets and the relation between fykenet catch per unit of effort (cpue) and its standard deviation were examined using data from western Ireland.

In 1987 and 1988, 2614 eels were captured in fykenets, marked and released in the Burrishoole (Poole and Reynolds, 1996a). The proportion of these eels which were recaptured in fykenets increased from nil at length 30–35 cm to over 0.2 at length 60–65 cm (Figure 14.1). This size bias must be accounted for if slopes of length–frequency distributions are used to determine biological parameters.

Based data from >20 000 net-nights (Matthews *et al.*, 2001; Poole, 1994), the standard deviation of cpue increased linearly with cpue (Figure 14.2). Increasing the number of fykenets in a chain of nets from five to ten did not decrease standard deviation of cpue (Figure 14.3). This suggests that increasing chain length does not assist in achieving accurate estimates. Instead, more locations or more fishing nights may be more helpful in producing accurate estimates. A power analysis indicates that the sample size required to achieve a given precision in cpue is strongly influenced by population density. Overall, cpue is an insensitive tool with wide variation in numbers and weight per net. A relatively high effort is required to attain tight precision in cpue.

For the Irish surveys, the number of hauls required to achieve even modest precision in cpue (e.g. CV =10%) is high, especially where eel density is low (Figure 14.4). Achieving a CV of 10% where the average cpue is high requires approximately 50 hauls. Assuming chains of 5 fykenets are used this equates to 250 net-nights.

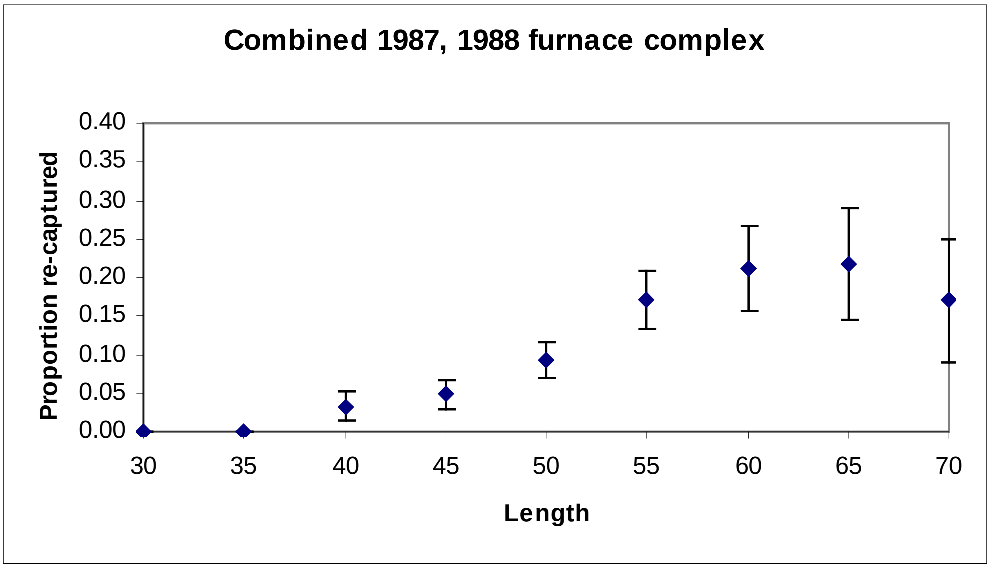

Figure 14-1. Proportion of European eels recaptured in fykenets in relation to length.

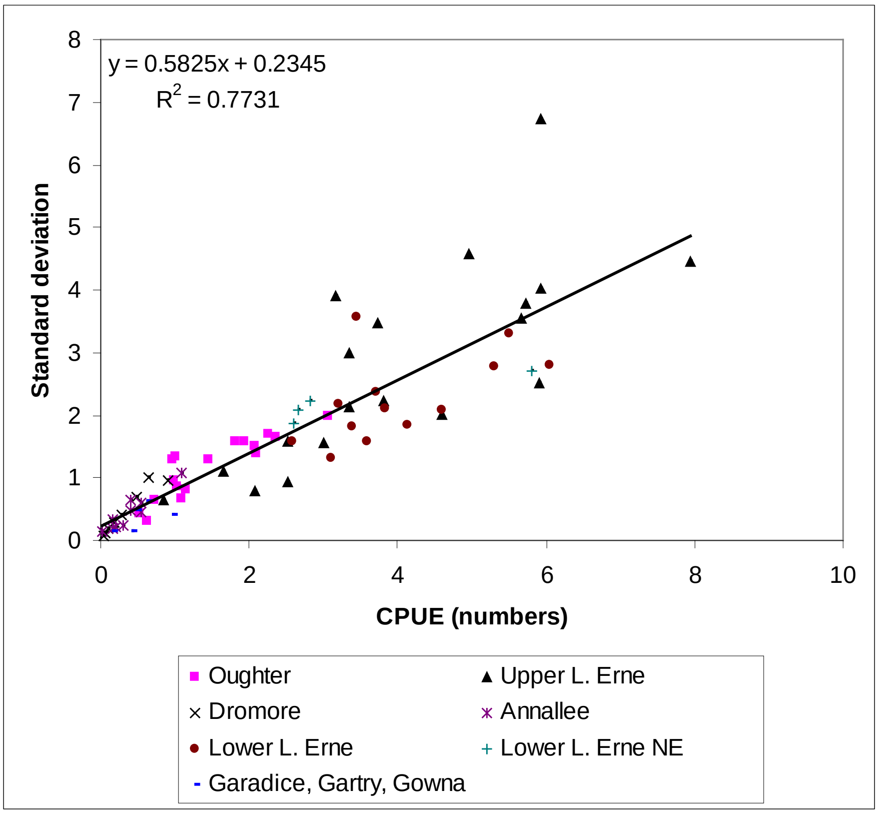

Figure 14-2. Relation between the standard deviation of 5 fyke chain cpue and cpue.

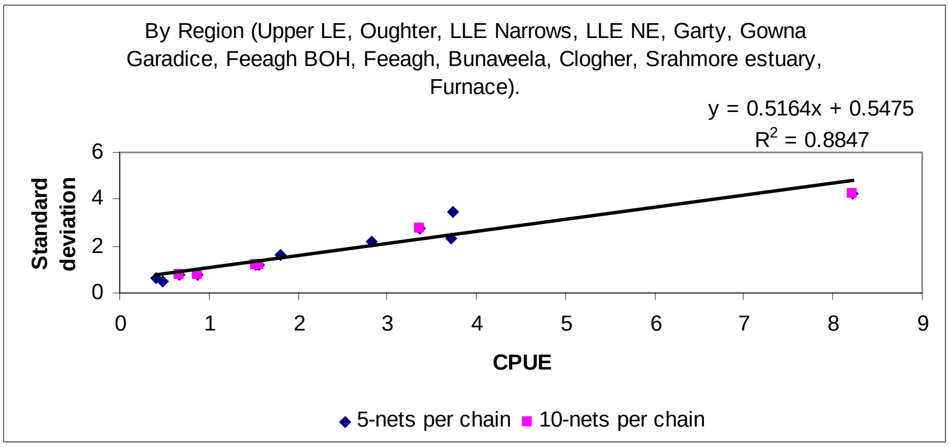

Figure 14-3. Relation between standard deviation and cpue for fykenets with five and ten nets per chain.

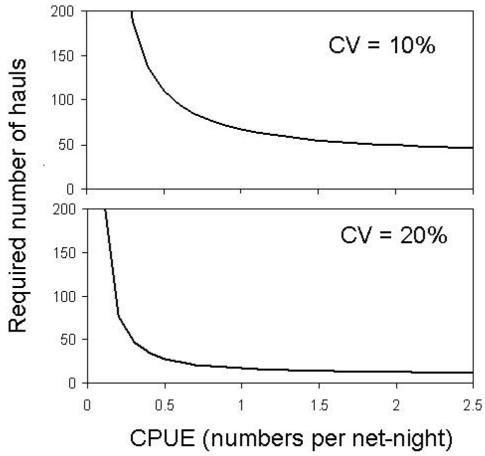

Figure 14-4. Power analysis of the number of hauls required to achieve precision levels in cpue consistent with indicated coefficients of variation. The required sample size is highly sensitive to the population density (assuming cpue is directly related to density).

14.2 Length sampling of silver eel

Data for length, weight, age, etc. have not been analysed in detail as a time-series or to look at change over time. Annual variation has been observed in silver eel lengths and this raises an issue relating to timing of sampling and differential timing of migration of large and small eel.

The lunar silver eel length data collected in 1995, and in other years, indicates a change in length distribution of the migrating silver eels throughout the season (Figure 14.5). This means that careful planning of silver eel sampling is required.

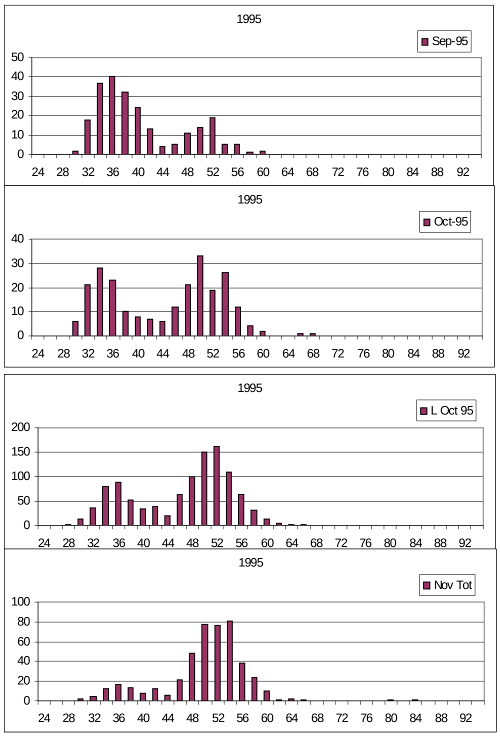

Figure 14-5. Monthly length distributions, taken for each lunar phase, for Burrishoole silver eels.

15 Standardisation and harmonisation of methodology

15.1 Survey techniques

Fykenets – Standard summer fykenets (Matthews *et al.*, 2001; McCarthy *et al.*, 1994; Moriarty, 1975; Poole, 1990; 1994; Poole and Reynolds, 1996a) have been widely used in eel surveys around Ireland since the early 1970s. The nets used have been generally similar in all the surveys, normally fished in chains of five or ten nets. A "typical" summer fykenet consists of two traps (each 3.3 m in length), facing each other, joined by a leader net (8 m in length), mesh size 16–18 mm. Each trap consists of two chambers and a codend with knot to knot mesh sizes of 16, 12, and 10 mm respectively. The diameter of the trap entrance was 58 cm and the outer ring of each trap was 'D' shaped.

Catch per unit of effort (cpue) data are normally reported in number of eels, or weight, per net (pair of traps) per night fished.

Fykenets are the standard tool for the 2009–2011 monitoring programme.

Longlines – Longlines have not been extensively used as a survey tool in Ireland. On the Shannon (McCarthy and Cullen, 2000) longlines have been standardised and the bait is restricted to earthworm allowing some comparisons to be made between fishing areas and years.

River Surveys – In deeper rivers and estuaries, fykenets have been the standard survey tool. In smaller rivers electrofishing is generally employed, in spite of being fraught with difficulties when applied to eel, with a variety of backpack portable and bankside generator gear being used. Single pass and three fishing depletion methods are used, but often eel assessments are carried out as a "byproduct" of other surveys, in particular salmonid surveys.

15.2 Sampling commercial catches

There was no National programme for sampling commercial catches in Ireland during 2009–2011.

Erne – The survey of the Erne catchment 1998–2001 was carried out using a semi-commercial research team of crews (Matthews *et al.*, 2001). An observer was placed with each crew at least once a week to ensure standardisation. Eels were stored in keep nets or boxes similar to those used by commercial fishermen. Eels were graded and sold to eel dealers at the lake shore. The entire catch was sampled prior to grading and the fishermen were paid full price for undersized eel, before their release.

Shannon – Before 2009, commercial crews were authorised by the ESB sell to eel dealers at lakeside locations on designated dates. ESB staff and NUIG researchers attended at sales points, to monitor catches and to obtain samples for length, weight, age and parasitology analyses. Dealers were required to provide advance notice of their collection schedules. Comparisons were made annually between sales statistics and cumulative catches, reported in logbooks, by the fishing crews. Dealers were required to disinfect truck tanks, monitored by ESB staff, before collections begin and to ensure that no water/potential pathogens were introduced to the river system.

15.3 Sampling

Catch sampling is normally carried out on anaesthetised eel, although some samples may be taken from either freshly sacrificed or frozen samples. Lengths measured to ±0.1 cm and weights to ±5 g. Otoliths are stored dry in paper envelopes.

15.4 Age analysis

Age analysis of eel in Ireland has generally followed the methodology of burning & cracking (Christensen, 1964; Cullen and McCarthy, 2003; Hu and Todd, 1981; Moriarty, 1983; Poole and Reynolds, 1996b; Vollestad *et al.*, 1988). Otoliths are extracted as described by Moriarty (1973), stored dry and prepared by burning in either gas or spirit flame. There is no formal validation or quality control in Ireland. Some cross validation and double reading has been carried out between projects and between agencies and this has ensured some degree of continuity between samples and surveys, (i.e. Moriarty, 1983; Poole *et al.*, 1992; Matthews *et al.*, 2001; Matthews *et al.*, 2003; Maes, unpublished). Comparisons have also been made between age derived growth (back-calculations) and tag/mark–recapture determined growth, thereby validating the use of burning & cracking otoliths for age and growth determinations in slow growing Irish eel (Poole and Reynolds, 1996a; Moriarty, 1983).

Ireland is using the recommendations and manual of the ICES Workshop on Eel Age WKAREA 2009 and 2011. An initial training workshop was held in Inland Fisheries Ireland in February 2010, using the WKAREA information as a guideline and a follow-up workshop was held in the Marine Institute in February 2012.

15.5 Life stages

Glass Eel/Elver life stages are determined the pigmentation classification using that published by Elie *et al*. (1982).

Yellow eel and silver eel are categorised by a combination of capture method and season, colouration and eye size. Silver eels are generally captured during their downstream migration, or can be recognised in the yellow eel catch by the enlarged eyes and onset of coloration change.

15.6 Sex determinations

Yellow eel <25 cm are problematical to sex and >25 cm up to 45 cm are sexed by dissection.

Silver eel are sexed by length and some studies have carried out dissections on eels between ~38 cm and 48 cm in order to determine the length overlap between the sexes. Histological verification has not been used to any extent in Ireland.

16 Overview, conclusions and recommendations

Recruitment time-series are effort independent and up to date for the Shannon and Erne. Data is awaited for the other Stations for 2012.

Catch statistics are up to date to 2008 and with the closure of the fisheries in 2009, 2010 and 2011, these data cease to exist.

Ireland submitted an EMP and this was accepted in July 2009.

Ireland has implemented its management actions in 2009, 2010 and 2011 and undertaken the National Monitoring programme also in 2009–2011.

Ireland intends determining current escapement on a three year rolling average (2009–2011) in line with the reporting schedule laid out in the EU Regulation. Where available historic production estimates, wetted areas, etc. were also be improved and updated for 2012. Ireland submitted a Report to the EU in 2012 with 3B & A estimates for all freshwaters. Estimates were not provided for transitional and coastal waters.

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Report on the eel stock and fishery in Italy 2011/'12

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Reporting Period: This report was completed in August 2012, and contains data up to 2011 and some provisional data for 2012.

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2 Introduction

The years 2010, 2011 and 2012 have been important years in Italy with regards to eel management. Following the submission of the Italian Eel Management Plan (IT-EMP), with the latest amendment submitted to the European Community September 30, 2010, the Plan was finally adopted in July 2011 (PNG Italia, 2010). With it, Italy has set the instrument to participate in the process recovery of the eel stock, as required by Regulation 1100/2007.

Meanwhile, at different levels in Italy the process of implementation of the IT-EMP was already in place. The work concerning the IT-EMP has been coordinated within a National Working Group that has involved Administrations, Technicians and Scientists. During the first part of 2012, the work of the Nat Working Group has been finalized to the gathering of data for the evaluation of the parameters required to assess progress achieved through the implementation of the National EMP, as foreseen by Article 9 of Regulation 1100/2007, for the first report (PNG Italia, 2012). Italy, as extensively explained in the IT-EMP and as discussed during the consultation meetings organized by the EC DGMare, has followed the approach of using a database for assessment progressively implemented. Compared to 2008, when the work for the compilation of the IT-EMP was initiated, a series of tools and activities have been put in place, that have resulted in a database much more detailed and reliable, and therefore for the assessment of the reference points required for the report foreseen by Art. 9 this updated dataset has been used.

Eel (*Anguilla anguilla* L.) exploitation in Italy has a long standing tradition, and is still important, despite a loss of interest towards this species. Fisheries still concerns all continental stages, i.e. glass eel, yellow and migratory silver eel. The most distinctive exploitation pattern for eel in Italy has been in the past coastal lagoon fishery, that yielded most of yellow and silver eel extensive culture and fishery production (Ciccotti, 1997; Ciccotti *et al.*, 2000; Ciccotti, 2005). Quite important was also eel intensive aquaculture, that played a major role within the national and European context up to a few years ago and that has strongly reduced today (Ciccotti *et al.*, 2000; Ciccotti and Fontenelle, 2001).

Eel is still present in lagoons and inland waters in all the regions, but its density, population characteristics and growth vary widely depending on the type of environment (lagoons, rivers, lakes), hence production patterns are also very diverse.

Lagoons cover around 1500 km^2, 610 of which are exploited at the present moment. Of the exploited area, about 300 km^2 are located in the upper Adriatic and 120 in the Po Delta, the rest being scattered in Puglia, Campania, Lazio, Toscana, Sicilia and Sardegna (Ardizzone *et al.*, 1988). In the upper Adriatic lagoons the typical form of management was the *vallicoltura* that slightly differed from other lagoon management and fisheries because relying on fry stocking and active hydraulic management.

Inland eel fisheries are still found in main rivers and lakes, even if a relic activity. Professional eel fisheries in rivers have never been important, confined to the low course of a small number of rivers even in the past, and further reduced now. Most of the eel catches were from the great Alpine lakes in the northern regions, but the eel also was an important target species for professional fisheries in some volcanic lakes of Central Italy. In lakes, fisheries were enhanced by eel restockings because accessibility to lakes was reduced also in pristine times owing to the structure of river-lakes systems, and secondarily to presence of dams, most of which were implemented after the II World War. Recreational eel fisheries, still allowed on the whole national territory, were common in some specific regions in relation to local traditions, and are still present with a patchy pattern.

Administrative responsibility for eel fisheries is relatively dispersed: sea fisheries and sea fishing up to river mouths come under the remit of central government (Ministry of Agricultural, Food and Forestry Policy, Directorate General for Sea Fishing and Aquaculture), whilst the regions are responsible for freshwater fisheries, including eel fishing, since Presidential Decrees No 11 of 15 January 1972 and No 616 of 24 July 1977 gave them this responsibility. Therefore the only eel fisheries under a central administration are the glass eel fisheries practiced in estuaries, as no marine adult eel fishery exists in Italy. With regards to inland fisheries, that include lagoon as well as lake and river fisheries, each region has its own regulations, none specific for eel. Up to now, as a rule individual professional fishing licences are issued, which are valid for six years, by each region, and are enlisted in registers kept by the provinces. The permitted gears vary from region to region, also in relation to local traditions, and are specified by each administration, together with authorised times and places. For the nets, mesh sizes and minimum and maximum dimensions of gears are listed.

Professional glass eel fisheries did occur in many river mouths, and in many channel mouths as well, while glass eel catch for recreational purposes is forbidden everywhere. Most of the glass eel yield was from the central and southern Thyrrenhian area. The main sites of glass eel catches were the estuaries of rivers such as the Arno and Ombrone in Toscana, the Tiber and the Garigliano in Lazio, and the Volturno and Sele in the Campania region. Those sites were frequented not only by local fishermen but occasionally also by fry fishermen from other regions, who reached those sites with trucks equipped with oxygenated tanks to collect mullet, sea bass, sea bream and eel fry. Local fishermen were usually single or cooperative fishermen that are were equipped with boats and structures to store the product alive. Fishing instruments vary depending on the characteristics of the site.

The management framework described above has influenced the setting up of the Eel National Management Plan (IT-EMP) foreseen by Regulation 1100/2007. IT-EMP takes into account the complexity of the situation in the country, and is therefore a combined plan: it provides a national framework covering coastal waters and those administrative regions which preferred to delegate eel management to central government (eleven regions in all, see Table IT.1.). For these eleven regions, a total closure of all eel fishing is foreseen, both commercial and recreational, and the transposition of this indication into regional regulations is underway. The remaining nine regions have drawn up their own Regional Eel Management Plans, which were prepared on a coordinated basis and using a standard calculation method for defining targets, whilst the intervention measures and implementation aspects were defined according to regional regulations. Italy has in fact decided to avail itself of the opportunity provided in Article 2 of the regulation, which stipulates that *'if appropriate justification is provided, a Member State may designate the whole of its national territory or an existing regional administrative unit as one eel river basin'* and, for the reasons highlighted above, therefore has proposed the regional administrations as Eel Management Units, point accepted by the Commission.

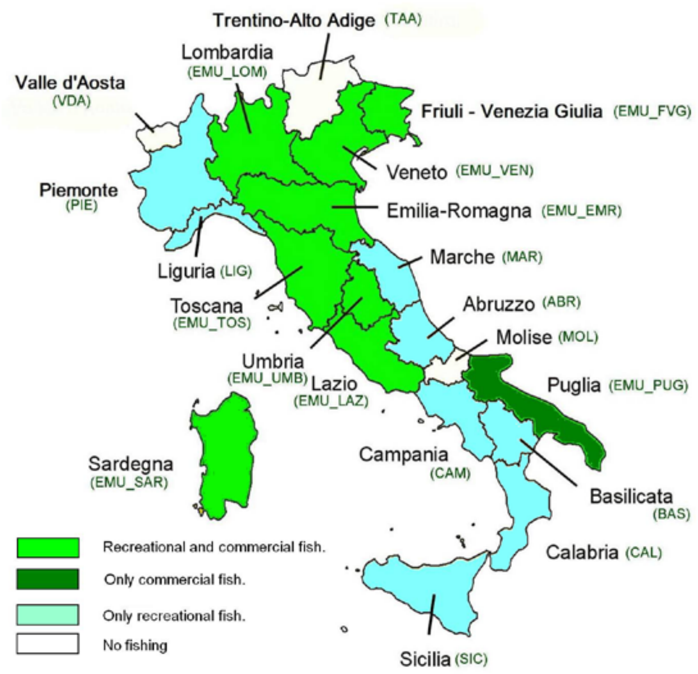

Figure IT.1. The 20 Italian Regions. Nine produced an Eel Regional Management Plan (green), eleven Regions have closed commercial eel fisheries (white), where only recreational fisheries are still allowed.

Figure IT.1 shows the geographical distribution of the regions that have provided their regional plans. In all these, areas of particular importance for eel fishing are included, either in terms of the presence of wetland areas (Grado and Marano Lagoons, the Venice Lagoon, the Po Delta and Valli di Comacchio, Lesina and Varano Lagoons, Orbetello Lagoon, Pontini Lakes and Sardinia's coastal wetlands) or in terms of the historical importance of eel fishing in the region's inland waters (Lombardia, Umbria, Lazio).

In each region/Management Unit, different habitat typologies (such as coastal lagoons, with or without fish barriers, lakes and rivers) have been considered. In fact in the different Italian EMU a great ecological heterogeneity exists, that reflects also in a diversified productivity of the different aquatic environments within each region/Management Unit. The habitat categories that were identified are as follows: coastal lagoons, lakes, rivers. In the case of coastal lagoons, for those regions that follow different management strategies an explicit distinction has been introduced, within the lagoons specifically managed (fish stockings, presence of fish barrier) from the lagoons where only artisanal fisheries are present. In Table IT.1, the wetted areas for the different habitat typologies in each administrative region in Italy are reported. A distinction is made between regions without a MP, where eel fishing has closed definitively, and regions with a Management Plan, that have been identified as EMU.

Table IT.1. Wetted area for the different habitat typologies in each administrative region in Italy. A distinction is made between regions without a MP, where eel fishing has closed definitively, and regions with a Management Plan, that have been identified as EMU.

Region or EMU	Code of Region or EMU	Regional Eel Management Plan	Lagoons (ha)	Managed lagoons (ha)	Private lagoons (ha) *	Rivers (ha)	Lakes (ha)	Total wetted area (ha)
Valle D'Aosta	VDA	N	-	-	-	-	-	0
Piemonte	PIE	N	-	-	-	-	780	780
Lombardia	EMU_LOM	Y	-	-	-	1.676	4.487	6.163
Trentino Alto Adige	TAA	N	-	-	-	-	370	370
Friuli Venezia Giulia	EMU_FVG	Y	12.700	-	1.660	1.356	-	15.715
Veneto	EMU_VEN	Y	63.120	-	18.597	9.252	1.665	92.633
Liguria	LIG	N	-	-	-	344	-	344
Emilia Romagna	EMU_EMR	Y	3.100	12.263	6.000	5.663	-	27.026
Toscana	EMU_TOS	Y	-	2.700	-	1.025	39	3.764
Marche	MAR	N	-	-	-	228	-	228
Umbria	EMU_UMB	Y	-	-	-	12.800	-	12.800
Lazio	EMU_LAZ	Y	913	630	-	714	1.145	3.402
Abruzzo	ABR	N	-	-	-	236	-	236
Campania	CAM	N	-	487	-	570	-	1.057
Molise	MOL	N	-	-	-	73	-	73
Calabria	CAL	N	-	-	-	192	-	192
Basilicata	BAS	N	-	-	-	218	-	218
Puglia	EMU_PUG	Y	11.533	-	-	414	-	11.947
Sardegna	EMU_SAR	Y	3.336	4.625	-	600	-	8.561
Sicilia	SIC	N		278	-	238	-	516
Total Italy			95.467	20.218	26.256	22.799	8.486	173.225

*** Private lagoons are not included in Regional Management Plans.**

Habitat	Code
River	RIV
Lake	LAK
Lagoon	LGN
Managed lagoon	MLG

A distinctive feature of the IT-EMP, which reflects on management at the national level, concerns the reforming of the regulation for glass eel fishing. The IT-EMP, in agreement with the individual Regional Management Plans, envisages fishing of glass eels (eels <15 cm), however the legislation governing this fishery has been radically changed. A new legislation has been introduced, that came into force in 2011, governing the fishing and sale of glass eels. It lays down rules regarding monitoring of the fishing and end-use of the product and gives priority to use for restocking purposes (thus aiming to reach the target of 60% of catches by 2013, as provided in Article 7 of the regulation), specifying that this quota relates to restocking into waters which flow into the sea, so that the measure will contribute to recovery of the eel stock. One of the ways envisaged for meeting the obligations under the council regulation is to create a system which will include a national register of fishermen authorised to fish glass eel, allocation of quotas and the obligation to submit catch returns. This new legislation has come in force in 2011, and, together with reinforced controls by the Corpo Forestale dello Stato, shall ensure that information on recruitment in Italy is available from year to year, that most glass eel is conveyed to restocking and that illegal fishing is definitively broken off.

Italy has now established its Data Collection Framework for Eel, as foreseen by the Regulation 199/2008 that has been included in the Italian National Programme. A pilot project aimed at establishing a methodology for Eel Data Collection has been completed by October 15th 2009, and the Eel Fisheries Data Collection (under Reg. 199/2008, DCF) is at present definitively in place, and concerns all eel fisheries in inland and coastal waters, commercial as well recreational. Most data presented in this Report for the year 2011 are derived from the Eel Fisheries DCF, presented for the national level or environmental typology (such as inland or coastal waters), and disaggregated by region (EMU) as well.

The management framework for DCF is the same that has been set up for the eel management under Regulation 1100/2007. In the eleven regions that preferred to delegate eel management to central government (Directorate General for Sea Fishing and Aquaculture of the Ministry of Agricultural, Food and Forestry Policy) where commercial eel fishing has been stopped completely since the year 2009 (in some, the ban for eel fishing is still to be formalized), no data collection is carried out. In the remaining nine regions, where eel fisheries are still ongoing, eel fishery data are collected with a standard methodology, as foreseen by the Italian National Plan for the Data Collection Framework.

The Data Collection Framework for Eel, as foreseen by the Regulation 199/2008, has replaced the previous statistical system, (ISTAT) in place up to 2004 for the marine compartment and to 2008 for inland fisheries. In this report, time-series for eel catches are presented only when available, joining data derived by the old official statistical system (ISTAT) and the new data from the Eel Fisheries Data Collection (under Reg. 199/2008). The data from the ISTAT system present some gaps such as uncertain estimates, possible overlaps with aquaculture production, no distinction between stages, no information on the fishing effort. Nevertheless, these time-series represent at the moment the only official source for eel for the period before 2009.

3 Time-series data

3.1 Recruitment-series and associated effort

Recruitment dataseries supplied in the past to the Working Group was relative to a fishery-based monitoring on the river Tiber Estuary, specifically carried out within a series of research projects for the resource assessment. The projects have stopped, and this monitoring has ceased as well. As this fishery has stopped to exist, no monitoring is at present in place and no information can be derived. No monitoring programmes of recruitment are in place at the present moment, but probably some monitoring for recruitment as well as for escapement shall be put in place from next year, in key sites in Italy, in order to assess the eel local stocks in the country.

3.1.1.1 Commercial

3.1.1.2 Recreational

3.1.1.3 Fishery independent

3.1.2 Yellow eel recruitment

3.1.2.1 Commercial

3.1.2.2 Recreational

3.1.2.3 Fishery independent

3.2 Yellow eel landings

Detailed data on catches and landings (by life stage, by type of fishing gear, by EMU, commercial and recreational, etc.) are available only from 2009, when the DCF has been definitively put in place. Time-series with this degree of detail (stage yellow and silver) are not available for the period antecedent to 2009, apart from some figures for 2007, year in which a pilot project for eel fisheries assessment took. At present, therefore, only dataseries from the old statistical system (ISTAT) are available, that are national catches (also available at the Region disaggregated level) separated for inland and coastal waters. These time-series for Italy landings are available at present only cumulated, i.e. yellow and silver eels. Inland waters catches are referred to lakes and reservoirs, riverine fisheries being too negligible also in pristine periods, while statistics for coastal waters are relative to coastal lagoons fisheries, marine fisheries not being present in Italy. These data are the landing data forwarded to FAO Fishery Statistic Department, and therefore coincide with the FAO FishStat data.

The ISTAT system has discontinued the collection of data from the brackish and marine waters compartment since 2004 that have been resumed only in 2009 within the DCF. Therefore a discontinuity in this dataseries shall probably remain. The ISTAT system is still going on for inland water fisheries, but up to now no cross-check with the DCF has been done, so the two sources might present discrepancies.

Eel total landings from lagoon fisheries in Italy from 1969 to 2011 are reported in Figure IT.3, data refer to coastal lagoons only, no marine fisheries existing, and are derived from the ISTAT system up to 2004 and to the DCF from 2009, while the 2007 figure is from Unimar (2007).

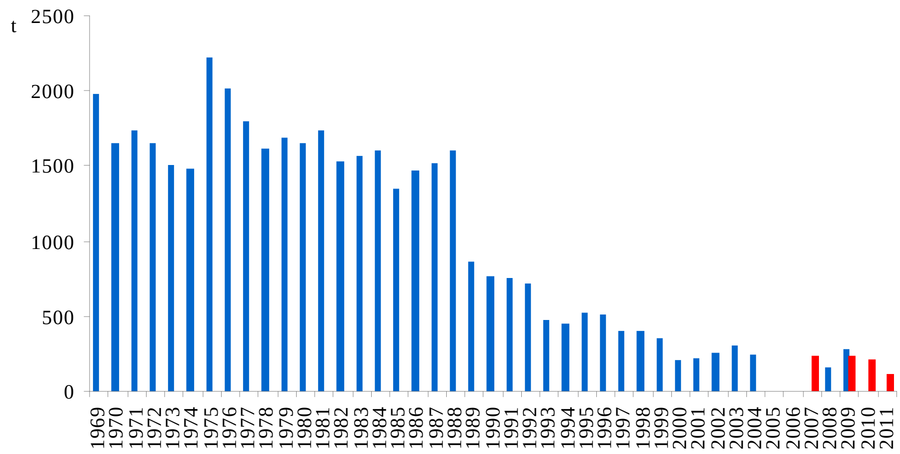

Figure IT.3. Eel landings (yellow and silver cumulated) in Italy, period 1969–2011, from coastal lagoon fisheries (Istituto Nazionale di Statistica 1969–2004, blue; Unimar, 2007, and DCF, 2009, 2010, 2011 red).

Inland waters eel landings from 1969 to 2011 are reported in Figure IT.4; statistics refer only to lakes and artificial basins for the ISTAT dataseries (green), and include rivers for the 2007–2011 DCF data (red).

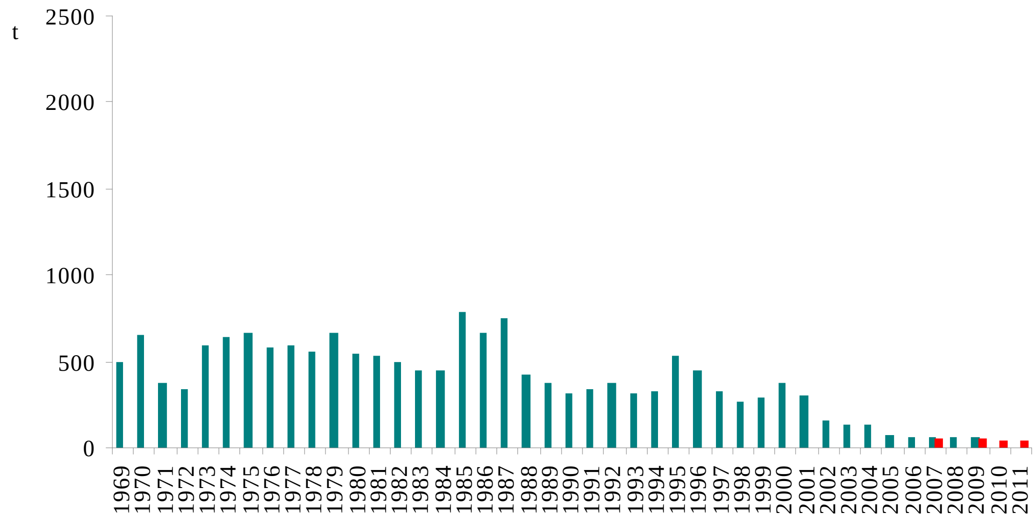

Figure IT.4. Eel landings (yellow and silver cumulated) in Italy, period 1969–2011. Data sources: 1969–2006 ISTAT - Istituto Nazionale di Statistica, referred only to lakes and artificial basins; 2007: Unimar and 2009–2011: DCF, riverine fisheries included.

In Table IT.2, the DCF dataseries from 2009 is presented, with data disaggregated by stage, with the 2007 reference value from the Unimar (2007) pilot study.

Table IT.2. DCF new catch dataseries (2009–2011): commercial landings (t) disaggregated by stage, and 2007 value from the Unimar (2007) pilot study.

	Inland waters: lakes & rivers			Coastal waters: lagoons			National
year	Yellow	Silver	Total	Yellow	Silver	Total	
2007	25,078	19,702	44,782	151,817	81,786	232,318	277,1
2008	na	na	na	na	na	na	na
2009	23,578	19,993	43,574	149,274	88,333	236,546	280,12
2010	22,136	18,4	40,536	73,127	135,727	208,854	249,39
2011	23,260	17,141	40,401	48,738	50,541	109.279	149,680

The conspicuous reduction in landings in 2011, that concerns mostly silver eel catch, is a consequence of the fact that the reduction in fishing effort foreseen by the IT-EMPs has become effective between 2010 and 2011.

3.2.1 Commercial

See above.

3.2.2 Recreational

See above.

3.3 Silver eel landings

See above.

3.3.1 Commercial

See above.

3.3.2 Recreational

See above.

3.4 Aquaculture production

In Italy, total aquaculture production accounted for 587 t in 2009, with intensive production accounting for 278 t and extensive for 309 t.

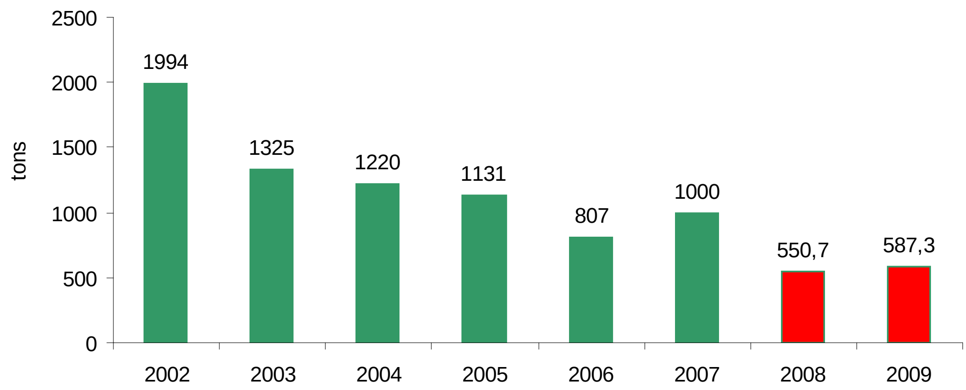

Figure IT.5. Aquaculture production in Italy from 2002 to 2009 (Source: 2002–2007 Idroconsult, green; 2008–2009: Unimar, red).

3.4.1 Seed supply

No data available.

3.4.2 Production

No data available.

3.5 Stocking

3.5.1 Amount stocked

See below.

3.5.2 Catch of eel <12 cm and proportion retained for restocking

The new glass eel regulation foresees that glass eel fisheries can continue on a local scale, provided that 60% is used for restocking in national inland waters open to the sea, and provided that fishers compile specific and detailed logbooks of catches and sales. This new system, together with reinforced controls by the Corpo Forestale dello Stato, shall ensure that information on recruitment in Italy is available from year to year, that most glass eel is conveyed to restocking and that illegal fishing is definitively broken off. Up to 2010, the new regulation was not in force, its definite approval being achieved in 2011, therefore no licences were issued in 2010 and there were no catches, nor information on quantities used for restocking. From 2011, the new regulation being in force, fishing has started again and catches are declared to the Ministry on a weekly basis. In Table IT.3 glass eel catches in kg for the season 2011/2012 are reported, as inferred by the fishers declarations, separated for coastal waters (estuaries) under the Central Administration, and inland waters (rivers up of the tidal limit), under regional administrations.

Table IT.3. Glass eel catches (eel <12 cm) - kg -, season 2011/2012.

	EMU Veneto	EMU Toscana	EMU Lazio	TOTAL
Inland waters	10	51,38	153	214,38
Coastal waters		16	69,1	85,1
Total	10	67,38	222,1	299,48

Based on data reported by authorized firms, it has been possible to document where the catches have occurred (Figure IT.6). Catches were mostly from rivers mouths on the Tyrrhenian coast, only one reported catch being from an estuary on the Adriatic coast.

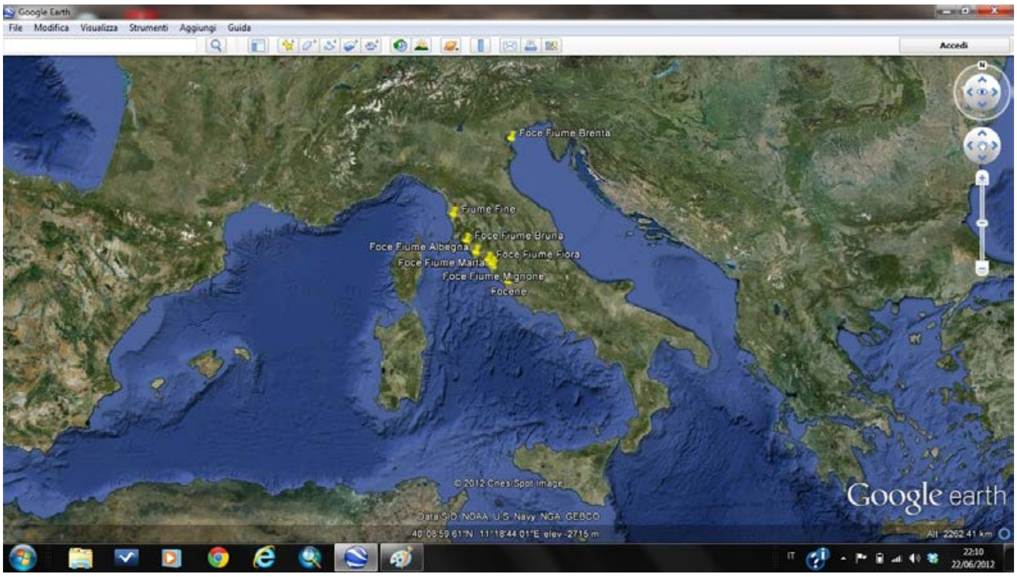

Figure IT.6. Glass eel fishing sites; season 2011/2012.

With regard to destination of glass eel catches, and to the proportion retained for restocking, on the basis of the forms returned to administrations it has been possible to document the destination of glass eel only in a generic way. Glass eel destination from national fisheries seems documented, while import data escape registration (Table IT.4).

Table IT.4. Destination of glass eel catches (eel <12 cm) - kg, season 2011/2012.

	Restocking	Aquaculture	Vallicoltura	Destination not reported	Total
National fisheries	248,49	51,6		72,2	372,29
Import				130	130
Unknown origin			300		300
Total	248,49	51,6	300	202,2	802,3

In the 2011–2012 season, 248.49 kg of glass eels from national fisheries have been used for restocking, amounting to 82.9% of the total glass eel catch in Italy in this season (299.48 kg). The remainder (51 kg, 17.2%) was used for aquaculture, either intensive or extensive (vallicoltura). At present, it is not possible to document where exactly restocking was performed, as provinces and regions have not provided documentation that allows documenting exact destinations.

Overall, this first year of implementation of the new regulatory framework for glass eel fisheries must be considered as a pilot year, accounting for the setting up of the declaration system. For the present, filling of the forms was lacking, and the details of the documents of purchase and sale were also deficient. This does not allow complete traceability of movements on the Italian territory. To overcome this problem, a full traceability system is currently being studied, developed in collaboration with the Corpo Forestale dello Stato - Unit CITES. This system should ensure the full traceability of all glass eel movements, either from national waters or imported, also aiming to definitively eradicate illegal fishing of glass eels.

The unavailability of glass eels on the domestic market in 2010 and 2011 has resulted in the fact that some regions have used eels of size greater than 12 cm (20–30 g, and in some cases (EMU Veneto) also of larger size (400 g) to make restocking in public waters, as foreseen by the Regional Management Plans. The source of this restocking seed is aquaculture or imported (France). This highlights the need to pay attention to health and quality when dealing with restocking of eel of size exceeding 12 cm.

The amounts of bootlace and yellow eels (size >12 cm) restocked in 2009, 2010 and 2011 are reported in Table IT.5.

Table IT.5. Quantities of bootlace and yellow eels (>12 cm) - kg - used for restocking, years 2009–2011.

	EMU LOM	EMU VEN	EMU EMR	EMU UMB	Total
2009	3.905,0	967,0	1.330,0	3.300,0	9.502,0
2010	3.220,0	3.375,0	1.050,0	1.295,3	8.940,3
2011	850,0	5.447,0	560,0	-	6.857,0
Total	7.975,0	9.789,0	2.940,0	4.595,3	25.299,3

3.5.3 Reconstructed time-series on stocking

In Table IT.6, a reconstruction of time-series of stockings is tentatively presented, on the basis of data gathered for the Report prepared for the DG Mare on the basis of Art. 9 of the Regulation 1100/2007 (PNG Italia, 2012). For 2009 and 2010, stockings were performed only within some experimental trials performed by two EMUs, because glass eel fisheries were still closed. For 2012 data are partial.

Table IT.6. Reconstructed time-series of stockings.

	Local Source				Foreign Source			
Year	Glass Eel	Quarantined Glass Eel	Wild Bootlace	On-grown cultured	Glass Eel	Quarantined Glass Eel	Wild Bootlace	On-grown cultured
2009 *	100		9.502 °					
2010 *	44,5		8.940 °					
2011 *	65		6.857 °					
2012	248,49 (134)		Na		130 ?			

*** in the years 2009, 2010 and 2011 glass eel fisheries were closed, apart a few particular cases of experimental fishing or Province authorizations for stocking purpose. Glass eel fisheries under the new rule began again in 2011/2012.**

° bootlace and yellow eels used for stocking are in part wild eels from France (Camargue), and part from on-grown cultured (Italy, Netherlands), but the exact quantities of each source are not available.

4 Fishing capacity

Total fishing capacity for eel in Italy is difficult to assess, it should coincide with the whole amount of fishers licensed for fishing in inland waters (river and lakes) and coastal lagoons, both commercial and recreational, and for authorized glass eel fishers in coastal and inland waters. Glass eel fishing is allowed by authorization on a yearly basis, both in coastal and inland waters, in the nine EMUs. For 2011 the new regulation was entered in force only in December, and hence only a few authorizations were issued (four firms).

For the eel commercial fishing capacity relative to the nine MUs where eel fisheries are present, fishing being prohibited in the remaining eleven regions where non EMP is in place, the best estimates are from census returns (the first carried out in 2007 and then a revision in 2011) of the total number of fishermen involved in eel fishing.

Commercial eel fisheries occur in nine regions: Lombardia, Veneto, Friuli Venezia Giulia, Emilia Romagna, Toscana, Umbria, Lazio, Puglia e Sardegna. Within these regions, four main habitat typologies have been identified, where eel fishing takes place that are rivers, lakes, lagoons and managed lagoons. The latter differs from lagoons, where only artisanal fisheries occur, for the fact that more detailed management strategies are carried out, such as stocking or water management.

Overall, 1232 operators have been interviewed and are involved in eel fishing, in the nine regions all typologies included (see Table IT.7). These fishermen are licensed fishers as well as employees in the managed lagoons, and they do not target only eel, but other freshwater or euryhaline fish as well. In most cases, eel importance in catches is quite low. An assessment of eel importance among catches has been performed in 2010, on all the fishermen operating in rivers lakes and lagoons, and it revealed that for 77,1% of the fishermen, eel represents at most 15% of total catch. For 22,9% of the fishermen, eel is less that 1% of total catch.

Table IT.7. Total number of commercial fishermen, by EMU and by habitat typology, from the census DCF 2011.

EMUs	River	Lake	Lagoon	Managed lagoon	total/EMU	%
EMU_LOM	0	30	0	0	30	2,4
EMU_FVG	38	0	109	0	147	11,9
EMU_VEN	166	0	113	0	279	22,6
EMU_EMR	7	0	141	0	148	12,0
EMU_TOS	1	1	0	28	30	2,4
EMU_UMB	0	28	0	0	28	2,3
EMU_LAZ	5	25	11	0	41	3,3
EMU_PUG	0	0	79	0	79	6,4
EMU_SAR	107	0	317	26	450	36,5
total/HT	324	84	770	54	1.232	100
%	26,3	6,8	62,5	4,4	100	100

For recreational fisheries, potential fishing capacity coincides with all licensed fishers in the whole national territory, all regions included. The effective number of recreational fishermen involved in eel fishing is obviously much lower. The estimate of the total amount of eel recreational fishermen was obtained within the DCF programme, on the basis of the information provided by two different recreational fishermen organizations (FIPSAS and ARCI Pesca), that account for most of inland waters recreational fisheries, The effective number of eel recreational fishers estimated for 2011 amounts to 6392 (see following section).

For both commercial and recreational fisheries, target is both the yellow and the silver eel stage that are exploited by the same fishers on a seasonal basis.

Table IT.8. Total number of recreational fishermen in the 20 Regions (DCF, 2011).

Region	EMU CODE	Total Licences
Valle d'Aosta	-	NA
Piemonte	-	45.480
Lombardia	EMU_LOM	65.692
Trentino Alto Adige	-	33.000
Friuli Venezia Giulia	EMU_FVG	20.833
Veneto	EMU_VEN	90.880
Liguria	-	5.447
Emilia Romagna	EMU_EMR	71.000
Toscana	EMU_TOS	48.000
Umbria	-	15.685
Marche	EMU_UMB	10.069
Lazio	EMU_LAZ	54.468
Abruzzo	-	12.730
Molise	-	4.514
Campania	-	17.682
Calabria	-	18.500
Basilicata	-	2.447
Puglia	EMU_PUG	830
Sardegna	EMU_SAR	2.789
Sicilia	-	4.226
Total		524.272

4.1 Glass eel

Glass eel fishing is allowed by authorization on a yearly basis, both in coastal and inland waters, in the nine EMUs. For 2011 the new regulation entered in force only in December, and only a few authorizations were issued (four firms). In future, a board of authorized firms for glass eel fisheries should be built up.

4.2 Yellow eel

See above.

4.3 Silver eel

See above.

4.4 Marine fishery

No marine fishery exists for eel in Italy.

5 Fishing effort

The methodology to describe the commercial fishing effort is based on direct and detailed interviews to a sample of fishermen, extracted on a statistical basis for each habitat typology in each MU. Almost total eel catch is from fykenets fisheries, used in all habitat typologies in all MUs, with the exception of fish barriers used in managed coastal lagoons. Longlines are sporadically used only in one or two lakes.

The interviews consist of questionnaires where each fisherman reports catch data (yellow and silver eel separated), type of gear, number of gears used daily and number of fishing days per year. A detailed cpue in each habitat typology of all nine MUs has been derived from a reliable subset of interviewed fishermen: an average parameter of fishing effort (number of gears * number of fishing days) was multiplied by the total fishermen operant in each habitat typology. Results are reported in Table IT.9. Yellow and silver eel catches were assessed with the same method.

Table IT.9. Effort parameters used for eel commercial fishing in Italy in 2011, disaggregated by EMU and habitat typology (DCF, 2011). NA: not applicable.

Region (EMU)	Habitat typology	Gear type	Eel stage	Number of gears used per day	number of fishing days per year	Number of fishermen	Effort
LOM	LAK	Fykenets	Y	4,7	6,2	30	868,4
LOM	LAK	Fykenets	S	4,7	6,2	30	868,4
VEN	LGN	Fykenets	Y	51,6	115,8	113	675.381,6
VEN	LGN	Fykenets	S	51,6	55,8	113	325.183,7
VEN	RIV	Fykenets	Y	40,0	111,1	166	737.936,4
VEN	RIV	Fykenets	S	40,0	43,9	166	291.263,6
FVG	LGN	Fykenets	Y	48,6	151,8	109	803.880,5
FVG	LGN	Fykenets	S	48,6	77,8	109	412.020,0
FVG	RIV	Fykenets	Y	70,0	90,0	38	239.400,0
FVG	RIV	Fykenets	S	70,0	30,0	38	79.800,0
EMR	LGN	Fykenets	Y	20,0	58,6	141	165.339,1
EMR	LGN	Fykenets	S	20,0	16,0	141	45.200,6
EMR	MLG	Lavoriero (Barrier)	S	NA	94,0	NA	
EMR	RIV	Fykenets	Y	46,4	58,6	7	19.043,3
EMR	RIV	Fykenets	S	46,4	16,0	7	5.206,1
TOS	LAK	Fykenets	Y	18,0	10,0	1	180,0
TOS	LAK	Fykenets	S	18,0	10,0	1	180,0
TOS	MLG	Lavoriero (Barrier)	S	NA	120,0	NA	
TOS	MLG	Fykenets	Y	15,9	34,6	28	15.423,0
TOS	MLG	Fykenets	S	15,9	140,7	28	62.646,0
TOS	RIV	Fykenets	Y	10,0	20,0	1	200,0
TOS	RIV	Fykenets	S	10,0	80,0	1	800,0
UMB	LAK	Fykenets	Y	35,2	87,4	28	86.141,4
LAZ	LAK	Fykenets	Y	13,0	70,4	25	22.950,4
LAZ	LAK	Fykenets	S	13,0	76,3	25	24.857,5
LAZ	LGN	Fykenets	Y	65,2	102,0	11	73.154,4
LAZ	LGN	Fykenets	S	65,2	66,0	11	47.335,2
LAZ	RIV	Fykenets	Y	73,0	68,6	5	25.046,6
LAZ	RIV	Fykenets	S	73,0	77,6	5	28.319,0
PUG	LGN	Fykenets	Y	27,1	42,2	79	90.238,9

Region (EMU)	Habitat typology	Gear type	Eel stage	Number of gears used per day	number of fishing days per year	Number of fishermen	Effort
PUG	LGN	Fykenets	S	27,1	42,2	79	90.238,9
SAR	LGN	Fykenets	Y	15,0	67,2	107	107.775,8
SAR	LGN	Fykenets	S	15,0	67,2	107	107.775,8
SAR	MLG	Lavoriero (Barrier)	S	NA	95,0	NA	
SAR	MLG	Fykenets	Y	15,0	48,4	317	230.142,0
SAR	MLG	Fykenets	S	15,0	48,4	317	230.142,0
SAR	RIV	Fykenets	Y	5,0	44,5	26	5785,0
SAR	RIV	Fykenets	S	5,0	44,5	26	5785,0

The same methodology (interviews to a sample of fishermen) has been used to assess data for recreational fishermen (Table IT.10).

Table IT.10. Effort parameters used for eel recreational fishing in Italy in 2011, disaggregated by EMU and habitat typology and type of gears (DCF, 2011).

Region	Pool sample (Recreational fishing association members)	Sample representa-tiveness (%)	Habitat typology	Eel fishermen interviewed per gears type					Effort
				Fishing rod	Umbrella	Shore lift net	Big Shore lift net	Total	number of fishing days * year
VDA	163	NA	RIV	NA					NA
PIE	40702	89,5	RIV	36	0	0	0	36	7,8
EMU_LOM	88 411	95,9	RIV	569	0	0	0	569	28,7
			LAK	413	0	80	0	493	21,6
TAA	2390	7,24	RIV/LAK	0	0	0	0	0	0
EMU_FVG	6775	29,32		NA			4	4	15
EMU_VEN	31 644	34,8	LGN/RIV	251	0	111	0	362	16,9
			LAK	929	0	0	0	929	18,1
LIG	14 955	99,1	RIV	103	54	0	0	157	22,9
EMU_EMR	30 439	42,9	RIV	217	0	431	240	788	13,6
EMU_TOS	23 965	49,9	RIV	71	0	5	21	97	9,0
EMU_UMB	4543	29,0	LAK	237	0	0	0	237	5,8
			RIV	217	0	0	0	217	5,4
MAR	5171	51,4	RIV	217	8	0	0	225	5,2
EMU_LAZ	9034	16,6	RIV	86	0	0	42	128	20,6
ABR	4688	36,8	RIV	16	95	0	0	111	16,6
CAM	8532	48,3	RIV	16	17	78	28	139	23,2
MOL	670	14,8	RIV	0	0	0	0	0	0
CAL	4864	26,3	RIV	298	0	0	0	298	21,9
BAS	1057	43,2	RIV	97	0	0	0	97	32,2
EMU_PUG	3637	90,36	RIV	0	0	0	0	0	0
EMU_SAR	4113	89,6	RIV	79	0	0	0	79	5,6
SIC	5050	94,7	RIV	81	0	0	0	81	10

5.1 Glass eel

Glass eel fishing is allowed by authorization on a yearly basis, both in coastal and inland waters, in the nine EMUs, to firms dealing with juvenile fish harvest and commercialization. Authorized firms are obliged to return catch data inclusive of details on the fishing site and fishing effort, but for this first year of implementation, returned forms were unsatisfactory with regards to thise information.

5.2 Yellow eel

See above.

5.3 Silver eel

See above.

5.4 Marine fishery

No marine fishery exists for eel in Italy.

6 Catches and landings

Annual catch by life stage for commercial fisheries in the year 2011, as evaluated under the DCF programme, is reported in Table IT.11, by EMU, and by stratum (EMU_Habitat typology) in Table IT.12. For glass eel catches, data for 2011 are reported in Section 3.5.2. Total catch by life stage for recreational fisheries by Region is reported in Table IT.13, relative to 2011, evaluated under the DCF Programme.

Table IT.11. Yellow and silver eel commercial catches, and total for the two stages cumulated, for 2011, disaggregated by EMU (DCF, 2011).

EMUs	Yellow eels (kg)	Silver eels (kg)	Total (kg)	Total (tons)
LOM	107	534	641	0,6
FVG	3.833	2.661	6.494	6,5
VEN	9.673	9.024	18.697	18,7
EMR	8.320	4.443	12.763	12,8
TOS	14.484	30.821	45.305	45,3
UMB	7.853	0	7.853	7,9
LAZ	5.131	5.920	11.051	11,1
PUG	3.330	5.116	8.446	8,4
SAR	19.266	19.164	38.430	38,4
Total	71.998	77.682	149.680	150

Table IT.12. Yellow and silver eel commercial catches, and total for the two stages cumulated, for 2011, disaggregated by stratum (EMU and habitat typology) (DCF, 2011).

EMUs	Habitat typology	Yellow eels (kg)	Silver eels (kg)	Total (kg)	Total (tons)
LOM	LAK	107	534	641	0,6
VEN	LGN	2.789	2.040	4.829	4,8
VEN	RIV	6.884	6.984	13.868	13,9
FVG	LGN	1.625	2.569	4.194	4,2
FVG	RIV	2.208	92	2.300	2,3
EMR	LGN	8.087	651	8.738	8,7
EMR	MLG	0	3.790	3.790	3,8
EMR	RIV	233	3	236	0,2
TOS	LAK	0	19	19	0,0
TOS	MLG	14.364	30.772	45.136	45,1
TOS	RIV	120	30	150	0,2
UMB	LAK	7.853	0	7.853	7,9
LAZ	LAK	2.660	4.940	7.600	7,6
LAZ	LGN	638	913	1.551	1,6
LAZ	RIV	1.833	67	1.900	1,9
PUG	LGN	3.330	5.116	8.446	8,4
SAR	LGN	3.442	1.819	5.261	5,3
SAR	MLG	14.463	12.871	27.334	27,3
SAR	RIV	1.362	4.473	5.835	5,8
Total		71.998	77.682	149.680	150

Table IT.13. Yellow and silver eel catches, and total for the two stages cumulated, from recreational fisheries in 2011, disaggregated by Region (DCF, 2011).

Region	Code	Yellow eel (kg)	Silver eel (kg)	Total (kg)	Total (tons)
Valle d'Aosta	VDA	NA			
Piemonte	PIE	101	0	101	0,1
Lombardia	EMU_LOM	4.670	0	4.670	4,7
Trentino Alto adige	TAA	0	0	0	0,0
Friuli Venezia Giulia	EMU_FVG	NA	120	120	0,1
Veneto	EMU_VEN	24.159	2.760	26.919	26,9
Liguria	LIG	2.375	0	2.375	2,4
Emilia Romagna	EMU_EMR	7.610	7.200	14.810	14,8
Toscana	EMU_TOS	421	630	1.051	1,1
Umbria	EMU_UMB	4.367	0	4.367	4,4
Marche	MAR	1.212	0	1.212	1,2
Lazio	EMU_LAZ	1.296	1.260	2.556	2,6
Abruzzo	ABR	2.498	0	2.498	2,5
Campania	CAM	637	840	1.477	1,5
Molise	MOL	0	0	0	0,0
Calabria	CAL	7.084	0	7.084	7,1
Basilicata	BAS	1.810	0	1.810	1,8
Puglia	EMU_PUG	0	0	0	0,0
Sardegna	EMU_SAR	672	0	672	0,7
Sicilia	SIC	856	0	856	0,9
Total		59.769	12.810	72.579	72,6

6.1 Glass eel

See above.

6.2 Yellow eel

See above.

6.3 Silver eel

See above.

6.4 Marine fishery

No marine fishery exists for eel in Italy.

7 Catch per unit of effort

Catch per unit of effort has been assessed under the DCF Programme for year 2011, for both commercial and recreational fisheries. Cpue has been calculated as mean catch of the year per fisherman. The detailed cpue has been derived for a small and reliable subset of fishers, and then referred to the whole set of fishermen. In Table IT.14, annual mean cpue for 2011 are reported by stratum (EMU_Habitat typology), for commercial landings. In Table IT.15, annual mean cpue for 2011 are reported by stratum (EMU_Habitat typology), for recreational landings.

Table IT.14. Yellow and silver eel cpue (kg/fisherman) for commercial fisheries for 2011, disaggregated by stratum (EMU and habitat typology) (DCF, 2011).

EMU	Habitat typology	Type of gear	CPUE Yellow eel	CPUE Silver eel
			Kg/fisherman	Kg/fisherman
LOM	LAK	FYK	3,6	17,8
VEN	LGN	FYK	24,7	18,1
VEN	RIV	FYK	41,5	42,1
FVG	LGN	FYK	14,9	23,6
FVG	RIV	FYK	58,1	2,4
EMR	LGN	FYK	57,4	4,6
EMR	MLG	BAR	NA	NA
EMR	RIV	FYK	33,3	0,4
TOS	LAK	FYK	0,0	18,8
TOS	MLG	BAR	NA	NA
TOS	MLG	FYK	513,0	769,3
TOS	RIV	FYK	120,0	30,0
UMB	LAK	FYK	280,5	0,0
LAZ	LAK	FYK	106,4	197,6
LAZ	LGN	FYK	58,0	83,0
LAZ	RIV	FYK	366,7	13,3
PUG	LGN	FYK	42,2	64,8
SAR	LGN	FYK	32,2	17,0
SAR	MLG	BAR	NA	NA
SAR	MLG	FYK	45,6	38,9
SAR	RIV	FYK	52,4	172,0

Table IT.15. Yellow and silver eel cpue (kg/fisherman) for recreational fisheries in 2011, disaggregated by stratum (EMU and habitat typology) (DCF, 2011).

EMU	Habitat typology	Type of gear	CPUE Yellow eel	CPUE Silver eel
			Kg/fisherman	Kg/fisherman
PIE	RIV	FRD	2,5	0
EMU_LOM	RIV	FRD	2,5	0
EMU_LOM	LAK	FRD	6,2	0
EMU_LOM	LAK	SLN	6,2	0
EMU_FVG	RIV	SLN	NA	30,0
EMU_VEN	LGN	FRD	5,1	0
EMU_VEN	LGN	SLN	5,1	30,0
EMU_VEN	LAK	FRD	7,1	0
LIG	RIV	FRD	15,0	0
LIG	RIV	UMB	15,0	0
EMU_EMR	RIV	FRD	5,0	0
EMU_EMR	RIV	SLN	5,0	30,0
EMU_TOS	RIV	FRD	2,8	0
EMU_TOS	RIV	SLN	2,8	30,0
MAR	RIV	FRD	2,8	0
MAR	RIV	UMB	2,8	0
EMU_UMB	LAK	FRD	2,9	0
EMU_UMB	RIV	FRD	2,7	0
EMU_LAZ	RIV	FRD	2,5	0
EMU_LAZ	RIV	SLN	NA	30,0
ABR	RIV	FRD	8,3	0
ABR	RIV	UMB	8,3	0
CAM	RIV	FRD	2,8	0
CAM	RIV	UMB	2,8	0
CAM	RIV	SLN	NA	30,0
CAM	RIV	SLN	2,8	0
BAS	RIV	FRD	8,1	0
CAL	RIV	FRD	6,3	0
EMU_SAR	RIV	FRD	7,6	0
SIC	RIV	FRD	10,0	0

7.1 Glass eel

See above.

7.2 Yellow eel

See above.

7.3 Silver eel

See above.

7.4 Marine fishery

No marine fishery exists for eel in Italy.

8 Other anthropogenic impacts

No relevant data available.

9 Scientific surveys of the stock

10 Catch composition by age and length

Biological surveys under the DCF National Program are carried out for every MU (Region), in a site, lagoon or catchment, representative of the MU in terms of habitat extent and/or amount of eel landings. Sampling is usually carried out by taking a random batch of eels from a fisherman cumulated catch of the day or of the week. Sample processing foresees different procedures depending on data to be obtained from the samples. Usually length and weight are directly measured on anaesthetized eel, and digital pictures for subsequent specific morphometric measurements are obtained. Samples are released if no other observations are due, or else sacrificed or frozen for further analyses.

For 2011, only length and weight measurements were foreseen, that have been used for the assessment performed for the 2012 June Report foreseen by Art. 9 of the Eel Regulation.

11 Other biological sampling

No routine programmes for eel are in place at the present moment, except those foreseen under the DCF, but some monitoring at the local level are carried out by scientific entities and other institutions. In most cases, standard methodologies derived from the literature are used.

For the purpose of the assessment for the 2012 June Report due by Art. 9 of the Eel Regulation, some coordinated monitoring of recruitment and escapement were required to the Administrations of the nine EMUs involved in Management Plans, but the setting up of such monitoring and its coordination found some difficulties for the year 2011.

11.1 Length and weight and growth (DCF)

No relevant data.

11.2 Parasites and pathogens

No relevant data because new data were not available and no routine monitoring has been implemented.

11.3 Contaminants

Some lake fisheries have been closed in 2011, and have concerned also eel (such as the Lago di Garda, Lombardia), in relation to fish contamination by dioxin or other contaminants. Contaminant data are not available, because carried out by local Health Agencies.

11.4 Predators

The impact of ichthyophagous birds is unanimously reported to be present in all Italian coastal lagoons, mostly to be ascribed to great cormorants. In the area of the Fogliano coastal lake, bout 2000 cormorants were estimated to be present and 800 of them wintering there but the impact of their presence on the fish community has not been directly estimated. The impact of their presence is remarkable also in the Orbetello lagoon, given the presence of about 2500–3000 wintering cormorants since 2000 (Ceccarelli *et al.*, 2005). Cormorants are the greatest negative impact that fishermen have to endure also in the lagoon of Lesina, with some thousands of birds every year that during the migration period can cause the loss of large quantities of product. Over 11 700 cormorants were recorded in the Sardinian wetlands in 1995 (Cannas *et al.*, 1995). Icthyophagous birds are a source of loss for all fish species of economic interest in coastal lagoons, eel among other species. No recent census data are available for Italy as a whole.

Ichthyophagous birds have a strong impact in the area of the lagoon of Venice and in all the North Adriatic area, mainly in relation to fish predation in the Valli, and represent one of the main causes of product loss.

Predation by ichthyophagous birds represents the main factor limiting fish productions in Italian coastal lagoons or in the North Adriatic extensive aquaculture situations (Valli). The specific impact on eel cannot be quantified; it depends on a number of factors that vary among lagoons. On the other hand, the presence of other water birds represents a main attraction in these same sites, in relation to the different usages of lagoons (tourism, conservation, hunting).

Another predator of eel that is found in some rivers and estuaries is *Silurus glanis*. Its presence is ascertained in the Tiber River (Lazio) and in the river Po lower course (Emilia Romagna), but its impact on eel local stocks cannot be quantified at the present moment.

12 Other sampling

NA.

13 Stock assessment

13.1 Local stock assessment

Italy presented a mixed Eel Management Plan that includes a National EMP and nine regional EMPs. The former deals only with coastal waters, and hence only with glass eel fisheries. The stock assessment for eel was however carried out for all the 20 Italian regions, i.e. including the nine MUs with a Regional Eel Management plan and the other eleven regions where no recovery plans for the eel were foreseen.

Within each Region, a habitat- based approach was used for assessments, considering separately lake, river and estuarine waters and lagoon surfaces. Local stock assessment was performed at EMUs (i.e. regions) for wetted areas and also taking into account specific habitat typologies (lakes, lagoons, rivers), by means of a demographic model tuned on available data on recruitment, fishing effort and age/size structure or on bibliographic data. The model (DemCam), developed by Bevacqua *et al*. from University of Parma and Politecnico di Milano and evaluated in the ICES working group SGIPEE, was used, specifically revised for this purpose.

DemCam was developed specifically for the assessment of the eel stock and catches in spatially implicit environments such as lagoons, lower water systems or uniform traits of rivers. A general formulation makes it suitable to describe the demography of different eel stocks, provided that a sufficient number of data are available for parameter calibration. The model covers the whole continental phase of the European eel's life cycle, from the recruitment at the glass eel stage up to the escapement of migrating silver eels. It defines the eel stock and the harvest structured by age, length, sex and maturation stage (yellow or silver) on an annual basis. The model allows also considering the system in pristine conditions by using the extension of pristine habitat in the absence of human pressure (fishing mortality and presence of dams) and the abundance of recruitment to the maximum carrying capacity.

As far as the data of body growth curves are concerned, the model proposed by Melià *et al*. (2006a) was used: for each region (MU) and habitat type parameters calibrated with the data obtained from DCF biological samplings in the respective reference site of the habitat typology have been used, or from other available data, extending these parameters in those cases where no other data were available.

The probability of reaching sexual maturity, and natural mortality were estimated with the model proposed by Bevacqua *et al*. (2006; 2011).

Fishing mortality rate (F) was calculated as the result of the effort applied, the selectivity of the nets used (depending on the length and the mesh size of the gears, and the catchability, Bevacqua *et al*., 2009).

In the case of managed lagoons, where fishing barriers are present, all silver eel caught by these traps were deducted from the total silver eel biomass estimated by the DEMCAM model in this habitat typology.

The model allows to consider other anthropogenic mortalities such as the silver eels survival during the downstream migration, by considering the number of dams with hydroelectric turbines and their correspondent probability of survival of each plant (ς = 0,682, ICES 2011).

On the basis of the escapement pristine data, B_o, (assessed with different levels of productivity for each habitat typology, from 3,2 to 34,5 kg/ha taken from scientific literature) and the pristine available wetted areas (in hectares), the model estimates the current level of recruitment. From this value and considering the current actual available wetted areas, it simulates the system until equilibrium is reached in the absence of human pressure to obtain an estimate of the potential silver eel biomass (B_{best}).

With regards to recruitment, an estimation of the fraction of actual recruitment different from that suggested by ICES (2011) of 10% of pristine recruitment has been used. This choice was due to the fact that in many cases, with this percentage it was not possible to match the biomass obtained by the catch of fishermen with that estimated by the model. The provisional error of the model was mainly due to an underestimation of recruitment resulting in an underestimation of the stocks currently present within the catchments. Therefore, a tuning between the actual and pristine recruitment to reduce the model error was introduced, by considering in Italy four macro areas differing in recruitment level. With this procedure it was estimated that recruitment is currently 10% for the pristine inland waters (not directly connected to the sea), 15% for the northern Adriatic Sea, 20% for the southern Adriatic Sea and 30% for the Tyrrhenian area and the islands.

The limits to the application of this model are largely due to the lack of specific data for each site. The generalization process for a particular species so may lead to overestimates or underestimates the biomass of spawners. In particular the value of recruitment, both pristine and actual, has a strong influence on model predictions and the lack of specific data for the estimation of this parameter makes assessments less reliable.

13.2 International stock assessment

During the first part of 2012, the work of the National Working Group has been finalized to the gathering of data for the evaluation of the parameters to be used for the international stock assessment in 2013 (Article 9 of Regulation 1100/2007, for the first report scheduled for June 30, 2012). Italy has followed the approach of using a database for assessment progressively implemented. Compared to 2008, when the work for the compilation of the IT-EMP was initiated, a series of tools and activities have been put in place, that have resulted in a database much more detailed and reliable, and therefore for the assessment of the reference points required for the report foreseen by Art. 9 (PNG Italia, 2012), this updated dataset has been used and these data are used in the present report.

In the EU report (PNG Italia 2012), two sets of reference values have been calculated. One has been derived using a standard silver eel productivity set at 20 kg/ha, as imposed by ICES within the IT-EMP evaluation. A second assessment has also performed using differentiated silver eel productivity levels ranging between 3,2 and 34,5 kg/ha, based on new scientific evidence because only these can account for the varying ecological conditions of the different habitat typologies. In the present report only the second set of values has been reported, because we consider it to be more coherent.

13.2.1 Habitat

A first revision has concerned the assessment of habitat, that in the IT-EMP (PNG Italia, 2010) had been made by using a rough estimate based on available data of wetted areas, such as the layer produced by ISPRA, " National watersheds 1:250.000", a database created under the provisions of the Water Framework Directive 2000/60/EC. These estimates have proven to be scarcely accurate, in particular for the riverine areas, calculated based on an average value of the river bed width equal to 5 m, an underestimation compared to the actual width in most cases.

The revision has concerned the assessment of both the pristine and the current wetted areas of the different habitat typologies identified in the Italian MUs. For the river habitat, the wetted surface currently available to eel colonization, downstream of the dams considered impassable based on satellite or aerial images, was measured using the appropriate tool of the Web GIS "National Geoportal" (Ministry of Environment) (Figure IT.7). Using as a base the aerial ortho-photos of 2006, the perimeter of the river area (red line) has been traced, from the river mouth to the first impassable dam, using a scale image analysis between 1:1000 and 1:3000. The software has calculated the area inside the perimeter track, in km^2. The whole river system, considering 1st, 2nd and 3rd order rivers, has been measured by this method, considering both the rivers with a direct outlet to the sea and the tributaries to the main river downstream of the first impassable barrier. The estimate of the river area in pristine conditions has been made with a similar method applied to the whole river length from the source to the estuary, and using a weighted average of the river width measured in 13 sections, respectively six on the lower course, four on the middle course and three sections for the upper course of the river.

The same methodology was used for the calculation of lakes and coastal lagoons areas, using the geometrical function of the software. For the lakes, only a portion of the entire surface has been considered useful as eel habitat, on the basis of the bathymetric profiles: areas with depth greater than 50 m were excluded. The result is a useful area for the eel estimated on average in 10% of the total area of each lake basin. For the lagoons, in consideration of the reduced bathymetries, the entire available surface was considered as eel habitat.

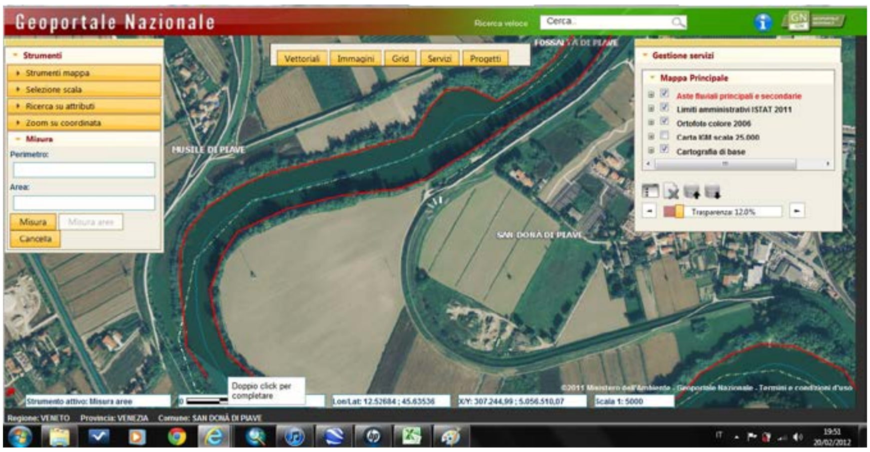

Figure IT.6. Example of section selected for the calculation of the area - National Geoportal.

Results for both the pristine wetted area and for the current wetted area are reported in Table IT.16 for the 20 Italian regions, nine of which are Eel Management Units and in Table IT.17 summed for the five habitat typologies.

Table IT.16. Calculated pristine and current wetted area, disaggregated by Region or EMU.

Region or EMU code	Pristine wetted area (ha)	Current wetted area (ha)
VDA	338	0
PIE	4.610	780
EMU_LOM	17.336	6.163
TAA	2.111	370
EMU_FVG	16.185	15.715
EMU_VEN	94.666	92.633
LIG	526	344
EMU_EMR	31.045	27.026
EMU_TOS	5.521	3.764
EMU_UMB	1.115	0
MAR	1.099	228
EMU_LAZ	6.895	3.402
ABR	602	236
CAM	1.924	1.057
MOL	282	73
CAL	494	192
BAS	724	218
EMU_PUG	12.121	11.947
EMU_SAR	9.250	8.561
SIC	1.000	516
Total	207.845	173.225

Table IT.17. Calculated pristine and current wetted area, aggregated by Habitat typology.

Habitat typology	Pristine wetted area (ha)	Current wetted area (ha)
RIV	49.618	22.799
LGN	95.467	95.467
MLG	20.218	20.218
LAK	16.287	8.486
VAL	26.256	26.256
Total	207.845	173.225

13.2.2 Silver eel production

13.2.2.1 Historic production

B_0, the biomass values of the escapement in the pristine state, relative to the nine Italian EMUs and in the other eleven regions that have no Management Plan in place, are reported in Table IT.18. As explained above, these values have been calculated on the basis of differentiated (3,2–34,5 kg/ha) pristine silver eel productions in the different habitat typologies, and not using the standard values of 20 kg/ha used in the eel IT-EMP.

Table IT.18. Biomass of the escapement in the pristine state (B_o), disaggregated by EMU and Region.

Region or EMU code	Bo (kg)	Bo (tons)
VDA	1.082	1,1
PIE	15.632	15,6
EMU_LOM	65.561	65,6
TAA	7.195	7,2
EMU_FVG	293.033	293,0
EMU_VEN	1.773.133	1.773,1
LIG	1.684	1,7
EMU_EMR	458.236	458,2
EMU_TOS	75.404	75,4
EMU_UMB	3.569	3,6
MAR	3.516	3,5
EMU_LAZ	71.054	71,1
ABR	1.928	1,9
CAM	14.339	14,3
MOL	903	0,9
CAL	1.580	1,6
BAS	2.318	2,3
EMU_PUG	399.772	399,8
EMU_SAR	210.386	210,4
SIC	7.872	7,9
Total	3.408.195	3.408,2

13.2.2.2 Current production

B_{best}, the estimated biomass in the year 2011, based on the recently observed recruitment, but assuming no anthropogenic impacts have occurred (neither positive nor negative impacts), relative to the nine Italian EMU and in the other eleven regions that have no Management Plan in place, are reported in Table IT.18. In the report presented to EU DGMare (PNG Italia 2012), estimates of B_{best} relative to the years 2007–2010 are also reported.

Table IT.19. Estimated biomass in the year 2011, based on the recently observed recruitment, but assuming no anthropogenic impacts have occurred (B_{best}), disaggregated by EMU and region.

Region or EMU code	B_{best} (kg)	B_{best} (tons)
VDA	192	0,2
PIE	2.712	2,7
EMU_LOM	10.908	10,9
TAA	1.233	1,2
EMU_FVG	74.814	74,8
EMU_VEN	452.231	452,2
LIG	787	0,8
EMU_EMR	117.658	117,7
EMU_TOS	34.744	34,7
EMU_UMB	640	0,6
MAR	914	0,9
EMU_LAZ	32.538	32,5
ABR	484	0,5
CAM	6.639	6,6
MOL	299	0,3
CAL	521	0,5
BAS	765	0,8
EMU_PUG	130.467	130,5
EMU_SAR	97.313	97,3
SIC	3.692	3,7
Total	969.551	969,6

13.2.2.3 Current escapement

B_{curr}, the biomass of the escapement in the year 2011, relative to the nine Italian EMU and in the other eleven regions that have no Management Plan in place, are reported in Table IT.20. In the report presented to EU DGMare, estimates of B_{curr} relative to the years 2007–2010 are also reported (PNG Italia 2012).

Table IT.20. Biomass of the escapement in the assessment year 2011 (B_{curr}), disaggregated by EMU and region.

Region or EMU code	Bcurr (kg)	Bcurr (tons)
VDA	0	0,0
PIE	697	0,7
EMU_LOM	4.273	4,3
TAA	680	0,7
EMU_FVG	50.313	50,3
EMU_VEN	340.863	340,9
LIG	192	0,2
EMU_EMR	80.406	80,4
EMU_TOS	2.670	2,7
EMU_UMB	0	0,0
MAR	248	0,2
EMU_LAZ	10.949	10,9
ABR	365	0,4
CAM	3.230	3,2
MOL	197	0,2
CAL	156	0,2
BAS	526	0,5
EMU_PUG	89.550	89,6
EMU_SAR	27.831	27,8
SIC	2.132	2,1
Total	615.277	615,3

13.2.2.4 Production values e.g. kg/ha

The production values in kg/ha relative to the current biomass escaping from each EMU in the year 2011, relative to the nine Italian EMU and in the other eleven regions that have no Management Plan in place, are reported in Table IT.21. In Table IT.22 average production values in kg/ha relative to the current biomass escaping from the different habitat typologies is reported.

As far as the production values in kg/ha relative to the pristine biomass escaping from Italian waters, in the Report 2012 (PNG Italia 2012) a revision of the pristine values has been presented, on the basis of a throughout revision of available data. In fact, the average pristine production value of 20 kg/ha of escaping silver eels proposed by ICES for the approval of the IT-EMP in 2010 has proven to be reliable only if referred to the Comacchio area and to the other coastal lagoon environments of the northern Adriatc area. In the case of the Thyrrhenian coastal lagoons and of the Sardinian ponds, this value represents an underestimate of the former silver eel biomass, and in the case of most lakes and rivers in pristine conditions an overestimate. Detailed values and calculations are presented in the Report 2012 (PNG Italia 2012).

Table IT.21. Production values in kg/ha relative to the current biomass escaping from each EMU or region.

Region or EMU code	Kg/ha
VDA	0
PIE	0,89
EMU_LOM	0,69
TAA	1,84
EMU_FVG	3,20
EMU_VEN	3,68
LIG	0,56
EMU_EMR	2,98
EMU_TOS	0,71
EMU_UMB	0
MAR	1,09
EMU_LAZ	3,22
ABR	1,55
CAM	3,05
MOL	2,72
CAL	0,81
BAS	2,41
EMU_PUG	7,50
EMU_SAR	3,25
SIC	4,13
Mean	2,46

Table IT.22. Production values in kg/ha relative to the current biomass escaping from each habitat typology.

Habitat typology	Kg/ha
RIV	1,47
LGN	4,47
MLG	2,93
LAK	0,65
VAL	3,43
Mean	2,59

13.2.2.5 Impacts

No relevant data available.

13.2.3 Stocking requirement eels <20 cm

Stocking requirements of glass eels remain the same that were defined within the IT-EMP (PNG Italia, 2010), but the difficulty to find available seed (both on the national market and by import) shall probably require a revision of the stocking requirements.

13.2.4 Summary data on glass eel

The year 2011 is this first year of implementation of the new regulatory framework for glass eel fisheries, and therefore it must be considered as a pilot year, accounting for the setting up of the declaration system. For the present, filling of the forms by the fishers and dealers was lacking, and the details of the documents of purchase and sale were also deficient. This does not allow complete traceability of movements on the Italian territory. To overcome this problem, a full traceability system is currently being studied, developed in collaboration with the Corpo Forestale dello Stato - Unit CITES. This system should ensure the full traceability of all glass eel movements, either from national waters or imported, also aiming to definitively eradicate illegal fishing of glass eels.

Table IT.23. Summary of available data for glass eel.

	2009	2010	2011	2012
caught in the commercial fishery	0	0	65	299,48
exported to Asia	0	0	0	0
used in stocking	100	46	65	248,49
used in aquaculture for consumption	?	?	?	51,6 (300)
consumed direct	0	0	0	0
mortalities	na	na	na	na

*** in the years 2009, 2010 and 2011 glass eel fisheries were closed, apart a few particular cases of experimental fishing or Province authorizations for stocking purpose. Glass eel fisheries under the new rule began again in 2011/2012.**

13.2.5 Data quality issues

No relevant data available.

14 Sampling intensity and precision

No relevant data available.

15 Standardisation and harmonisation of methodology

In all samplings, those under the DCF Italian Programme as well as those carried out within specific research programmes, standard methodologies are usually followed, according to the most recent literature and/or debated within specific working groups. The following information concerns standardised methodologies carried out within recent national programmes that have involved some research groups (University of Rome Tor Vergata, University of Parma, University of Padova), but not necessarily all monitoring and researches in the country, especially at local levels, follow the same methodology. It is as a matter of fact possible that some monitoring and scientific activities take place that follow other methodologies.

15.1 Survey techniques

Usually surveys rely on professional fishermen, hence traditional fykenets have mostly been used in all recent surveys. Fykenets are usually used in chains of ten nets each, or organised in a triangle arrangement with a net in each vertex. A traditional fykenet consists of three chambers and a codend with knot to knot mesh sizes of 30, 12, 10, and 8 mm respectively. The diameter of the trap entrance is usually around 30 cm and the outer ring of each trap is O or D shaped.

15.2 Sampling commercial catches

The sampling scheme under DCF National Programme foresees to perform biological samplings by local commercial fishers. For 2011, the sampling scheme has foreseen to sample from five different habitat typologies (lagoon, managed lagoon, private lagoon, river, lake) in nine EMUs. For each EMU the sampling has been carried out in the most representative commercial fisheries site, where catches were >20 t. A definitive sampling scheme has been presented in the 2011–2013 Italian National Program under Council Regulation N° 199/2008 and Commission Regulation (EC) N° 665/2008.

15.3 Sampling

Sampling is usually carried out by taking a random batch of eels from a fisherman cumulated catch of the day or of the week. Sample processing foresees different procedures depending on data to be obtained from the samples. Usually length and weight are directly measured on anaesthetised eel, and digital pictures for subsequent specific morphometric measurements are obtained. Samples are released if no other observations are due, or else scarified or frozen for other analyses. Length is measured usually to the precision level of $\pm$0.1 cm and weight to $\pm$1 g. When gonadal tissue is taken, it is fixed in Bouin liquid or buffered formaline. Otoliths are stored dry in *eppendorf*.

15.4 Age analysis

Age analysis of eel in Italy usually relies on the grinding and polishing method (Daverat, 2005). Otoliths are extracted and cleaned to eliminate any remainder of organic tissues. Then the right otolith is embedded in resin and mounted in a slide. Polishing is done with water on a series of abrasive paper with decreasing roughness and finishing with 1 um alumina paste on a polishing cloth. The process is checked frequently under light microscope to reach exactly the primordium. Last step foresees a decalcification process of the grinded otolith surface with acid attack (EDTA 5%) and staining with toluidine blue (5%). Otolith reading is performed under a microscope with high resolution power. The reading is facilitated if a video camera and monitor are coupled to the microscope. There is no specific formal validation or quality control, besides those carried out within ICES coordinated actions such as WKAREA I and II.

15.5 Life stages

Glass eel/elver stages are determined by evaluating pigmentation using the classification by Strubberg (1913), and/or the one by Elie *et al*. (1982).

Yellow eel and silver eel are categorised by a combination of different approaches: skin colouration, the ocular area index (Pankhurst, 1982), the silvering index (Durif, 2005) and gonads histological analysis. Silver eels are generally captured during their downstream migration, or can be recognised in the brown eel catch by the enlarged eyes and onset of coloration change.

15.6 Sex determinations

Yellow eel <25 cm are considered undifferentiated. Eels >25cm are sexed by dissection and histological analysis following the protocol of Colombo and Grandi (1996).

16 Overview, conclusions and recommendations

In the present report an overview of the European eel stock and fisheries is presented for Italy, that takes into account the activities that have taken place in 2010 and 2011 among the actions for the implementation of the IT-EMP (under Regulation 1100/2007), that has been approved in July 2011 and hence in force.

Italy has followed the approach of using a progressively improved database for the assessment of the reference points required by Art. 9 of the Regulation 1100 for the international stock assessment. Compared to 2008, in fact, a series of tools and activities were set up that have resulted in a database much more detailed and reliable.

In this report, as in the Report (PNG Italia, 2012), revised estimates of B_o and estimates of B_{curr} and B_{best} have been presented, calculated using revised estimates of wetted areas and using productivity values in kg/ha diversified by habitat type, based on new evidence from the literature. This approach seems more appropriate, and the only one that allows to take into account the diversity of situations in the various EMU in Italy, balancing the roles of different Management Units in the process of recovery of the eel stock, depending on the type of habitat prevailing in each.

In this report preliminary estimates of some parameters are provided for those regions (11) that do not have presented a Regional Management Plan, choosing the option of a total closure of the eel fisheries in their waters. For these regions, which do not participate for the moment in the process of recovery of the eel stock, no data of eel biomass in pristine conditions or in current conditions had been provided in the IT-EMP (PNG Italia, 2009). However, it became necessary to quantify the role that the complete closure of the fishery in these regions can have in terms of biomass of escaping silver eels.

Overall, despite the delay in the approval of the National Management Plan in Italy and the consequent delays in the implementation of regional plans, the general structure and the implementation framework are now in place. A coordination table which involves the central and regional administrations has been set up, with the support of scientists and technicians, which is unprecedented in Italy for the fisheries and management of inland waters.

Furthermore, the DFC for eel is definitively in place, and this has proven to be a valuable tool for eel management and fisheries evaluation, that also provides a coordinated framework for other actions for eel monitoring and assessment.

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Report on the eel stock and fishery in Latvia 2011/'12

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Reporting Period: This report was completed in August 2012, and contains data up to 2011 and some provisional data for 2012.

2 Introduction

Latvia's system of fishing regulation and catch recording has been adapted from the respective legislation of the former USSR, when the private sector in fisheries was almost non-existent. Therefore these requirements in Latvia are tighter than in the majority of EU Member States. This is the reason why it is not necessary to change the principles and control system of fishing in inland waters in accordance with Article 10 of EC 1100/2007 as the existing fishing regulatory and control system covers both public and private waters. More it reflects to the coastal waters where the direct eel fisheries are not conducted at all.

2.1 Management of eel fisheries

Fishery Law determines the commercial fisheries and self-consumption fisheries. It is forbidden to sell the fish caught in self-consumption fisheries. Limits (in numbers and types) on eel fishing gear are allocated only for commercial fisheries.

The number of eel fishing gear units (trapnets or eel weirs) is set individually for each waterbody (fishing gear limit). Such practice of fishing regulations in eel fisheries has established since 1999 (in some lakes since 2000). In order to conduct commercial fishing, an operator needs:

- in public waters or waters where fishing rights belongs to the state, a fishing right lease agreement, which has been concluded with the local municipality;
- a permit for commercial entrepreneur activities issued by the local municipality;
- fishing licence issued by Marine and Inland Waters Administration (MIWA) regional control sector.

These requirements apply both to public and private waters. Fishing regulations determine specifications of fishing gear (size, mesh size), fishing seasons, fishing areas and eel size limits in fishing, provisions apply to all waters, including the privately owned waters.

Landings are reported in monthly logbooks by the date, number and type of gear, catch/landing in kg.

Since 2010 the number of commercial fishing gears in inland waters is fixed. Every changes of gear number should be accepted by BIOR (as adviser) and Ministry of Agriculture and finally approved by Cabinet of Ministers for one year period.

2.2 Collection of fishing data

Every person fished by gear used in commercial fishing obligates fill up the logbook. Logbooks are based on registration of fishing occasions.

Logbooks from coastal and inland fisheries were collected by local Boards of MIWA and transmitted to BIOR for data summarization and storing. All logbook data were verified by BIOR.

National sea and coastal fisheries data base (ICIS) are administrated by Department of Fisheries Ministry of Agriculture. ICIS is connected with vessels register.

Inland fisheries data maintained by BIOR and at once in quarter handed to State Board of Statistics (SBS).

ICIS data and data from SBS are used as official country data.

3 Time-series data

Only time-series of landings (yellow and silver eel mixed) in inland and coastal waters and data of restocking by waterbody available.

3.1 Recruitment-series and associated effort

NA.

3.1.1 Glass eel

NA.

3.1.1.1 Commercial

Time-series for inland and coastal fishery (yellow and silver eel mixed).

3.1.1.2 Recreational

NA.

3.1.1.3 Fishery independent

NA.

3.1.2 Yellow eel recruitment

NA.

3.1.2.1 Commercial

NA.

3.1.2.2 Recreational

NA.

3.1.2.3 Fishery independent

NA.

3.2 Yellow eel landings

Eel landings are not separated by yellow and silver eel. Dataseries on eel landings (mixed) available for:

- eight lakes restocked by eel. These lakes are not accessible for natural eel. Time-series available of all species landings since 1945~1946 till now;
- one lake and one lake system of four interconnected lakes without eel re-stocking before 2011. These lakes are accessible for eel. Time-series available of all species landings since 1945~1946 till now;
- Coastal waters time-series of all species landings from 1924 till now (except II World War years).

3.2.1 Commercial

All landings noted in Section 3.2 are commercial.

3.2.1 Recreational

Only data on commercial fishing is available.

3.3 Silver eel landings

Only from the year 1992 is possible to divide eel landings by gears, assuming that eel landed by eel weirs or traps in lakes outlets targeting mostly silver eel. Currently this data is not ready made.

3.3.1 Commercial

All landings noted in Section 3.2 are commercial.

3.3.2 Recreational

Only eel angling is allowed in Latvia for recreational purposes. Some eel are caught as bycatch in self-consumption fishery.

The catches of eel by anglers were estimated in an inquiry carried out in 2007. The targeted angling of eels takes place mostly in lakes where eel has been artificially re-stocked. Data from personal consumption fisheries are exhaustive because fishermen are obliged to report the catches by the same type of logbooks as commercial ones. These data covers all seasons, gear and watercourse.

In 2011 eel catches by anglers were estimated to be 1,2 t and in self-consumption fishery 0,2 t.

3.4 Aquaculture production

No eel aquaculture enterprises in Latvia.

3.4.1 Seed supply

NA.

3.4.2 Production

NA.

3.5 Stocking

All stocking of any species in natural waterbodies must be reported by special protocol to Ministry of Agriculture. Generally few persons ("commission") representing local municipality and fish supplier participates in stocking at situ to certify the fact.

3.5.1 Amount stocked

Number of eel by age groups stocked in Latvia:

Year	Number of eel*1000	
	glass eel	ongrown
2008	0	3
2009	0	0
2010		7,7
2011	386	3,6
2012	1030	

Supplier: Marten Business Group s.r.o., reg.num.: CZ28989821, Legal address: Mezibranska 1579/4, 110 00, Praha 1 – Nove Mesto.

3.5.2 Catch of eel <12 cm and proportion retained for restocking

No eel less than 12 cm fishery in Latvia.

3.5.3 Reconstructed time-series on stocking

There are only foreign sources of restocked eel in Latvia. Restocking time-series data were presented to WGEEL previously.

4 Fishing capacity

There is no fishing targeting the eel in Latvia's coastal waters. In 2011 62 fishermen's (legal and physical entities) reported caught eels with total amount of 1.04 t. All persons, fishing rights leaseholders are registered in national database (ICIS).

In total 51 fishermen's enterprises/legal persons (mostly family enterprises) operated with eel gear in inland waters of Latvia. All together eel fishing in 2011 carried out in 16 lakes and one artificial reservoir, only three of them are accessible for natural eel. Logbooks information: waterbody, municipality, fishermen identity, gear, number of days in operation, landing are registered in database managed by BIOR.

4.1 Glass eel

NA.

4.2 Yellow eel

Fishing capacity would explain as number of eel traps (number of fishing enterprises, number of licences issued) in lakes restocked by eel.

4.3 Silver eel

Fishing capacity in inland waters would explain as number of eel traps and eel weirs in lakes outlets (lakes connected with rivers blocked by dams but at one time restocked by eel- in Latvian EMP- eel rearing lakes), and number of gear in lakes accessible for eel. In coastal waters- number of fishermen's reporting eel bycatch.

4.4 Marine fishery

No eel marine fishery in Latvia.

5 Fishing effort

Gear types– inland waters

Earlier eels were mainly caught with bottom anchored longlines using fish (herrings, roaches and sandeels) and earthworms for a bait. Longlines are not allowed now in Latvias inland waters. At present eels are caught with different types of traps, fykenets and eel weirs of various types. It should be mentioned that direct eel fisheries in Latvia are conducted only in inland waters and only with stationary fishing gears; traps and eel weirs.

Fykenets in lakes. They are stationary, small-size fykenet with a 6–10 m long fence and a cage or trap fastened at both ends. These traps are connected with each other in setlines. Such gears are used in big quantities, up to 300, in eel stocked production Lake Rāzna located in the Daugava RBD. They are only up to 1 m high and are used in the depth close to the bottom.

Eel trap construction is identical to a common fish trap, except allowed mesh size which is 12 mm (from knot to knot). It consists of a fence with one (parallel to the fence) or two (perpendicular to the fence) cage(s) or trap(s) at its end. Depending on the length of the fence, there are two categories of these traps; traps with a fence up to 30 m long and longer than 30 m. These eel traps are used for fishing in the area from the littoral zone towards the open part of the lake at the depth of 5–6 m. The allowable mesh size for eel traps used in lakes may not be less than 12 mm (the distance between two knots of the netting).

Eel traps in the river outlets at lakes consist from two wings with a cage or trap placed between them. To keep access for fish migration it is forbidden to cross more than 50% of the river width with the traps of this type. The mesh size of such fishing gear shall not be less than 12 mm.

There are two types of **eel weirs**, and they are used in river outlets at lakes. An eel weir is a fundamental construction: it is a dam that has two functions; water level control in the lake and eel catching. Before start the eel fishing the water in the lake is held up, but on the beginning of fishing activity water is leaded through the eel weir. Such manipulations with the water levels and flow facilitate eels' migration downstream. The lower part of the eel weir consists from a chamber, where eels are caught using a "tale" or codend made from the netting. Eel weirs were built to earn the maximum fishable production from eel stocked production lakes.

For purpose of fishery regulatory measures since 1990s the term 'eel weir' is also used to designate the eel traps where it is allowed to cross a river outlet from the lake along its entire width. However, their efficiency in fishing seems to be lower than that of stationary eel weirs.

Until 2004 bottom longlines were often used in eel fishing in the inland waters. Later they were totally prohibited to use.

Gear types– coastal waters

No direct eel fishing is conducted in coastal fisheries today. According to catch statistics, eels are caught as bycatch mainly during fishing with small fish traps (traps for herring, smelt, perch) with the mesh size 18 to 30 mm and in flounder fishing with longlines. Eels are also caught during direct eelpout fishing with eelpout traps and in small amounts in herring trapnets.

Number of gear/eel fishing/inland waters

Number of eel fishing gears and licences in Latvia inland waters.

Year	Accessible for eel	Not accessible restocked by eel			
	Trapnets <30 m	Trapnets >30 m	Trapnets <30 m	Eel weirs- traps	Eel weirs- stationary
1999	65		514	27	10
2000	65	26	449	27	10
2001	65	26	554	28	6
2002	65	26	554	27	6
2003	65	26	494	27	10
2004	65	26	494	25	11
2005	70	23	484	24	11
2006	68	9	434	23	11
2007	68	9	327	23	11
2008	68	9	327	23	11
2009	68	13	327	27	11
2010	68	13	347	27	11
2011	68	13	347	27	11
	Number of licences issued				
Year					
	Accessible for eel	Not accessible restocked by eel			
	Trapnets <30 m	Trapnets >30 m	Trapnets <30 m	Eel weirs- traps	Eel weirs- stationary
2009	15	1	11	21	8
2010	13	1	11	18	7
2011	12	1	11	19	7

5.1 Glass eel

NA.

5.2 Yellow eel

Fishing effort is limited by number of gear, 347 fykenets and 13 trapnets were available for lease holders. Number of licenses issued- 12, number of gear in operation- less than available.

5.3 Silver eel

Fishing effort is limited by number of gear, 68 trapnets, 27 weirs- traps and eleven stationary weirs were available for lease holders. Number of licences issued- 38, number of gear in operation- less than available.

5.4 Marine fishery

NA.

6 Catches and landings

At present the annual catches of eel in Latvia no exceed 20 t. Landings are reported by monthly logbooks on date basis. Number and type of gear, time in operation are registered in logbooks.

Logbooks from coastal and inland fisheries were collected by local Boards of MIWA and transmitted to BIOR for data summarization and storing.

Catches and landings are not separated in life stages of eel.

In 2011 0,66 t of eel landed in coastal waters 0,7 t and 5,4 t from inland waters.

6.1 Glass eel

NA.

6.2 Yellow eel

Estimated from mixed catch- 2,07 t.

6.3 Silver eel

Estimated from mixed catch- 4,05 t.

6.4 Marine fishery

No eel marine fishery in Latvia.

7 Catch per unit of effort

Not calculated, number of gear days and catches available from national or BIOR d_bases, series from 1990s. Angling data are not available.

7.1 Glass eel

NA.

7.2 Yellow eel

7.3 Silver eel

NA.

7.4 Marine fishery

NA.

8 Other anthropogenic impacts

All together at least 700 artificial obstacles stand on rivers of Latvia as at 2011. Largest part of them are mill dams, ~140 HPS and dams built for water level regulation in lakes. Estimated, that 60% from country territory inland waterbodies are not accessible for migratory fish. It's estimated that inland waters belonging approximately to 61% of state territory are not accessible for eel.

9 Scientific surveys of the stock

No scientific surveys of eel in Latvia. The overall monitoring results in Latvia's rivers show that at present the quantity of eels in rivers is small, the population density apparently is less than 1 ind./ha.

10 Catch composition by age and length

Only DCF sampling carried out in Latvia. No eel age reading in Latvia.

11 Other biological sampling

11.1 Length and weight and growth (DCF)

NA.

11.2 Parasites and pathogens

NA.

11.3 Contaminants

NA.

11.4 Predators

NA.

12 Other sampling

13 Stock assessment

13.1 Local stock assessment

NA.

13.2 International stock assessment

NA.

13.2.1 Habitat

Wetted Area accessible for eel:

lacustrine- 16 102

riverine- 7476

coastal&transitional- 89 776

In Latvia the habitats accessible to the eel species *Anguilla anguilla* constitute area of 113 354 ha. In total 7476 ha in rivers, 16 102 ha in lakes and about 89 776 ha along the coastline of the Gulf of Riga and the Baltic Sea (ICES Subdivision 28).

13.2.2 Silver eel production

There are only historical catch data of eel in Latvia.

Production values of silver eel.

	Area (ha)	Prod./ha	
		max_observed	avg from 1980s
Coastal waters*	89 000	0.7	0.01
Lakes, acessible for eel[2]	5419	2	0.1
Lakes restocked by eel[1]	22 375	5.6	0.6

***- till 10 m depth.**

[1]- 10 lakes, restocked by eel.

[2]- lakes with commercial fishery data from 1946.

13.2.2.1 Historic production

NA.

13.2.2.2 Current production

NA.

13.2.2.3 Current escapement

NA.

13.2.2.4 Production values e.g. kg/ha

NA.

13.2.2.5 Impacts

NA.

13.2.3 Stocking requirement eels <20 cm

NA.

13.2.4 Summary data on glass eel

Glass eel restocked in Latvia:

2010-0;
2011-386 000;
2012-1 030 000.

13.2.5 Data quality issues

NA.

14 Sampling intensity and precision

NA.

15 Standardisation and harmonisation of methodology

15.1 Survey techniques

NA.

15.2 Sampling commercial catches

Eel sampling area: Area near the river Daugava outlet (Gulf of Riga, ICES Subdivision 28) 57’03’57.11N; 24’01’31.28E.

One trapnet, checked 2–3 times per week from 1st of May till 1st of October.

Sampling carried out by local fisherman (trained for sampling) engaged by BIOR for data collection.

Eel sampling (100–200 specimens per year- all eel landed from one trap):

- fresh eel, killed;
- length (mm), weight (g), length of pectoral fin (mm), eye diam. (mm) (vertical and horizontal), sex by macroscopic examination, otholits, *Anguillicola* (presence or absence).

Also all eel caught by longlines and/or fykenets used in coastal fisheries research by BIOR staff sampled as describe above.

No eel age reading in LV.

Eel sampled from coastal fisheries in Latvia.

Vieta	Number	L+ stdev (mm)	W + stdev. (g)
The river Daugava outlet Subdivision 28	35	776+ 162	1058+ 487
Jūrkalne- Main Baltic coast Subdivision 28	48	708+ 119	827+ 445
Pape- Main Baltic coast Subdivision 28	9	664+ 105	641+ 359
Total	92	729+ 139	898+ 471

15.3 Sampling

NA.

15.4 Age analysis

NA.

15.5 Life stages

NA.

15.6 Sex determinations

From macroscopic examination; all eels sampled in 2011 were females.

16 Overview, conclusions and recommendations

17 Literature references

Report on the eel stock and fishery in Lithuania 2011/'12

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Reporting Period: This report was completed in August 2012, and contains data up to 2011 and some provisional data for 2012.

2 Introduction

2.1 Eel habitats

Eel habitats in Lithuania include lakes, reservoirs, the Curonian Lagoon and the Baltic Sea coastal zone. According to Barak and Mason (1992), natural populations of eel in rivers are concentrated in estuaries or lower reaches. Eel are found more than 1000 km upstream. However, normally the migration rate of their populations is less than 20 km a year (Dekker, 2004). It is evident that this migration, when occurring during the stage of the yellow eel, depends on the population density. With regard to the fact that in Lithuania eels from the sea enter a highly productive Curonian Lagoon where the population density is meagre, it can be assumed that eel migration from the Curonian Lagoon upstream the Nemunas River is possible but highly unlikely in the present state of the population. Yellow eel are extremely rare in Lithuanian rivers; according to Virbickas (pers. comm.) in Lithuania and Birzaks in Latvia (pers. comm.), decades-long studies of electrofishing have shown just a few eels caught in rivers. Those few eel in rivers have been found in the streams in short distance from the lakes stocked with eel (Lithuania) or by river dams near the sea (Latvia). Commercial fishing statistics recorded eel catches in water bodies of the Nemunas delta area (delta branches, old riverbeds and polders) during the period 1950 to 1969 which averaged between 0.1 t and 0.3 t per year. Thus, in the present state of stocks, rivers in Lithuania are not considered typical eel habitats, but they are ways of silver eel migration.

2.2 River basins in Lithuania and EMU according to national EMP

Lithuania has 2782 lakes with areas exceeding 0.5 ha (88 548 ha) and 1159 reservoirs with areas over 0.5 ha (28 306 ha), also 4418 rivers longer than 3 km, their total length measuring 37 636 km and their surface area totalling 33 200 ha. Lakes and reservoirs over 50 ha number 285 (68 754 ha) and 70 (21 291 ha) respectively. Lithuanian territory covers 41 300 ha (26%) of the Curonian Lagoon (total area 158 400 ha). The Baltic Sea coastal zone is the area between the coastline and the 20 m depth isobath. This zone makes up an area of 41 500 ha. According to Directive 2000/60/EC, there are four RBDs in the territory of Lithuania (Figure 2.2.1):

1) Nemunas RBD (73.9% of the LT territory);
2) Daugava RBD (2.8% of the LT territory);
3) Lielupe RBD (13.7% of the LT territory);
4) Venta RBD (9.6% of the LT territory).

All four RBDs are transboundary basins. The largest one is the Nemunas RBD where 41.9% of the river basin area is in the territory of Lithuania, 39.6% in Belarus, 9.7% in Poland, 8.7% in Russia (the Kaliningrad region) and 0.1% in Latvia.

The Daugava, Lielupe and Venta RBDs are situated in the territories of Lithuania and Latvia. The Daugava RBD is also located in the territories of Russia and Belarus. Only 2.8% of the territory of this RBD is in Lithuania, where eel habitats (lakes) are not numerous. In addition, the habitats are not viable for the recovery of eel stocks as there are as many as three large HPs on the Daugava River in the territory of Latvia. With regard to this, Lithuania does not find it reasonable to recover stocks in this part of the Daugava RBD as long as the HPs should cause mortality for migrating the silver eel. Lithuania will apply common EMP measures by way of fishery restrictions in this part of the Daugava RBD, just as it does in the remaining territory of the country.

The Lielupe and Venta RBDs are situated in the territories of Lithuania and Latvia only. In Lithuania, these two basins cover 23.3% of the country's area, but habitats appropriate for eel (lakes and reservoirs) make up only 4.2% and 4.4%, respectively. It should be noted that over the past ten years the annual eel catch in inland water bodies has only been 5.1 tonnes on average and has depended on stocking. The Lielupe and Venta RBDs practically have no eel as there is no stocking in the waterbodies of the Lielupe basin has occurred since 1983, while stocking in the Venta basin has amounted to 0.1% of the total quantity of stocked eel in the same period. In addition, the Venta basin has a number of hydropower plants built in series on rivers that have their source in the basin's largest lakes. Under these circumstances Lithuania does not see need to prepare the individual plans for the RBDs where eel are practically non-existent at present. However, common EMP measures will be applied to the territories of these RBDs by imposing fishery restrictions. With a view to recovering the eel population in these RBDs, Lithuania will apply measures similar to those in the whole territory of the country. However, it would implement those actions only upon coordinating them with Latvia to ensure migration of silver eel.

Lithuania has designated one Management Unit for the EMP based on Council Regulation (EC) 1100/2007 where Article 2(1) stipulates such a possibility and is developing one EMP for the whole territory of the country. The EMP Management Unit has been designated according to Lithuania's division into RBDs under Directive 2000/60/EC. The EMP also includes the Baltic Sea coastal zone. Assumptions for the designation of one EMU:

- The commercial catch and stocks of eel are not high in the territory of Lithuania and have averaged around 15 t annually over the past ten years;
- The Nemunas RBD comprises 74% of the territory of Lithuania and 81% of eel habitats;
- About 99% of eels stocked since 1983 are found in the Nemunas RBD;
- About 99% of the eel catch and stocks are attributed to the Nemunas RBD;
- The Nemunas RBD includes 96% of lakes of reservoirs from which eel can escape unaffected by turbines or through passes installed on HP dams;

- Although the Daugava RBD comprises a fairly large part of lakes and reservoirs (11.6%), escapement of eel to the sea is restricted by three large HPs in Latvia;
- Conditions in the other RBDs are similar (except for the different impacts of HPs), thus no specific measures for implementation of the plan in the other basins are needed.

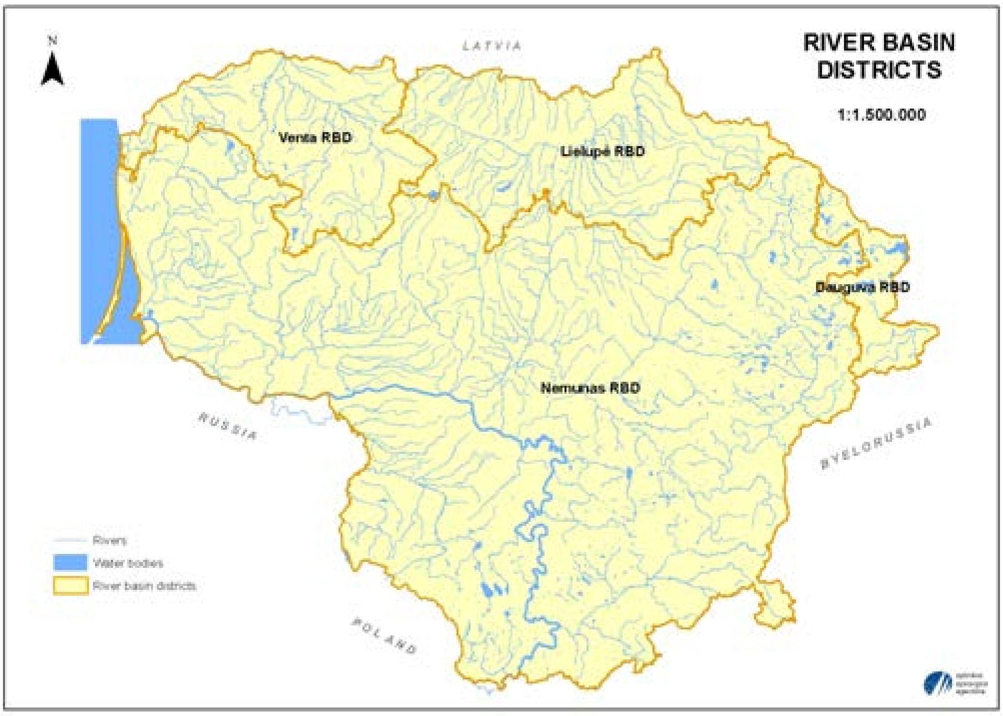

Figure. LT. 2.2.1. Lithuanian River Basin Districts.

2.3 Eel fishery

According to importance, fishery features, catches and the origin of eels, fisheries in Lithuania should be divided into fishery in inland waters and the Curonian Lagoon, and very small-scale fishery in the Baltic Sea. Commercial fishery statistics have been available since 1926. That year saw a 55.1 tonne catch of eel. Similar catches were recorded until 1938. Active fishing began again from the early 1950s (at least statistics became available), and the average catches of eel were 141 tonnes during 1953–1978. The largest catches amounting to 260 tonnes were recorded in 1963. Catches went into decline from the mid-1970s, and over the last ten years they have made up 15 tonnes on average. Slightly higher catches (average 17.1 tonnes) in 2004–2007 are to be linked with improved fishery controls and reporting. During 1926–2007, the major part of catches (88.5%), came from the Curonian Lagoon During the period from 1926 to 1938, eels on average accounted for 18.8% of the value of fishery in inland waterbodies and the Curonian Lagoon (excluding the Vilnius region). The value of catches from these water bodies in 2007 amounted to about LTL 6.3 million. Eels accounted for 13.4% of the value of catches at the price of 56.5 LTL/kg (the average price of other fish was 3.3 LTL/kg). Therefore, despite relatively low catches, income from the eel fishery in the structure of fishermen's income is very significant.

2.4 Fishery management and authorities responsible for EMP implementation

Pursuant to the Law on Fisheries of the Republic of Lithuania (27 June 2000, No VIII-1756), the regulatory authorities in the fisheries sector are:

The Ministry of Agriculture which participates in the making and implementation of the Lithuanian fisheries policy, conducts management of the fisheries sector, implements the Common Fisheries Policy of the European Union, organises and implements conservation and control of fish stocks in maritime waters; establishes the procedure for commercial fishery and issues permits for fishing in maritime waters; owns, manages and uses a data system of fisheries in maritime waters (exploitation of fish stocks, users, economic and biological data, etc.).

The Ministry of Environment which participates in the making and implementation of the fish stock conservation and control policy, conducts public management of the fisheries sector in inland waterbodies; establishes the regulation for commercial and recreational fisheries in inland waterbodies and issues permits (except for private fish waterbodies); owns, manages and uses a data system of fisheries in inland waterbodies (use of fish stocks, users, economic and biological data, etc.).

The Ministry of Agriculture and the Ministry of Environment which, within their respective competence, organise the recovery of fish stocks and fisheries research in fisheries waterbodies.

The Ministry of Environment is responsible for the exploitation of fish stocks in inland waterbodies, including the Curonian Lagoon. The Ministry of Agriculture is responsible for the implementation of the Common Fisheries Policy of the European Union. Since the Council Regulation contains the obligation to prepare and implement the EMP, therefore both ministries assume the responsibility for preparing and implementing the plan. In addition, conservation measures for protected fish species, including the eel, and their habitats and migratory routes are established and their implementation is controlled by the Ministry of Environment, while the work of improving the conditions for farming, spawning and migration of protected fish species is organised by the Ministry of Agriculture or a body authorised by it. The procedure for fisheries in public fisheries waterbodies and also of eel stocking, carried out according to the programmes approved by the Ministry of Agriculture and agreed with the Ministry of Environment, is also established by both ministries.

3 Time-series data

3.1 Recruitment-series and associated effort

3.1.1 Glass eel

Glass eel do not occur in Lithuanian waters. The likelihood that eel used to come to the Lithuanian coast in the glass eel stage at the beginning of the 20th century cannot be ruled out. However, the last two reports on glass eel found in coastal streams come from the mid-1940s.

3.1.1.1 Commercial

Glass eel do not occur in Lithuanian waters.

3.1.1.2 Recreational

Glass eel do not occur in Lithuanian waters.

3.1.1.3 Fishery independent

Glass eel do not occur in Lithuanian waters.

3.1.2 Yellow eel recruitment

3.1.2.1 Commercial

No available data.

3.1.2.2 Recreational

No available data.

3.1.2.3 Fishery independent

A study of eel otoliths' microchemistry intending to restore the migratory past and origin of eels have established that all eel examined in inland waterbodies are stocked, while in the Curonian Lagoon and the Baltic Sea coastal zone 80% and 98% of eel respectively come from natural migration and 20% and 2% are stocked. These studies indicate that eel arrive in Lithuania's fresh waterbodies in the stage of the yellow eel at the age ranging between one and 10 years (average 5.2 (±2.1)) (Schiao *et al*., 2006; Lin *et al*., 2007).

3.2 Yellow eel landings

3.2.1 Commercial

No available data. Total landings of yellow and silver eels are combined.

3.2.2 Recreational

No available data.

3.2.3 Fisheries independent

No available data.

3.3 Silver eel landings

3.3.1 Commercial

No available data. Total landings of yellow and silver eels are combined.

3.3.2 Recreational

No available data.

3.3.3 Fisheries independent

No available data.

3.4 Aquaculture production

3.4.1 Seed supply

No available data.

3.4.2 Production

In Lithuania, eel have been reared by one company Auksinis ungurys Ltd. since 1998, which in recent years has produced about ten tonnes of eel annually (Table 3.4.2.1). After it is completed the company will need 280 kg of glass eels annually. According to the company, they exported eels for stocking to Belarus in 2004–2008 (Table 3.4.2.2).

Table. LT. 3.4.2.1. Marketable eel production in aquaculture during 1998–2011.

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Production, t	2	2	1	5	17	20	9	8	12	13
	2008	2009	2010	2011						
Production, t	10,6	12,0	8,3	12,6						

Table. LT. 3.4.2.2. Auksinis ungurys Ltd information on exports to Belarus.

Year	Quantity, units	Size
2004	375 000	1–4 g
2005	1 050 000	glass eels
2006	150 000	1–5 g
2007	350 000	1 g
2008	260 000	1–5 g
Total	2 185 000	

3.5 Stocking

3.5.1 Amount stocked

Stocking of lakes with glass eel in the territory of Lithuania was carried out in 1928-1939 in the Vilnius area (a part of the area and the stocked lakes now belong to Belarus). Back then, about 3.2 million glass eel were stocked. In the post-war period, stocking of Lithuanian inland waterbodies with glass eel originating from France or Great Britain began in 1956 (or 1952, according to other data). During 1956–2007, a total of 148 lakes and reservoirs covering an area of 95 618 ha was stocked. About 50 million glass and juvenile eels were stocked in total, or 1.25 million per year on average (Figure 3.5.1.1). Some 89% of them were stocked in the Nemunas RBD, mostly in the basins of the rivers Žeimena and Šventoji. Stocking during the most intensive period of 1960–1986 amounted to 33.2 million eel. The area of waterbodies where stocking was carried out comprised 40 204 ha, and the average stocking density made up almost 826 individuals/ha throughout the whole period. Later on, the quantities declined and stocking was sporadic, but small quantities were stocked on an annual basis. The last more sizeable stocking took place in 2004 with 70 100 juvenile eel stocked. From 1983 (a period when at least some eel could have remained in the country's waterbodies) about ten million eel were stocked, their major part (96.5%) being in the Nemunas basin (99% of the Nemunas RBD). Lakes of the Žeimena (60%) and the Šventoji (19%) subbasins saw the most intensive stocking. Stocking in the Curonian Lagoon (143 000) in that period was low (Figure 3.5.1.2). Stocking activities started again in 2011. 134 000 ongrown individuals were released in 2011, 444 000 individuals; in 2012 to the inland waters. More than 10% of released individuals were marked by Alizarin S.

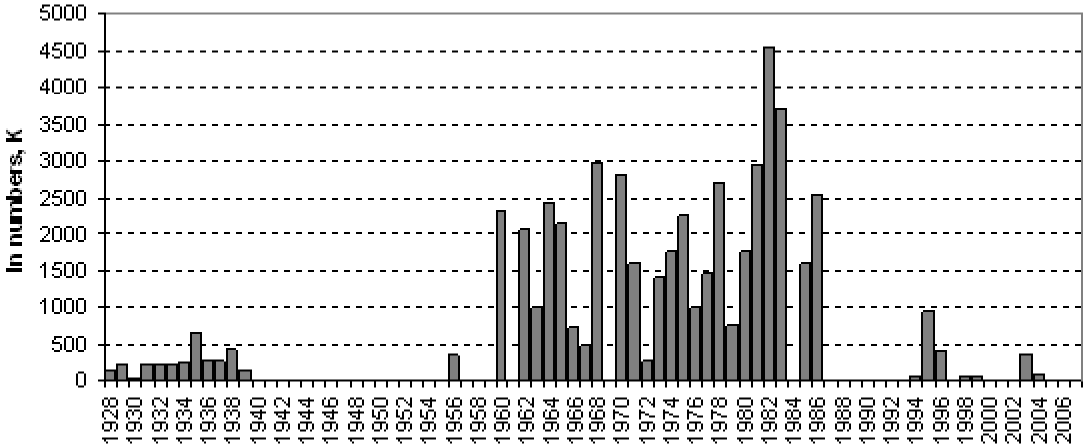

Figure. LT. 3.5.1.1. Stocking of inland waterbodies with glass eels in the period 1928 to 2012 (in thousands).

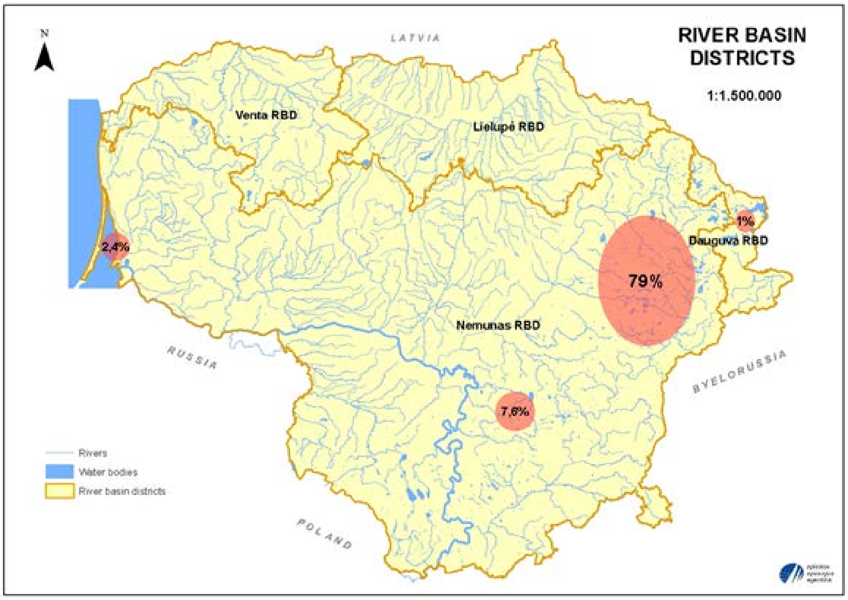

Figure. LT. 3.5.1.2. Major eel stocking regions since 1983 to 2010.

3.5.2 Catch of eel <12 cm and proportion retained for restocking

There is no fishery of eel <12 cm.

3.5.3 Reconstructed time-series on stocking

Table 3.5.2.1. LT. Stocking of eels in Lithuania (in millions) stocked.

	Local Source				Foreign Source			
Year	Glass Eel	Quarantined Glass Eel	Wild Bootlace	On-grown cultured	Glass Eel	Quarantined Glass Eel	Wild Bootlace	On-grown cultured
1950					-			
1951					-			
1952					-			
1953					-			
1954					-			
1955					-			
1956					0.344			
1957					-			
1958					-			
1959					-			
1960					2.300			
1961					-			
1962					2.100			
1963					1.000			
1964					2.400			
1965					2.200			
1966					0.750			
1967					0.500			
1968					3.000			
1969					-			
1970					2.800			
1971					1.600			
1972					0.237			
1973					1.400			
1974					1.750			
1975					2.240			
1976					1.000			
1977					1.450			
1978					2.700			
1979					0.750			
1980					1.750			
1981					2.950			
1982					4.550			
1983					3.700			
1984					-			
1985					1.600			
1986					2.550			
1987					-			
1988					-			

	Local Source				Foreign Source			
Year	Glass Eel	Quarantined Glass Eel	Wild Bootlace	On-grown cultured	Glass Eel	Quarantined Glass Eel	Wild Bootlace	On-grown cultured
1989					-			
1990					-			
1991					-			
1992					-			
1993								0.013
1994					0.065			
1995					0.529			
1996					0.394			
1997								0.004
1998					0.064			
1999								0.050
2000								0.004
2001								0.009
2002								
2003					0.353			
2004								0.071
2005								0.002
2006								
2007								0.005
2008								0.005
2009								0.01
2010								0.002
2011								0.134
2012								0.444

4 Fishing capacity

4.1 Glass eel

There is no glass eel fishery.

4.2 Yellow eel

In Lithuania's inland waters, comparing statistical data on eel catches during the period of 2007–2011, 48% of eel, mostly in the stage of the yellow eel, is caught in rivers using traps, while a small amount is caught using longlines. Average amount of caught eel in the period is 6,1 tonnes per year. In 2012 there was eel fishing quota established in 51 rivers, it was distributed to 34 fishing companies and individual fishermen. According to studies of escapement seasonality, 60% of eel escape in spring. Only 14 of eel during the period were caught in lakes, where average catch was 1,8 tonnes per year. Fishery in the Curonian Lagoon lands mostly yellow eel also, however some small portion of silver eel are caught as well. Here the established quota for fykenets in 2003 was 413 units; now in 2012 it is reduced to 219 units. Fykenets to catch eel are used by 48 local fishing companies, which are small enterprises only with two or three employees. Most companies own between one and four small vessels (up to 10 m long). There are only a few vessels with the length exceeding 10 m. A total of 148 vessels are registered in the Curonian Lagoon. Pursuant to the rules of implementation of the activity 'Modification for reassignment of inland fishing vessels' of priority axis 2 'Aquaculture, inland fishing, processing and marketing of fishery and aquaculture products' under the Operational Programme for the Lithuanian Fisheries Sector for the period 2007–2013, approved by Order No 3D-549 of the Minister for Agriculture of 9 October 2008, LTL 10 million are to be allocated to modification for reassignment of inland fishing vessels to other activities. Up to now, 20 fishing companies that were fishing in the Curonian Lagoon participated in the Operational Programme, fishing fleet was reduced by 73 vessels.

4.3 Silver eel

According to rough estimations, 55% of eel caught at the inland waters are in seaward migration (silver eel); they are caught by setting trap in the river. The number of companies or individual fishermen fishing (silver eels) in rivers in 2012 is 34. Fishing sites are established and fishing permits are issued by the Ministry of Environment, while the Ministry of Agriculture distributes fishing quotas among fisheries companies and individual fishermen by way of competition. In 2005–2008, the number of fishing sites in rivers was reduced from 77 to 44 and in 2012 it increased to 51 (Figure 4.4.2.4). Fishing with one trap is allowed in each fishing site at a time. On average, one company fished in 4.3 sites in 2004 and in 1.8 sites in 2007, while 1.5 in 2012.

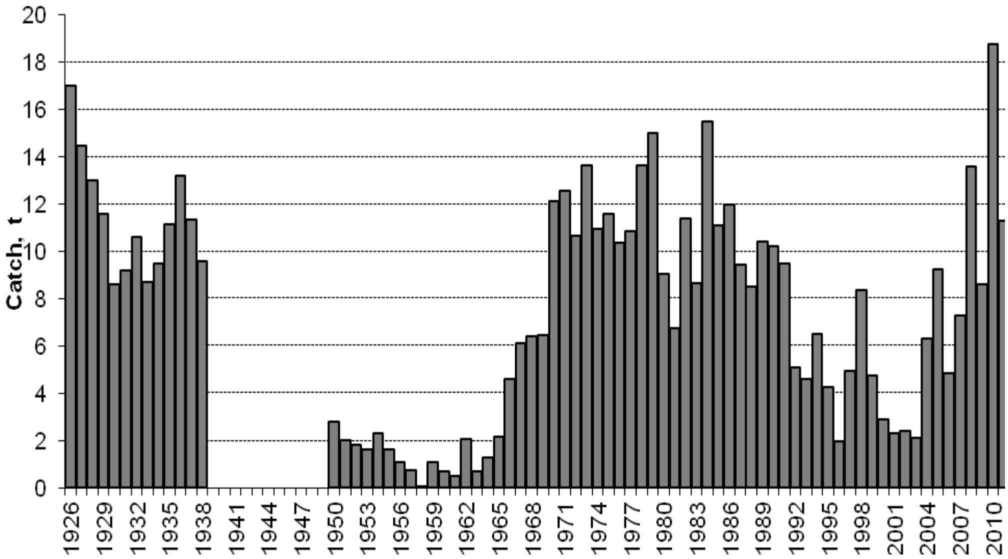

Figure. LT. 4.3.1. Eel catches (in tonnes; mixed yellow and silver eel fishery) in inland waterbodies during 1926–2011. (Note: 1926–1938 excludes the Vilnius area; no data on catches in 1939–1949; catches prior to 1939 are mostly from inland waterbodies of the coastal region).

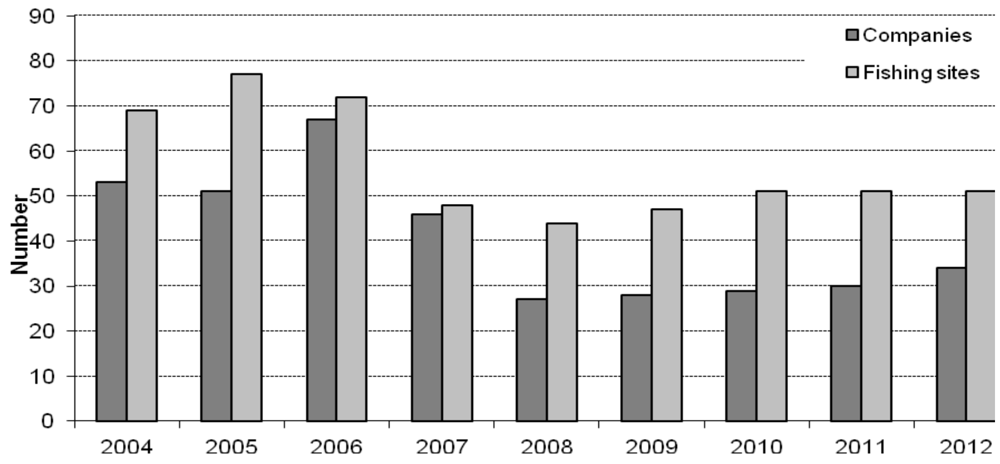

Figure. LT 4.3.2. Number of companies engaged in the eel fishery with river traps and trap quotas in 2004–2012.

4.4 Marine fishery

The eel fishery in the Baltic Sea coastal zone has never been significant. Pre-war commercial fishery statistics mentioned eels in 1931 (0.6 tonnes), with catches in 1937 and 1938 making up 0.5 tonnes and 0.2 tonnes respectively. In the subsequent years, there must have been no eel catches at all, as commercial fishery statistics were sufficiently accurate and well managed in Lithuania at that time.

During the Soviet occupation, commercial fishery in the coastal zone was banned until 1991. Since 1991, about 100 mainly small companies with two to three employees and one or two small vessels (up to 10 m) have fished in the coastal zone. Most employees are only engaged in fishing part-time. Recently, the number of fisheries companies has dropped and stood at 56 in 2012. Eel are fished with longlines in the stage of the yellow eel. Eel recorded in commercial fishery in the period 1995 to 2011 inclusive made up only about 0.14 tonnes on average. Only a few companies have been engaged in the specialised eel fishery in recent years, their number (five in 2005 and none in 2012) and catches have been declining. By reason of eel fishing ban in coastal zone according to 2011 commercial fishery statistics, eel catches were 0 kg. Low catch rates are probably a result of low stocks and low fishing efforts. Almost all eels studied in the coastal zone were of natural origin.

5 Fishing effort

Fisheries companies provide information according to their logbooks (each fishing case, including gears used and catch must be obligatory recorded) about fishing effort on a monthly basis to the authority issuing permits: a regional environmental protection department under the Ministry of Environment of the Republic of Lithuania if a company is engaged in inland fisheries (including the Curonian Lagoon), or the Fisheries Service of the Ministry of Agriculture of the Republic of Lithuania if an company is engaged in maritime fisheries.

5.1 Glass eel

There is no glass eel fishery.

5.2 Yellow eel

There is no information summarized by lifestage. Specific analysis of the reports is needed.

5.3 Silver eel

There is no information summarized by lifestage. Specific analysis of the reports is needed.

5.4 Marine fishery

Eel fishery in marine waters is banned since 2010.

6 Catches and landings

Fisheries companies provide information according to their logbooks (each fishing case, including gears used and catch must be obligatory recorded) about catch on a monthly basis to the authority issuing permits: a regional environmental protection department under the Ministry of Environment of the Republic of Lithuania if a company is engaged in inland fisheries (including the Curonian Lagoon), or the Fisheries Service of the Ministry of Agriculture of the Republic of Lithuania if a company is engaged in maritime fisheries.

Table. LT. 6.1. Eel landings in Lithuania during the period of 1995–2011.

	Lakes and rivers (small fykenets and trapnets)	Curonian Lagoon (fykenets)	Baltic Sea (longlines)
	Inland	Inland	Coastal
	Yellow/silver	Yellow/silver	Yellow
1995	4.3	5.1	0.1
1996	2.0	6.6	0.1
1997	5.0	5.7	0.0
1998	8.4	8.7	0.1
1999	4.7	13.2	0.3
2000	2.9	8.1	0.2
2001	2.3	9.2	0.3
2002	2.4	10.4	0.2
2003	2.1	9.7	0.6
2004	6.3	9.7	0.3
2005	9.9	12.4	0.1
2006	4.9	10.9	0.1
2007	7.3	7.6	0.0
2008	6.7	6.8	0.0
2009	3.7	4.9	0.0
2010	13.8	5.0	0.0
2011	7.9	3.4	0.0

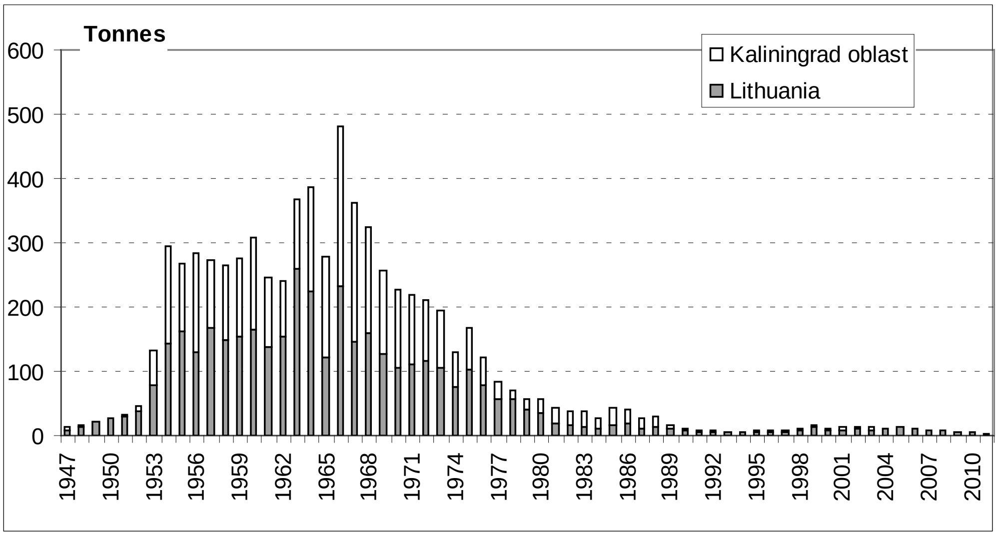

Figure. LT. 6.1. Eel landings in the Kaliningrad oblast (Russia) and Lithuanian fishermen in the Curonian lagoon during the period of 1947–2011.

6.1 Glass eel

There is no glass eel fishery.

6.2 Yellow eel

Yellow eel fishery is mixed with silver eel in most cases except coastal waters of the Baltic Sea, where small numbers of yellow eel are caught using longlines.

6.3 Silver eel

Statistical data do not provide information on the eel stage; specific analysis of the reports or logbooks is needed.

6.4 Marine fishery

Banned since 2010.

7 Catch per unit of effort

7.1 Glass eel

There is no fishery for glass eel.

7.2 Yellow eel

No available data.

7.3 Silver eel

No available data.

7.4 Marine fishery

No available data.

8 Other anthropogenic impacts

According to a rough GIS analysis, 32% of eel stocked to inland lakes during the last 20 years are in the basins blocked by hydropower stations. Detailed analyses as well as surveys of mortality in turbines are needed.

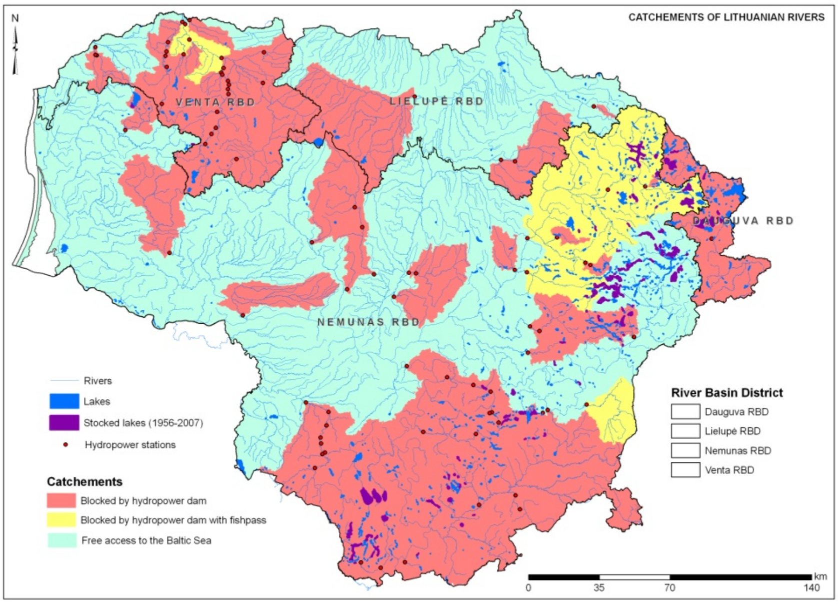

Figure. LT. 8.1. Catchments of Lithuanian rivers and hydropower stations.

9 Scientific surveys of the stock

There are no research surveys of eel stock done in Lithuania until 2011.

10 Catch composition by age and length

Fisheries landings were not sampled until 2010. Sampling started in 2011.

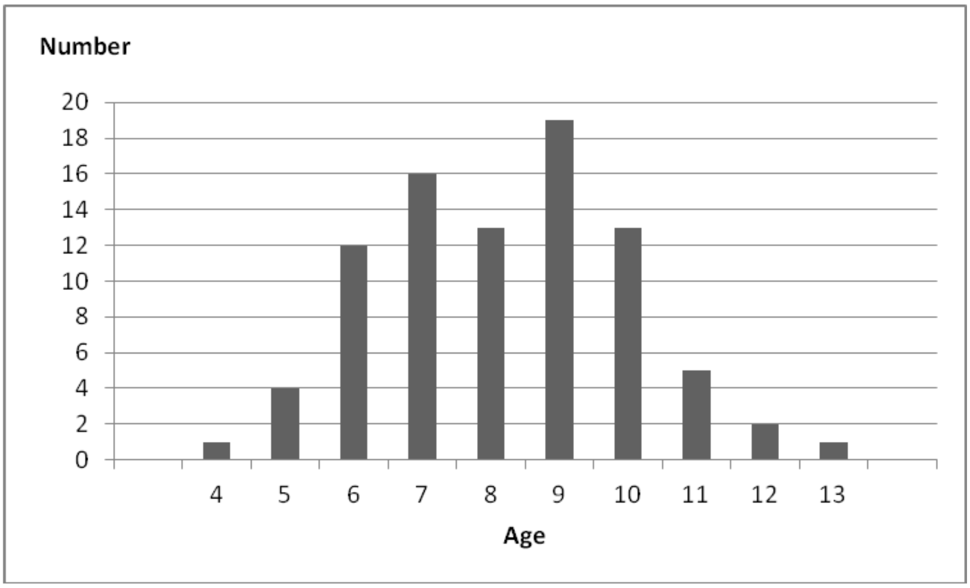

Figure 10. Age composition in Curonian lagoon fykenets eel fishery catches in 2011 (N=86).

11 Other biological sampling

11.1 Length and weight and growth (DCF)

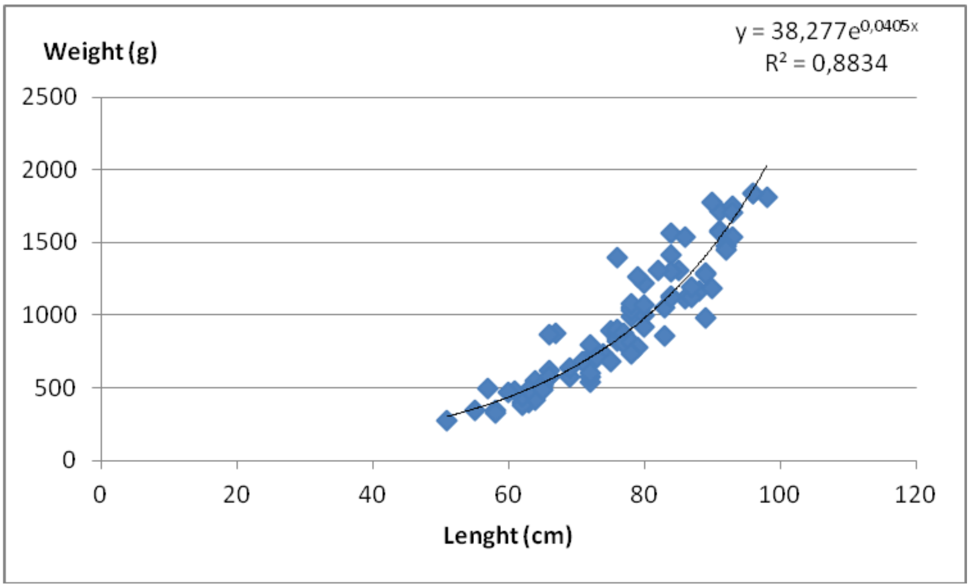

Figure 11.1.1. Length–weight relationship of eels fished in Curonian lagoon by fykenets in 2011 (N=87).

Fisheries landings were not sampled until 2010. Sampling started in 2011 and is implemented by Fisheries Service under the Ministry of Agriculture.

11.2 Parasites and pathogens

No available data.

11.3 Contaminants

No available data.

11.4 Predators

No available data.

12 Other sampling

Sampling for cormorant diet analysis is done on regular basis as part of PhD project on Cormorant effect on fish stocks in the Curonian Lagoon since 2005. About 1000 samples were analysed and no eel are found in the diet.

According study on recreational fishery about 3 tonnes of eels could be caught by recreational fishermen in 2011 (interviewed 1460 respondents). Average weight of eels was 0,914 kg.

13 Stock assessment

There are no stock assessment surveys in Lithuania. However, first stock assessment was conducted in 2008 using Simplified model of the eel population dynamics (Dekker *et al.*, 2008). Using the model natural escapement levels of silver eel under pristine conditions were calculated as well as current escapement.

13.1 International stock assessment

13.1.1 Habitat

Wetted Area:

Lacustrine: 117.000 ha (lakes and reservoirs);
Riverine: 33.200 ha (38.000 km);
Transitional and lagoons: 41.300 ha (Curonian Lagoon);
Coastal: 41.500 ha (Baltic Sea).

Lithuania has 2782 lakes with areas exceeding 0.5 ha (88 548 ha) and 1159 reservoirs with areas over 0.5 ha (28 306 ha), also 4418 rivers longer than 3 km, their total length measuring 37 636 km and their surface area totalling 33 200 ha (Table 13.2.1.1). Lakes and reservoirs over 50 ha number 285 (68 754 ha) and 70 (21 291 ha) respectively. Lithuania has 41 300 ha (26%) of the Curonian Lagoon (total area 158 400 ha). The Baltic Sea coastal zone is the area between the coastline and the 20 m depth isobath. This zone makes up an area of 41 500 ha. According to Directive 2000/60/EC, there are four RBDs in the territory of Lithuania (Figures 13.2.1.1 and 13.2.1.2).

Table 13.1.1.1. LT. Eel habitats in Lithuania.

Habitat	Number	Length, area
Rivers	4418	37 636 km
Lakes	2782 (>0.5 ha)	88 548 ha
Reservoirs	1159 (>0.5 ha)	28 306 ha
Curonian Lagoon	1	41 300 ha
Baltic Sea coastal zone	1	41 500 ha

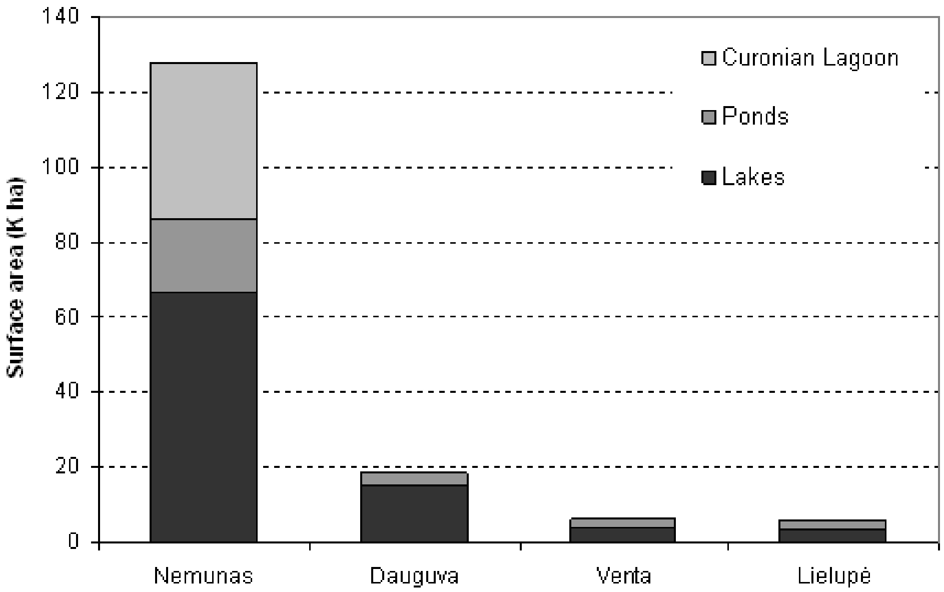

Figure 13.1.1.1. LT. Areas of RBD waterbodies in Lithuania (thousand ha).

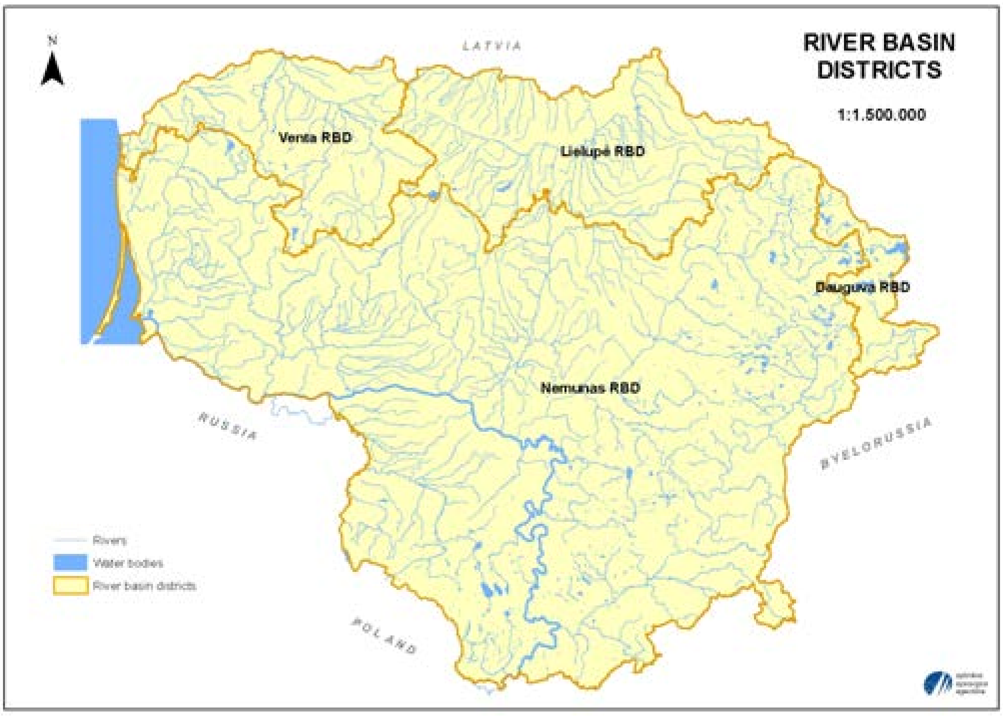

Figure 13.1.1.2. LT. Lithuanian River Basin Districts.

13.2.2 Silver eel production

Based on historical data on eel catches and information about the structure of catches, the average production of silver eel was calculated simplified model of the eel population dynamics (Dekker *et al*., 2008).

According to the calculations presented in Tables 13.2.2.1 and 13.2.2.1.1, in the Lithuanian EMP the 40% target level of escapement of the spawning–stock biomass from Lithuanian waterbodies (SSB is calculated under pristine conditions) makes up 35 tonnes of silver eel per year. Meanwhile, according to theoretical calculations, the current escapement from the Curonian Lagoon, where the major part of the eel population is natural, and from stocked lakes should be around five tonnes. Thus, to achieve the objective set by the Council Regulation, Lithuania would have to stock at least such a quantity of glass eel that would allow additional production of at least 30 tonnes of silver eel in Lithuanian waterbodies, provided that the natural eel population and its recruitment with new individuals in the Curonian Lagoon do not decline in future.

Table 13.2.2.1. LT. Eel production in the absence of anthropogenic impacts.

Eel habitat	Period	Stocking	Catch, t	Catchnat. indiv., t	SSBnat, t
Curonian Lagoon (total area)	1954–1978	0	250	250	333

13.2.2.1 Historic production

Calculations of the historical production are done using simplified model of the eel population dynamics (Table 13.2.2.1.1). It was assumed that the effectiveness of the silver eel fishery in the past was similar to that of other Baltic countries (the level established by experiments with tagged eel in Scandinavia, i.e. 25%). In addition, the calculations were based on the assumption that an insignificant overfishing of yellow eel had occurred, with the rate of yellow eel exceeding that of silver eel in catches. The calculation was only done for the Curonian Lagoon, as catches in other inland waterbodies had been extremely poor in the past, while current catches mostly include stocked eel. In the Baltic Sea coastal zone, eel catches have always been insignificant, usually amounting to a few hundred kilograms per year or no eel fishery has occurred at all. Plans are made to support the eel fishery of very low intensity (<100 kg/year) and to prohibit any specialised fishery in the Baltic Sea. Thus, it can be assumed that there were no and there will be no anthropogenic impacts on eel in Lithuania's coastal zone of the Baltic Sea. For that reason, the spawning eel stock biomass under pristine conditions and the target level of escapement in these waterbodies were not included in the calculations.

Table 13.2.2.1.1. LT. Calculation of EMP target SSB (SSB_{prist} is SSB under pristine conditions and $SSB_{curr.}$ is the current level of escapement).

Escapement	Spawning Stock Biomass, t
SSBprist, t (Curonian Lagoon, total area)	333
SSBprist, t (Curonian Lagoon, LT section (26%))	87
SSB, 40% under pristine conditions)	35
SSBcurr. (lakes and Curonian Lagoon (LT section))	5

13.2.2.2 Current production

There are no calculations.

13.2.2.3 Current escapement

See above and Table 13.2.2.1.1.

13.2.2.4Production values e.g. kg/ha

There are no calculations.

13.2.2.5Impacts

There are no calculations.

13.2.3 Stocking requirement eels <20 cm

The quantity of glass eel needed for stocking was calculated by taking into account the optimal stocking density for the area's latitude where Lithuania is located (100 glass eel ha^{-1}) and the area of waterbodies appropriate for stocking. The Lithuanian EMP contains a specific stocking strategy: in stocking, priority will be given to habitats that are unaffected or partially affected by HP turbines (HPs have fish passes), have low levels of pollution and are remote from cormorant colonies. Stocking of priority lakes unaffected by HP turbines (excluding rivers and the Curonian Lagoon) requires one tonne of glass eel per year approximately (≈€ 0.5 million per year). If the country has sufficient financial resources and the possibility to acquire glass eel (if recruitment of glass eel does not decline, their fishery is not banned and all Member States have sufficient glass eel resources for implementing their national EMPs), Lithuania plans to stock up to 30 000 ha of waterbodies in implementing the EMP. This would allow expecting a larger escapement level of silver eel than that set out in the Council Regulation (40% of natural production). The maximum total surface area of priority lakes was calculated, as not all lakes will be stocked due to various risk factors, and stocking in some lakes and reservoirs will be below 100 units ha^{-1} where a waterbody has lower productivity. In addition, some waterbodies still contain eels and these basins will not be stocked or stocking will be low-scale.

Stocking activities started again in 2011. 134 000 individuals were released in 2011, 444 000 individuals in 2012 in inland waters. More than 10% of released individuals were marked by colorant Alizarin S.

Table 13.2.3.1 LT. Quantity of glass eel needed for stocking and expected annual costs (if the price is about 500 €/kg).

Water bodies by order of priority	Surface area, ha	Quantity of glass eels, kg (units, million)	SSB production, t*
Lakes and reservoirs unaffected by HPs	23 995	800 (2.4)	44
Lakes and reservoirs partially affected by HPs	15 159	500 (1.5)	28
Curonian Lagoon	41 300	1400 (4.2)	78

Note: *SSB production without prohibiting the fishery (catches of 5% of yellow eel and 25% of silver eel per year).

13.2.4 Summary data on glass eel

No glass eels caught in Lithuania. All glass eels or on grown are imported and used for stocking in Lithuania.

13.2.5 Data quality issues

No available data.

14 Sampling intensity and precision

Sampling started in 2011. 87 individuals were measured (length, weight), Samples of 86 individuals are collected for further ageing. Sampling is implemented by Fisheries Service under the Ministry of Agriculture.

15 Standardisation and harmonisation of methodology

Sampling under DCF started in 2011; sampling activities are implemented by Fisheries Service under the Ministry of Agriculture.

15.1 Survey techniques

No data available.

15.2 Sampling commercial catches

Eels were collected from fykenets fishery in the Curonian Lagoon.

15.3 Sampling

No data available.

15.4 Age analysis

Otoliths were soaked ten minutes in xylene ((CH3)2C6H4), after that observation of rings was made with binokuliar changing intensity of light.

15.5 Life stages

No data available.

15.6 Sex determinations

Sex was not determined, however, according to earlier studies in Lithuania and eel size it is presumed that most sampled eels were females.

16 Overview, conclusions and recommendations

Eel studies in Lithuania in the past were undertaken only in occasional cases aiming to collect samples for different research purposes (e.g. otolith microchemistry, recreational fishery study). Implementation of the national EMP until the end of 2010 was limited to legal regulations which are aimed to reduce fishery impact on the stock. Lithuania submitted national DCF program and started collect data in 2011. In 2011 Lithuania started programme for implementation of the EMP using financial mechanism of the European Fisheries Fund. The programme is aimed to restock lakes and to fulfil gaps in the research on the eel stock.

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Report on the eel stock and fishery in Morocco 2011/2012

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Reporting Period: This report was completed in August 2012, and contains data up to 2011 and some provisional data for 2012.

2 Introduction

2.1 General context

Regarding to the critical situation of European eel, which was claimed by the scientists over all the world, the International Council for the Exploration of the Sea (ICES) have recommended that a recovery plan should be developed for the whole stock of European eel as a matter of urgency and that exploitation and other human activities affecting the stock be reduced to as close to zero as possible. Indeed, it has been often showed the stock is outside safe biological limits and that current fisheries are not sustainable.

Considering its position in the reconstitution process of European eel, Morocco intends to participate to all Working Groups and European projects in developing methodologies and data collection and modelling for eel stock assessment.

In addition to that, and in response to the council regulation of the European commission (CE1100/2007) and because Morocco has ratified the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the Moroccan **High Commissioner's Office** for Waters, Forests and Desert Control (MHCOWFDC), has initialized an urgent program concerning the assessment and the monitoring of eel stocks (yellow eel, silver eel and elvers) and the recruitment of glass eel. To goal is to establish measures for the recovery of the stock of European eel, through **an Eel Management Plan** (EMP).

The area covered by this programme consists of five important Moroccan fishing sites of this species, which are : Sebou river, Loukkos river, Drader river, Moulouya river and Merja Zerga lagoon (Permanent Biological Reserve, Ramsar Site in 1980).

It should be noted that the MHCOWFDC is a Department of Water and Forests of the Moroccan government, aimed at preserving Morocco's forests, woodlands, freshwater fisheries and aquaculture. Therefore, this department plays a vital role in balancing environmental preservation and the needs of local communities for grazing, firewood collection, timber and freshwater fish production.

Also, the development of inland fisheries, in general, and that of eels, in particular, was one of the priorities of the **Master Plan for Fisheries and Aquaculture in Morocco**, elaborated by the High Commissioner's Office.

However, concerning the project of the **Eel Management Plan** (EMP), the study is conducted by the Private Office on Hydrobiology, Environment and Aquaculture: **Biodiversity Consulting**, during the period 2011–2013. For the development of that Plan, this Office had to collect data on eel habitats, eel stocks and fisheries and had to develop models to predict former and present silver eel escapement.

Regarding the following report, on the **Eel Stock and Fishery in Morocco**, it was realized on August 2012 and it covers two successive seasons, according to the annual fishing report of MHCOWFDC (2011–2012). Thus, this report will be provided to the European Commission for the 2012 meeting of the Working Group on Eel.

In fact, on March 9th, 2012 the committee meeting of fishing in inland waters of Morocco has set urgent measures (changing the close seasons, reducing the quota of eel fishing (cf. Legislation), controlling the aquaculture companies of eels…) which will improve the management and the conservation of eels.

After listing eel in Appendix II of CITES on March 13th 2009, the export and the import of this species for the trade to Europe have to be licensed by the authorities of MHCOWFDC as well as an importation document which must be delivered by the authorities of the country concerned.

This document has been prepared according to the Guidance document for the drafting of Eel Stock and Fishery report. It provides the most recent information about eel stocks, eel fishery and eel surveys in Morocco.

2.4 Presentation of eel fisheries in Morocco

The Moroccan eel fisheries occur mainly in inland waters (rivers, estuaries, and lagoons) but also in coastal waters. The most important fishing sites of eel in this country are Sebou estuary, Loukkos estuary and Merja Zerga lagoon (Figure 1). The glass eel fisheries are more important in the Atlantic Ocean, especially in Sebou estuary. However the production of the Mediterranean lagoons became very scarce since the beginning of the year 2000, obliging the exploiting firms to abort their activities in this region. It should be remembered that the exploitation of the eel in Morocco is attributed to the companies.

It should be remembered that the exploitation of the eel in Morocco is attributed exclusively to companies that have a growing eel station and that have the authorization delivered by the High Commissioner's Office.

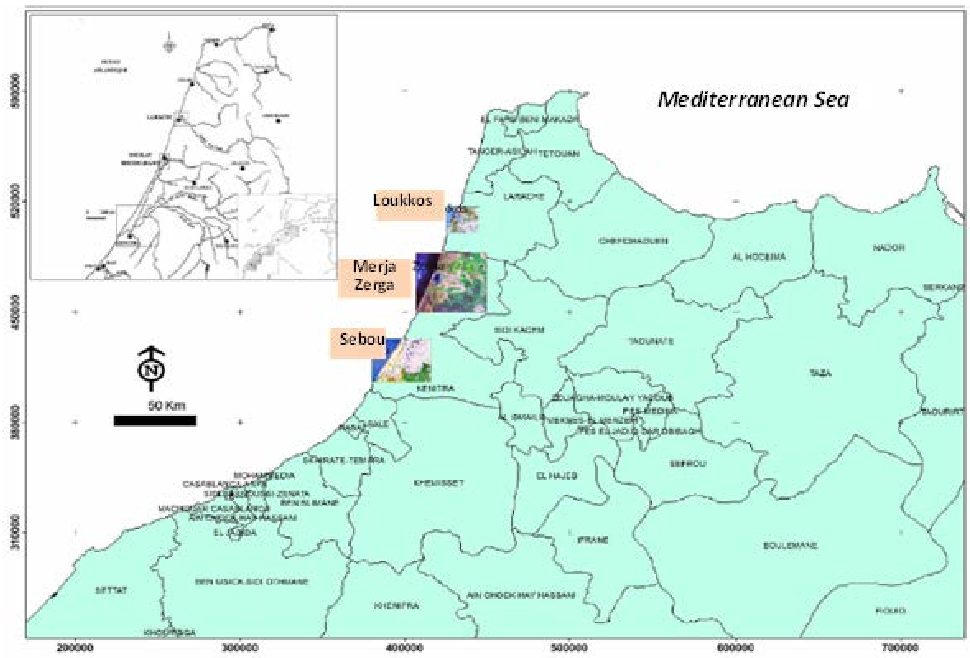


Figure 1. Situation of most important Moroccan sites of eel fishing.

Concerning the geographic situation, Morocco is considered as the southern limit of eel distribution. This limit is indicated by the Massa River at latitude 30°N. However, in September 2010, a specimen corresponding to the last phase of the yellow eel stage (not yet subadult), has been caught, for the first time, in the Tissint River, a tributary of the Dra River to the latitude 28°N (Figure 2).

This discovery has extended the southern limit of the distribution range of the species from 30°N to 28°N, a distance of about 200 km to the south. This distance makes it separates the river mouth of the Massa river (old limit) and that of Dra River (new limit) (Qninba *et al*., 2011). This desert area must be extremely vulnerable and incurring dangers. In the absence of security measures for protecting eels in Morocco, this fish species could follow a probable disappearance like Moroccan Shad (*Alosa alosa*). Eel remains one of the most overly exploited species in Morocco, in regard to its economic benefits. Fishing campaigns and surveys have been carried out to show that eel populations are at their lowest level, though they are still fished.

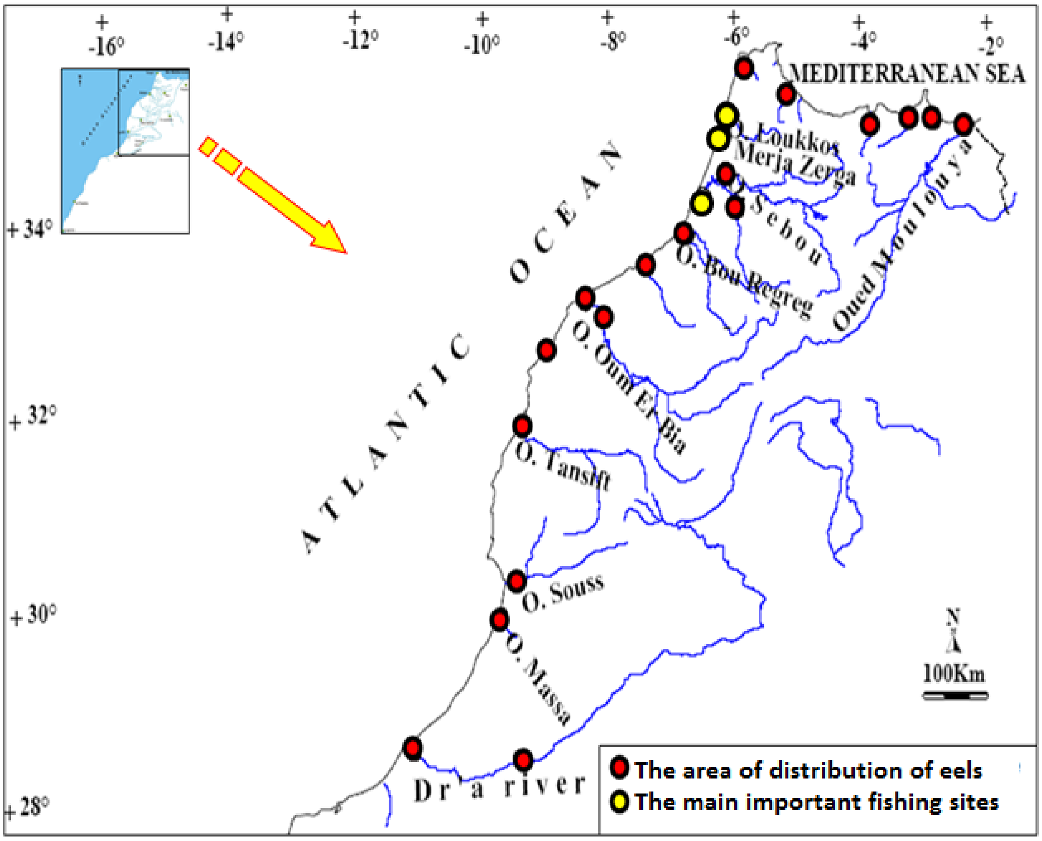


Figure 2. Distribution area of European eel (*Anguilla anguilla*) in Morocco.

Fishing frequency

In Europe, the decline of European eel populations has been registered since the 1980s (Moriarty and Dekker, 1997), and since 2000 it is at an historical low at just 1–5% of the pre-1980 levels, showing a 95 to 99% decline. This recent decline in recruitment will translate into a future decline in adult stock, at least for the coming two decades (ICES, 2006). But we can observe the increase of aquaculture production, since mid-1980s, in response to that decline (Figure 3).

However declining stocks in Moroccan waters, considered as meridional limit for this species distribution, began to be recorded later, right after the peak catches in 1997 (Figure 4).

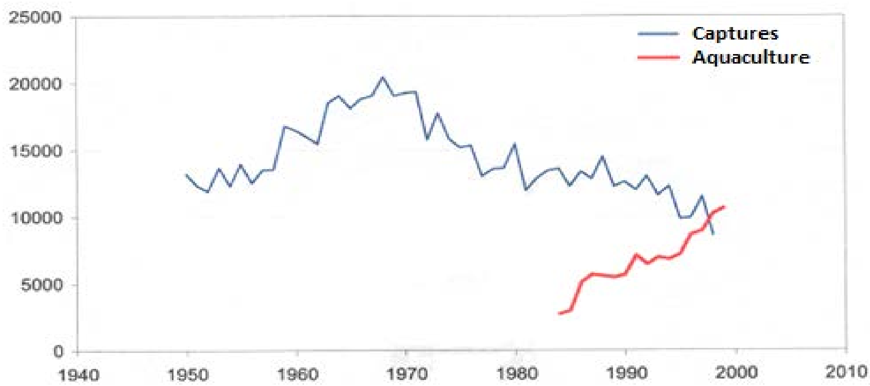
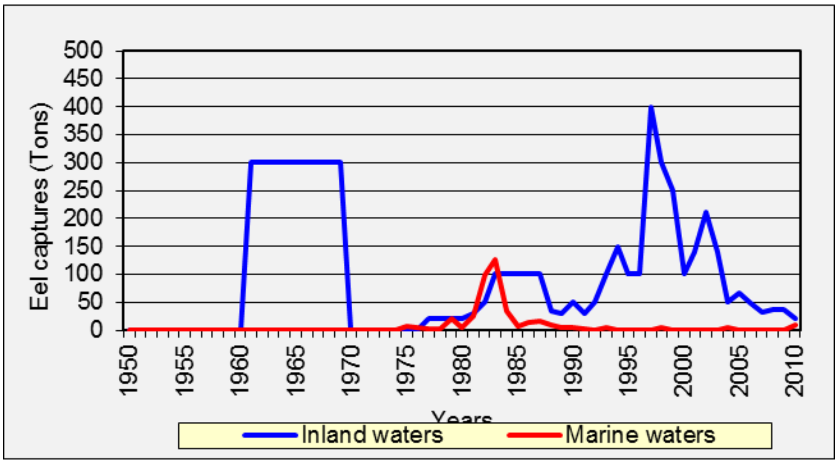
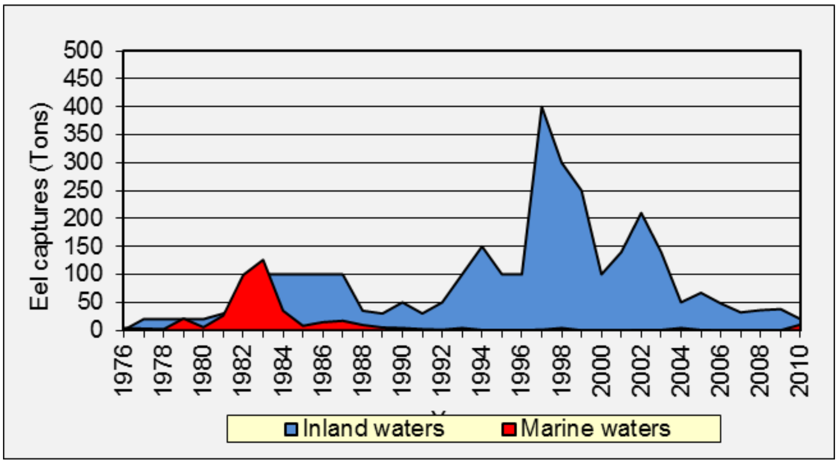


Figure 3. Evolution of the yield and production trend World eel (FAO).



Period [1950–2010]



Period [1976–2010]

Figure 4. Evolution of eel catches in Moroccan continental and marine waters (FishStat Plus V.2.32, FAO).

It should be noted that, in less than 20 years, eel production in continental waters has diminished to more than 75%. For example, in 2006 eel production (50 tons in captures and 50 tons in aquacultures) remains inferior to the one estimated by Fontenelle in 1987 (400 tons of eel and 200 tons of glass eel in inland waters (Figure 5).

Indeed, yield and stock abundance are then in a continual declined. Indeed, as the recruitment rate is so low the population is continuing to decline as older eels disappear from the stock. According to the FAO global catch landings (which cannot be directly linked to population due to stocking and harvest effort, though scientific evidence supports this decline) show that in 2005 only 4855 tons were caught, a decline of 76% since a harvest peak in 1968, 37 years earlier (three generations of the species is estimated to be 60 years) (Freyhof and Kottelat, 2010).

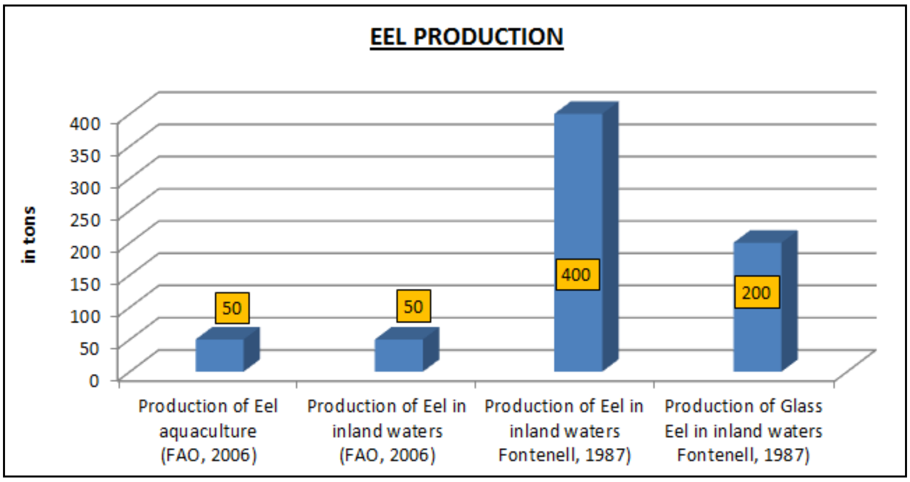


Figure 5. Eel production in Morocco (tons).

Eel and glass eel commercialization

Fish are sold to leased fishing sites who then sell them to eel farms. The fish from there are directly exported or kept until they get bigger and then exported. On a national level the eel are exported for consumption or for production in eel farms (Figure 6).

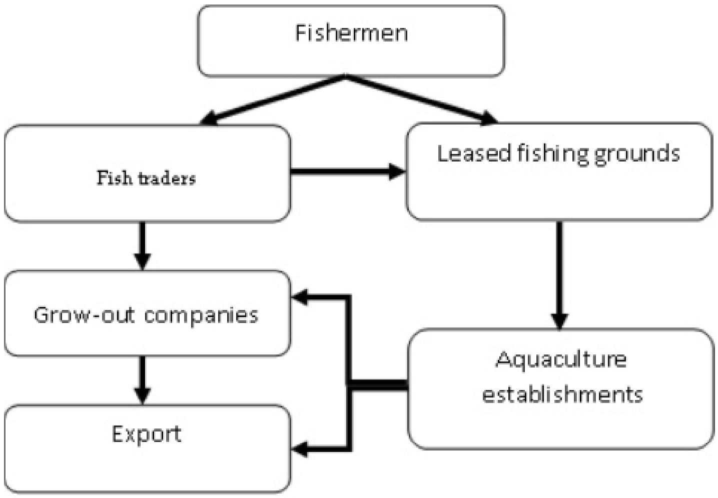


Figure 6. Commercial schema of eel in Morocco.

Legislation

Accordance with the provisions of the Dahir of 11 April 1922 on fishing in inland waters, in particular its Article 3, the right to great fishing can be farmed out by public auction, or OTC market if the auction has remained no avail. The great fishing concern mainly migratory species legally defined as shad in running waters, eels in the closed lagoons and all other migratory fish in the lagoons connected to the sea.

In this context, the exploitation of the eel and elver was undeveloped until the mid-1970s, a period during which one person had the monopoly. This operation was conducted through special licences reserved for rivers of the North Atlantic Ocean (especially Loukkos, Ghrifa River and Tahadart River). It's only from the 1980s, that the popularity of this species began to take up and operation was taking place either by auction (until 1986) or by tender or by private agreement, in the absence of competitors and companies instead of having renounced the operation.

Only by 1992 that, for the sake of enhancement of that resource, the Forestry Administration has subordinated the leasing of fishing rights in rivers to the implementation of livestock projects. Thus, the sector has seen the emergence of specialized aquaculture units in the magnification of glass eels and elvers, and whose number has varied between one and five. These are primarily companies Marost, Aquagruppen, Fishery Marocco Iberique, Aquastar, and Nounemaroc. The first two companies no longer exercise any activity in the field.

However, it should be pointed out that the resource is under intense pressure, whether by fishing communities by fish farmers, further contributing to the decline of the species in its range. This situation is even more amplified by the age of the legal system which dates from the early last century, and deserves to be amended and updated to fit the current context where priorities should be oriented toward development and conservation of national fishery resources, including first, the eel.

The exploitation of the studies were performed in *Anguillicole* field, has identified some practices that go against this initiative to preserve the species. This is particularly the work of Yahyaoui (1991) and El Hilali (2007). Indeed, it was noted that the legislative perspective, the authorized fishing periods that span from October 1st to June 30th (nine months), every day, according to the annual fishing stopped before 2010, only seem to protect banks that perform elvers upstream migration. This period is largely overlapping with the recruitment period, thus inducing considerable samples of larvae and consequently a decrease in the numbers of eels in the following years. It is therefore proposed to adjust the dates of opening and closing of the fishing season for eel to allow a fraction of elvers colonization of inland waters and downstream migration of a number of spawners.

To fill this gap, the High Commissioner has adjusted this time as part of the annual order regulating fishing in inland waters and fixing the fishing reserves during the 2010–2011 season. Instead of nine months of operation, the period was reduced to seven months distributed between March 14th to May 2nd 2010 and 28 November 2010–April 30th 2011. While for the 2011–2012 season, these periods were again adjusted on the following dates (Table 1):

Table 1. Opening and closing the fishery for eels and elvers in Morocco.

Opening date at sunrisE	Closing date at sunset	Number of fish authorized	Observations
March 14, 2010	May 2, 2010	According to the attributed quota	Exploitation, reserved exclusively to leased fishing grounds
Nov. 28, 2010	April 30, 2011		
March 18, 2011	June 12, 2011	According to the attributed quota	
Dec. 11, 2011	June 10, 2012		

Regarding the number of fishing gear, the Vizierial Order of April 14th 1922 fixed only the types of fishing gear and not their number, for the case of glass eel and eel. These gaps can therefore only strengthen the impact of poaching and the use of prohibited means. Given the irregularity and the underestimation of catch reports, fishing statistics are not reliable because they do not reflect reality.

The issue is so important that a large amount is not declared, which is in favour of poachers that generate very large financial returns. This situation is supported by the fact that the legislation provides for sanctions rarely exceeding a few hundred dirhams.

Nevertheless, it should be noted the commendable efforts and measures taken by the departments concerned of the High Commissioner for Water, Forests and Desertification Control whose purpose is the recovery of stocks, through a rational and sustainable management of the resource eel. Thus, at the renewal of land lease contracts of fishing rights, certain measures have been introduced, including the use of the tender for the granting of fishing rights in the eel, the recasting of specifications relating to the granting of that right farmout, the catches of quota management and building operations against poaching.

Indeed, on catches, as well as the eel than the elver, fishing is allowed without limitation in the number or amount. It was only from 2010 that a draft decree regulating annual fishing in inland waters, establishes special regulations for fishing for elvers and eels to be managed by quotas fishing, which mobilizes all users and all those affected. In this new situation, fishermen are forced to report their catches, service managers will provide a link with stakeholders and monitor quota uptake in their units. These relate to the Sebou River, Drader River, respective Loukkos and their tributaries.

As for quotas, they were set at 2400 kg for glass eels of 10 centimetres long or less, and at 40 tons for indigenous eel, for the 2010–2011 season (Table 2). For the period 2011–2012, these quotas of glass eel catches are set at 2500 kg for glass of 10 centimetres long or less and at 28 tons for indigenous eel of 30 centimetres long or more, according to the Article 14 of the decree of the Moroccan High Commissioner's Office for Water, Forests and Desert Control (2011–2012). The Article 14, of the Moroccan legislation, has set the allowed minimal length for yellow eel to 30 centimetres. Quotas set for the three areas are shown on Table 3.

Table 2. Fishing quotas of glass eel and eel from leased fishing sites 2010/2011.

	allowable catch for				
	Glass eels		Eels		
SITE	Kilo	%	Tons	%	Mean %
Sebou river	2000	83,3	22	55,0	69%
Drader river	150	6,3	15	37,5	22%
Loukkos river	250	10,4	3	7,5	9%
Total	2400	-	40	-	-

Table 3. Fishing quotas of glass eel and eel from leased fishing sites 2011/2012.

	allowable catch for				
	Glass eels		Eels		
SITE	Kilo	%	Tons	%	Mean %
Sebou	2000	80,0	22	78,6	79,3%
Oued Drader	150	6,0	2	7,1	6,6%
Oued Loukkos	350	14,0	4	14,3	14,1%
Totaux	2500	-	28	-	-

It was also stipulated that the catch quotas for each site are divided into subquotas among the lessees the right to fish for this species. The subquota is determined for each lessee taking into account the average catch reports for the last three years and the production capacity of its unit magnification. The quantity reported corresponds to a given year, the sum of the total catch measured in kilograms and attested by the statements validated following the administrative checks.

A commission is appointed by the High Commissioner or his delegate, to assess the ability of grow-out facilities and thus determine the corresponding subquotas. When the subquota of a lessee shall be exhausted, the continued fishing of the species in question is prohibited. Any remaining subquota may be postponed for the next fishing season. Moreover, and in accordance with the listing decision of the eel on Appendix II of CITES, which aims to regulate its international trade, export and import of eel in from March 13 2009, require the submission of a permit previously said CITES permit, issued by the High Commissioner, in his capacity as Management Entity National Convention, and that an import permit issued by the management authority of the Member State of destination.

It is also worth noting the efforts undertaken by the external services of forests and waters that fight against poaching, become routine, especially after the increase in the number of fishermen due to the conversion of several peasants to fishermen in years of drought. Indeed, for samples of glass eels from legal fishing, are added those of poaching, misjudged, but exists throughout the range of the eel, which is also rising due to the high price of this resource.

2.3 Subdivision of eel fishing area

The majority of yellow and silver eel and glass eel are caught in lagoons and estuaries located in the northwest of Morocco (Figure 7).

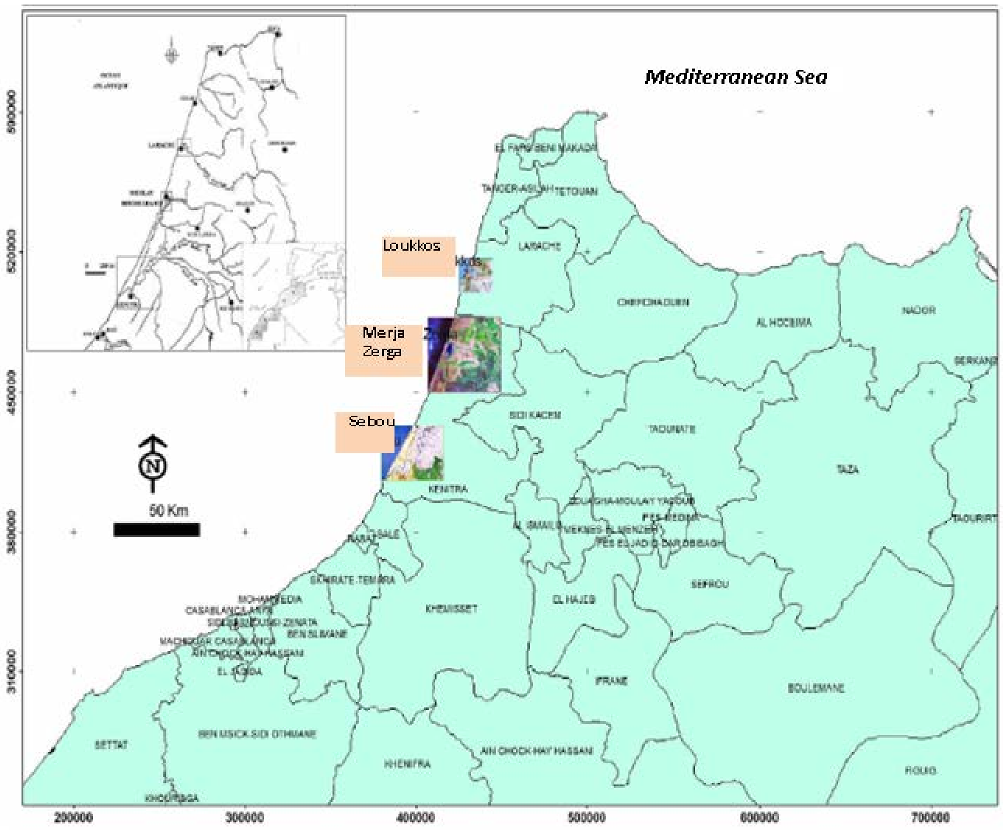


Figure 7. Moroccan northwest lagoons and estuaries of eel fishing.

Sebou estuary

This estuary is located on the Moroccan Atlantic coast 34°27'N/6°64'W. The Lalla Aicha guard dam is located 40 km upstream (Figure 8). The Sebou drainage basin has a surface area of 40 000 km^2. Eel and glass eel are fished throughout the estuary, an ecosystem heavily influenced by urban, agricultural and industrial sewage. To this day in Morocco, eel are exploited during several of its life stages: glass eel, yellow eel, and silver eel. Glass eels are the most targeted due to its commercial importance. In some cases, the fishing activity has gone to extremes and thus is illegal due to inefficient controls. In 2006, 10 tons of eels and 5 tons of glass eels were fished by local fishermen.

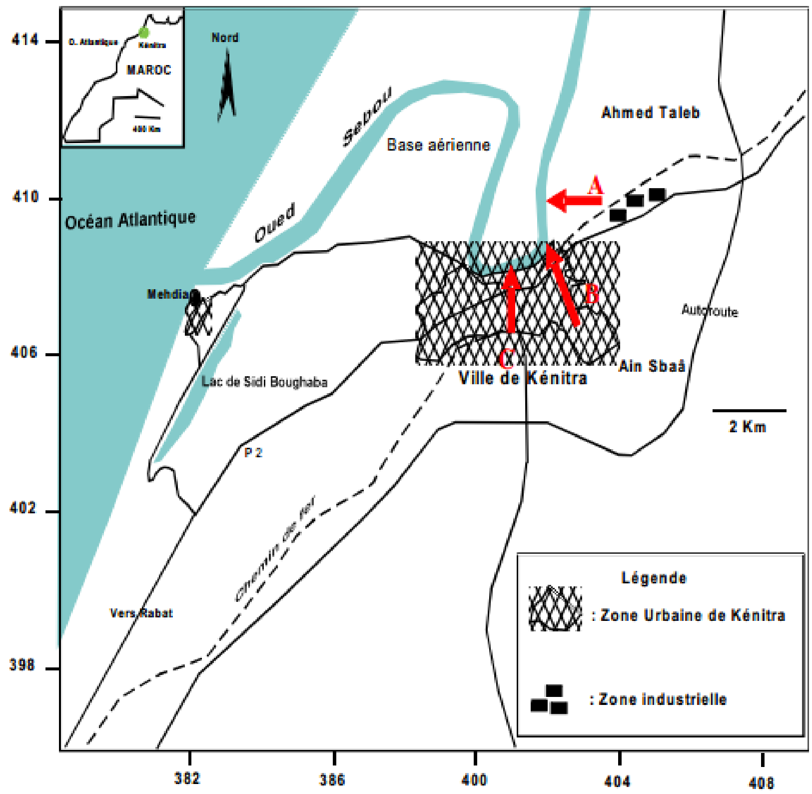


Figure 8. Sebou estuary.

Loukkos estuary

These wetlands are part of the estuarine complex of the Bas Loukkos, which were designated as a Ramsar site in June 2005. The Loukkos 35°15′N/6°09′W empties out into the Atlantic Ocean and 20 km upstream a guard dam was implanted. Its water originates from the Rif Mountains and the surface area of this drainage basin is 3730 km^2 (Figure 9).

Glass eel and eel (yellow and silver) are fished from a fish outlet just at the edge of the dam. Unfortunately this passage is very narrow and badly maintained and monitored as a result fish get trapped rather than allowing them to swim through it freely.

One company has the licence for fishing eel and glass eel according to the quota limited by the authorities by leasing the entire river. In 2006, only 0.2 tonne of eel (yellow and silver eel) and 0.75 tonne of glass eel were caught.

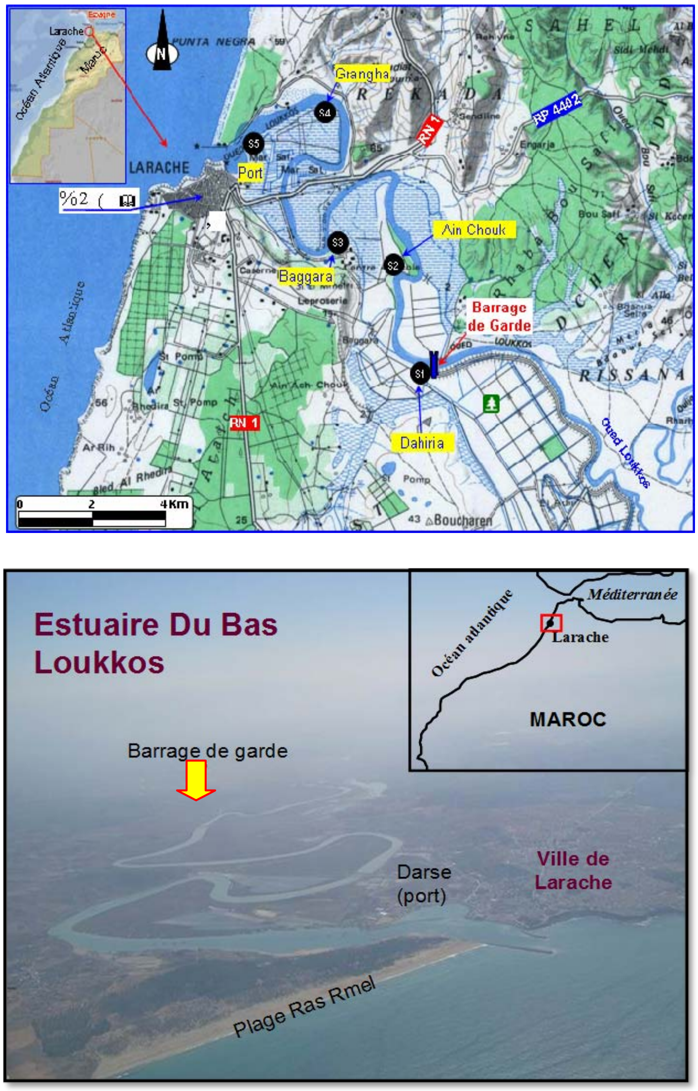


Figure 9. Loukkos estuary.

Merja Zerga lagoon

Merja Zerga 34°86′N/06°28′W Permanent Biological Reserve, Ramsar Site (1980) is a tidal lagoon located 70 km north of Kenitra on the Atlantic coast (Figure 10), in the North-East of Sebou estuary (Figure 11). The outlet to the ocean lays at the seaside resort and fishing village of Moulay Bousselham, hence the site's alternative name of Moulay Bousselham lagoon. In addition to its tidal inflow, the lagoon receives freshwater from the Oued Drader and the underlying water-table, which is very close to the surface here. The lagoon itself covers 4500 ha, of which 30% is open water, and has an average depth of 1.5 m.

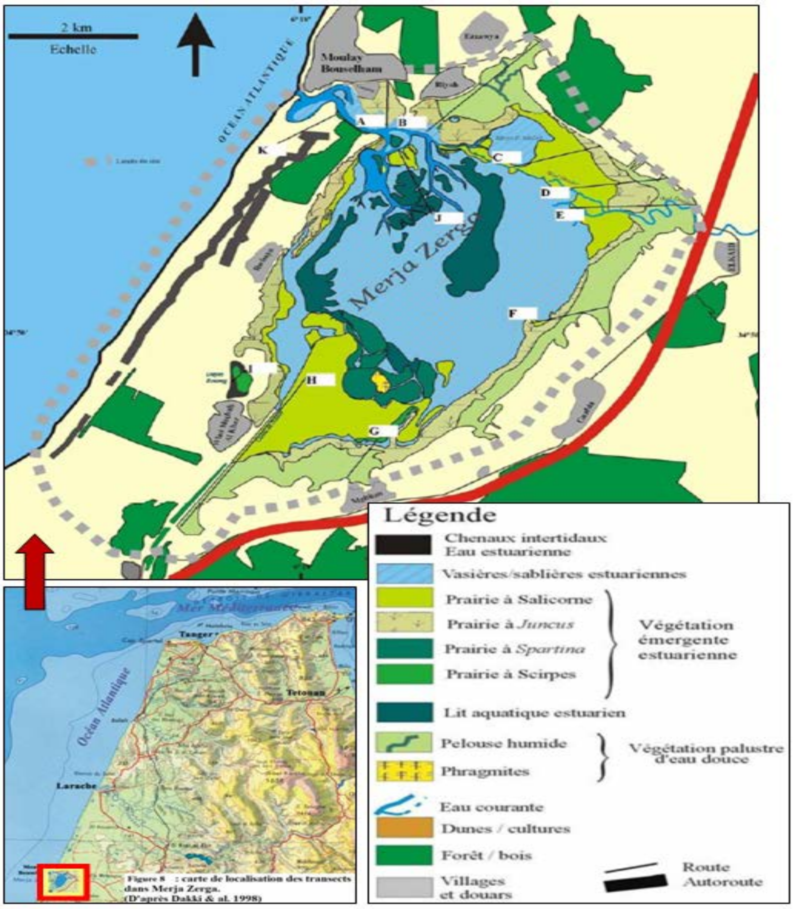


Figure 10. Merja Zerga lagoon (Benhoussa *et al.*, 2011).

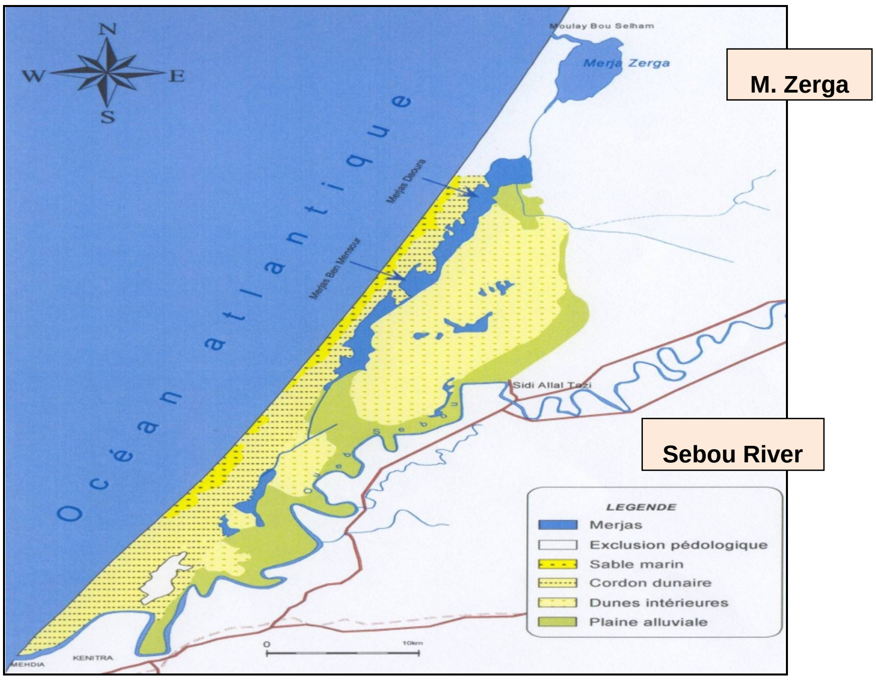


Figure 11. Relation between Merja Zerga lagoon and Sebou river.

3 Time-series data

3.1 Recruitment-series and associated effort

3.1.1 Glass eel

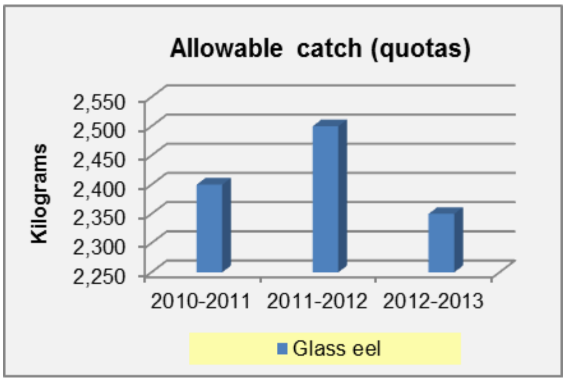
3.1.1.1 Commercial

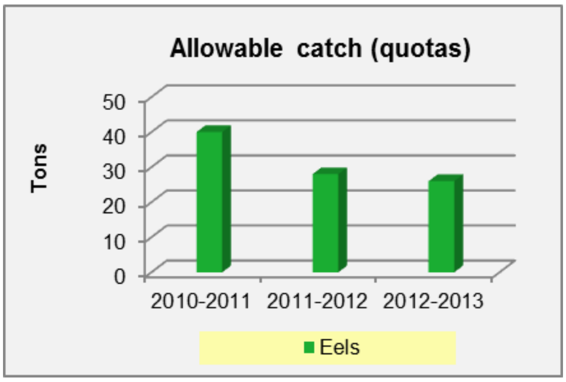
Glass eel fishery is practised only by companies which have the licence of leased fishing ground. Glass eel fishery is limited with quotas by the Moroccan High Commissioner's Office for Waters, Forests and Desert.

For the period 2012–2013, these quotas for glass eel catches are set at 2350 kg for glass eel of less than 10 centimetres and 26 tons of wild eel. These quotas are divided between the two main rivers, Sebou and Loukkos, as shown in Table 4. Their evolution during the three last campaigns are also presented below (Figure 12).

Table 4. Fishing quotas of glass eel and eel from leased fishing sites 2012/2013.

	allowable catch for				
	Glass eels		Eels		
SITE	Kilo	%	Tons	%	Mean %
Sebou river	2000	85,1	22	84,6	84,9%
Loukkos river	350	14,9	4	15,4	15,1%
Total	2350	-	26	-	-





Glass eel **Wild eel**

Figure 12. Glass eel and eel quotas evolutions.

3.1.1.2 Recreational

Recreational glass eel fisheries are not allowed.

3.1.1.3 Fishery independent

No data available.

3.1.2 Yellow eel recruitment

For the period 2011–2012, the quotas for wild eel catches are set at 26 tons for wild eel of 30 centimetres long or more.

3.1.2.1 Commercial

Commercial yellow eel fisheries are practiced only by companies who are proceeding to eel growing campaigns.

3.1.2.2 Recreational

No recreational yellow eel landing has occurred.

3.1.2.3 Fishery independent

No data available.

3.2 Yellow eel landings

No data are available.

3.2.1 Commercial

No data are available.

3.2.2 Recreational

No recreational data are available.

3.3 Silver eel landings

No data are available.

3.3.1 Commercial

No data are available.

3.3.2 Recreational

No recreational data are available.

3.4 Aquaculture production

Actually, the right to fish for elvers and eels is detained by only two companies: NouneMaroc and Aquastar, instead four companies last year Pêcherie Maroco Ibérique, Aquagruppen, Aquastar and Nounemaroc. However, Nounemaroc, which is located in Kénitra, became the most active and productive company in Morocco, since its creation in 2008. During the past 13 years, production has varied between 16 and 76 tons of farmed eels (Figure 13).

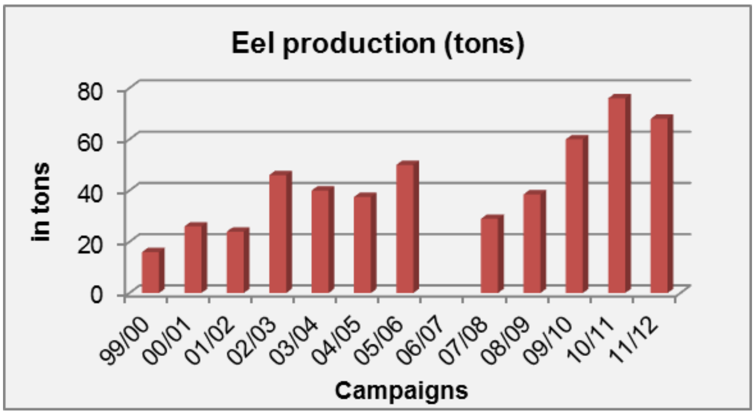


Figure 13. Eel productions of eel in Morocco.

It should be noted, that in the absence of control and incentive to the application of prescribed quota, the eel sector would experience a shortage more pronounced over time. Indeed, the intensive exploitation of natural resources contribute to the rapid depletion of stocks, especially that production of farmed eels depends exclusively on the wild stock, which is already in decline. Add to this, the fact that since the installation of these companies, fishermen who previously were focusing their catches on eels of medium and large size, began to take more interest in eels of 10 to 15 cm in size, and also in elvers whose economic value is high. This action could compromise, at medium term, the future of this sector.

3.4.1 Seed supply

Local fishermen sell glass eels to the farm companies. A part of these glass eel is used for their grow-out station and the other ones are destined for export.

There is no quantitative data.

3.4.2 Production

The mean production per year is given in Table 5.

Table 5. Aquaculture production (tons) in Morocco per company. (according to the annual status of report of the MHCOWFDC).

	PRODUCTION CAMPAIGNS												
Sociétés	99/00	00/01	01/02	02/03	03/04	04/05	05/06	06/07	07/08	08/09	09/10	10/11	11/12
P.M. Ibériq.	-	-	-	-	-	-	-	-	-	-	-	-	-
Aquagruppen	-	13	12	23	-	3	10	-	3	6	0	-	-
Aquastar	16	13	12	23	40	34,5	40	-	16	13	0	-	-
Nounemaroc	-	-	-	-	-	-	-	-	10	19,5	60	76	68
Total	16	26	24	46	40	37,5	50	-	29	38,5	60	76	68

3.5 Stocking

No available data.

3.5.1 Amount stocked

3.5.2 Catch of eel <12 cm and proportion retained for restocking

The catch of eel <30 cm is prohibited by the law.

4 Fishing capacity

4.1 Glass eel

Glass eel fishery is practiced only by companies getting the licence of leased fishing in Sebou and Loukkos.

4.2 Yellow eel

Traditional fishing boats (Tables 6 and 7).

In the inland freshwaters eel is fished using artisanal methods (Yahyaoui, 1991; Melhaoui, 1994).

The estuarine fishermen mainly fish for eel using boats. In the Merja Zerga area they have flat bottoms that allow them to glide easily over muddy zones and shallow parts. Approximately 100 operational boats have been registered.

In the Sebou estuary, 240 artisanal fishing boats have been registered and six in the Loukkos estuary. Among the three areas, boats are relatively similar in size (about 4 m long and 1.5 m wide). Their price ranges between 2000 DH and 3500 DH, while annual maintenance fees average is 575 DH. Depending on the amount of use, the boats last from five to 13 years.

Table 6. Fishing boat characteristics.

	NUMBER OF BOATS	LENGTH (M)	WIDTH (M)	PRICE (DH AND €)	MAINTENANCE (DH/YEAR)	AVERAGE AGE (YEAR)
Loukkos	6	4.00	1.50	2000 (174€)	-	13
Merja Zerga	100	4.24	1.44	3500 (304€)	600 (52€)	5.13
Sebou	240	4.07	1.54	3416 (297€)	550 (48€)	6

Table 7. Fykenets characteristics and trapping periods.

AREA	NUMBER OF TRAPS/FISHERMAN	MESH (MM)	FISHING PERIOD	DURATION OF TRAPS (YEARS)	PRICE (DH)
Loukkos	60	5	October–January (four months)	3	-
Merja Zerga	36	5	September–May (nine months)	3	100 (8.7€)
Sebou	30	5	September–June (ten months)	2	70 (6€)

Data concerning the local fishing population

In the Merja Zerga area, prior data shows that the number of fishermen has increased between the 1930s and the 1990s (Figure 14). Ever since the 1990s the population has been decreasing, which may be explained by the decline in economic performance, forcing many to find a more stable profession.

This decrease would probably be linked to a performance regression; itself closely relied to the decline experienced by the sector internationally. This new situation has made the business of fishing for eels and elvers speculation unprofitable, which has prompted some fishermen to change profession squarely, when others are out fishing further downstream (Sebou estuary).

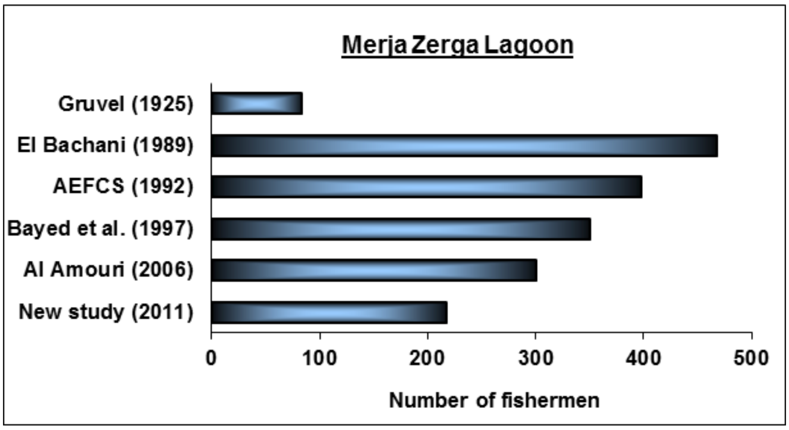


Figure 14. Evolution of the number of fishermen in the Merja Zerga area (between 1931 and 2011).

In general, and following investigations by the team in charge of the study which is conducted by Biodiversit Consulting Office, it was found that in the estuaries of the Atlantic coast of Morocco, fishing for eels and elvers is practiced regularly by a community of more than 783 fishermen, of which 93.6% in the Sebou and 6.4% in the Loukkos (Table 8).

Table 8. Diagnostic on the number of fishermen (24/06/2011).

		Présente étude 2011[(1)]		Al Amouri 2006[(2)]	
SITE		Nombre	%	Nombre	%
Sebou	Moulay Bousselham Lagoon	217	27,7	300	40
	Drader River	5	0,6	400	53
	Nador Canal	4	0,5		
	Dam guard	7	0,9		
	Sebou estuary	500	63,9		
Loukkos	Loukkos River	50	6,4	50	7
Total Atlantic side		783 fishermen		750 fishermen	

[1] **Survey of 24/06/2011.**

[2] **Survey of 2006.**

In the Mediterranean part, particularly at the estuary of Moulouya River, the fishing activity, which makes the livelihoods of hundreds of fishermen, has been reduced to zero, following net depletion of raw material (glass eels) and stopping the activity of Marost in the region.

The age group of fishermen in the Merja Zerga and Sebou areas ranges between 20 and 29 years old and between 30 and 39 in the Loukkos area (Figure 15).

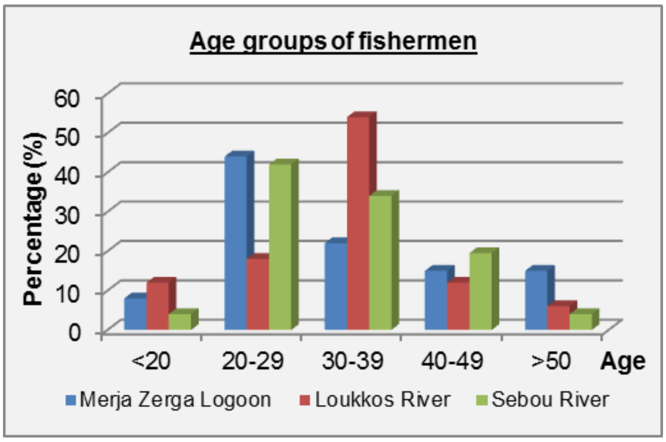


Figure 15. Different age groups of fishermen.

According to Table 9 bellow, the average fisherman age increases with time which shows that there is no new turnover for fisherman over 40 years old. Perhaps, fishermen at a certain age abandon this activity to seek financial stability or to emigrate to the city or to another foreign country.

Table 9. Evolution of the average age group of fisherman.

	EL BACHANI (1989)	KARZARI (1988)	TOUZANI (2001)	AL AMOURI ET AL. 2008
Mean age group (years)	25–30	27.9	27.7	32

4.3 Silver eel

The same fishermen fish indifferently yellow and silver eels with same techniques.

4.4 Marine fishery

No data are available. Eel fishing in the sea is negligibly small.

5 Fishing effort

5.1 Glass eel

5.1.1 Glass eel fishing methods

Fish traps are most commonly used between the two estuarine and lagoon areas. Dipnets are also used in the Sebou and Loukkos estuaries. Finally, in the larger parts of the Sebou area, large nets known as «damnets» are more adapted (Table 10).

Table 10. Fishing methods of glass eel.

FISHING MATERIAL	LOCAL NAME	ESTUARINE AREA
Stopnet	Chebka	Sebou
Dipnet	Gherbal	Sebou and Loukkos

In the Loukkos estuary, there are twice as many fishing traps used per fishermen compared to other two sites. Even more, as described in Table 5, the traps are used during certain periods of the year, depending on the area. For example in the Loukkos Estuary traps are set out between October and January whereas in Sebou estuary and Merja Zerga lagoon, they're used respectively between September and June, according to the rules. The costs of traps range between 70 (6.25€) and 100DH (9.93€), and they usually last up to three years.

5.2 Yellow eel

Yellow and silver eel are fished by using fykenets in all the area of fishing (Lachheb, 2004).

Table 11. Fishing activity data recorded in 2006.

AREA	Number Fishing Day/Year	Number of outings/Day	Average Length of Outing (Hours)	Total Fishing Hours/Year
Merja Zerga	303.67	1	3h 49min	1159
Sebou	264.45	1.72	1h 24min	637
Loukkos	117	1	3h	351

5.3 Silver eel

Data are mixed with yellow.

5.4 Marine fishery

No data are available. Eel fishing in the sea is negligibly small.

6 Catches and landings

6.1 Glass eel

In the Sebou estuary, annual glass eel catches are the highest (5 tons) followed by the Loukkos estuary (0.75 tons) (Table 12). The quantities of catches in Loukkos are dramatically decreasing.

Table 12. Glass eel catches in major Moroccan fishing areas.

	GLASS EEL (TONS		
	Merja Zerga	Sebou	Loukkos
Fontenelle (1987) ; Sabatié and Fontenelle (2003)	-	150	40
Al Amouri (2006)	-	5	0.75
2007	-	-	0.11
Al Amouri *et al*. (2008)	-	-	0.10
2009	-	0.10	0.14
2010	-	0.21	0.05
2011	-	0.36	0.03

6.2 Yellow eel

Eel catches of both stages (yellow and silver) is highest in the Merja Zerga area (16 t) and lowest in the Loukkos (0.2 t). When comparing production estimated in 1987 and 2003 (Table 13), we can easily notice how eel stock in Morocco has been declining at alarming rates. In less than 20 years, eel stocks in the Sebou estuary have declined to 2.5% and less than 3.5% for glass eel stocks.

Table 13. Eel catches in major Moroccan fishing areas.

	EEL (TONS		
	Merja Zerga	Sebou	Loukkos
Fontenelle (1987) ; Sabatié and Fontenelle (2003)	12–15	420	-
Al Amouri (2006)	16	10	0.2
Survey of 2011	2.7	12.34	0.12

6.3 Silver eel

Data of yellow and silver eel are mixed.

6.4 Marine fishery

No data are available. Eel fishing in the sea is negligibly small.

7 Catch per unit of effort

Estimated data are collected from questionnaires.

7.1 Glass eel

Table 14. Cpue of glass eel in Loukkos estuary.

YEAR	TOTAL CATCH (KG)	TOTAL EFFORT (DAYS)*	CPUE (KG/DAYS)
2003	40 000	-	-
2006	750	56	13.39
2007	111	56	1.98
2008	100	56	1.79
2009	140	56	2.50
2010	50	56	0.89
2011	30	56	0.54

*** The mean number of fishing days per fishing season.**

Table 15. Cpue of glass eel in Sebou estuary.

YEAR	TOTAL CATCH (KG)	TOTAL EFFORT (DAYS)*	CPUE (KG/DAYS)
1987	150 000	-	-
2006	5000	56	89.29
2009	100	56	1.79
2010	210	56	3.75
2011	360	56	6.43

*** The mean number of fishing days per fishing season.**

7.2 Yellow eel

Table 16. Cpue of eel (yellow and silver combined) in Merja Zerga lagoon, in Sebou estuary and in Loukkos estuary.

YEAR	SITE	Total catch (Kg)	Total effort (Days)*	CPUE (Kg/Days)
2003	Merja Zerga	13 500	-	-
	Sebou estuary	420 000	-	-
	Loukkos estuary	-	-	-
2006	Merja Zerga	16 000	304	52.63
	Sebou estuary	10 000	264	37.88
	Loukkos estuary	200	117	1.71
2011	Merja Zerga	2700	304	8.88
	Sebou estuary	12 340	264	46.74
	Loukkos estuary	120	117	1.03

*** The mean number of fishing days per fishing season.**

7.3 Silver eel

Data of yellow and silver eel are combined.

7.4 Marine fishery

No data are available. Eel fishing in the sea is negligibly small.

8 Other anthropogenic impacts

The most common causes of eel decline in Morocco may be due to:

- Diseases such as the one caused by the hematophagous parasite, *Anguillicoloïdes crassus*, which was found in Moroccan continental waters in 1990 (El Hilali *et al.*, 1996).
- Illegal fishing (poaching and the use of illicit fishing nets).
- Hydraulic infrastructures such as dams without fish passages, embankments, diversions, pumping from rivers, gravel extracting, etc., all of which deteriorate or destruct eel habitats, especially their growth space.
- Pollution from agricultural, industrial, and domestic activities.

In addition, commercial fishing activities and eel farming which are restocked only with wild species in their elver stage, contribute to the species' decline. Eel is of great commercial importance and is probably the only fish to be exploited at all its life cycle stages by man. Due to the increasing amount of eel farming and decreasing populations caused by overfishing, prices have increased along with fishing activity.

9 Scientific surveys of the stock

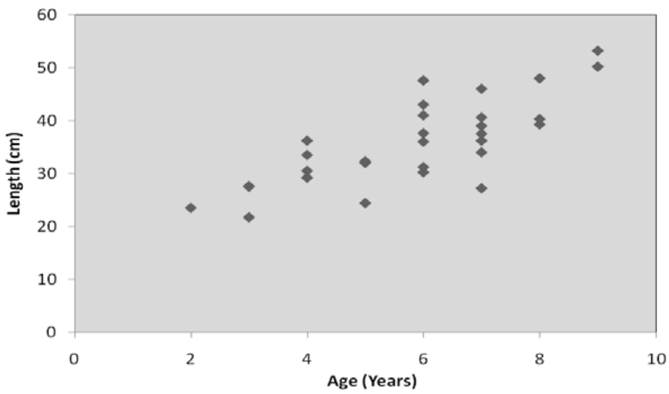
No routine surveys of eels are performed in Morocco.

10 Catch composition by age and length

The otolithometry method used for this age reading is cracking and burning methods for both Sebou and Loukkos samples.

The results show that most of eels from Sebou are younger than those caught in Loukkos. Most of eel are ranged between six and eight years for Loukkos samples and for those of Sebou they are ranged between five and six years (Figure 16).

(a)



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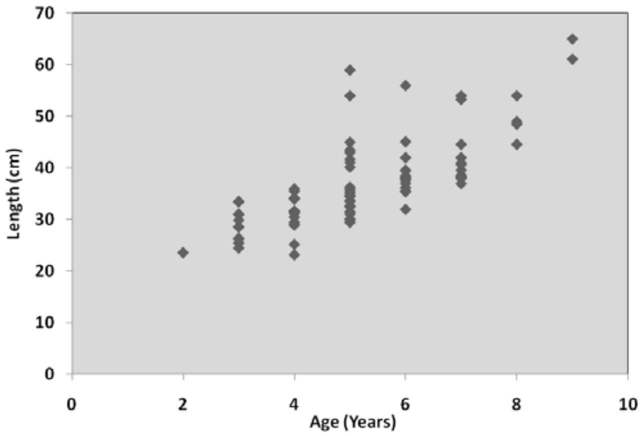
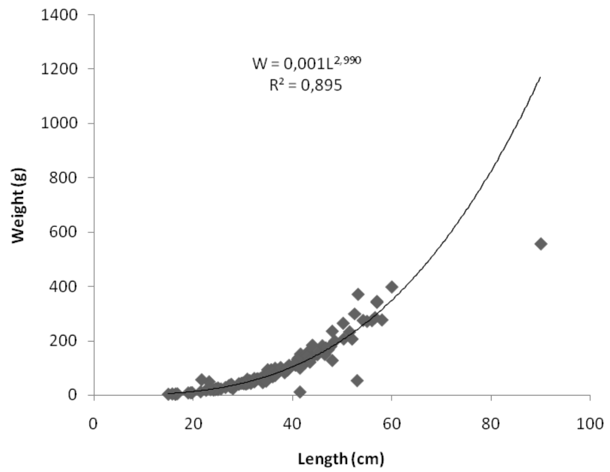


Figure 16. (a, b). Distribution of the age (years) according to the length (cm) of eels caught in 2008 in Loukkos estuary (a) and Sebou estuary (b) (Wariaghli *et al.*, 2010; unpublished data).

11 Other biological sampling

11.1 Length and weight and growth (DCF)

(a)



(b)

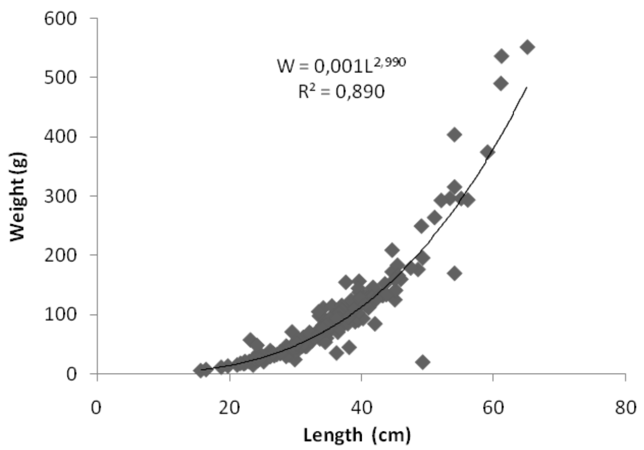


Figure 17. (a, b). Distribution of the length (cm) according to the weight (g) of eels caught in Loukkos estuary (a) and Sebou estuary (b), showing their growth factor and the correlation between these two parameters (Wariaghli *et al*., 2010; unpublished data).

11.2 Parasites and pathogens

Epidemiological data of the swimbladder nematode *Anguillicoloïdes crassus* in Moroccan rivers was initially described by El Hilali *et al*. (1996); Lachheb (1997); Kheyyali *et al*. (1999); El Hilali *et al*. (2005); Wariaghli (2006); Zouhir (2006) and Loukili and Belghyti (2007).

The way of introduction of *Anguillicoloïdes crassus* is still unknown, since Morocco has never imported live eels but does only export them. This parasite is still spreading over all Moroccan eel fishing areas. The prevalence of the swimbladder *A. crassus* is still spreading in Moroccan waters, but within sites there is a trend for stabilization or even decrease in prevalence values. Figure 18 shows the mean of prevalence, intensity and abundance of eels (yellow and silver eels) caught in Sebou estuary between 2004 and 2009.

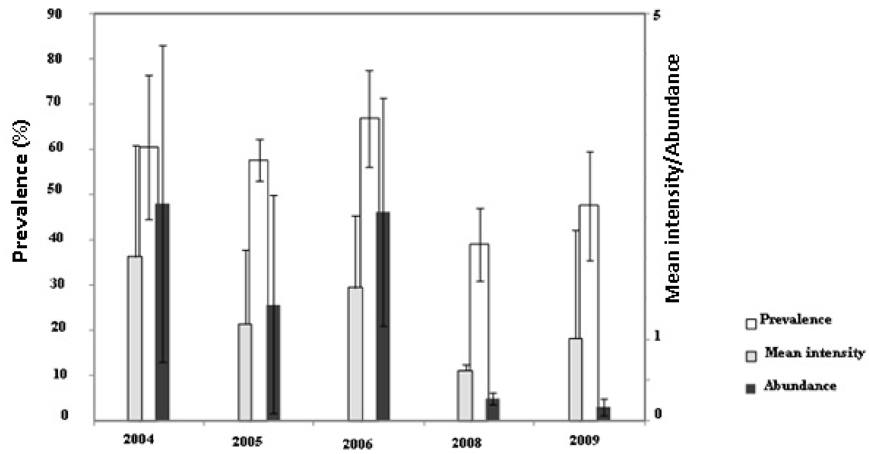


Figure 18. Prevalence (%), mean intensity ± SD and abundance ± SD of *Anguillicoloïdes crassus* for eels caught in Sebou estuary 2004–2009 (Wariaghli *et al.*, 2011; submitted).

11.3 Contaminants

Heavy metals assessment

This work involves an assessment of the degree of heavy metal contamination (Pb, Cd and Cr) in liver, gills and muscle of eel (*Anguilla anguilla*) inhabiting two ecosystems along the Moroccan Atlantic coast: the Sebou and Loukkos estuaries (Figure 19). In these areas *A. anguilla* is widespread and a common predator at the top of the food chain. In this study, heavy metals were determined with flame atomic absorption spectrometry. Metal concentrations reveal high and widespread tissue contamination in eel caught from Sebou estuary than in Loukkos, with preferential accumulation in liver for Cd (chronic accumulation) and in gills for Cr and Pb (recent accumulation).

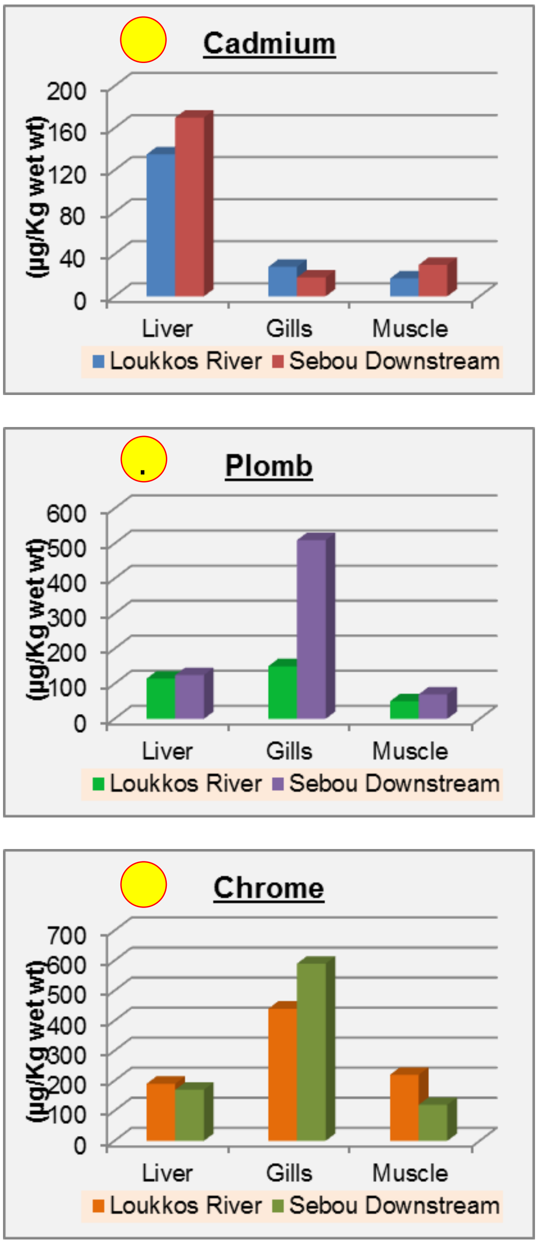


Figure 19 (a, b, c). The concentrations of cadmium, lead and chromium (µg/g wet wt), in liver, gills and muscle of eels caught from Loukkos and Sebou rivers (Wariaghli *et al.*, 2010; unpublished data).

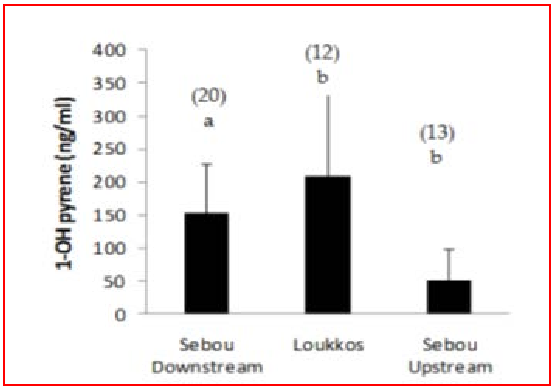
PAH metabolites

This study investigated in the usefulness of biliary polycyclic aromatic hydrocarbon (PAHs) metabolites of European eel (*Anguilla anguilla*) as bioindicator of pollution in Moroccan sites. Eels were collected at two locations (upstream and downstream) in the river Sebou and in the Loukkos estuary. October and November 2009. Biliary 1-Hydroxypyrene, 1-Hydroxyphenantrene and 3-hydroxybenzo[a]pyrene metabolites were measured in eel by HPLC analysis with fluorescence detection. Only 1-OH pyrene and 1-OH phynantrene were detected while 3-OH benzo[a]pyrene was not detected.

No statistical differences between the sexes and ages for any of the PAH metabolites or biological parameters could be detected. Data from the three trawls were therefore pooled (Figure 20).These results show significant differences between Sebou upstream and Loukkos sites in mean concentration of 1-OH pyr and 1-OH phen metabolites ($p<0.05$, two sample t-tests), as well as between Sebou downstream and sebou upstream sites ($p<0.05$) which had similar concentrations of PAH metabo-lites. Increasing levels of biliary PAH metabolites in eel suggest higher pollution levels downstream in the river Sebou and Loukkos.

Linear regression analysis of the individual data found significant relationships between the concentrations of 1-OH pyrene measured and biliverdin concentrations in the bile ($P=0.001$, $p<0.05$).

a)



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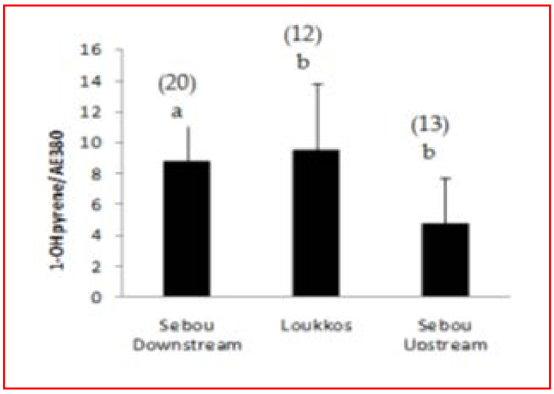


c)

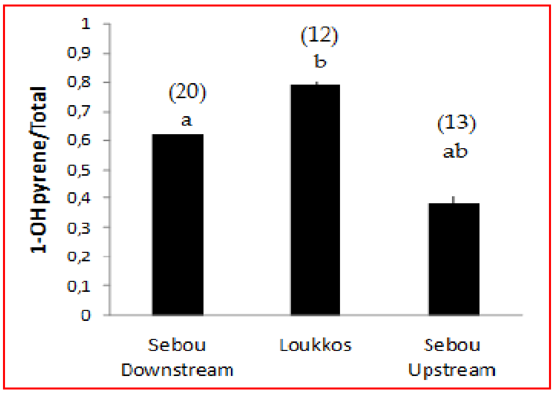


Figure 20 (a,b,c). Mean (±SE) of the concentration of 1-OH Pyrene concentration (ng/ml) in the bile of eel (*Anguilla anguilla*) in three sampling stations in autumn 2009: Without normalization (a), after normalization (dividing) of the values for the absorbance at 380 nm (b), and after normalization of the values at the total concentration of PAH (c). Columns labels with different letters differ significantly from each other ($p<0.05$), (Wariaghli *et al.*, 2010; unpublished data).

11.4 Predators

The cormorants are the most common predators of eels in Morocco.

12 Other sampling

There were no routine biological sampling programs or eel research projects. The results are the scientific work of thesis of researcher students interested in working on this thematic. In this period a project was run by the government in order to provide an EMP and to start the implementation of this plan.

13 Stock assessment

13.1 Local stock assessment

Non available data.

13.2 International stock assessment

Non available data.

13.2.1 Habitat

Wetted Area:

Lacustrine (0%)
Riverine (19%)
Transitional and lagoon (80%)
Coastal (≤1%)

13.2.2 Silver eel production

13.2.2.1 Historic production

13.2.2.2 Current production

13.2.2.3 Current escapement

13.2.2.4 Production values e.g. kg/ha

13.2.2.5 Impacts

Given the long duration and complexity of the life cycle of the eel, the future of this specie is exposed to several constraints which may be spread throughout its migration routes. Indeed, the early 1980s, scientists have sounded the alarm over the dramatic decline of eel throughout its distribution area. This regression has unfortunately extended over the following decades, so that the eel was considered outside the limits of its biological security, and associated fishing as unsustainable.

- **Natural threats** are common to several fish species, but some of them relate specifically to the eel, in which they are most likely amplified because of spatio-temporal characteristics of the life cycle of this species. The main constraints are found during the continental phase, resulting in the reduction of biomass potentially fruitful eels leaving internal waters.

  These threats are essentially predatory (by cormorants particularly), parasitic infestations, microbial infections, algal blooms and hydroclimatic changes.

- Concerning **anthropogenic threats**, they are numerous and severe. They are caused by human activities responsible for environmental disturbances, which are physical, chemical and biological. These threats are often synergistic, contributing actively to the scarcity of this resource ichthyological. Some of them are fairly obvious and well known as the barriers that prevent fish from accomplishing their migrations between the sea and fresh waters, the destruction of their habitats through the creation of canals for water diversion, or fishing and poaching which cuts much of the stock, when the biomass is in sharp decline. Other anthropogenic factors have different modes of action and more difficult to assess impacts on populations such as changes in water regimes or multiple forms of water pollution.

13.2.2.6 Stocking requirement eels <20 cm

So far, no restocking process has taken place.

13.2.2.7 Summary data on glass eel

Fishing activity in the lower parts of rivers has increased by practitioners who have been amplified over the years by the purchase price of glass eels offered by the wholesalers and traders, including Spanish. This surge in price is in close contact with a large demand for glass eels alive on the international market. Series of indicators that will be presented from fish, at least in part, data from scientific monitoring of fisheries obtained through university. They are supplemented with data provided by the Administration in charge of inland fisheries.

At the three sites studied, the European eel (*Anguilla anguilla*) has the highest commercial value, especially the elver stage with almost all of the catch is exported. As previously reported, the eel fishing is practiced by 62% of fishermen Merja Zerga, only 12% of Sebou and one fisherman Loukkos, which is also used by the leasee company the right to fish. As to glass eels, they are caught in both estuaries. Capture fishing activity is the largest and most profitable. This stage of the eel is operated by 88% and 81% respectively Loukkos and Sebou fishermen, which confirms the intense pressure on this resource. Monitoring of fishing effort becomes necessary.

Indeed, the effort is even more relevant than the catch per unit of effort (cpue) represent an index of abundance of the fishable stock. Cpue are therefore used as an estimate of the relative abundance of eels in the different sites. Hence, they allow monitoring the availability of the resource regardless of variations in the number of fishermen. At study sites (lagoon Merja Zerga and estuaries Loukkos and Sebou), the variation in cpue was determined as follows (Table 17).

Table 17. Cpue des anguilles argentées et jaunes.

Année	Site	Capture (Kg)	Total Effort (day)*	CPUE (Kg/day)
2003 (Sabatier)	Merja zerga	13 500	-	-
	Sebou	420 000	-	-
	Loukkos	-	-	-
2006 (Amouri)	Merja zerga	16 000	304	52.63
	Sebou	10 000	264	37.87
	Loukkos	200	117	1.70
2011 (New study)	Merja zerga	2700	304	8.88
	Sebou	12 340	264	46.74
	Loukkos	120	117	1.02

For commercial fishing of elvers in the three Atlantic sites, it has seen an increase in catches between 2009 and 2011 at a rate of 8.4% [2009–2010] and 50% [2010–2011] (Figure 21).

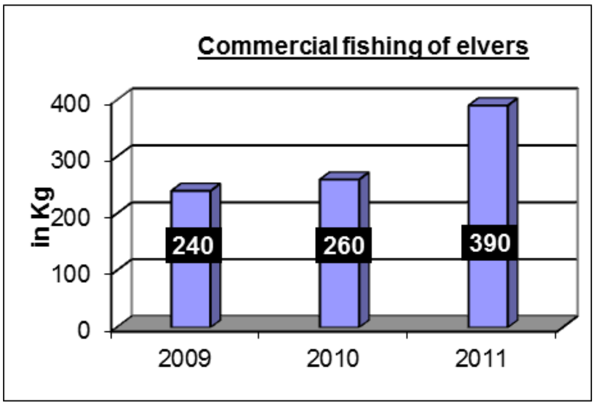
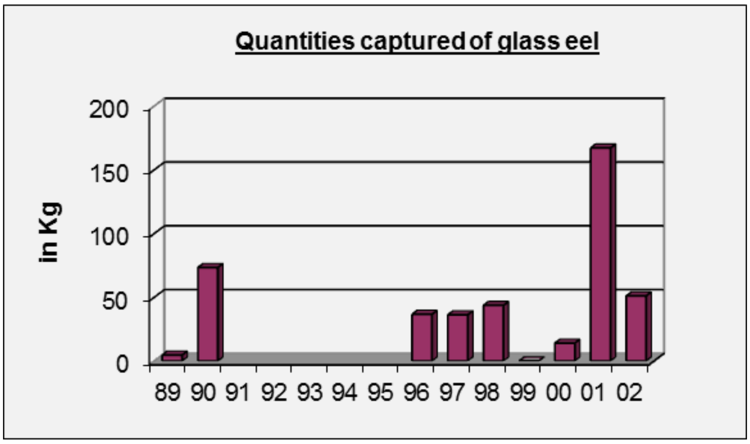


Figure 21. Quantities of glass eel caught in the commercial fishery (Atlantic side).

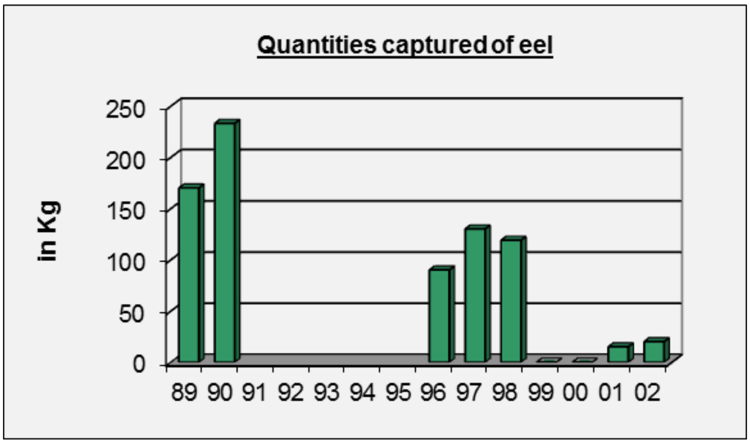
- Quantities of glass eel exported to Asia: No data available.
- Quantities of glass eel used in stocking: No stocking is done for glass eel.

- Quantities of glass eel used in aquaculture for direct consumption: Badly consumed in Morocco (0.1%).
- Mortalities of glass eel: No data available.

While at the the Moulouya estuary (Mediterranean side), the only site concerned by the fishing of elvers and eels, fishing activity has been prohibited since the departure of the company Marost. The only available data were collected from the Forestery Service of Berkane. According to the graphs below, we note that in general, there is a trend of increasing quantities of glass eels caught and decreased those of eels (Figure 22). These have varied in the range of 4.6 and 167 kg for elvers and between 15 and 233 kg for eels. It should be noted that during last year, these amounts have declined drastically for both stages, which has also encouraged the lessee companies to give up their activity.



Glass eel



Eel

Figure 22. Evolution of captures in Moulouya estuary.

13.2.2.8 Data quality issues

14 Sampling intensity and precision

15 Standardization and harmonization of methodology

15.1 Survey techniques

15.2 Sampling commercial catches

- Eels (yellow and silver eel) are caught using fykenets by the fishermen working for the Aquaculture companies.
- Glass eels are fished using the dipnet in Loukkos river, and in Sebou river they are caught by trapnets and dipnet.

15.3 Sampling

Catch sampling are carried out to the laboratory then they are frozen until they could be examined and dissected in the laboratory. The length (±0.1 mm) and weight (±0.01 g) is recorded for each eel. Otoliths are extracted and stored dry in paper envelopes. After the dissection the swimbladder was removed and macroscopically examined for the presence of adult and pre-adult *Anguillicoloïdes crassus* (lumen worms). The prevalence, the mean intensity and the mean abundance were calculated according to Bush *et al*. (1997).

15.4 Age analysis

Staining of otoliths

Otoliths prepared for ageing are embedded in a synthetic resin (polyester) then grounded on the convex side and polished with 600–1200 abrasive papers and then stained with a few drops of a 50% solution of 1% EDTA (ethylene-diamine-tetra-acetic acid) and 5% toluidine blue. After five minutes the solution was wiped off with damp tissue paper leaving the protein (otolin) in annuli and supernumerary checks stained a deep blue (Liew, 1974; Richter and McDermott, 1990; Panfili and Ximénès, 1994).

Cracking and burning techniques

Both otoliths were extracted from all eels and placed, concave side up, and held securely in position by covering them with transparent adhesive tape (Graynoth, 1999). One of each pair was then sawn along the transverse plane through the nucleus with a fine scalpel blade. The otolith halves were heated on a scalpel blade under for 20–25 seconds using a Bunsen burner. Burnt otoliths were examined under reflected and transmitted light, respectively using Olympus (50–400 X).

15.5 Life stages

- Silver eel: sides of the colour of silver or copper;
- Yellow eel: sides brown, grey, green, belly brown, green, grey, yellow;
- Eye diameter (the enlarged eyes are belonging to silver eels).

15.6 Sex determinations

From macroscopic examination of the gonads after the dissection of eels, confirmed by length and colour.

16 Overview, conclusions and recommendations

In Morocco, the **High Commissioner's Office** for Waters, Forests and Desert Control (MHCOWFDC), is preparing a preliminary study to elaborate a management plan for the exploitation of the European eel. This intervention is necessary, especially that since the end of the 1990s, eel stocks have been declining at alarming rates. The growing fisherman population lacks awareness on the ecological importance of eel and prizes them only for their economic value. Thus, it is urgent to:

- Restore and improve the quality of eel habitats by:
  - Restoring migration paths (rendering fish outlets more efficient in dams) in order to allow elvers to reach growth habitats and to allow silver eel to reach the sea.
  - Reducing harmful effects of pollution (remediation, reduction of pesticide and fertilizer use…)
  - Reducing effects from climate changes on river flow and on the quality of habitats (by prohibiting pumping and draining water from rivers).
  - Reduce the introduction of allotchonous species to avoid habitat degradation and new diseases.
- Prevent heavy exploitation of eel by:
  - Improving fishermen's living conditions and developing normalized, fishing infrastructures and recognizing the importance of the upkeeping of local fishing practices to ensure diversified production.
  - Applying stricter measures concerning the repopulation of some areas with young eels and the way sliver eels are transferred from confined areas to habitats from which they will migrate out to sea.
  - Regulating eel fishing: shortening eel fishing periods in order to reduce anthropic mortality. Establishing set fishing periods according to their developmental stages and controlling production methods.
  - Taking necessary measures in order to determine the origins of eel and to trace their commercialization from Morocco.
- Establish a regular follow-up of social and economic impacts of eel fishing and the evolution of their stock in order to assess the efficiency of the proposed eel management measures. Without a management program, eel may disappear from the southern limit of its distribution area as shad did in Moroccan freshwaters.

All these measures are urgent, especially that eel stocks have undergone a sharp decline throughout Morocco over the last few decades as a result of the accumulation of different factors, such as loss and alteration of its habitats, contamination, obstacles preventing its movement in rivers, overfishing, environment changes, and diseases and parasites.

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Report on the eel stock and fishery in The Netherlands 2011/'12

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Reporting Period: This report was completed in August 2012, and contains data up to 2011 and glass eel recruitment data for 2012.

Contributors to the report: Contributions: The following persons and institutions provided information for this report: Nicola Tien (ACTMON and PASMON data analysis), Arjan Heinen (Combinatie van Beroepsvissers; stocking data), Jaap van der Meer (NIOZ; yellow eel data NIOZ fyke), Michiel Kotterman (IMARES; eel contaminants), William Swinkels (DUPAN, glass eel data and eel aquaculture production).

2 Introduction

2.1 General overview fisheries

Eel fisheries in the Netherlands occur in coastal waters, estuaries, larger and smaller lakes, rivers, polders, etc. Management of eel stock and fisheries has been an integral part of the long tradition in manipulating water courses (polder construction, river straightening, ditches and canals, etc.). Governmental control of the fishery is restricted to on the one hand a set of general rules (gear restrictions, size restrictions, for course fish: closed seasons), and on the other hand site-specific licensing. Within the licensed fishing area, and obeying the general rules, fishermen are currently free to execute the fishery in whatever way they want. Since 1/1/2010 there is a general registration of landings, a general registration of fishing efforts has not been implemented yet. In recent years, licensees in state-owned waters are obliged to participate in so-called Fish Stock Management Committees [‘Visstand Beheer Commissies’ VBC,], in which commercial fisheries, sports fisheries and water managers are represented. The VBC is responsible for the development of a regional Fish Stock Management Plans. The Management Plans are currently not subject to general objectives or quality criteria. The future of VBC and their role in fish stock management is under debate.

Until April 2011 the total fishery involves approx. 200 companies, with an estimated total catch of nearly 442 tonnes in 2010. However, on 1 April 2011 a large part of the fishery was closed due to high PCB-levels in the eel (Figure 1). This closure has affected ~50 fishing companies catching 170 tonnes of eel in 2010, roughly a third of the annual landings of inland waters in the Netherlands. For details on the closure , visit the following website; http://www.rijksoverheid.nl/ministeries/eleni/nieuws/2011/03/31/vangstverbod-paling-en-wolhandkrab-vanaf-1-april-van-kracht.html.

Figure NL. 1. Overview of the areas closed for eel and Chinese mitten crab fishery as of 1 April 2011 (Source Ministry of Economic Affairs, Agriculture & Innovation).

2.2 Spatial subdivision of the territory

The fishing areas can be categorised into five groups:

1) The Waddensea; 53ºN 5ºE; 2591 km^2. This is an estuarine-like area, shielded from the North Sea by a series of islands. The inflow of sea water at the western side mainly consists of the outflow of the river Rhine, which explains the estuarine character of the Waddensea. The fishery in the Waddensea is permitted to licence holders and assigns specific fishing sites to individual licensees. Fishing gears include fykenets and poundnets; the traditional use of eelpots is in rapid decline. The fishery in the Waddensea is obliged to apply standard EU fishing logbooks. Landings statistics are therefore available from 1995 onwards; <50 tons per year. There are 21 companies having a commercial licence for fishing eel, and the total number of fykenets is estimated at 400.

2) Lake IJsselmeer; 52º40'N 5º25'E; now 1820 km^2. Lake IJsselmeer is a shallow, eutrophic freshwater lake, which was reclaimed from the Waddensea in 1932 by a dike (Afsluitdijk), substituting the estuarine area known before as the Zuiderzee. The surface of the lake was stepwise reduced by land reclamation, from an original 3470 km^2 in 1932, to just 1820 km^2 since 1967. In preparation for further land reclamation, a dam was built in 1976, dividing the lake into two compartments of 1200 and 620 km^2, respectively, but no further reclamation has actually taken place. In managing the fisheries, the two lake compartments have been treated as a single management unit. The discharge of the river IJssel into the larger compartment (at 52º35'N 5º50'E, average 7 km^3 per annum, coming from the River Rhine) is sluiced through the Afsluitdijk into the Waddensea at low tide, by passive fall. Fishing gears include standard and summer fykenets, eelboxes and longlines; trawling was banned in 1970. Licensed fishermen are not spatial-

ly restricted within the lake, but the number of gears is controlled by a gear-tagging system. The registered landings at the auctions are assumed to cover some the actual total. There are, however, differences in estimated landings reported by PO IJsselmeer, PVIS and catch registration system of the Ministry of EL&I. There are 70 fishing licences, owned by ca. 30 companies. The total number of gears allowed in 2010 was: fixed fykes 1579, train fykes 6386, eelboxes 7415 and unknown numbers of longlines.

3) Main rivers; 180 km^2 of water surface. The Rivers Rhine and Meuse flow from Germany and Belgium respectively, and constitute a network of dividing and joining river branches in the Netherlands. Traditional eel fisheries in the rivers have declined tremendously during the 20th century, but following water rehabilitation measures in the last decades are now slowly increasing. The traditional fishery used stow nets for silver eel, but fykenet fisheries for yellow and silver eel now dominates. Individual fishermen are licensed for specific river stretches, where they execute the sole fishing right. No registration of efforts is required. There are 28 fishing companies, using an estimated number of 318 fixed fykes, 2433 train fykes, 551 eel boxes, and unknown quantities of other gears (electric dipnet, longlines, etc). This fishery has been almost completely stopped due to the introduction 1/4/2011 of a total fishing ban on eel and Chinese mitten crab in rivers polluted with dioxins. Since 1 April 2011 the eel fishery on the main rivers has been closed due to high levels of pollutants in eel (Figure 1).

4) Zeeland; 965 km^2. In the Southwest, the Rivers Rhine, Meuse and Scheldt (Belgium) discharge into the North Sea in a complicated network of river branches, lagoon-like waters and estuaries. Following a major storm catastrophe in 1953, most of these waters have been (partially) closed off from the North Sea, sometimes turning them into freshwater. Fishing is licensed to individual fishermen, mostly spatially restricted. Fishing gears are dominated by fykenets. Management is partially based on marine, partly on fresh water legislation. There are 27 companies, using an estimated number of 174 fixed fykes, 233 train fykes, and unknown numbers of eelpots. This area has also been affected by the ban of eel and Chinese mitten crab fishery in the closed (dioxine) areas.

5) Remaining waters; inland 1340 km^2. This comprises 636 km^2 of lakes (average surface: 12.5 km^2); 386 km^2 of canals (>6 m wide, 27 590 km total length); 289 km^2 of ditches (<6 m wide, 144 605 km total length); and 28 km^2 of smaller rivers (all estimates based on areas less than 1 m above sea level, 55% of the total surface; see Tien and Dekker, 2004 for details). Traditional fisheries are based on fykenetting and hook and line. Individual licences permit fisheries in spatially restricted areas, usually comprising a few lakes or canal sections, and the joining ditches. Only the spatial limitation is registered. Eight small companies operating scattered along the North Sea coast have been added to this category. There are approximately 100 companies, using unknown quantities of gears of all types.

The Water Framework Directive subdivides the Netherlands into four separate River Basin Districts, all of which extend beyond our borders. These are:

a) the <u>River Ems</u> (Eems), 53º20'N 7º10'E (=river mouth), shared with Germany. This RBD includes the northeastern Province Groningen, and the eastern part of Province Drente. Drainage area: 18 000 km², of which 2400 km² in the Netherlands.

b) the River Rhine (Rijn), 52º00'N 4º10'E, shared with Germany, Luxemburg, France, Switzerland, Austria, Liechtenstein. Drainage area: 185 000 km², of which 25 000 km² in the Netherlands, which is the major part of the country.

c) the River Meuse (Maas), 51º55'N 4º00'E, shared with Belgium, Luxemburg, France and Germany. Drainage area: 35 000 km² , of which 8000 km² in the Netherlands.

d) the River Scheldt (Schelde), 51º30'N 3º25'E, shared with Belgium and France. Most of the south-western Province Zeeland used to belong to this RBD, but water reclamation has changed the situation dramatically. Drainage area: 22 000 km², of which 1860 km² in the Netherlands.

Within the Netherlands, all rivers tend to intertwine and confluent. Rivers Rhine and Meuse have a complete anastomosis at several places, while a large part of the outflow of the River Meuse is now redirected through former outlets of the River Scheldt. Additionally, the coastal areas in front of the different RBDs constitute a confluent zone. Consequently, sharp boundaries between the RBDs cannot be made; neither on a practical nor on a juridical basis. This report will subdivide the national data on a pragmatic basis.

In the following, we will subdivide the national data on eel stock and fisheries by drainage area on a preliminary assumption that water surfaces and fishing companies are approximately equally distributed over the total surface, and thus, totals can be split up over RBDs proportionally to surface areas.

2.3 Dutch Eel Management Plan

The Ministry of Economic Affairs, Agriculture and Innovation (responsible for fisheries) has submitted an Eel Management Plan (MinLNV, 2008); the initial version (December 2008) has been replaced by a second version (April 2009), which in turn has been replaced by a new decision in July 2009 (decision published 14 July 2009, approved by EU on 20 October 2010). Major elements of this plan are:

1) One single Eel Management Plan for the whole territory, including coastal areas.

2) Target escapement for Lake IJsselmeer estimated at 3080 t (length structured model, auction statistics), for the whole country at 4000–6000 t (historical landings per surface area, 1950s data, recent surfaces). Following the initial version of the EMP, the calculations have been reviewed by a committee, and targets are now set at 2600–8100 t, "most probably lower than the previous" calculations.

3) Current escapement is estimated at 400 t, half of which is silver eels from upstream, only passing through Dutch territory.

4) Fisheries for yellow and silver eel currently occurs in almost all waters, see previous section. Relative impact on the stock is unknown.

5) Other mortalities are omnipresent, but unquantified. Minimum estimates (including fishing) are: 1000 t for yellow eel, and 345 t for silver eel.

6) Restocking of approximately 0.2 million individuals (mostly bootlace); future restocking of 1–1.6 t of glass eel is foreseen.

7) Management measures planned as follows:
   7.1) Reduction of mortality at pumping stations. Within the framework of the WFD, a budget of 200 M€ is available.
   7.2) The hydropower industry will be asked to reduce mortality by 35%. On new installations, a migration passage is obligatory.
   7.3) Fishery-free zones near barriers and sluices, presumably extending 500 m up- and downstream.
   7.4) Release of angler catches; this is a voluntary measure by the recreational fisheries.
   7.5) Ban on recreational fishing (a few fykenets per person) in coastal areas from 2011.
   7.6) Stop on sniggle licences in state owned waters.
   7.7) For the fishery, version 1 of the EMP set a closed season in Sept+Oct (yellow & silver eel, total ca. 50% of the annual catch).; version 2 decided to trap and transport 157 t of silver eels (of which 50 t from unpolluted waters) for release into the sea, but no closed season; and the July 2009 decision returns to a closed season (2009: Oct+Nov; 2010 onwards: Sept+Oct+Nov).
   7.8) The time until recovery depends very much on the immigration of glass eels in the years to come. Assuming that glass eel recruitment will have recovered by 2027, the targets set for silver eel escapement will be met.

3 Time-series data

3.1 Recruitment-series and associated effort

3.1.1 Glass eel

3.1.1.1 Commercial

Glass eel fisheries is forbidden, no available data.

3.1.1.2 Recreational

Glass eel fisheries is forbidden, no available data.

3.1.1.3 Fishery independent

Recruitment of glass eel in Dutch waters is monitored at Den Oever and eleven other sites along the coast (Figure NL.2; see Dekker, 2002 for a full description). In Den Oever (Figure NL.3), 2011 recruitment was lower than 2010 and similar to levels observed during the first part of the decade. The data at the other sites (Figure NL.2) confirm the overall trend, though individual series may deviate. Note that in contrast to previous years the glass eel data are presented simply as the average number of glass eels per haul in the months April and May.

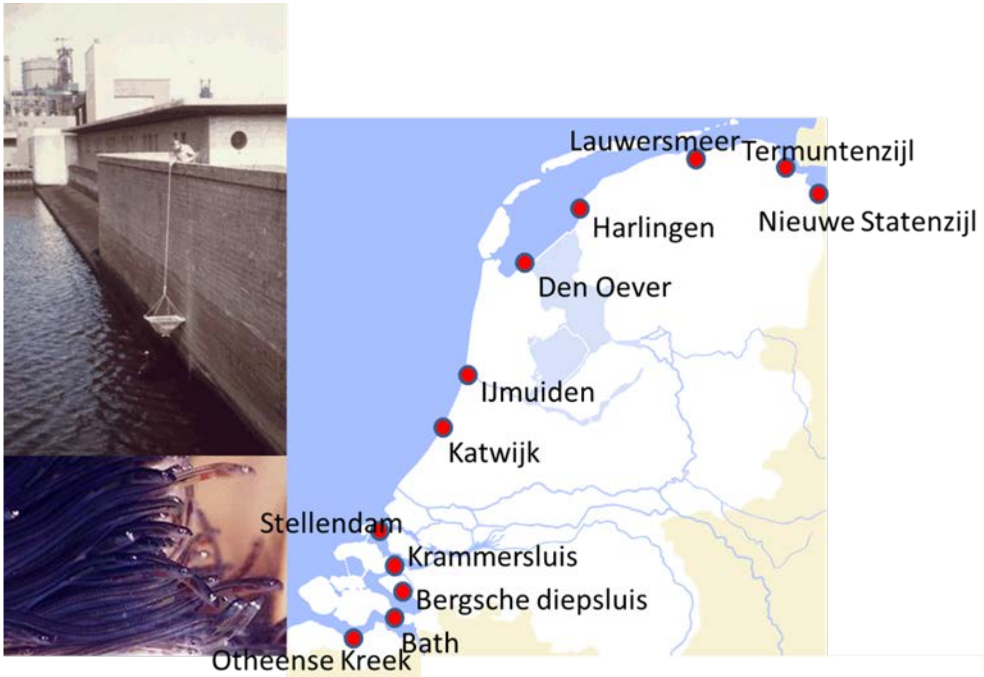

Figure NL.2. Locations of glass eel monitoring in the Netherlands.

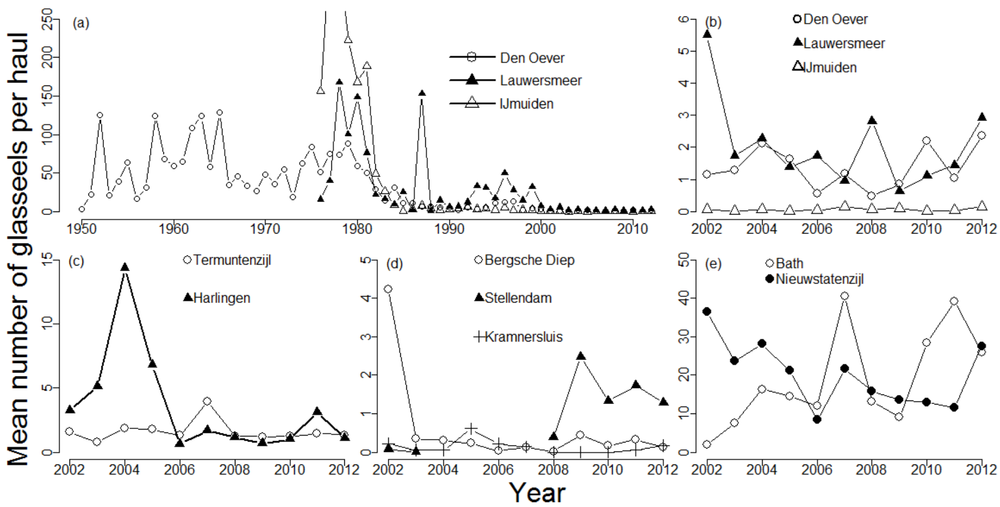

Figure NL.3. Trend indices (mean number per haul in April and May) of glass eel recruitment at different locations along the coast of the Netherlands.

Table NL.A. Average number of glass eel caught per lift net haul at the sluices in Den Oever in de period April–May.

Decade Year	1930	1940	1950	1960	1970	1980	1990	2000	2010
0		22.4	2.7	58.9	48.1	59.0	4.9	2.8	2.2
1		14.3	21.9	65.2	36.1	50.4	1.8	0.6	1.1
2		17.5	125.6	108.9	55.0	29.4	5.2	1.2	2.4
3		13.7	21.1	123.7	18.8	14.7	3.5	1.3	
4		46.1	38.8	58.1	63.0	31.6	5.4	2.1	
5		NA	64.1	128.3	84.3	11.2	11.1	1.6	
6		7.5	16.1	34.0	51.4	11.4	12.5	0.6	
7		7.2	31.3	45.8	75.0	6.2	12.6	1.2	
8	15.3	4.8	124.0	32.9	73.6	7.0	2.4	0.5	
9	71.5	6.6	67.6	27.1	87.7	4.8	3.7	0.9	

Table NL.B. Average number of glass eel caught per lift net haul in the period April-May at twelve sites in the Netherlands. If five or less hauls were conducted it was recorded as NA. * = very early season (warm spring), sampling stopped early (start of May), low number of empty samples. ** = sampling took place in part of the season.

	Otheense Kreek	Bath	Krammersluis	Bergsche Diep	Stellendam	Katwijk	Ijmuiden	Den Oever (schiplock)	Harlingen	Lauwersmeer	Nieuwstaten-zijl	Termunten-zijl
RBD	Scheldt	Scheldt	Meuse	Meuse	Meuse	Rhine	Rhine	Rhine	Rhine	Rhine	Ems	Ems
1969							50.79					
1970							28.00					
1971					18.45							
1972					5.58							
1973							30.67					
1974												
1975												
1976										15.42		
1977												
1978												
1979							222.33			100.43		
1980												
1981							188.71			75.92		
1982										21.62		
1983										15.77		
1984							8.14			9.55		
1985							0.58			25.17		
1986							3.33			1.30		
1987							7.73					
1988					13.78		4.00			1.00		

	Otheense Kreek	Bath	Krammersluis	Bergsche Diep	Stellendam	Katwijk	Ijmuiden	Den Oever (schiplock)	Harlingen	Lauwersmeer	Nieuwstaten-zijl	Termunten-zijl
1989					4.37		1.52			14.33		
1990	0.29		0.28		10.86		3.20			6.00		
1991	0.00		0.19	1.31	3.08	5.13	3.60			6.63		0.52
1992	0.00	14.50	0.44	2.22	16.93	8.15	5.75		16.70	12.07		0.61
1993	0.00	22.67	0.42		10.13	13.53	3.33			33.19		1.17
1994	0.00	14.20	0.49		4.01	15.12	4.00		16.04	31.00		2.77
1995	0.53	17.81	0.43		3.26	29.67	2.00	34.66	6.57	16.85		3.69
1996	1.21	35.33	0.71		0.48	25.35	4.54	11.02	34.17	49.37	27.48	7.69
1997		41.56	0.59		2.80	12.25	1.78	11.37	14.00	27.76	30.00	15.56
1998	0.67	28.19	0.62		0.99	38.82	2.00	6.46	18.33	14.38	21.83	1.38
1999	1.38	29.74	0.47		1.18	122.67	1.90	7.22	19.10	31.69	13.50	10.14
2000	0.85	10.15	1.00	3.75	7.11	11.60	0.70	5.04	2.94	7.21	38.81	8.74
2001	0.37		0.06	0.08	0.95	14.08	0.53	1.67	2.30	2.38	39.73	1.13
2002		1.93	0.22		4.23	12.32	0.07	1.43	3.22	5.50	36.42	1.56
2003		7.54	0.06		0.34	12.70	0.00	4.73	5.13	1.72	23.61	0.80
2004	0.00	16.38	0.05		0.31	4.48	0.06		14.33	2.26	28.07	1.87
2005	0.00	14.58	0.61		0.23	5.63	0.00		6.79	1.37	21.14	1.76
2006	0.00	11.99	0.21		0.03	1.42	0.04	0.28	0.63	1.74	8.33	1.29
2007	0.00	40.48	0.14	0.39	0.13	24.81	0.13		1.67	0.96	21.67	3.95
2008	0.00	13.15	0.00	2.47	0.02	4.13	0.07	0.76	1.15	2.81	15.89	1.25
2009	0.00	9.08	0.00	1.33	0.45	3.53	0.10		0.67	0.63	13.56	1.21
2010		28.44	0.00	1.73	0.17		0.00	1.19	1.00	1.11	12.97	1.22
2011		39.17	0.05	1.29	0.33		0.04		3.08	1.44	11.58	1.44
2012		25.81	0.17	0.77	0.13	1.58	0.13		1.09	2.91	27.59	1.33

3.1.2 Yellow eel recruitment

3.1.2.1 Commercial

No available data.

3.1.2.2 Recreational

No available data.

3.1.2.3 Fishery independent

At various places in the Netherlands, facilities have been built to allow glass eel and yellow eel to migrate through or over dykes and sluices. Some of these places monitor the quantities of eel being caught and transported, but these dataseries are currently too short to be used as time-series. There is one noticeable exception: for the eel trap at pumping station Stroink in Vollenhove (52º42'16N 5º28'22E), records have been kept since the late 1950s, but unfortunately, the data prior to 1976 have been lost. Unfortunately no data are available for 2011; check WGEEL 2010 Country Report the Netherlands for further information.

One of the few long time-series for yellow eel is the fyke monitoring at NIOZ (Den Burg, Texel; van der Meer *et al*., 2011). This dataset shows a familiar pattern of a steep decline in abundance since the 1980s

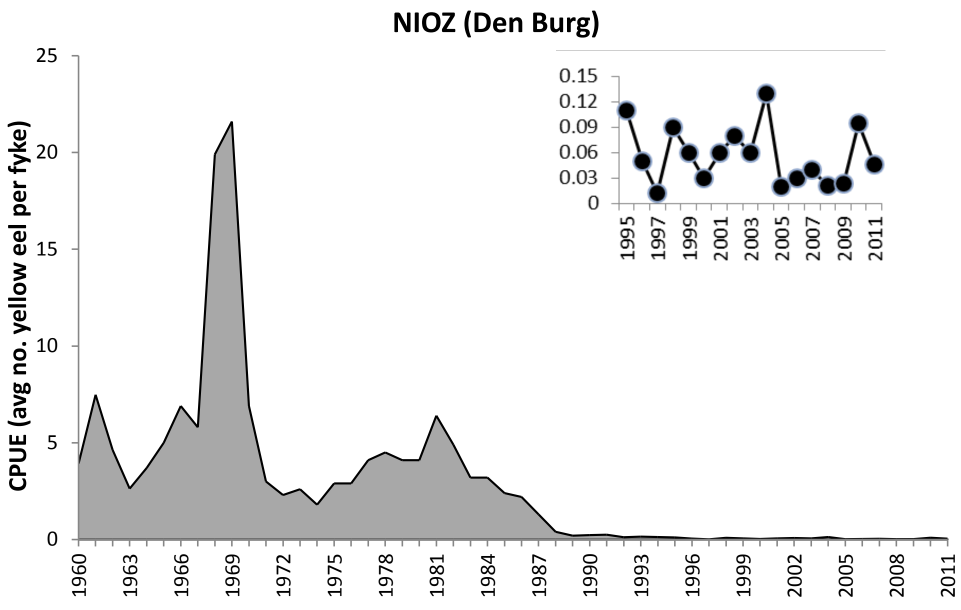

Figure NL.4. Time-series of the mean catch per fyke (numbers) of yellow eel at NIOZ (data NIOZ and van der Meer *et al*., 2011.).

3.2 Yellow eel landings

3.2.1 Commercial

No reliable long term time-series of yellow eel landing exist; total landings of yellow and silver eel combined, have been reported. However, data from auctions around Lake IJsselmeer did report yellow and silver eel separately, but information in recent years (early 1990s onwards) is unreliable: yellow eel from eel boxes and silver eel from all gears have been combined; see Section NL.6.2.1 for details. An obligatory catch registration system was introduced in the Netherlands in January 2010 by the Ministry of Agriculture, Nature and Food Quality. However, weekly catches of eel are reported but yellow eel and silver eel catches are combined in this program and no information on effort and gears is reported.

3.2.2 Recreational

No available data.

3.2.3 Fishery independent

No available data.

3.3 Silver eel landings

3.3.1 Commercial

No reliable long-term time-series of yellow eel landing exist; total landings of yellow and silver eel combined, have been reported. However, data from auctions around Lake IJsselmeer did report yellow and silver eel separately, but information in recent years (early 1990s onwards) is unreliable: yellow eel from eel boxes and silver eel from all gears have been combined; see Section NL.6.2.1 for details. An obligatory catch registration system was introduced in the Netherlands in January 2010 by the Ministry of Agriculture, Nature and Food Quality. However, weekly catches of eel are reported but yellow eel and silver eel catches are combined in this program and no information on effort and gears is reported.

3.3.2 Recreational

No available data.

3.3.3 Fishery independent

No available data.

3.4 Aquaculture production

3.4.1 Seed supply

Table NL.C. Origin of glass eel used for aquaculture in the Netherlands in 2011 (Source DUPAN).

Season	France	Spain	England	Total (kg)
2010/2011	4725	1890	135	6750
2011/2012	5325	1350	100	6775

3.4.2 Production

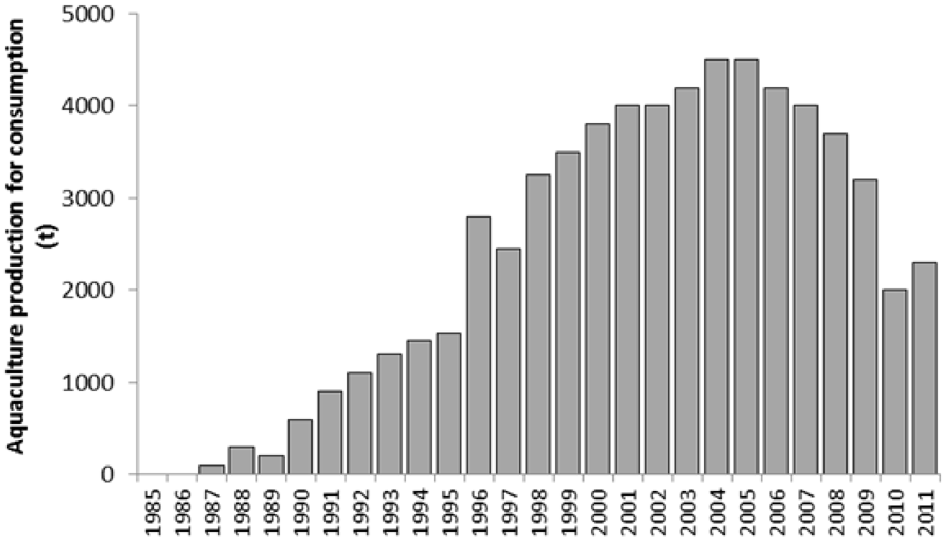

Figure NL.5. Trend in aquaculture production for consumption in the Netherlands (Source DUPAN).

3.5 Stocking

3.5.1 Amount stocked

Table NL.D. Overview of glass eel and young yellow eel stocked in the Netherlands in 2012 (Source CvB, DUPAN). Note that all young yellow eel stocked in 2012 originated from glass eel caught in France in 2011 and 2012.

Date	Stocking Location	Type	Origin	Quarantined	kg	#/kg	#
4/2/2012	Veerse Meer	Glass eel	*Anguilla anguilla* (Fr)	yes	170	3100	527 000
4/2/2012	Friese Boezemwateren	Glass eel	*Anguilla anguilla* (Fr)	yes	513	3100	1 590 300
6/12/2012	Westeinder plassen	Glass eel	*Anguilla anguilla* (Fr)	yes	7	3100	21 700
6/12/2012	Wieden (NW overijssel)	Glass eel	*Anguilla anguilla* (Fr)	yes	21	3100	65 100
6/12/2012	Kanaal van Steenenhoek en Linge	Glass eel	*Anguilla anguilla* (Fr)	yes	5	3100	15 500
6/12/2012	Binnenwater Walcheren	Glass eel	*Anguilla anguilla* (Fr)	yes	4	3100	12 400
6/12/2012	Polders ten Noorden van Amsterdam	Glass eel	*Anguilla anguilla* (Fr)	yes	9	3100	27 900
6/12/2012	Wormer en Jisperveld polders in Noord-Holland	Glass eel	*Anguilla anguilla* (Fr)	yes	24	3100	74 400
6/12/2012	Rond Zaandam	Glass eel	*Anguilla anguilla* (Fr)	yes	3	3100	9300
6/12/2012	Friesland	Glass eel	*Anguilla anguilla* (Fr)	yes	10	3100	31 000
			TOTAL		766		2 374 600
6/12/2012	Tjeukemeer and Slotermeer	Young yellow eel	Anguilla Anguilla (Fr)/Nijvis	?	1200	340	408 000
	Zuid-Holland	Young yellow eel		?	30	200	6000
5/28/2012	Elburg	Young yellow eel	Aquafarm (Putten, NL)	?	27.5	218	6000
5/12/2012	Kampen	Young yellow eel	Aquafarm (Putten, NL)	?	146.8	218	32 000
6/1/2012	Reeuwijk	Young yellow eel	Kraan	?	70	250	17 500
7/6/2012	Markiezaatsmeer	Young yellow eel	Nijvis	?	100	200	20 000
5/3/2012	Westeinder plassen	Young yellow eel	Kraan	?	100	100	10 000
			TOTAL		1674		499 500

3.5.2 Catch of eel <12 cm and proportion retained for restocking

Catch and retain of eels <28 cm is illegal. There is no organised trap and transport of undersized eels.

3.5.3 Reconstructed time-series on stocking

Table NL.E.

	Local Source				Foreign Source			
Year	Glass Eel	Quarantined Glass Eel	Wild Bootlace	On-grown cultured	Glass Eel	Quarantined Glass Eel	Wild Bootlace	On-grown cultured

No (historical) data available with regards to origin and whether or not stocked eels were quarantined, overall all stocked of glass eel (see Figure NL.6) is sourced outside the Netherlands.

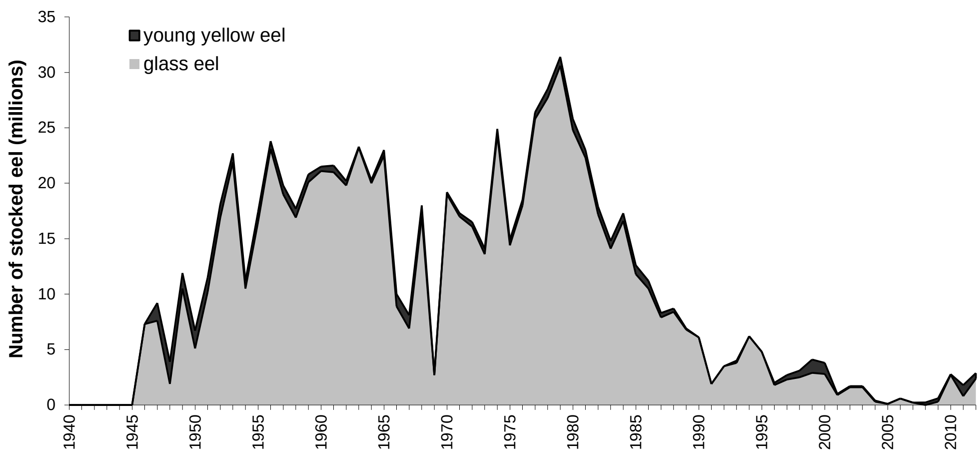

Figure NL.6. Overview of glass eel and young yellow eel stocking in the Netherlands.

4 Fishing capacity

For marine waters and Lake IJsselmeer, a register of ships is kept, but for the other waters, no central registration of the ships being used is available. Registration of the number of gears owned or employed is lacking. For Lake IJsselmeer, a maximum number of gears per company is enforced (authenticated tags are attached to individual gears), but the actual usage is often much lower, amongst others since restrictions apply on the combinations of types of fishing gears (e.g. no fykenets and gillnets should be operated concurrently, since perch and pikeperch are the target species of the gillnetting, while landing perch and pikeperch from fykenets is prohibited).

5 Fishing effort

For most of the country, fishing capacity is unknown. In areas where fishing capacity is known, no record is kept of the actual usage of fishing gears. Consequently, no information is available on fishing effort. For Lake IJsselmeer, an estimate of the number of gears actually used is available for the years 1970–1988 (Dekker, 1991). In the mid-1980s, the number of fykenets was capped, and reduced by 40% in 1989. In 1992, the number of eel boxes was counted, and capped. Subsequently, the caps have been lowered further in several steps, the latest being a buy-out in 2006. Since the number of companies has reduced at the same time, the nominal fishing effort per company has not reduced at the same rate, and underutilisation of the nominal effort probably still exists. The effort in the longline fishery is not restricted, other than by the number of licences.

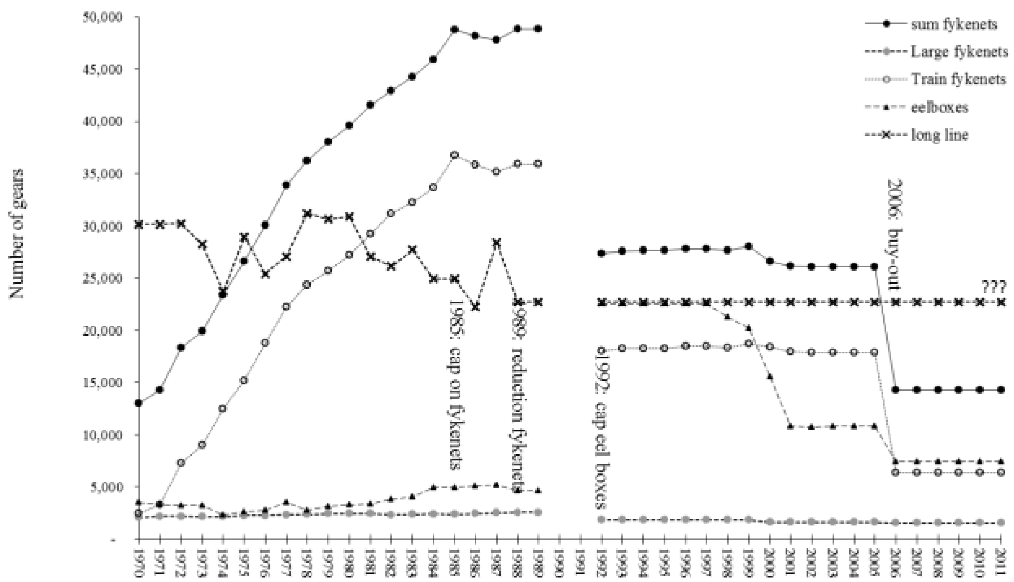

Figure NL.7. Trends in the nominal number of fishing gear employed in the eel fishery on Lake IJsselmeer. Information before 1989 is based on a voluntary inquiry in 1989 (Dekker, 1991); after 1992, the licensed number of gear is shown. Note that longline fishery is only restricted by the number of licences; the number of longlines per licence is not regulated. The number of longlines since 1992 is unknown.

The Ministry of Economic Affairs, Agriculture and Innovation conducted a survey of eel fishing gears used outside IJsselmeer/Markermeer in 2010 and 2011 (Figure NL.8). In 2012 information on fishing effort has been added to the obligatory catch registration system of the Ministry.

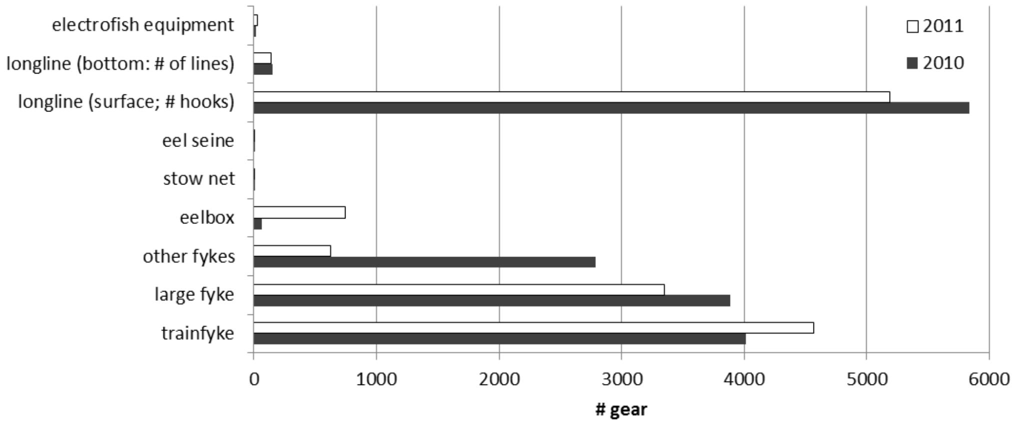

Figure NL.8. Number of fishing gear employed in the eel fishery outside Lake IJsselmeer/Markermeer in 2010 and 2011 (source Min EL&I).

6 Catches and landings

6.1 Glass eel

Glass eel fishing is forbidden, no available data.

6.2 Yellow eel

6.2.1 Catches and landings from lake IJsselmeer

For Lake IJsselmeer, statistics from the auctions around Lake IJsselmeer are now kept by the Fish Board (Table NL.e); before 1994, the government kept statistics. These statistics are broken down by species, month, harbour and main fishing gear; the quality of this information has deteriorated considerably over the past decade, due to misclassification of gears, and the trading of eel from other areas at IJsselmeer auctions. For example, the estimates for the total number of eel caught in Lake IJsselmeer in 2010 vary from 117 t (registration Min EL&I), 79 t (PO IJsslmeer) to 65 t (Fish Board). Starting in 2011 the estimates of the obligatory registration of the Min EL&I will be used.

Table NL.F. Landings in tons per year, from the auctions around Lake IJsselmeer, Rhine RBD. Only landings recorded at the auctions are included; other landings are assumed to represent a minor and constant fraction. Figures in italics are suspect, due to misclassification of catches and trade from areas outside Lake IJsselmeer at the IJsselmeer auctions. Source 2011 data is Min of EL&I.

Decade Year	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000	2010
0	324	620	1157	838	3205	4152	2999	1112	641	472	368	65
1	387	988	989	941	4563	3661	2460	853	701	573	381	179
2	514	720	900	1048	3464	3979	1443	857	820	548	353	
3	564	679	742	2125	1021	3107	1618	823	914	293	279	
4	586	921	846	2688	1845	2085	2068	841	681	330	245	
5	415	1285	965	1907	2668	1651	2309	1000	666	354	234	
6	406	973	879	2405	3492	1817	2339	1172	729	301	230	
7	526	1280	763	3595	4502	2510	2484	783	512	285	130	

8	453	1111	877	2588	4750	2677	2222	719	437	323	122
9	516	1026	1033	2108	3873	3412	2241	510	525	332	42

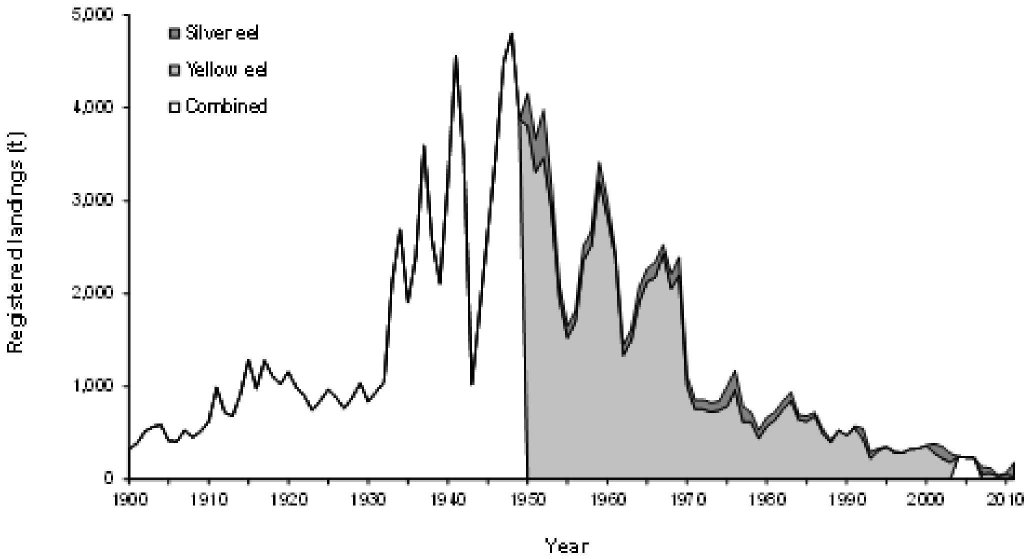

Figure NL.8. Time trend in the landings from Lake IJsselmeer.

6.2.2 Catches and landings inland waters

For the inland areas outside Lake IJsselmeer, no detailed records of catches and landings were available until 2010. In January 2010 the Ministry of Economic Affairs, Agriculture and Innovation introduced an obligatory catch recording system for inland eel fishers (IJsselmeer and Rivers). Fishermen are required to report their weekly eel catches for each of the 43 so-called Fish Stock Management Committees ['Visstand Beheer Commissies' VBC].

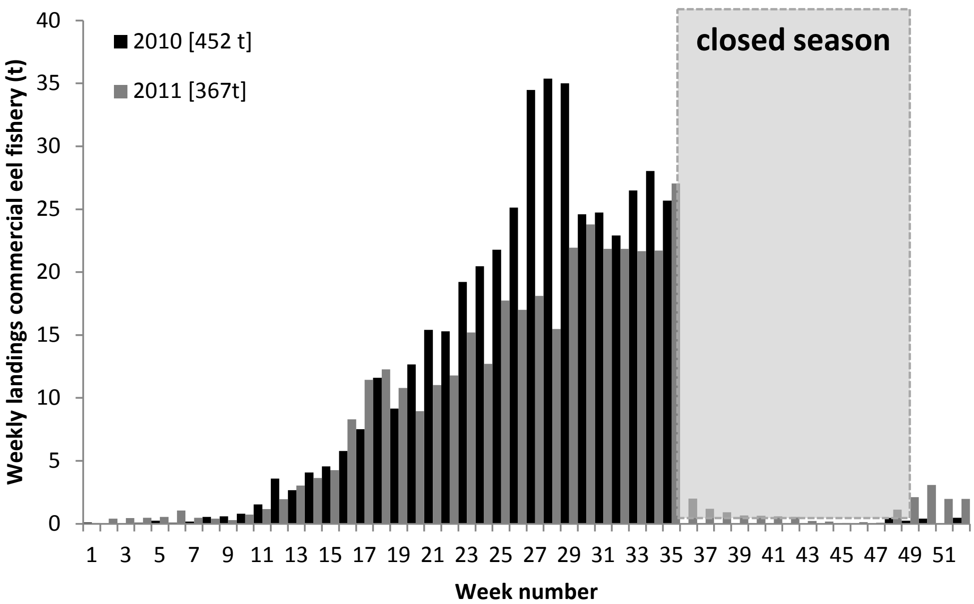

Figure NL.9. Weekly catches in tons of eel (yellow + silver eel combined) by inland fishermen.

6.2.3 Recreational fisheries

In 2009 an extensive Recreation Fisheries Program was started in the Netherland. In December 2009 50 000 households were approached during the screening survey to determine the number of recreational fishermen in the Netherlands (result 1.69 million recreational fishermen). In 2010, 2000 recreational fishermen were selected for a twelve month logbook programme (March 2010–February 2011). In the Netherlands around ~1 500 000 eels are caught while ~500 000 eels are retained by recreational fishermen. Due to the lack of reliable length–frequency data of the caught eel, upscaling the number of caught eel to a biomass of caught eel remains difficult (van der Hammen and de Graaf, 2012).

Table NL.G. Overview of eel catches (retained and released) by the recreational fishery in the Netherlands in 2010 (Source van der Hammen and de Graaf, 2012).

	numbers			uncorrected weight (kg)			corrected weight (kg)		
	marine	fresh	sum	marine	fresh	sum	marine	fresh	sum
retained	174 215	340 536	514 751	36 287	78 259	114 546	17 161	37 374	54 535
released	108 462	872 570	981 032	23 834	137 186	161 020	26 253	149 917	176 170
sum	282 677	1 213 106	1 495 783	60 121	215 445	275 566	43 414	187 291	230 705
% retained	62%	28%	34%	60%	36%	42%	40%	20%	24%

6.3 Silver eel

See 6.2 Yellow eel.

6.4 Marine fishery

Catches and landings in marine waters are registered in EU logbooks, but these do not allow for a break down by RBD. Registrations are available for the years since 1995; data prior to 1984 are presented in the 2009 Country Report. Until 2001, vessels with a total length (LOA) ≥15 m were obliged to report all their eel catches. This obligation did not apply top smaller vessels. From 2001 onwards, vessels with a total length ≥10 m are obliged to report their eel catches, if their landings per day exceeded 50 kg. That is: in 2001 the number of ships potentially reporting rose, but the actual reporting per ship potentially declined. This change in the regulations was partly driven by changing practices, and vice versa. Since 2001 the number of ships, total landings and the landings per ship have been declining.

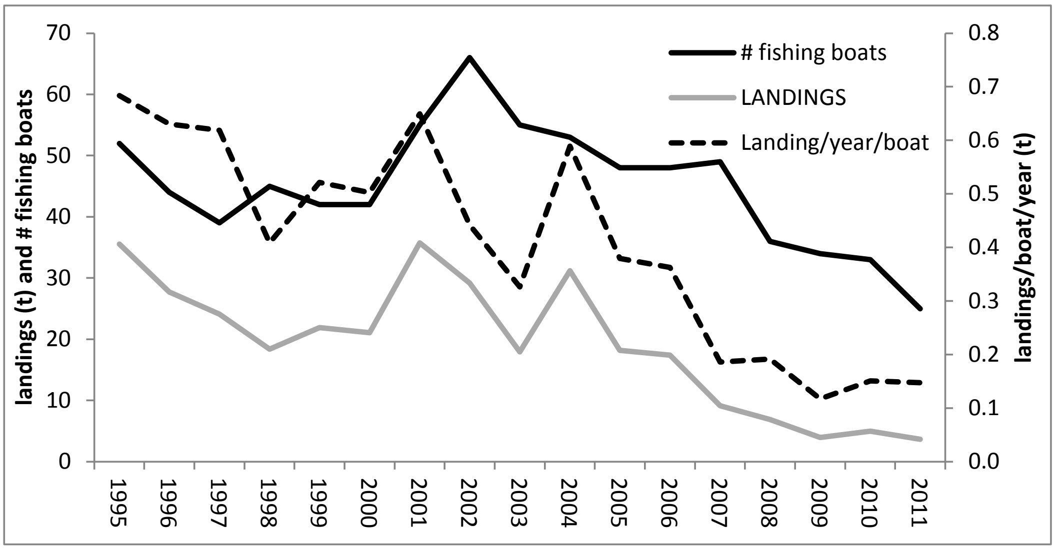

Figure NL.10. Time trend in the total registered landings from marine waters in Dutch harbours.

7 Catch per unit of effort

No data on cpue are available in the Netherlands.

8 Other anthropogenic impacts

See Section 13.2.2.5.

9 Scientific surveys of the stock

9.1 Recruitment surveys, glass eel

See Section 3.1.1.3.

9.2 Stock surveys, (yellow) eel

9.2.1 Lake IJsselmeer (active gear)

Figure NL.11 presents the trends in cpue for the annual (yellow) eel surveys in Lake IJsselmeer (25 sites) and Lake Markermeer (15 sites), using the electrified trawl.

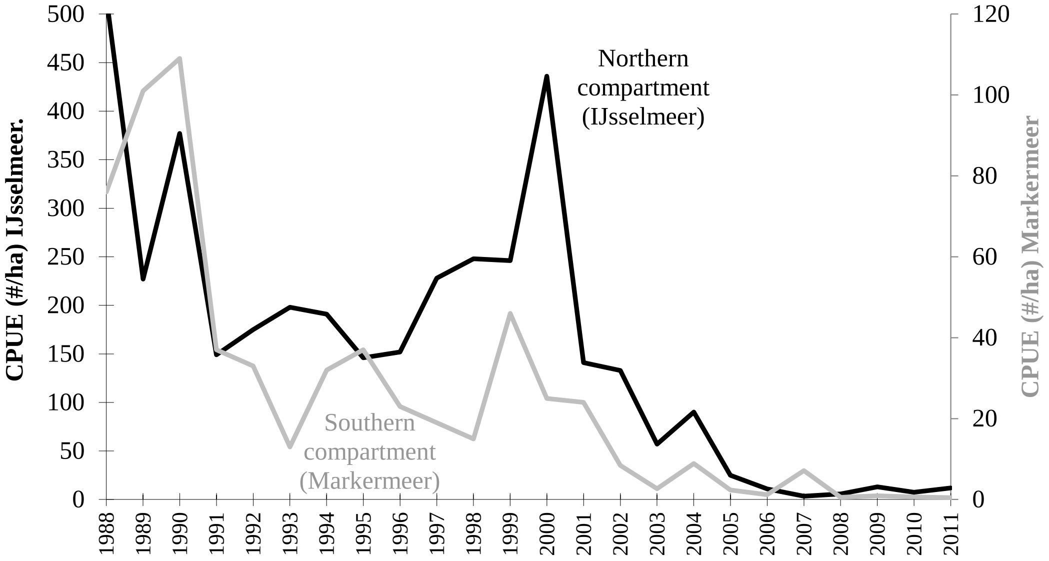

Figure NL.11. Cpue trends in Lake IJsselmeer stock surveys, in number per hectare swept area, using the electrified trawl. Note: The northern and southern compartments are separated by a dyke.

9.2.2 Main Rivers (active gears)

Eel stocks in the main rivers are surveyed yearly since 1998. Within a river, the main stream is sampled with a beam trawl and the river banks are sampled with an electric dipnet. Data is collected annually in eleven river systems, which are clustered in six regions. In Figure NL. 12, data are presented for three regions, namely Downstream (consisting of Hollands Diep, Nieuwe Merwede and Oude Maas), Gelderse Poort (consisting of the upstream section of the Rhine, Waal, Nederrijn and Gelderse IJssel, near the German border) and the Grensmaas (a shallow, upstream section of the Maas, near the Belgian border). Downstream is surveyed in September/October (i.e. during the migratory period of the silver eel), Gelderse Poort in March/April, and Grensmaas in May.

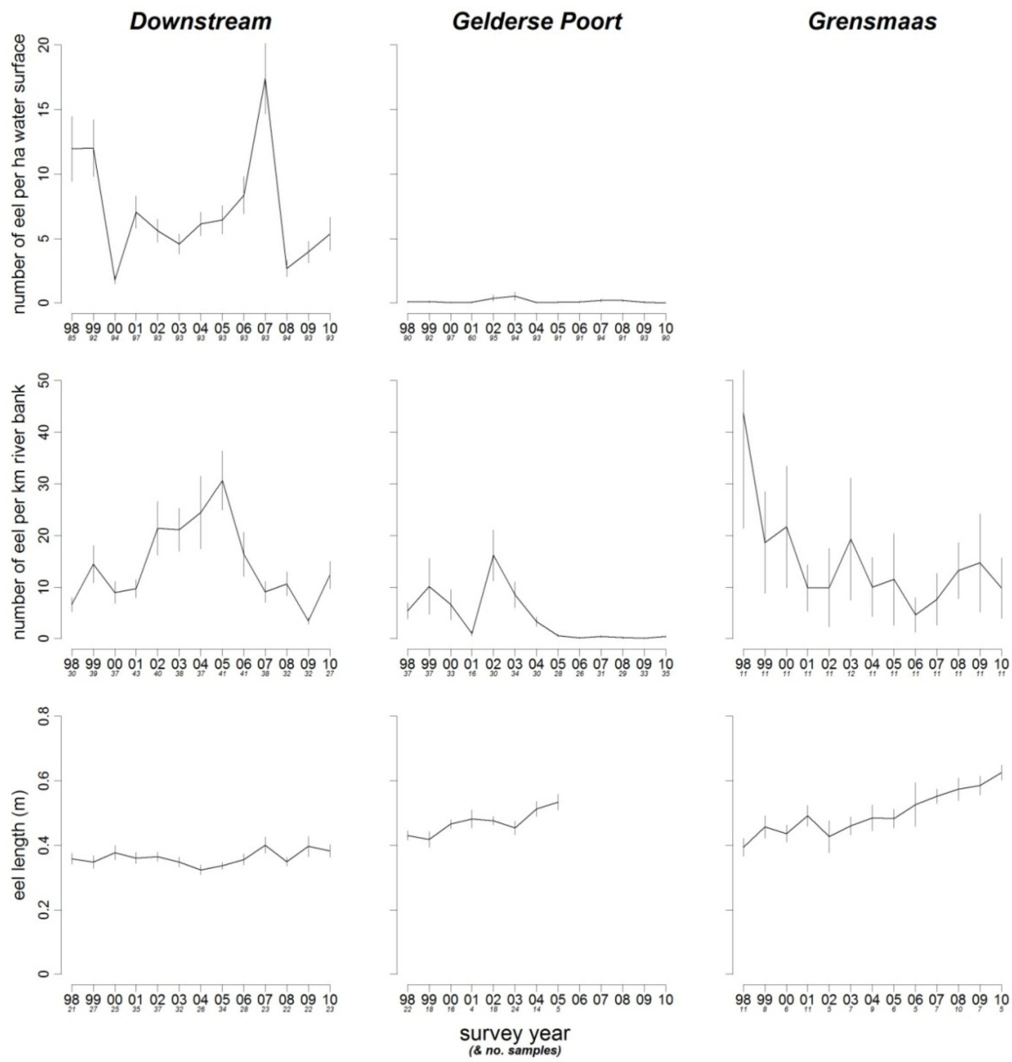

Figure NL.12. Eel stock survey in downstream and upstream (Gelderse Poort; Grensmaas) the main rivers; densities with beam trawl (top graphs), densities with electrofishing (middle graphs) and average length (bottom graphs).

For the downstream region, Figure NL.12 shows high densities of eel, both in the main stream and the river bank. In this region, no trend seems present through the years, in either abundance or length. The upstream location of the Gelderse Poort has very low densities of eel in the main stream, and strongly declining densities in the river banks, with almost no eel detected in the last four years. Also, the average length in the Gelderse Poort seems to increase, for the years in which enough data are available. The trend in the Grensmaas seems to be similar to that in the Gelderse Poort, with decreasing densities and increasing average length.

These data suggest that in the upstream regions the abundance of eel is decreasing while the average length is increasing, which could imply a declining recruitment of young eel in the upstream regions.

9.2.3 Main rivers (passive gear)

Starting in 1993, the fish assemblage in the main rivers and linked waters has been monitored, by means of logbook registration of commercial catch and bycatch, in a restricted number of fykenets (four large fykenets or two pairs of summer fykenets per location), mostly on a weekly basis. For eel, the number of yellow eels and silver eels caught is recorded. Results show a slowly declining trend over the years in the main rivers, but the year-to-year and site-to-site variation is considerable. The closed season (August–October) since 2009 and especially the closing of the fishery in the dioxine areas (indicated blue in Figure NL.13) caused an interruption of this time-series.

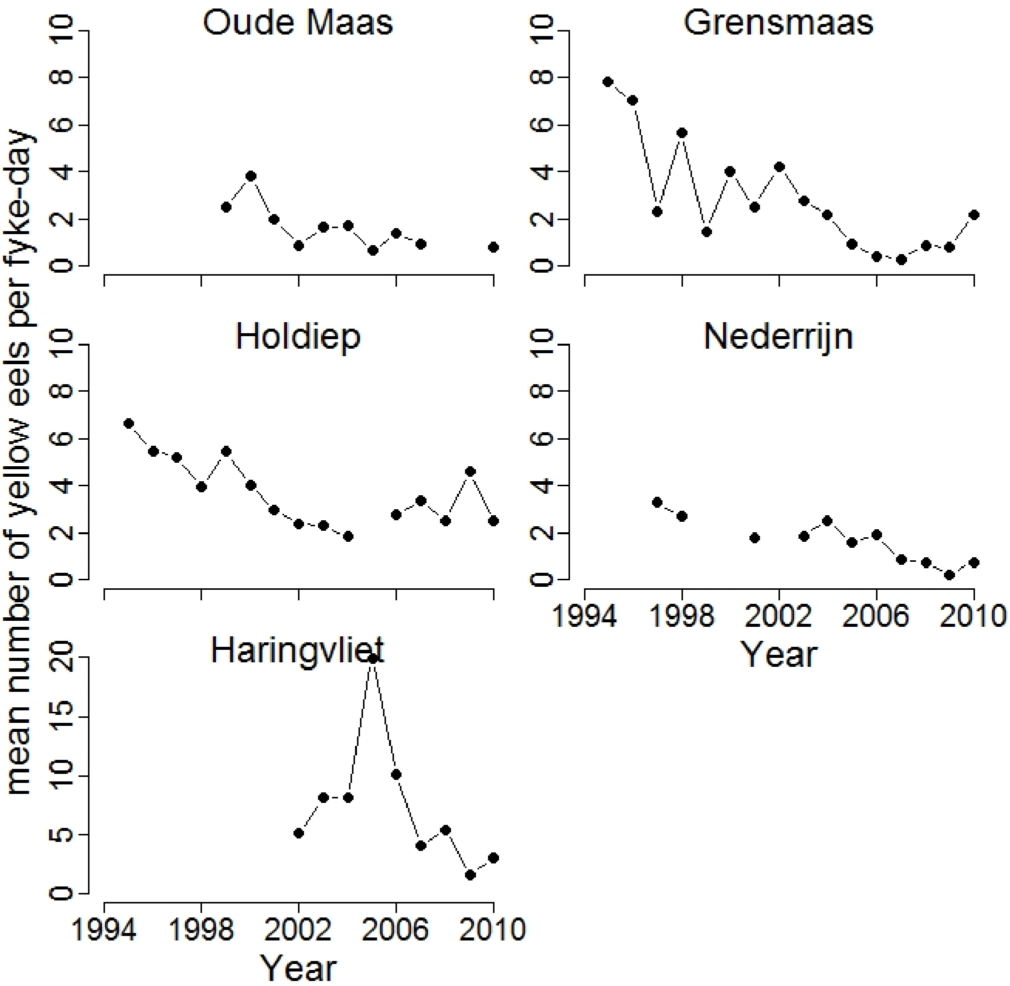

Figure NL.14. Mean number of yellow eel per fyke day in the lower and upper reaches of the rivers Meuse and Rhine in the Netherland.

9.2.4 Coastal waters

The number of eels caught in coastal surveys (Dutch Young Fish Survey) is presented in Figure NL.15. Until the mid-1980s, considerable catches of eel were observed. Since that time, a gradual decrease is observed.

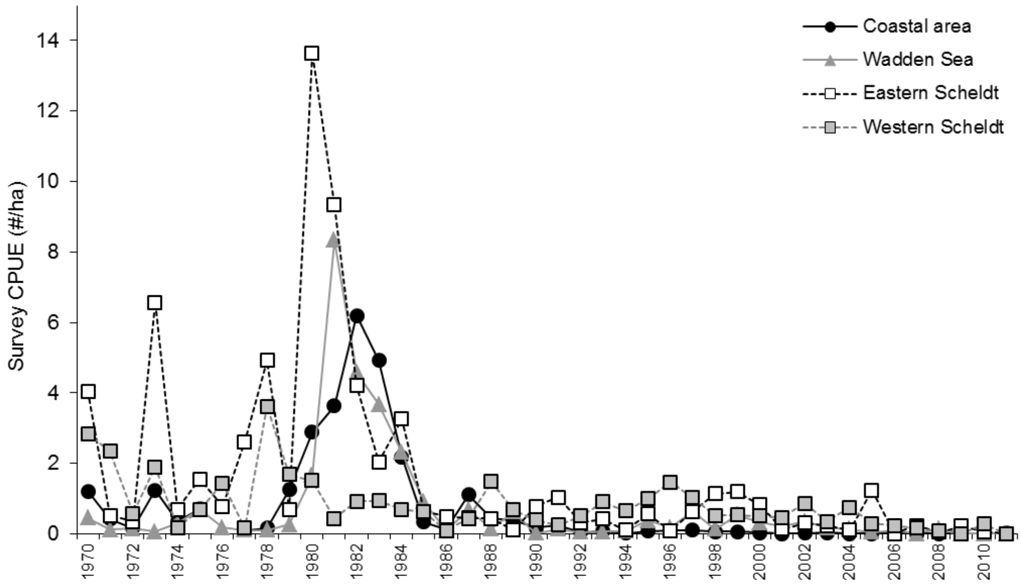

Figure NL.15. Trends in coastal survey cpue. Most of the Wadden Sea belongs to RBD Rhine; Eastern Scheldt is mixed Scheldt and Meuse; Western Scheldt belongs to RBD Scheldt (with an extra inflow from Meuse), Coastal area belongs to RBD Rhine.

A more elaborate statistical analysis of the abundance and length composition of the eel stock in coastal waters is presented in Dekker (2009b).

9.3 Silver eel

There are no routine surveys for silver eel in the Netherlands. *Ad hoc* estimates based on tagging and/or transponder experiments are available from:

Klein Breteler, J., Vriese, T., Borcherding, J., Breukelaar, A., Jörgensen, L., Staas, S., de Laak, G., and Ingendahl, D. 2007. Assessment of population size and migration routes of silver eel in the River Rhine based on a 2-year combined mark-recapture and telemetry study. – ICES Journal of Marine Science, 64: 1–7.

Winter, H. V., Jansen, H. M., and Breukelaar, A. W. 2007. Silver eel mortality during downstream migration in the River Meuse, from a population perspective. – ICES Journal of Marine Science, 64(7):1444–1449.

A Silver Eel Index is currently being designed and is expected to be implemented in the autumn of 2012.

10 Catch composition by age and length

No new data available.

11 Other biological sampling

11.1 Length and weight and growth (DCF)

No new data available.

11.2 Parasites and pathogens

The swimbladder nematode *Anguillicoloides crassus* was introduced in wild stocks of European eels in The Netherlands at the start of the 1980s, from SE-Asia. The market sampling for Lake IJsselmeer collects information on the percentage of eels showing *Anguillicoloides crassus* infection based on inspection of the swimbladder by the naked eye. Following the initial break-out in the late 1980s, infection rates have stabilised between 40 and 60%. As part of the extended market sampling program in 2009, data on *Anguillicoloides* infection rates were also collected in two other areas (Friesland and Rivers). In both areas the infection rate was similar to the levels observed in Lake IJsselmeer over the past years. In 2011 the market sampling was conducted in most of the country (Table NL.H).

Table NL.H. Overview of *A. crasssus* infection rates the Netherlands.

	IJsselmeer		Friesland		Meuse & Rhine		Noord Holland		Randmeren		Zeeland		Zuid Holland	
year	%	# eels	%	# eels	%	# eels	%	# eels	%	# eels	%	# eels	%	# eels
1986	31	699	44	421	70	30								
1987	93	244												
1988	75	520												
1989	51	423												
1990	60	200												
1991	61	240												
1992	57	165												
1993	65	238												
1994	64	224												
1995	55	225												
1996	67	241												
1997	58	240												
1998	60	240												
1999	60	255												
2000	57	450												
2001	62	240												
2002														
2003														
2004	52	1654												
2005	56	45												
2006	55	1520												
2007	45	1215												
2008	41	1319												
2009			44	991	55.3	262								
2010	46	390	46	589	47	456								
2011	41	345	30	164			32.2	115	57	76	37	153	41	130

11.3 Contaminants

In 2011 five trend locations have been monitored. As shown in the Figure NL.16 there is no change compared to the previous years; historically, a substantial decrease in

PCB concentrations has been achieved, but the current rate of decline is low or non-existent.

Pooled samples of eels (approximately 25 individuals, 30–40 cm length) from in total 29 locations have been monitored in The Netherlands, see Table NL.I. Again the general picture is not changed compared to the previous years. All locations that have eels with concentration of sum-TEQ or PCB153 above the regulatory levels are fed by the river Rhine or Meuse. Only those water ways not influenced by Rhine, Meuse or local industry can be considered low contaminated.

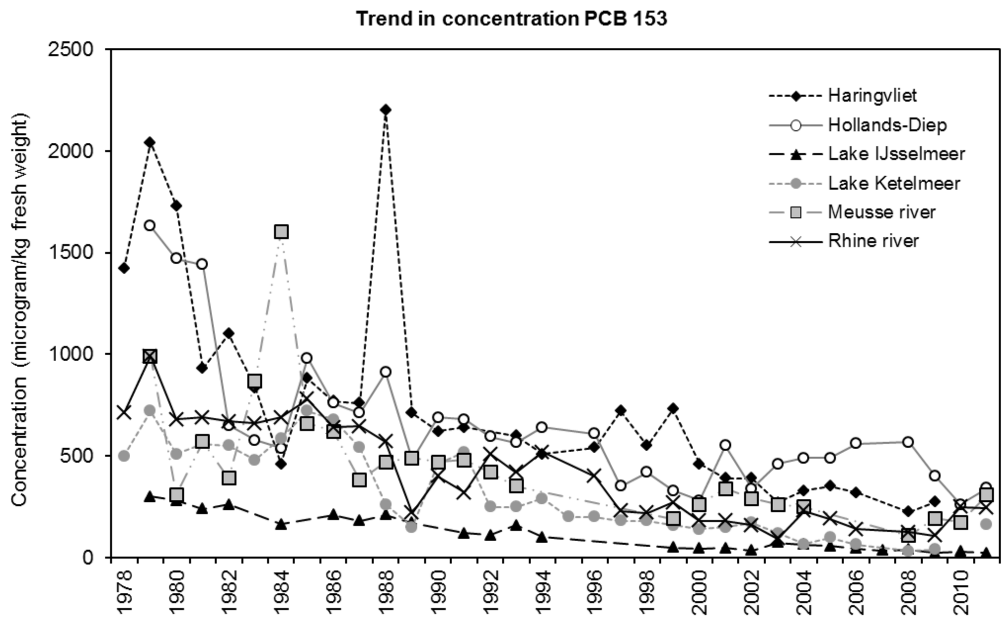

Figure NL. 16. Temporal trend in PCB in eel (data from IMARES and RIKILT).

Table NL.I. Monitoring data of 2011 The Netherlands. Shaded numbers are above the regulatory limits of 2011 (12 pg/g sum-EQ and 500 ng/g PCB153, 10% uncertainty included).

	Som TEQ	PCB 153		Som TEQ	PCB 153
Locatie	[pg TEQ/ g product]	[ng/g product]	Locatie	[pg TEQ/ g product]	[ng/g product]
Afgedamde Maas - Andelse Maas	13	187	Markiezaatmeer	2.0	12
Amsterdam-Rijnkanaal, Muiden	25	200	Nieuwe Maas, Krimpen a/d Lek	21	224
Bakkerskil (Buitendijkse waterloop Biesbosch)	16	216	Nieuwe Maas, Pernis tot Botlek	17	135
Belterwijde	3.9	14	Noordhollands Kanaal (Akersloot)	4.0	23
Binnenbedijkte Maas (Hoekse Waard) Z-H	9.1	189	Noordzeekanaal, Zijkanaal C	11	145
Dortsche Biesbosch (Koekplaat)	48	595	Oostvoornsemeer	13	180
Hollands Diep	33	341	Rijn (Rijnsburg tussen Leiden en Katwijk)	9.6	73
IJssel, Deventer	11	108	Rijn, Lobith	28	243
IJsselmeer tussen Ketelbrug en Flevocentrale	20	176	Twentekanaal Wiene-Goor	8.6	61
IJsselmeer, Medemblik	3.4	23	Volkerak	15	138
Kanaal Gent-Terneuzen	15	118	Vossemeer, IJssel	9.5	69
Kanaal Wessem-Nederweert	12	184	Waal Tiel	28	233
Ketelmeer, Oostelijk deel	17	164			
Lek, Culemborg	19	214			
Maas, Eijsden	23	307			
Maas, Maasbommel	25	361			
Maasplassen, Roermond	27	474			

11.4 Predators

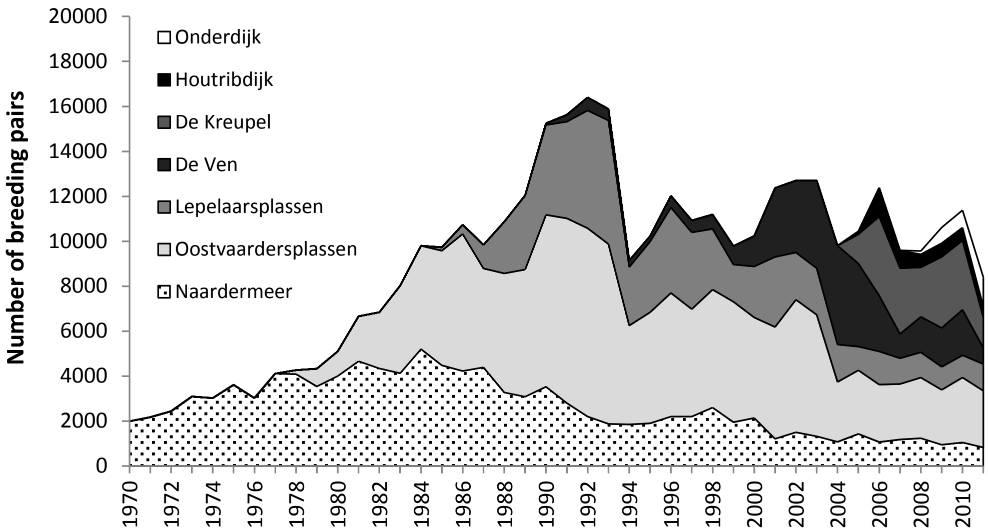

Figure NL. 17. Trends in the number of breeding pairs of cormorants (*Phalacrocorax carbo*) in and around Lake IJsselmeer (Source van Eerden, Waterdienst RWS).

Predation of eel by cormorants (*Phalacrocorax carbo*) is much disputed amongst eel fishermen and bird protectionists. The number of cormorant breeding pairs increased rapidly until the early 1990s, and then stabilised (Figure NL.17). For Lake IJsselmeer, food consumption has been well quantified (van Rijn and van Eerden, 2001; van Rijn, 2004); eel constitutes a minor fraction here. In other waters, neither the abundance, nor the food consumption is accurately known, but predation on eel appears to be a bigger issue here.

12 Other sampling

Nothing to report under this heading.

13 Stock assessment

13.1 Local stock assessment

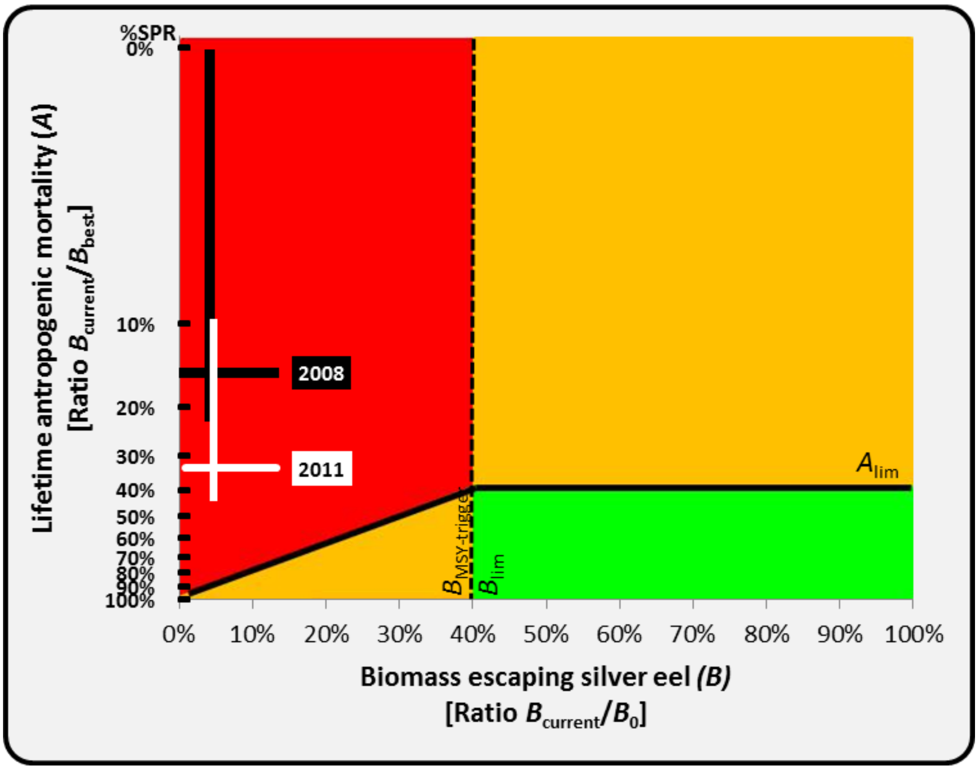

Figure NL.18. ICES modified precautionary diagram illustrating the uncertainties around the biomass estimates of escaping silver eel (range B_0; Eijsackers, 2009) and estimates of anthropogenic morality (scenarios 1–3; catch efficiency, densities eel in open water) in the Netherlands in 2008 and 2011 with respect to management targets. The horizontal axis represents the status of the stock in relation to pristine conditions, while the vertical axis represents the impact made by anthropogenic mortality. %SPR = spawner potential ratio, a measure for the survival to silver eel relative to pristine conditions.

13.2 International stock assessment

13.2.1 Habitat

An overview of habitats available is presented by Dekker *et al.* (2008), based on the information in Tien and Dekker (2004), and complemented with data from various sources. The summarising table is reproduced here in **Table NL.J.**

Province	Ditches †	Canals †	Lakes ‡	Rivers	Coastal waters	sum
Friesland	5345	7057	9454		-	21 856
Groningen	2003	2040	6905		3843	14 791
Drenthe	657	503	-		-	1160
Overijssel	1516	1985	1872		-	5372
Gelderland	831	733	-		-	1564
Flevoland	3115	4959	-		-	8074
Utrecht	1699	2349	2699		-	6747
Noord-Holland	5227	7938	1243		-	14 408
Zuid-Holland	4843	6935	7454		-	19 232
Zeeland	2421	2873	17 871		95 745	118 909
Noord-Brabant	1247	1241	-		-	2488
Limburg	-	-	-		-	-
Larger waterbodies						
Randmeer			16 110		-	16 110
Ijsselmeer/Markermeer			169 150		-	169 150
Rijn & Maas				18 067	-	18 067
kleinere rivieren				2800	-	2800
Waddenzee, incl Eems			-		259 214	259 214
Zeeuwse Delta			17 871		95 745	113 616
sum	28 905	38 610	232 758	20 867	358 802	679 942

† For ditches and canals, only the areas less than 1 m above sea level have been considered.

‡ Fresh water areas in the southwestern delta have been included under Lakes, the saline waters under Coastal Waters.

13.2.2 Silver eel production

13.2.2.1 Historic production

B_0 = 13 000 t (coastal + inland waters) or B_0 = 10 400 t (only inland waters).

13.2.2.2 Current production

$B_{best\ (2011)}$ = 1443 t (only inland waters).

$B_{best(2008)}$ = 2927 t (only inland waters).

13.2.2.3 Current escapement

B_{2011} = 482 t (only inland waters).

B_{2008} = 439 t (only inland waters).

13.2.2.4 Production values e.g. kg/ha

Table NL.K. Eel standing stock biomass, total effective surface area, biomass and biomass corrected for catch efficiency presented per water body type. Biomasses are provided in metric tonnes using scenario 2 (see Bierman *et al.*, 2012 for details). For those water types that were not sampled the overall average production of 7.1 kg/ha was used, presented at the end of the table. Data from Bierman *et al.* (2012).

Water Type	Biomass (kg/ha)	Total Area (ha)	Biomass (tonnes)	Biomass, efficiency corrected (tonnes)
M10	6.9	979.1	6.76	33.80
M14	10.2	18 848.2	193.04	965.19
M1a	1.6	132.3	0.21	1.06
M2	5.3	8.8	0.05	0.23
M20	11.9	2255.1	26.78	133.89
M23	0.0	48.9	0.00	0.00
M27	7.3	11 444.9	83.16	415.81
M3	4.8	2089.3	9.99	49.97
M6a	5.3	357.8	1.89	9.43
M6b	11.8	1037.0	12.26	61.32
M7b	7.0	1866.4	13.02	65.10
M8	0.9	647.9	0.58	2.89
R12	3.0	47.2	0.14	0.70
R14	0.0	11.5	0.00	0.00
R18	8.7	38.0	0.33	1.66
R4	2.0	73.0	0.15	0.74
R5	3.9	892.2	3.45	17.24
R6	7.9	1804.3	14.32	71.60
R7	39.3	1151.7	45.28	226.40
R8	3.9	12.2	0.05	0.24
M1b	7.1	0.1	0.00	0.00
M30	7.1	1188.5	8.42	42.09
M7a	7.1	7.7	0.05	0.27
R13	7.1	4.4	0.03	0.16
R15	7.1	22.0	0.16	0.78
R17	7.1	7.3	0.05	0.26
Subtotal		44 975.9		2100.82
Ditches	2.0	33 000	66	330
Total		77 975.9		2430.82

Table NL.L. Silver eel standing stock biomass, total effective surface area, biomass and biomass corrected for catch efficiency presented per water body type. Biomasses are provided in metric tonnes, using scenario 2 (see Bierman *et al.*, 2012 for details). For those water types that were not sampled the overall average production of 1.3 kg/ha was used, presented at the end of the table. Data from Bierman *et al*. (2012).

Water Type	Biomass (kg/ha)	Total Area (ha)	Biomass (tonnes)	Biomass, efficiency Corrected (tonnes)
M10	1.1	979.1	1.09	5.44
M14	1.4	18 848.2	26.38	131.90
M1a	0.5	132.3	0.07	0.35
M2	1.2	8.8	0.01	0.05
M20	2.1	2255.1	4.81	24.06
M23	0.0	48.9	0.00	0.00
M27	1.2	11 444.9	13.19	65.95
M3	1.1	2089.3	2.20	11.01
M6a	1.1	357.8	0.39	1.93
M6b	1.2	1037.0	1.22	6.12
M7b	0.8	1866.4	1.46	7.32
M8	0.4	647.9	0.24	1.22
R12	0.7	47.2	0.03	0.17
R14	0.0	11.5	0.00	0.00
R18	2.4	38.0	0.09	0.46
R4	0.5	73.0	0.03	0.17
R5	0.8	892.2	0.73	3.67
R6	1.2	1804.3	2.22	11.11
R7	7.6	1151.7	8.77	43.83
R8	1.2	12.2	0.01	0.07
M1b	1.3	0.1	0.00	0.00
M30	1.3	1188.5	1.57	7.85
M7a	1.3	7.7	0.01	0.05
R13	1.3	4.4	0.01	0.03
R15	1.3	22.0	0.03	0.15
R17	1.3	7.3	0.01	0.05
Subtotal		44 975.9		322.96
Ditches		33 000		49.5
Total		77 975.9		342.76

13.2.2.5 Impacts

Table NL.M. Overview of eel stock indicators in 2011.

	Estimate	Source
B_0	10 400 t*	EMP (2009)
$B_{current}$	482 t	Bierman *et al*. (2012)

B_{best}	1443 t	Bierman *et al.* (2012)
∑F	1.06	Bierman *et al.* (2012)
∑H	0.04	Bierman *et al.* (2012)
∑A	1.1	Bierman *et al.* (2012)
R	0	

***excluding coastal waters.**

Barrier mortality of silver eel during migration is estimated at 11% of the total amount of silver eel that start their migration (total silver eel biomass – silver eel catch = migrating biomass silver eel).

13.2.3 Stocking requirement eels <20 cm

The Dutch EMP mentions a budget of ~300 k€ annually for a four year period (2009–2013), but additional budget may become available from private sources. It is unclear what quantities of eel will be purchasable for this budget, while a turbulent price development is expected, because of the implementation of CITES restrictions and the impact of restocking programmes on the glass eel market.

13.2.4 Summary data on glass eel

Table NL.N. Overview usage of glass eel.

KG	2012	2011	2010	2009
Caught in commercial fishery	0	0	0	0
Used in stocking	766*	244	904	100
Used in aquaculture for consumption	6775	6750	?	?
Consumed direct	0	0	0	0
Mortalities	?	?	?	?

***not all translocated glass eel is stocked for recovery purposes.**

13.2.5 Data quality issues

14 Sampling intensity and precision

Nothing new to report, see Country Report WGEEL 2010.

15 Standardisation and harmonisation of methodology

15.1 Survey techniques

Glass eel monitoring.

Gear	Location	Frequency	Time	Period
liftnet (1x1 m; mesh 1x1 mm)	Den Oever	daily	five hauls every two hours between 22:00–5:00	~March–May
	ten other locations along the coast	weekly	two hauls at night time	

Passive Monitoring Programme: Main Rivers and Lake Ijsselmeer.

Gear	Location	Frequency	Period
Summer fykes (four) (stretched mesh 18–20 mm)	34 locations in main rivers, estuaries and lakes	continuous	~May–September
Fykes (four) (stretched mesh 18–20 mm)			

Due to closure of the eel fishery in polluted areas, this programme which started in the 1990s has been interrupted. Almost two thirds of the sampling stations are located in the polluted areas and sampling ceased on 1 April 2011. An alternative programme is currently being developed and will hopefully start in 2012.

Active Monitoring Programme: Main Rivers.

Gear	Location	Frequency	Period
bottom trawl (channel; 3 m beam; 15 mm stretched mesh)	~50 locations in main rivers	10 min trawl, ~1000 m transect	~May–September
Electrofishing (shore area)		20 min, 600 m transect	

15.2 Sampling commercial catches

Area	No. eels for Length-frequency	Sampling frequency	Locations	Biology (sex, life stage, parasites)	Period
Grevelingen	150–200 eels per sample	twice	2	two eels per 10 cm size class	April–August
Friesland	150–200 eels per sample	twice	4	two eels per 10 cm size class	April–August
Hollands Noorderkwartier	150–200 eels per sample	twice	4	two eels per 10 cm size class	April–August
Amsterdam Rijnkanaal	150–200 eels per sample	twice	1	two eels per 10 cm size class	April–August
Brabantse Delta	150–200 eels per sample	twice	1	two eels per 10 cm size class	April–August
Hunze en Aa's	150–200 eels per sample	twice	1	two eels per 10 cm size class	April–August
Stichtse Rijn landen	150–200 eels per sample	twice	1	two eels per 10 cm size class	April–August
Veluwe Randmeren	150–200 eels per sample	twice	1	two eels per 10 cm size class	April–August
Veerse Meer	150–200 eels per sample	twice	1	two eels per 10 cm size class	April–August
Zuiderzeeland	150–200 eels per sample	twice	1	two eels per 10 cm size class	April–August
Lake IJsselmeer	150–200 eels per sample	twice	16 (samples collected for each fishing gear: summer fyke, fyke, eelbox, longline)	two eels per 10 cm size class	April–August
Lake Markermeer	150–200 eels per sample	twice	16 (samples collected for each fishing gear: summer fyke, fyke, eelbox, longline)	two eels per 10 cm size class	April–August

15.3 Sampling

Nothing to report.

15.4 Age analysis

Since 2010 age readings were obtained annually of ~150 otoliths, which were collected from eels in different areas of the Netherlands. The number of annuli was counted to determine the age of individuals ("crack and burn" method). Furthermore distances between consecutive annuli were measured using image analysis software to determine individual growth curves.

15.5 Life stages

Life stages (yellow, silvering, silver) are visually determined based on colouration of body and fins and eye diameter. Criteria for life stages are at present not formally described.

15.6 Sex determinations

Sex is determined by macroscopic examination of the gonads.

16 Overview, conclusions and recommendations

During the development of the current models for the evaluation of the eel management plan in the Netherlands, the main weaknesses of the current methodology surfaced quickly. Here we list the main recommendations to improve the quality of the assessment before the next evaluation in 2015.

Dynamic population model

Key biological parameters: improve the quality of the following key biological parameters.

Sex-ratio of cohorts: estimates could be improved by using eels smaller than 30 cm. These eels could be obtained during the WFD fish sampling.

Growth rate: estimates could be improved by including eels smaller than 30 cm. These eels could be obtained during WFD fish sampling. Population models could be improved by including variation in growth curves between individuals and locations.

Maturation-at-age: estimates of the silvering ogive for a given area could be improved by using data collected year round. Furthermore, it is recommended to record the stage of the eel (yellow/silver) during research surveys (e.g. IJsselmeer electro-trawl survey). Quantitative data on maturity stage should be collected such as eye diameter, rather than a purely visual (informal) assessment. **Anthropogenic mortalities**: quantify sources of anthropogenic mortalities that are excluded from the current assessments; 1) catch-&-release mortality of recreational fisheries, 2) yellow eel mortality pumping stations and hydropower plants.

Static spatial model

WFD survey data: improve the accessibility of WFD fish survey data of regionally managed waters by establishing a central database for the Netherlands, and ensure that the data are properly checked to ensure the quality of data.

Catch efficiency: conduct experiments to determine efficiencies of electrofishing for eel in different WFD water types in both nationally and regionally managed waters.

Spatial distribution: conduct experiments to determine the spatial distribution of eel in wide rivers and lakes in both nationally and regionally managed waters.

Ditches: conduct elecrofishing surveys for eel in ditches to supplement the existing WFD eel survey data in regionally managed waters.

Habitat: correct eel densities for habitat in nationally and regionally managed waters.

Electro-beam trawl: develop an electro-beam trawl to provide reliable estimates of eel (>30 cm) densities in large lakes and wide rivers.

Silver eel migration model

Migration routes: finalise the GIS model (Appendix A in Bierman *et al*., 2012) to improve the estimate of silver eel mortality during migration. When this proves difficult or too expensive, an alternative is to further refine the simpler model based on hierarchies of waterbodies (Chapter 6 in Bierman *et al*., 2012) by creating such a model for various spatially separate parts. For example, such a simple model could be constructed for various water boards. The proportions of silver eels choosing different routes could be set equal to water discharge levels. It is not clear which of the two methods (GIS model, or further refinement of the 'simple' model) would lead to the best results or would be most cost-effective to get up and running. The GIS method would certainly need a lot more investment, but would be generic and work for the whole of the Netherlands and could be adapted for other species too. For the 'simple' model based on hierarchies of waterbodies, information will have to be collected from water boards which will also take a lot of time and the results will apply only to that particular water board.

Silver eels migrating downstream from Belgium and Germany: The mortality caused by hydropower stations on silver eels migrating downstream on the river Meuse from Belgium and the river Rhine from Germany ('foreign' silver eels) have not been taken into account in the estimation of LAM in this report. It is unclear at the time of the writing of this report whether these mortalities have been included in the LAM of silver eels that were produced in German and/or Belgian waters. It is recommended that come to an agreement on how these mortalities should be accounted for.

Furthermore, as many other European countries (France, UK, Ireland) are using similar spatial models to estimate yellow eel standing stock and silver eel production, close international cooperation and collaboration will enhance the quality and uniformity of these models in the years to come.

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Report on the eel stock and fishery in Norway 2011/'12

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Reporting Period: This report was completed in August 2012, and contains data up to 2011 and some provisional data for 2012.

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2 Introduction

2.1 Distribution

Eel occurs in coastal areas and numerous watersheds along the entire coastline, with a reduced abundance towards the north. The occurrence and abundance of eel is generally not well known. The length of the continental coastline is 25 148 km (including fjords and bays). Including islands, the total shoreline adds up to 83 281 km. Occurrence of eel is registered in 1788 lakes in 361 precipitation areas, but many areas and habitats have not been surveyed, so this is a minimum estimate (Thorstad *et al.*, 2010).

2.2 Fishing

Eel fishing has mainly taken place along the coast in southern (Skagerrak coast) and southwestern Norway, in estuarine, brackish and saltwater areas around coastal islands, but also to some extent in freshwater. Fykenets are set on soft and muddy bottom, with preference of areas with seagrass beds (eel grass *Zostera marina*). No distinction is made between yellow and silver eels and they are both caught with eelpots and fykenets. Glass eel fishing is prohibited in Norway. Catch is officially recorded by the Fisheries Directorate, but there is no record of effort by the authorities (only the number of licences). There is a minimum legal size of 37 cm for silver eels and 40 cm for yellow eels.

Some fishers were asked by the Institute of Marine Research to report their catch in logbooks since 1971. They recorded fishing gear, the number of days the traps were set out, and the number of small and large eels (limit was approximately 200 g because fishers obtained different prices for those eels).

Fishing for eel has been banned in Norway since January 1st 2010, except for a quota of 50 tons marine 'scientific monitoring' fishery. Several fishers applied to participate in the scientific monitoring fishery, of which 26 received authorizations to participate. The fishers are located in Østfold, Oslo/Busker, Vestfold, Telemark, Aust-Agder, Rogaland and Hordaland counties. They have to record their catch and the number of pots/fykenets, the number of eels below and above 45 cm and whether they are yellow or silver. Some of these fish have been collected by the Institute of Marine Research for analyses of biological characteristics (body measurements, age). Some eel samples have also been collected by NIFES (National institute for nutrition and seafood research) for contaminant analyses.

Recreational fishing (prohibited since 2009) was quite important relative to commercial fishing (represented approximately 100 tons: average between 2000–2008). Recreational fishing boats along the southern coast of Norway caught eel and sold them through fishmongers. There was no limitation on fishing gear, and it was allowed to sell the catch until 6250 Euros/year.

2.3 Management plan

The European eel is included in the Norwegian Red List since May 2006, categorized as critically endangered. In 2007, a working group (with people from the Institute of Marine Research and the Directorate of Fisheries) was appointed with the objective of writing a report on the status of eel in Norway and to draft a subsequent management plan. The report was completed in 2008[1]. Several research needs were identified among which the necessity to investigate the distribution of eels in saltwater. The report concluded in two alternative management strategies: 1) that all eel fishing be banned in Norway for a period of 15 years, or 2) that eel fishing catches be halved compared to the level of 2004–2007. It was finally decided by the fisheries director that there will be a temporary ban of eel fishing. The first evaluation will be in 2012.

All recreational fishing for eel in freshwater and marine waters in Norway was stopped from 1 July 2009 (not allowed to catch, land, or keep eel on board). The total quota for commercial fisheries in 2009 was 50 t, with cessation of fishing when this quota was reached. All commercial fisheries were stopped from 1 January 2010. However, since 2010 and onwards, fishers could apply to a ‘scientific fishery’ with an annual quota of 50 t, aiming at monitoring eel and collecting scientific catch data. This scientific fishery was supposed to be financed by the fishers being allowed to keep and sell the catch. However, since eels cannot be imported into the EU, and there is no local market, all fishing has ceased.

2.4 Eel monitoring

The following monitoring plan (details are available upon request to C. Durif or E. Thorstad) was submitted (by IMR in March 2011) to the authorities (Nature Directorate) to monitor eel in saltwater:

1) Monitoring eel abundance trend using existing time series (Skagerrak IMR beach-seine survey, cpue of scientific fishery;
2) Monitoring biological characteristics (age, length, weight, sex, maturity);
3) Monitoring eel quality (parasites, contaminants);
4) Filling in knowledge gaps (salt vs. freshwater residency, geographic distribution in the sea).

There has been no follow-up on these issues in 2012, because of a lack of budget.

[1] Anonymous, 2008. Forvaltning av ål I Norge: rapport med forslag til revidert forvaltning av ål I saltvann fra arbeidsgruppe nedsatt av Fiskeridirektøren. Bergen, 15.10.2008.

3 Time-series data

3.1 Recruitment-series and associated effort

3.1.1 Glass eel

3.1.1.1 Commercial

No available data.

3.1.1.2 Recreational

No available data.

3.1.1.3 Fishery independent

Table 3.1.1.3. Recruitment of elvers at the NINA research station on the River Imsa (see 9 for details). Numbers have been revised and updated since the previous country reports.

year	total elvers
1975	51 250
1976	57 750
1977	34 000
1978	15 000
1979	3000
1980	41 500
1981	18 500
1982	54 250
1983	19 250
1984	7607
1985	4971
1986	6723
1987	4348
1988	18 385
1989	8805
1990	33 138
1991	6588
1992	11 078
1993	8774
1994	2085
1995	2208
1996	1177
1997	5765
1998	1842
1999	4338
2000	1717
2001	2003
2002	1576
2003	3774

year	total elvers
2004	418
2005	494
2006	468
2007	15
2008	1428
2009	6947
2010	1312
2011	5

3.1.2 Yellow eel recruitment

3.1.2.1 Commercial

No available data.

3.1.2.2 Recreational

No available data.

3.1.2.3 Fishery independent

See elver data in Section 3.1.1.3.

3.2 Yellow eel landings

3.2.1 Commercial

Table 3.2.1. Cpue (kg.net^{-1}.night^{-1}) calculated from fishers logbooks recorded by IMR (see introduction for details).

1975	1.6
1976	2.1
1977	2.3
1978	2.2
1979	3.1
1980	2.7
1981	2.2
1982	13.9
1983	13.0
1984	13.0
1985	18.7
1986	13.3
1987	7.9
1988	26.3
1989	3.5
1990	12.2
1991	5.1
1992	5.2
1993	5.4

1975	1.6
1994	7.4
1995	7.2
1996	2.1
1997	4.6
1998	4.3
1999	3.9
2000	7.2
2001	5.6
2002	6.3
2003	5.7
2004	4.7
2005	16.2
2006	16.1
2007	20.0
2008	19.1
2009	14.4
2010	86.4
2011	No fishing activity

3.2.2 Recreational

Table 1. Registered landings for recreational eel fishing in Norway.

year	landings (recreational) in tons
2000	109
2001	122
2002	130
2003	106
2004	96
2005	104
2006	106
2007	74
2008	79
2009	10*
2010	1*
2011	*

*** Recreational fishing prohibited from 1 July 2009.**

3.3 Silver eel landings

3.3.1 Commercial

There was no differentiation being made between yellow and silver eels. Everything is included in Section 3.2.

3.3.2 Recreational

There was no differentiation being made between yellow and silver eels. Everything is included in Section 3.2.

3.4 Aquaculture production

3.4.1 Seed supply

No data available.

3.4.2 Production

It is not known whether any of the licence holders are actually performing any aquaculture production.

year	aquaculture licenses
1994	9
1995	14
1996	19
1997	24
1998	28
1999	31
2000	32
2001	29
2002	25
2003	21
2004	22
2005	15
2006	13
2007	12
2008	17
2009	17
2010	16
2011	16

3.5 Stocking

There is no stocking.

3.5.1 Amount stocked

There is no stocking.

3.5.2 Catch of eel <12 cm and proportion retained for restocking

There is no catch of eel <12 cm, and there is no stocking of eel.

3.5.3 Reconstructed time-series on stocking

There is no stocking.

4 Fishing capacity

4.1 Glass eel

There is no glass eel fishing.

4.2 Yellow eel

Table 4.2. Number of registered commercial eel fishing licences in Norway.

Year	Number of licences
1977	326
1978	313
1979	374
1980	541
1981	501
1982	505
1983	478
1984	434
1985	399
1986	412
1987	425
1988	525
1989	479
1990	468
1991	449
1992	434
1993	404
1994	452
1995	423
1996	417
1997	445
1998	389
1999	429
2000	347
2001	336
2002	327
2003	284
2004	258
2005	241
2006	247
2007	234
2008	218
2009	180
2010	55
2011	0

4.3 Silver eel

There is no differentiation between yellow and silver eel.

4.4 Marine fishery

Most of the fisheries are marine.

5 Fishing effort

5.1 Glass eel

There is no glass eel fishery in Norway.

5.2 Yellow eel

Table 5.2. A limited number of fishers record their effort (in accordance with the Institute of Marine Research) in number of netnights since 1975. These data are also available according to each county (fylke), see figure below. (Data belongs to IMR-Flødevigen).

year	nb of nights	nb of nets	Nb of net nights
1975	383	925	38 790
1976	354	1060	36 170
1977	442	1200	51 400
1978	312	965	35 060
1979	329	1160	34 390
1980	453	1142	39 836
1981	460	1275	48 555
1982	2225	2708	233 615
1983	6242	13 820	678 032
1984	3825	16 307	446 096
1985	2751	11 957	282 133
1986	3576	12 118	383 063
1987	2563	10 177	338 784
1988	2804	10 818	333 668
1989	1230	4799	112 537
1990	2711	6333	238 069
1991	2280	5739	217 088
1992	1668	4295	182 001
1993	2095	4825	202 030
1994	1895	7261	194 937
1995	1323	4654	160 984
1996	518	3250	64 920
1997	1001	3700	114 650
1998	1247	3800	121 410
1999	1157	3075	102 245
2000	1759	4833	175 043
2001	1137	4770	135 020
2002	1091	3938	77 852

year	nb of nights	nb of nets	Nb of net nights
2003	798	2355	77 370
2004	1153	2719	109 582
2005	2418	2554	70 866
2006	3536	9109	250 874
2007	4850	14 033	309 022
2008	3836	13 190	265 873
2009	2222	6647	160 778
2010	4943	25 656	449 319
2011	No fishing activity		

5.3 Silver eel

There is no differentiation between yellow and silver eel.

5.4 Marine fishery

Most fisheries were marine.

6 Catches and landings

6.1 Glass eel

No glass eel catch.

6.2 Yellow eel

No differentiation is made between yellow and silver eels.

A quota of 50 tons has been set since 1.1.10.

Table 6.2.1. Registered (by the Fisheries Directorate) eel landings for commercial fisheries in Norway.

YEAR	total catch (tons)	YEAR	total catch	YEAR	total catch
1908	268	1943	136	1978	347
1909	327	1944	150	1979	374
1910	303	1945	102	1980	387
1911	384	1946	167	1981	369
1912	187	1947	268	1982	385
1913	213	1948	293	1983	324
1914	282	1949	214	1984	310
1915	143	1950	282	1985	352
1916	117	1951	312	1986	272
1917	44	1952	178	1987	282
1918	35	1953	371	1988	513
1919	64	1954	327	1989	313
1920	80	1955	451	1990	336
1921	79	1956	293	1991	323
1922	94	1957	430	1992	372
1923	140	1958	437	1993	340

YEAR	total catch (tons)	YEAR	total catch	YEAR	total catch
1924	290	1959	409	1994	472
1925	325	1960	430	1995	454
1926	341	1961	449	1996	353
1927	354	1962	356	1997	467
1928	325	1963	503	1998	331
1929	425	1964	440	1999	447
1930	450	1965	523	2000	281
1931	329	1966	510	2001	304
1932	518	1967	491	2002	311
1933	694	1968	569	2003	240
1934	674	1969	522	2004	237
1935	564	1970	422	2005	249
1936	631	1971	415	2006	293
1937	603	1972	422	2007	194
1938	526	1973	409	2008	211
1939	434	1974	368	2009	69
1940	143	1975	407	2010	32
1941	174	1976	386	2011	0.0175
1942	131	1977	352		

Table 6.2.2. Total landings of selected fishers (IMR logbook data).

Year	landings (IMR tons)
1975	6
1976	6
1977	7
1978	6
1979	6
1980	6
1981	6
1982	22
1983	43
1984	28
1985	26
1986	24
1987	21
1988	45
1989	9
1990	19
1991	15
1992	17
1993	16
1994	17
1995	16
1996	5

Year	landings (IMR tons)
1997	15
1998	12
1999	11
2000	10
2001	13
2002	8
2003	9
2004	12
2005	11
2006	26
2007	28
2008	29
2009	16
2010	40
2011	No fishing

6.3 Silver eel

Included in yellow eel data.

6.4 Marine fishery

Most fisheries were marine.

7 Catch per unit of effort

7.1 Glass eel

No available data.

7.2 Yellow eel

Table 7.12.1. Official catch (Fisheries Directorate) calculated according to the number of licences in Norway (the number of eelpots per licence is not registered).

YEAR	total catch (tons)	nb of licences	Catch (ton per fisherman)
1977	352	326	1.08
1978	347	313	1.11
1979	374	374	1.00
1980	387	541	0.72
1981	369	501	0.74
1982	385	505	0.76
1983	324	478	0.68
1984	310	434	0.71
1985	352	399	0.88
1986	272	412	0.66
1987	282	425	0.66
1988	513	525	0.98

YEAR	total catch (tons)	nb of licences	Catch (ton per fisherman)
1989	313	479	0.65
1990	336	468	0.72
1991	323	449	0.72
1992	372	434	0.86
1993	340	404	0.84
1994	472	452	1.04
1995	454	423	1.07
1996	353	417	0.85
1997	467	445	1.05
1998	331	389	0.85
1999	447	429	1.04
2000	281	347	0.81
2001	304	336	0.90
2002	311	327	0.95
2003	240	284	0.85
2004	237	258	0.92
2005	249	241	1.03
2006	293	247	1.19
2007	194	234	0.83
2008	211	218	0.97
2009	69	180	0.38
2010	32	55	0.58
2011	0.0175	0	0

Table 7.2.2. Cpue calculated from fishers logbooks recorded by IMR (see introduction for details).

year	CPUE (tons.day^{-1}pot^{-1})
1975	1.6
1976	2.1
1977	2.3
1978	2.2
1979	3.1
1980	2.7
1981	2.2
1982	13.9
1983	13.0
1984	13.0
1985	18.7
1986	13.3
1987	7.9
1988	26.3
1989	3.5
1990	12.2
1991	5.1
1992	5.2

year	CPUE (tons.day^{-1}pot^{-1})
1993	5.4
1994	7.4
1995	7.2
1996	2.1
1997	4.6
1998	4.3
1999	3.9
2000	7.2
2001	5.6
2002	6.3
2003	5.7
2004	4.7
2005	16.2
2006	16.1
2007	20.0
2008	19.1
2009	14.4
2010	86.4
2011	No fishing

Table 7.2.3. Logbook data according to each county (fylke), see figure above. (Data belongs to IMR-Flødevigen). Up until 2010.

fylke	CPUE (kg.net^{-1}.night^{-1})
BUSKERUD	0.1
AKERSHUS	1.9
TELEMARK	7.4
SOGN	10.7
VESTFOLD	20.1
HORDALAND	39.5
VEST-AGDER	45.7
ROGALAND	51.6
ØSTFOLD	77.8
AUST-AGDER	128.8

7.3 Silver eel

Included in yellow eel data.

7.4 Marine fishery

Included in yellow eel data.

8 Other anthropogenic impacts

Norway has abundant rivers and lakes, and 6% of the total area of 323 802 km^2 is covered by freshwater. There are 144 river systems with a catchment area ≥200 km^2. Approximately one third of the water covered areas are influenced by hydropower development. There are between 600 and 700 hydropower stations with an installed effect larger than 1 MW in operation. Effects by hydropower development on eel and eel distribution have not been studied or quantified.

Acidification has caused the loss or reduction of many Atlantic salmon (*Salmo salar* L.) populations in southern Norway, and many rivers are still severely affected by chronic or episodic acid water. The areas affected by acidification have likely been among the most important areas for eel in Norway. Based on surveys in 13 rivers that are now limed, it seems that occurrence and density of eel was reduced due to acidification (Thorstad *et al*., 2010). Densities of eel increased more than four-fold after liming when compared with pre-liming levels.

9 Scientific surveys of the stock

9.1 Recruitment surveys, glass eel *(includes yellow eel in Scandinavia)*

The only available time-series of elvers is from a trap at the mouth of the River Imsa in southwestern Norway (58°50′ N, 5°58′ E) (Figures 1 and 2). Staff at the Norwegian Institute for Nature Research (NINA) Research Station at Ims have been trapping and recording upstream migration of elvers annually since 1975. There is a wolf trap across the river at this site, collecting all downstream migrating fish as well. A few elvers may be able to migrate upstream at this site without being trapped, but probably not in large numbers. Larger elvers (>3 mm diameter) are counted, whereas smaller ones are measured in litres, with the assumption that there are 2000 elvers per litre. This assumption should have been checked. There should also have been a control check of the historical data, but still, the quality of the data series seems good. It should be noted that in Imsa, recruits migrating upstream are not true glass eel, but have already achieved a brown colour, and are here therefore termed elvers (true transparent glass eels do occur in Norway and have been reported in more coastal habitats.).

Figure 1. Map of Norway showing the location of the River Imsa and the Skagerak coast.

Table 9.1. Elver data from Imsa. The trap was destroyed during a flood in 2007, and the number of elvers not counted this year. This is repeated data from 3.1.1.3). Numbers have been revised (there had been some variation in the way the number of glass eels were calculated) and updated since the previous country reports.

Year	total elvers
1975	51 250
1976	57 750
1977	34 000
1978	15 000
1979	3000
1980	41 500
1981	18 500
1982	54 250
1983	19 250
1984	7607
1985	4971
1986	6723
1987	4348
1988	18 385
1989	8805
1990	33 138
1991	6588
1992	11 078

Year	total elvers
1993	8774
1994	2085
1995	2208
1996	1177
1997	5765
1998	1842
1999	4338
2000	1717
2001	2003
2002	1576
2003	3774
2004	418
2005	494
2006	468
2007	15
2008	1428
2009	6947
2010	1312
2011	5

9.2 Stock surveys, yellow eel

The Skagerrak beach-seine surveys data from Norway constitute the longest non-fishery-dependent set of data. It is also the only potential time-series on the subpopulation of marine eels. This unique monitoring programme was initiated at the Norwegian Skagerrak coast (Figure 1) as a result of a controversy between the founder of the Flødevigen Marine Research Station Gunder Mathiesen Dannevig (1841–1911) and the great pioneer in marine research Johan Hjort (1869–1948). Every year, a series of beach-seine hauls are carried out in some selected fjords of the Norwegian Skagerrak coast.

The first hauls of the Skagerrak monitoring program were conducted in 1904, and during the following years, new sampling stations were added, and a standard routine for the hauls was developed. Approximately 130 stations are sampled in 20 different areas. All hauls are taken at the same season (autumn) and always during daytime. Based on the initial results from these hauls, the monitoring programme was established and reached its present form in 1919. These data have recently been analyzed and compared to oceanic factors (Durif *et al.*, 2010).

The SSC (standardized Skagerrak catch) index has been calculated using sampling areas where eels represented at least 4% of the grand total. See Durif *et al.*, 2010 for complete details. These calculations (SSC) have not been updated for the most recent figures.

Data from the Skagerrak beach seine survey. It includes yellow (approximately 70%) and silver eels (30%).

Table 9.2. Data from the Skagerrak beach-seine survey.

Year	nb of eels	nb of hauls	nb of sampled areas	eels per haul
1925	4	68	12	0.06
1926	3	69	12	0.04
1927	8	66	12	0.12
1928	0	69	12	0.00
1929	12	69	12	0.17
1930	11	68	12	0.16
1931	14	72	12	0.19
1932	10	69	12	0.14
1933	2	66	12	0.03
1934	8	67	12	0.12
1935	4	68	13	0.06
1936	15	121	17	0.12
1937	38	121	17	0.31
1938	36	122	17	0.30
1939	30	118	17	0.25
1940				
1941				
1942	NO DATA			
1943				
1944				
1945	41	120	17	0.34
1946	28	120	17	0.23
1947	33	121	17	0.27
1948	25	119	17	0.21
1949	21	118	17	0.18
1950	20	117	17	0.17
1951	29	119	17	0.24
1952	14	101	17	0.14
1953	21	132	18	0.16
1954	30	128	18	0.23
1955	31	126	18	0.25
1956	23	133	18	0.17
1957	12	130	18	0.09
1958	44	131	18	0.34
1959	15	132	18	0.11
1960	12	133	18	0.09
1961	29	134	18	0.22
1962	12	138	20	0.09
1963	18	135	20	0.13
1964	28	135	20	0.21
1965	8	112	20	0.07
1966	26	112	20	0.23
1967	14	109	20	0.13

Year	nb of eels	nb of hauls	nb of sampled areas	eels per haul
1968	13	108	20	0.12
1969	11	109	20	0.10
1970	34	110	20	0.31
1971	19	111	20	0.17
1972	11	110	20	0.10
1973	15	107	20	0.14
1974	27	108	20	0.25
1975	28	112	20	0.25
1976	20	109	20	0.18
1977	26	106	20	0.25
1978	15	108	20	0.14
1979	16	106	20	0.15
1980	31	106	20	0.29
1981	45	104	20	0.43
1982	20	109	20	0.18
1983	19	108	20	0.18
1984	24	107	20	0.22
1985	28	110	20	0.25
1986	27	110	20	0.25
1987	17	111	20	0.15
1988	50	119	20	0.42
1989	31	122	20	0.25
1990	20	121	20	0.17
1991	18	118	20	0.15
1992	25	118	20	0.21
1993	15	119	20	0.13
1994	32	119	20	0.27
1995	16	120	20	0.13
1996	39	121	20	0.32
1997	19	120	20	0.16
1998	22	119	20	0.18
1999	23	119	20	0.19
2000	7	126	20	0.06
2001	15	129	20	0.12
2002	6	130	20	0.05
2003	5	130	20	0.04
2004	1	131	20	0.01
2005	2	129	20	0.02
2006	9	130	20	0.07
2007	0	130	20	0.00
2008	3	130	20	0.02
2009	7	75?	Series was truncated that year	0.09
2010	4	130?	20	0.03
2011	9	134	20	0.07

Table 6. Skagerrak standardized catch: index calculated on selected sampling areas in the beach-seine survey. (See Durif *et al.*, 2010 for details). This trend has not been updated.

year	SSC	year	SSC	year	SSC	year	SSC	year	SSC
1925	-0.67	1947	0.76	1965	-0.37	1983	0.11	2001	-0.26
1926	-0.77	1948	0.14	1966	-0.01	1984	-0.22	2002	-0.69
1927	-0.46	1949	0.20	1967	-0.08	1985	0.05	2003	-0.70
1928	-0.94	1950	0.08	1968	-0.45	1986	0.59	2004	-0.91
1929	-0.15	1951	0.38	1969	-0.31	1987	-0.08	2005	-0.78
1930	-0.20	1952	-0.08	1970	0.29	1988	0.54	2006	-0.04
1931	-0.64	1953	-0.18	1971	-0.14	1989	0.10	2007	-0.94
1932	-0.51	1954	0.67	1972	-0.54	1990	-0.23		
1933	-0.74	1955	0.34	1973	-0.36	1991	0.21		
1934	-0.52	1956	-0.06	1974	-0.10	1992	0.06		
1935	-0.51	1957	-0.32	1975	0.19	1993	-0.07		
1936	-0.24	1958	0.62	1976	0.00	1994	0.61		
1937	0.78	1959	-0.22	1977	0.04	1995	-0.38		
1938	0.20	1960	-0.41	1978	-0.30	1996	0.76		
1939	-0.14	1961	0.23	1979	-0.15	1997	-0.28		
1940-45	no data	1962	-0.49	1980	0.75	1998	-0.04		
1944	0.90	1963	-0.53	1981	0.88	1999	-0.09		
1946	0.15	1964	0.09	1982	0.04	2000	-0.57		

9.3 Silver eel

Skagerrak beach-seine survey

Silver eels are sampled along with yellow eels, but stages are not differentiated in the data. Lengths have been measured since 1993.

Eels have also been caught during the seasonal IMR cruises in the North Sea. Approximately 3000 eels have been caught since 1980. Data are not yet collated.

Downstream trap on the river Imsa

The only available time-series of downstream migrating silver eel is from a wolf trap at the mouth of the River Imsa in southwestern Norway (58°50′ N, 5°58′ E) (Figure 3). Staff at the Norwegian Institute for Nature Research (NINA) Research Station at Ims have been trapping and counting downstream migrating silver eel annually since 1975. All descending fish are captured in this wolf trap, except at days of extreme flood. The quality of the dataseries is good.

Table 9.3. Number of silver eels counted at the trap on the River Imsa (Sandnes).

year	estimated total silver eels
1975	5491
1976	4175
1977	5882
1978	4985
1979	2934
1980	3382
1981	2354
1982	3818
1983	3712
1984	3377
1985	4427
1986	3733
1987	1895
1988	4274
1989	2107
1990	2196
1991	1347
1992	1859
1993	681
1994	1704
1995	1515
1996	1420
1997	2833
1998	1723
1999	2596
2000	1749
2001	4580
2002	1850
2003	2824
2004	2076
2005	1894
2006	2827
2007	3067
2008	1952
2009	3246
2010	2133
2011	2776

10 Catch composition by age and length

Older data are published in Vøllestad (1985, 1986); Bergersen and Klemetsen (1988); Vøllestad (1992) and Vøllestad and Jonsson (1986, 1988).

Body lengths of eels measured during the Skagerrak survey are available between 1993 and 2006.

11 Other biological sampling

11.1 Length and weight and growth (DCF)

No available data.

11.2 Parasites and pathogens

No available data.

11.3 Contaminants

No available data.

11.4 Predators

No available data.

12 Other sampling

13 Stock assessment

13.1 Local stock assessment

No available data.

13.2 International stock assessment

No available data.

13.2.1 Habitat

Wetted Area: lacustrine
riverine
transitional & lagoon
coastal

13.2.2 Silver eel production

13.2.2.1 Historic production

No available data.

13.2.2.2 Current production

No available data.

13.2.2.3 Current escapement

No available data.

13.2.2.4 Production values e.g. kg/ha

No available data.

13.2.2.5 Impacts

No available data.

13.2.3 Stocking requirement eels <20 cm

No available data.

13.2.4 Summary data on glass eel

No available data.

13.2.5 Data quality issues

No available data.

14 Sampling intensity and precision

No available data.

15 Standardisation and harmonisation of methodology

15.1 Survey techniques

See paragraph 9.

15.2 Sampling commercial catches

No available data.

15.3 Sampling

No available data.

15.4 Age analysis

No available data.

15.5 Life stages

No available data.

15.6 Sex determinations

No available data.

16 Overview, conclusions and recommendations

Only two time-series of eel are available from Norway, which are beach-seine surveys in the Skagerak (since 1904), and counting of upstream and downstream migrating eel in the River Imsa (since 1975). Both time-series shows a decline (Durif *et al.*, 2008), with a collapse in the freshwater recruitment (number of ascending elvers) in the River Imsa from 1981. The silver eel escapement from the River Imsa showed a significant decline seven years after, which corresponds with the mean age of silver eels in this river. A collapse in eel numbers was also observed in the Skagerrak time-series at the end of the 1990s.

Recreational fishing was prohibited in Norway since 2009, and commercial fishing since 2010.

There is limited data on occurrence, abundance and biological characteristics of eel in Norway, and the knowledge level should generally be increased.

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Report on the eel stock and fishery in Poland 2011/'12

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Reporting Period: This report was completed in August 2012, and contains data up to 2011 and some provisional data for 2012.

2 Introduction

Eel fisheries in Poland are conducted in lakes, rivers, coastal open waters, and two brackish water basins; the Szczecin and Vistula lagoons. Part of the Szczecin Lagoon is in Germany, while part of the Vistula Lagoon is in Russia. Inland and coastal fisheries target silver and yellow eel, but no data on the shares of these forms in the catches are available. The total area of inland lakes and reservoirs exceeding 50 ha is 2293 km^2. Dams in the Vistula and Oder rivers and in many of their tributaries prevent migrations of eel and other fish species.

Eel fisheries have a long tradition in Poland. Prior to World War II they were conducted mainly in inland waters because the short length of coastline within Polish borders did not provide access to sea fisheries. Following the war, the length of the Polish coastline increased considerably to over 500 km. With this broader access to the Baltic Sea, Polish coastal eel fisheries developed and landings were as much as 388 tons annually. Inland eel fisheries also expanded to a substantially larger number of lakes, and landings were as much as 1500 tons annually. In the 1974–1994 period inland catches comprised up to 75% of the total annual Polish eel catch. Since the end of this period, catches have declined considerably, and the two types of eel fisheries together currently land about 200 tons annually.

Until the late 1950s Polish eel fisheries were based almost exclusively on natural recruitment. Later, extensive stocking programmes that released mainly glass eel were conducted in many lakes and in both lagoons. Changes in fishery management and the high price of glass eel put a near stop to these programmes by the late 1990s. This, in turn, resulted in very serious decreases in eel catches, mainly in inland fisheries.

2.1 River basins in Poland according to the Water Framework Directive, eel management units according to the Polish Eel Management Plan

The following river basins were designated based on the Water Framework Directive:

Oder – including the basins of Pomeranian rivers to the west of the Słupia mouth and those flowing into the Szczecin Lagoon;

Vistula – including the basins of Pomeranian rivers to the east of the Słupia mouth and those flowing into the Vistula Lagoon;

Other – river basins located within the territory of the Republic of Poland that are part of the international basins of the Dniester, Danube, Jarft, Elbe, Neman, Pregoła, Świeża, and Ücker rivers.

For the needs of the Eel Management Plan, in consideration of the availability of data essential to estimating the population size and the potential escapement of silver eel and in consultation with countries that share transboundary river basins, the territory of Poland was divided into two Eel Management Units (Figure 1).

Oder EMU

Vistula EMU

These EMUs include the following river basins, running waters, and maritime waters:

Oder EMU:

the transboundary Oder River basin within Poland;

the Szczecin Lagoon with nearby Polish waters;

the coastal zone (to 12 miles) of ICES Subdivision 24 (Pomeranian Bay);

the coastal zone (to 12 miles) of ICES Subdivision 25;

the transboundary Elbe and Űcker river basins within Polish borders.

Vistula EMU:

the Vistula River basin;

the transboundary Vistula River basin within Poland;

the inner Gulf of Gdańsk;

the coastal zone (to 12 miles) of ICES Subdivision 26;

the transboundary Jarft, Nemen, Pregoła, and Świeża river basins within Polish borders.

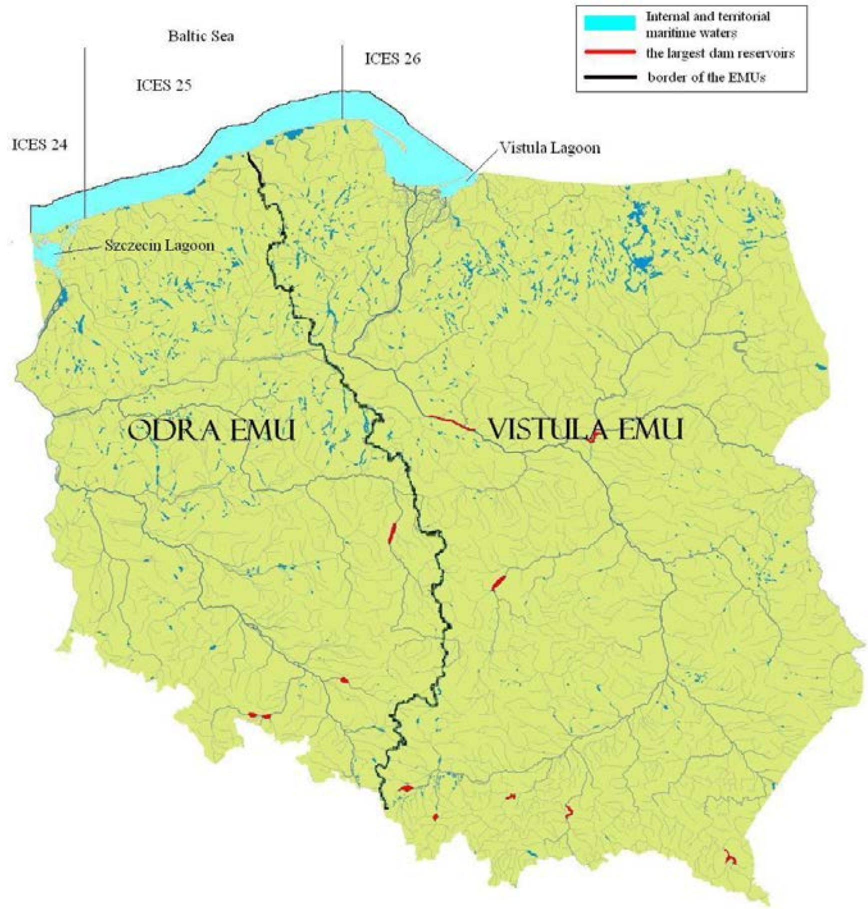


Figure 1. EMU in Poland according to the Polish EMP.

2.2 Fishery management

Areas of inland surface waters referred to as fisheries districts were established by the directors of the individual Regional Boards for Water Management, with the exception of waters located within the borders of national parks and nature reserves where fishing is banned. The basis for obtaining a permit to conduct fisheries in a fisheries district depends on winning a tender and signing a long-term exploitation agreement with the director of the corresponding Regional Board for Water Management.

Fisheries conducted within fisheries district are based on fishery plans. These documents set forth precise descriptions of proposed fisheries operations, with details regarding stocking programmes. Fishery plans must receive positive evaluations from an authorized institution. In total, there are 2370 fisheries districts in Poland. These support approximately 800 enterprises (natural persons and legal persons).

Recreational fisheries in inland waters are permitted if fishers hold fishing permits or underwater hunting licences. Local government officials issue these documents after the applicant has demonstrated knowledge of protection and catch regulations to a commission comprising volunteers from recreational fisheries organizations. Additionally, recreational fishers must have a fishing permit.

Marine fisheries are conducted using fishing vessels that have catch licences and special catch permits for a given calendar year. Special catch permits are issued by:

the minister in charge of fisheries – for the Polish Exclusive Economic Zone, in territorial maritime waters, in the Puck Bay and the Gulf of Gdańsk and outside Polish maritime regions;

the regional inspector in charge of marine fisheries – for catches in the Vistula Lagoon, the Szczecin Lagoon, the Kamieńskie Lagoon, and Lake Dąbie.

Sport and recreational catches can be made in Polish marine areas after sport catch permits are obtained. These are issued by regional marine fisheries inspectors or District Inspectorates for Marine Fisheries inspectors with permission to issue them. Permits are valid throughout the Polish EEZ.

2.3 Polish Eel Management Plan

The first version of Polish EMP was submitted to the EU in December 2008, and was updated by the document submitted in June 2009. The EU officially accepted the Polish EMP in January 2010. Regulations for protecting eel, such as designated minimum length and closed seasons, were introduced into Polish law in 2010, and stocking started in August 2011.

The major elements and measures of the Polish EMP are as follows:

stocking – 6 million glass eels annually in the Oder River basin and 7 million in the Vistula River basin, or 1.2 and 1.4 million elvers <20 cm, respectively;

make migration routes passable – removing barriers, building passes, closing hydroelectric facilities periodically during eel escapement, technical modifications;

designate closed seasons – to achieve the principles of the plan and reduce fishing mortality by 25% there must be a month-long closed fishing season from June 15 to July 15 throughout Poland;

unify minimum length – the optimum protected size for European eel in Polish waters should be 50.0 cm *L.t.* regardless of weight;

improve fishing gear selectivity – the selectivity of the most commonly used trap gear can be increased by installing selective sieves or by increasing the mesh size in the chamber to 20 mm (bar length);

limit daily rod catches to two eel – Polish regulations do not limit daily rod catches; doing so will counteract the increased mortality caused by recreational catches above that foreseen in the population model applied;

limit great cormorant pressure (predation);

limit IUU;

include protected areas in the eel protection process (national parks).

3 Time-series data

3.1 Recruitment-series and associated effort

3.1.1 Glass eel

Glass eel does not occur in Polish waters.

3.1.1.1 Commercial

Glass eel does not occur in Polish waters.

3.1.1.2 Recreational

Glass eel does not occur in Polish waters.

3.1.1.3 Fishery independent

Glass eel does not occur in Polish waters.

3.1.2 Yellow eel recruitment

3.1.2.1 Commercial

No commercial dataseries on recruitment exist, minimum landing size is 50 cm.

3.1.2.2 Recreational

No recreational dataseries on recruitment exist.

3.1.2.3 Fishery independent

No fishery-independent dataseries on recruitment exist, first estimation will be available from 2012.

3.2.1 Yellow eel landings

3.2.1.1 Commercial

No dataseries exist – total landings of yellow and silver eels combined (see Section 6.2).

3.2.1.2 Recreational

Some estimation is available. In 2011 IFI conducted a project related to eel recreational fishery (within EMP monitoring framework).

Information garnered from 57respondents exploiting nearly 250 thousand ha of inland waters permitted estimating recreational eel landings in Poland. According these data, the size of the catches are estimated at 0.16 g/ha in the Oder basin and 0.15 kg/ha in the Vistula basin. Simple extrapolation to the entire surface area of Polish lakes and reservoirs in these river basins produces the following figures:

Oder basin – 98 285 ha x 0.28 kg/ha =15.7 tonnes;

Vistula basin – 185 710 ha x 0.15 kg/ha = 27.9 tonnes;

Total – 15.7 t + 27.9 t = 43,6 tonnes.

What is striking here is the difference between this estimate and that presented in the Polish Eel Management Plan for recreational catches in both river basins. The PEMP figure for recreational catches was 212 tons, which would mean there has been close to a fivefold decrease in catches of this species. It should be underscored that the data presented in PEMP were based on questionnaires dating from the 2000–2004 period when the abundance of eel in Polish waters was substantially higher. Additionally, calculations included entire river basins without the limitations presented in the current report.

3.3.1 Silver eel landings

3.3.1.1 Commercial

No dataseries exist – total landings of yellow and silver eels combined.

3.3.1.2 Recreational

No catches.

3.4 Aquaculture production

3.4.1 Seed supply

3.4.2 Production

Currently, there is just one eel rearing facility in Poland. It produces about 1.5 tonnes of fingerlings annually. The fish are sold exclusively for stocking in Poland. Fingerlings are produced in 2–80 grams weight gradient.

3.5 Stocking

3.5.1 Amount stocked

Eel stocking was initiated in regions within current Polish borders as early as at the beginning of the 20th century, and it produced good results (Sakowicz, 1930). This was done mainly in rivers in the Vistula River basin and in the Vistula Lagoon. The stocking material of the day originated from the coasts of Great Britain (glass eel), although the Vistula Lagoon was also stocked with eel inhabiting the River Elbe (20–30 cm total length; Roehler, 1941). In the 1950s, great demand developed in Western Europe for live eel, and this fuelled efforts to stock all appropriate waters with this species. The restocking programme collapsed after the socioeconomic changes of 1989 transformed the former state fisheries enterprises into private enterprises. The Stocking Fund, which had been a department of the central government budget office, was also discontinued at this time. Private fisheries enterprises leased waters in which stocking had once been performed, and the import of eel recommenced in the mid-1990s. Because of economic concerns and the increasing price of glass eel, these were mostly elvers. Stocking did not recommence in either lagoon until 2005 as part of the stocking plan for Polish Marine Areas. Data on stocking quantities are listed in Table 1.

Table 1. Data on stocking quantities.

Decade	1950		1960		1970		1980		1990		2000		2010	
Year	glass eel	young yellow eel	glass eel	young yellow eel	glass eel	young yellow eel	glass eel	young yellow eel	glass eel	young yellow eel	glass eel	young yellow eel	glass eel	young yellow eel
0			64.4		23.5		52.9		8.6	1.0	3.1	0.8		1.4
1			65.1		17.4		60.5		1.7	0.1	0.7	0.6		2.7
2	17.6		61.6		21.5		64	0.1	13.8	0.1	0.0	0.6		3.9*
3	25.5		41.7		61.9	0.2	25.1	2.3	10.6		0.5	0.5		
4	26.6		39.2		71		49.2	0.3	12.2	0.1	2.3	0.5		
5	30.8		39.8		70		36.3	0.5	23.7			0.7		
6	21.0		69.0		68		54.4	0.2	2.8	0.5		1.1		
7	24.7		74.2		77	0.1	56.8		5.1	1.1		0.9		
8	35.0		16.6		73		15.9	0.1	2.5	0.6		1.0		
9	52.5		2.0		74.3		5.9	0.7	4.0	0.5		1.4		

***estimation based on previous year + EMP restocking in October 2012.**

Based on information from importers of stocking material, the amount of eel stocking material released into Polish waters was estimated with a high degree of accuracy. See Table 2.

Table 2. European eel stocking in lakes, rivers, and dam reservoirs in Poland in 2011 (data analysed based on information obtained from importers and producers of eel stocking material).

Type of eel stocking material [g/indiv.]	Weight [kg]	Number of specimens [indiv.]	Mean number of individual per kg of stocking material [indiv./kg]
0,33–7,5	2404	604 421	251
10	7241	724 100	100
15	356	23 733	67
20	1280	64 000	50
50	1845	36 900	20
100	7307	73 070	10
120	1410	11 750	8
Total	21 843	1 537 974	Mean - 70

3.5.2 Catch of eel <12 cm and proportion retained for stocking

There was no catch of eel <12 cm.

3.5.3 Reconstructed time-series on stocking

All eels are foreign source, glass eels – France, England , yellow eels – on grown cultured – Denmark, Germany, Sweden.

4 Fishing capacity

There is a lack of precise data regarding the number and type of fishing gear deployed and the types of fishing boats active in Polish inland waters, and there is no system in place to collect this type of statistical data. There are 800 enterprises authorized to catch eel on the basis on long-term agreements for their exploitation with directors of the responsible Regional Boards for Water Management.

4.1 Glass eel

No catches.

4.2 Yellow eel

Estimated data from questionnaires:

ODRA EMU: 250 fishing boats

VISTULA EMU: 470 fishing boats

4.3 Silver eel

See above.

4.4 Marine fishery

Fisheries in coastal and transitional waters are limited with regard to the number of vessels operating and the maximum number of gears deployed. Eel are fished almost exclusively by vessels of up to 12 m in the 12-mile zone. Special permits specify which types and the number of gear used.

As of 31 December 2011, the fishing capacity was as follows (boats up to 12 meters).

Fleet, number of vessels, 2011.

	Eel vessels <12 m*		TOTAL active vessels <12 m in 2011
ICES Area	eel directed**	total	
24–25	29	82	294
26	40	98	278

*** vessels which reported eel catches (regardless amount).**

**** vessels which reported even a single day of directed eel catches.**

5 Fishing effort

There is a lack of precise data regarding the number and type of fishing gear deployed and the types of fishing boats active in Polish inland waters, and there is no system in place to collect this type of statistical data. All data comes from questionnaires and are estimated values.

5.1 Glass eel

No catches.

5.2 Yellow and silver eel

ODER EMU

The fishing effort in inland waters is estimated at 1000 sets of trap gear, 50 sets of towed gear, and 120 fixed gears in flowing waters. The most important are fixed gears in flowing waters (Table 3).

Table 3. Fishing effort in inland waters of the Oder EMU.

	Share of gear in eel catches [%]	Estimated exploitation intensity [one gear/ 100 ha lake]
Trap	43	1.14
Towed	2	0.06
Fixed gear on flowing waters	34	0.14
Electric	8	No data
Hook	13	No data

VISTULA EMU

The fishing effort in inland waters was estimated at approximately 4200 sets of trap gear, 120 sets of hauled gear, and 500 sets of fixed gear set in running waters. The most important type of gear is fykenets, and other trapnets (Table 4).

Table 4. Fishing effort in inland waters of the Vistula EMU.

	Share of gear in eel catches [%]	Estimated intensity of deployment [one gear/100 ha lake]
Trap	45	2.66
Hauled	10	0.07
Fixed gear on flowing waters	24	0.32
Electric	3	No data
Hook	14	No data

5.3 Marine fishery (DCR data)

In coastal waters, eel is most frequently bycatch in catches of other species.

As of 31 December 2011, the fishing effort was as follows:

Table 5. Fishing effort in marine Polish waters.

		Eel as a bycatch			Eel directed fisheries*			Total: days	Total: kg	Total: no of gears
Gear	ICES subdivision	days	kg	no of gears	days	kg	no of gears			
FPO	27.3.d.24	2766	19 664	69 094	49	986	1092	2815	20 649	70 186
	27.3.d.26	816	3928	7560	217	1567	12 450	1033	5495	20 010
FPO TOTAL		3582	23 592	76 654	266	2552	13 542	3848	26 144	90 196
GNS	27.3.d.24	5	23	450				5	23	450
	27.3.d.25	2	30	30				2	30	30
	27.3.d.26	20	171	867	21	482	4196	41	653	5063
GNS TOTAL		27	224	1347	21	482	4196	48	706	5543
LLS	27.3.d.24	7	223	40 000	65	2613	284 410	72	2836	324 410
	27.3.d.25	26	424	103 200	25	332	85 740	51	756	188 940
	27.3.d.26	72	771	167 100	42	858	127 400	114	1629	294 500
LLS TOTAL		105	1418	310 300	132	3803	497 550	237	5221	807 850
SDN	27.3.d.26	21	70	142				21	70	142
SDN TOTAL		21	70	142				21	70	142
Total		3735	25 303	388 443	419	6837	515 288	4154	32 140	903 731

*** these days where eel constituted 50 or more percent of total catches.**

6 Catches and landings

6.1 Glass eel

There is no glass eel fishery in Poland.

6.2 Yellow and silver eel

No distinction has been made between yellow and silver eel in statistics. The data on inland catches were obtained by surveying selected fisheries facilities, then extrapolating the results for the entire river basin. These data are thus approximated. The data from the lagoons were drawn from official catch statistics (logbooks). These might also be incomplete because of poor statistics, the quality of which declined notably following 1990.

6.3.1 Total landings (time-series)

Table 6. Total landings of eel in entire basins and marine waters (1954–2011).

Decade Year	1950	1960	1970	1980	1990	2000	2010
0		733	847	1221	697	305	178
1		640	722	1018	580	296	119
2		663	696	1033	584	236	
3		762	636	822	495	204	
4	609	884	796	831	531	148	
5	732	682	793	1010	507	284	
6	656	804	803	982	499	257	
7	616	906	903	872	384	244	
8	635	943	946	923	397	227	
9	566	935	912	752	406	156	

7 Catch per unit of effort

7.1 Glass eel

There is no glass eel fishery in Poland.

7.2 Yellow eel

No data.

7.3 Silver eel

No data.

7.4 Marine fishery

The catch per unit of effort was only estimated in coastal waters. The negative trend is significant, and cpue is at the lowest reported level since 1995. See the 2008 Poland country report for details (WGEEL 2008).

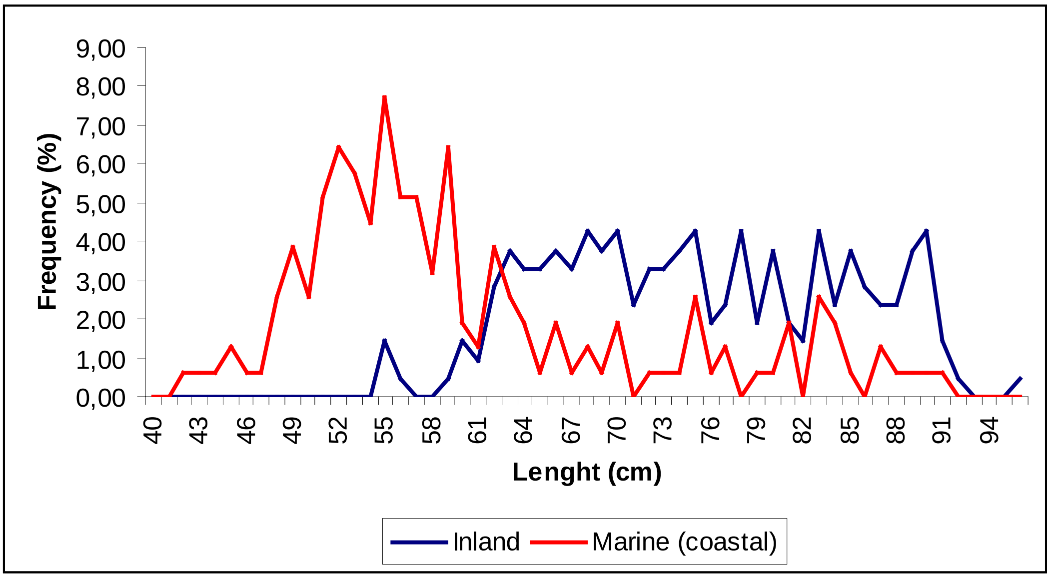
8 Other anthropogenic impacts

Not applicable.

9 Scientific surveys of the stock

10 Catch composition by age and length (DCF)

Landings are regularly sampled in marine harbours, and the main gears sampled are fykenets within FWS métier, because eel is only a bycatch in coastal freshwater fishery. Approximately 200–400 fish are analysed annually. Studies of eel from inland waters started in 2010 as a pilot project. In total 211 fish were sampled in the largest Polish lake – Śniardwy. All of eels were aged. Starting from 2011 sampling of inland catches for length-at-age data is conducted by Inland Fisheries Institute in Olsztyn, within EMP framework.



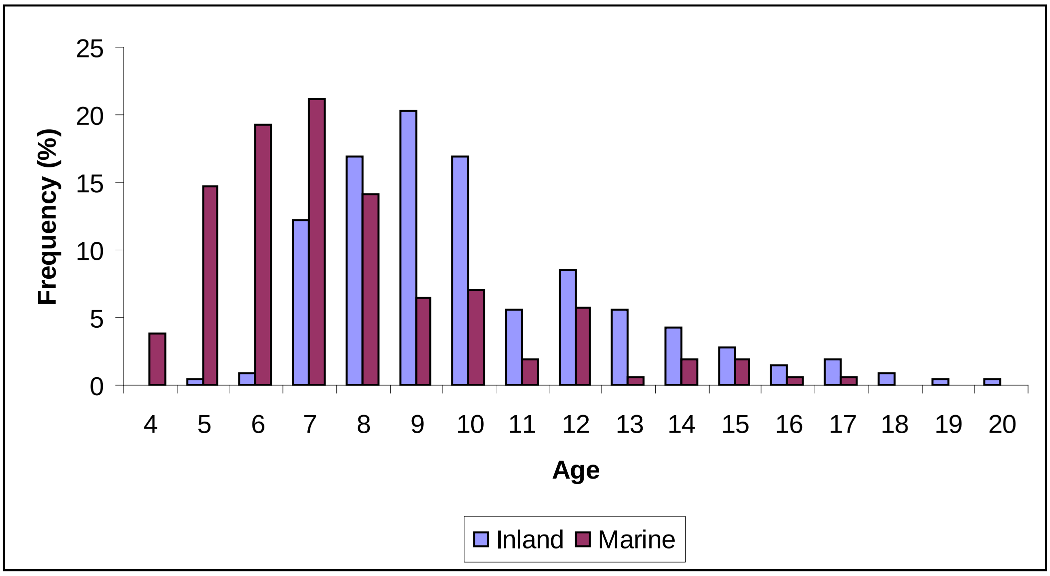


Figure 2. Length and age frequencies of commercial catch in inland and coastal waters in Poland (2011 DCF data).

11 Other biological sampling

11.1 Length and weight and growth (DCF)

Data regarding biological variables such as length, weight, and growth are collected regularly as part of DCF. NMFRI is responsible for collecting these data. See PL. 10 chapter.

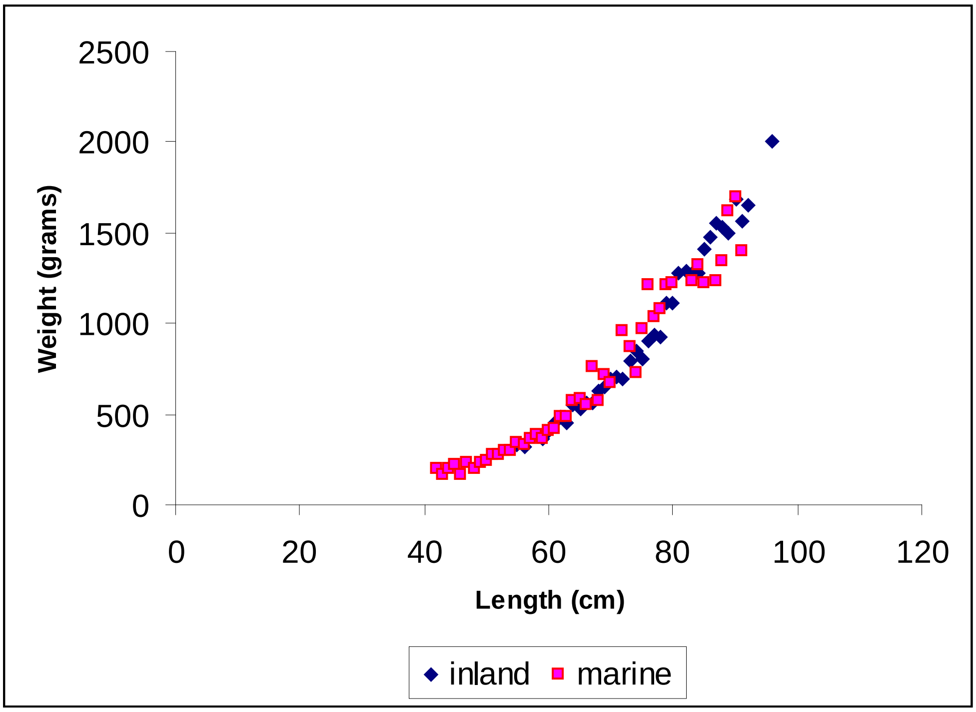


Figure 3. Length @ weight of eel from commercial catches conducted in 2011.

11.2 Parasites and pathogens

Studies to evaluate the health of eel from different fisheries enterprises and from different environmental conditions in various aquatic basins were performed as part of the monitoring project. A special protocol for monitoring eel health was developed and applied in the studies, and the eel from each of the enterprises were subjected to the same diagnostic procedures. Before the examinations, the eel were anesthetized with Propiscin (IFI Olsztyn). Each of the fish was examined individually for clinical and anatomopathological changes on the skin or in the gills and internal organs that would indicate the presence of disease. Blood samples were collected for further hematological, biochemical, and immunological test and samples were collected from particular parts of the fish and from the organs for virological, bacteriological, and immunological tests. The immunological tests included determining the activity of non-specific cellular and humoral immune defense mechanisms and resistance to infections. Full parasitological tests were also performed in order to confirm parasitic infection of skin, gills, and internal organs (swimbladder, digestive tract). Bacteriological tests included isolating and identifying pathogenic bacteria that threatened the health and life of the fish. The virological tests focused on isolating and identifying two viruses that are highly pathogenic to eel: EVEX, which is required by the European Union, and anguillid *herpesvirus* (AnHV). Simultaneously, tests were performed to determine if other viruses that are pathogenic for fish were present (VHSV, IHNV, IPNV, SVCV).

The analysis of the test results indicated that no significant differences were observed in the health of the fish that were subjected to clinical, anatomopathological, biochemical, or immunological tests. No pathology that would indicate disease was noted on the skin or in the gills of the tested fish, and anatomopathological examinations confirmed this evaluation as no pathology was noted in any of the internal organs (liver, kidneys, spleen, digestive tract). Bacteriological tests on the skin, gills, and internal organs did not indicate the presence of any pathogenic bacteria that could threaten health, and only saprophytic bacterial flora that occurs permanently in waters was isolated. Simultaneously, neither the EVEX nor the AnHV viruses, which are both pathogenic to eel, were detected among the fish tested. A significant element of the test was that no viruses that are pathogenic to other fish species were isolated among the eel tested which indicates that they are not carriers of pathogenic viruses of other fish species cultured in Poland. However, the parasitological tests focused on the eel swimbladder indicated a very high infection prevalence with the nematode *Anguillicoloides crassus* among the fish tested. The analysis of the test results of individual eel permit concluding that the degree of infection with the parasitic nematode *A. crassus* has an impact on the activity of non-specific cellular and humoral immune defense mechanisms that provide resistance to infections and on levels of total protein and glucose, which are fundamental parameters used to evaluate fish condition. A strict dependence between the degree of parasitic infection and fish condition was noted. In conclusion, the eel tested did not exhibit pathological changes, and microbiological and immunological tests confirmed the good health of the fish.

Stocking material imported to Poland

The condition and health of eel destined to be released as stocking material into the open waters of Poland were also included in the eel health evaluation project, and the health and condition of eel fry were evaluated similarly to the eel inhabiting Polish waters.

The analysis of the test results indicated there were no significant differences in health evaluations based on clinical, anatomopathological, biochemical, or immunological tests. Among the fish examined no pathology that would indicate disease was noted on the skin or in the gills of the tested fish, and anatomopathological examinations confirmed this evaluation as no pathology was noted in any of the internal organs (liver, kidneys, spleen, digestive tract). Parasitological tests indicated that no parasites occurred on the skin or gills or in the digestive tract. However, in single instances the swimbladder was infected with the nematode *Anguillicoloides crassus*. Comprehensive bacteriological tests detected increased incidences of the pathogenic bacteria *Aeromonas hydrophila*, while on other organs and the skin no pathogenic bacterial flora was noted. Simultaneously, neither the EVEX nor the AnHV viruses, which are both pathogenic to eel, were detected among the fish tested, and no other viruses were isolated that are pathogenic to other fish species cultured in Poland.

Comprehensive tests indicated unequivocally that eel destined to be released as stocking material into open waters were in good condition and were clinically healthy as was indicated by specialized virological and bacteriological tests, while the level of non-specific cellular and humoral immune defence mechanisms indicated high levels of immunity and good resistance to infection which guarantees survival under changing environmental conditions.

11.3 Contaminants

The chemical compounds in muscle tissues of eel, *Anguilla anguilla*, caught in 2011 in Puck Bay, the Vistula Lagoon, in the vicinity of Świnoujścia and Mielno, and in inland waters were assayed. Sixty samples were collected for the chemical tests. When an individual eel weighed more than 900 g, the sample comprised one individual, but when the individuals were smaller composite samples comprised from two to seven individuals.

Fat and protein contents

The samples tested varied widely in fat content from 8.86% (Vistula Lagoon sample comprising six individuals with a mean weight of 302 g) to 28.79 % (an eel weighing 2030 g from Lake Śniardwy). Generally, it can be concluded that higher fat contents are found in individuals of a higher body weight and in a more advanced stage of sexual maturity.

The protein content was more stable in the samples assayed as it fluctuated from 14.75% (an individual from the Vistula Lagoon weighing 1605 g) to 19.25% (a sample from the Vistula Lagoon comprising six individuals of a mean weight of 302 g). It is notable that samples comprising individuals of a lower weight have lower protein contents. The mean fat content was compared in samples from different sampling sites. Means with the same letter indexes do not differ significantly statistically ($P \leq 0.05$).

Heavy metals

The content of zinc and copper were compared with the recommended daily allowances of these macro-elements (Commission Directive 2008/100/EC), which are 10 000 µg for zinc and 1000 µg for copper.

The contents of cadmium and lead in all of the samples assayed were very low in comparison to the allowable limits. Cadmium contents fluctuated from 0.5 µg/kg to 5.5 µg/kg, which means that the maximum cadmium content was only 5.5% of the allowable limit. The lead contents fluctuated from 8.0 µg/kg to 38.4 µg/kg; thus, the maximum lead content was 10.8% of the allowable limit.

The results for mercury content were less advantageous. Although no sample exceeded the allowable limit (1000 µg/kg), the content in one tissue sample from an eel caught in Puck Bay was 999 µg/kg, which is at the threshold of the allowable limit.

In other fish species the permissible mercury content is 500 µg/kg. If the mercury content in eel tissues is compared with this limit, then it was exceeded in eight samples from the Vistula Lagoon and the Puck Bay. Additionally, the samples from these basins had the highest mean content of mercury, but the lowest mean mercury content was noted in the tissues of eel from inland waters.

However, the wide range of mercury content results from a given basin, and the resulting high standard deviation, meant that statistical calculations (t test) indicated that mean results for mercury content in eel tissues from different basins did not differ statistically significantly despite the high variation ($P \leq 0.05$).

The mean contents of zinc and copper indicated that 200 g of eel tissue meet 40% of the daily requirement of an adult person for zinc and approximately 4% of that of copper.

Organochlorine pesticides and total indicators of polychlorinated biphenyls

In the case of ΣDDT, while none of the assays indicated that the allowable limit was exceeded, the highest residue level of this group of pesticides (776.21 µg/kg in tissues of an eel from the vicinity of Świnoujścia weighing 1207 g) was 77.6% of the allowable limit. Elevated levels of Σ DDT were confirmed in the tissues of an eel from the Vistula Lagoon weighing 1605 g and in which the residues of this group of pesticides was 317.55 µg/kg. In all of the other samples, the levels of ΣDDT ranged from

2.32 µg/kg (composite sample of tissues from six individuals from Lake Bukowo with a mean weight of 290 g) to 168.75 µg/kg (tissue sample from a Puck Bay eel weighing 1276 g).

The permissible contents of Σ PCB_6 (300 µg/kg) in eel tissues was exceeded (375.20 µg/kg) in one sample from an individual weighing 1400 g that was caught in the Puck Bay. However, the allowable limit designated for other species of fish (75 µg/kg) was exceeded in eight eel tissue samples (six samples from the Puck Bay and two samples from the vicinity of Świnoujścia). The lowest Σ PCB_6 content was noted in samples of eel tissue from inland waters; the Σ PCB_6 residues in a sample from Lake Bukowo weighing 290 g was only 1.87 µg/kg.

Polybrominated diphenyl ethers (PBDEs)

The results obtained for indicator PBDEs were compared to the content of 4 µg/kg tissue, which is the reference value designated as allowable for living aquatic organisms during work on the Water Directive.

The allowable limit was exceeded in two eel tissue samples. It was substantial in a specimen weighing 1207 g from the vicinity of Świnoujścia in which the limit was exceeded four-fold. In the second instance (an individual from Puck Bay weighing 1540 g), the allowable limit was only exceeded by approximately 5%. Finally, PBDE exceeded 2 µg/kg in five samples; there included two samples from inland water, and one sample each from the Vistula Lagoon, the Puck Bay, and Mielno.

Dioxins (PCDD/Fs) and dioxin-like polychlorinated biphenyl (dl-PCB)

Assay results indicated that dioxin residues (PCDD/Fs) in the examined eel tissues are at relatively low levels. The most residue was confirmed in an individual from the vicinity of Świnoujścia weighing 1204 g at 1.10 ng WHO-TEQ/kg, which is approximately 31.5% of the allowable limit.

The eel assayed presented much higher dioxin-like polychlorinated biphenyl (dl-PCB) contamination. This is also why excessive amounts of total dioxin and dl-PCB (10 ng WHO-EQ/kg) were noted in two samples (an individual from Puck Bay weighing 1823 g and another from the vicinity of Świnoujście weighing 1207 g). In other samples assayed, the total dioxin and dl-PCB was lower, and did not even exceed the allowable limit permitted for other fish (6.5 ng WHO-TEQ/kg).

11.4 Predators

The abundance of the great cormorant population in spring in breeding colonies is determined by counting nesting pairs (nests). Populations are linked permanently to these nesting sites until their young leave the nests. The cormorant nests are counted in early spring (April) before they are hidden by the leaves of the trees.

Determining the breeding success of the colony by noting the mean number of reared individuals per nest permits determining the abundance of the great cormorant population in the colony in fall. Studying the breeding success of the colony is done just before the young birds leave the nests when they are clearly visible and very mobile in the nests and immediate vicinity. The water conditions in Poland mean that breeding success is often varied and is usually about two indiv./nest. Knowing the abundance of the colony is a fundamental element of establishing the share of eel in the overall diet of the colony. Cormorants will fish in waters within a radius of 30 km (and sometimes even of 50 km) from their nests.

Resting colonies are formed by young great cormorants that arrive but are not yet nesting. After the arrival of the year's young, these colonies are often supplemented by birds from nesting colonies. The great cormorants in resting colonies are loosely linked to these sites, and they tend to move around, which means that the abundance of birds at these sites is variable. Determining the mean numbers in such colonies requires frequent counts that are performed before the year's young leave the colony. All of the colonies are counted over the shortest span of time, which is done to eliminate error stemming from bird mobility.

The studies are conducted by verifying information obtained during previous field studies and based on current, supplementary data regarding the location and numbers of great cormorants throughout Poland. This permits updating this knowledge and helps in properly planning and conducting nation-wide counts of colony nests and birds.

Based on the results obtained by analyzing the materials collected, and knowledge regarding the abundance of great cormorants in the colonies studied, the periods during which the birds are in the area penetrated by the colony, and the daily feed ration (determined and verified based on studies of regurgitated pellets and fish), the total weight, abundance, and length distribution of the eel that are a component of the prey consumed by great cormorants is determined for different colonies. The results refer to the current eel state, which is linked to stocking and catches of this species.

Based on knowledge of the size of the entire great cormorant population inhabiting lakes in Poland and of the magnitude of cormorant pressure on eel in different basins, the total weight, size structure, and age structure are estimated for all eel that fall prey to great cormorants in the waters of the Oder and Vistula river basins. The primary eel habitats in Poland are lakes. In recent years, fishers landed approximately 100 tonnes of eel from 270 000 ha of lakes that are exploited by the fisheries, while great cormorants consumed approximately 35 tonnes. The mean weight of eel in the great cormorant diet is 197 g. The estimated mean weight of eel in fisheries catches was approximately 500 g. Thus, the great cormorants caught approximately 178 000 individuals, while fishers caught approximately 200 000 eel. In comparison to those of the 1980s, fisheries catches of eel decreased approximately ten-fold because of drastic reductions in stocking. This is also why the share of eel in the great cormorant diet also decreased from approximately 15% previously to less than 1% currently. Since the early 1990s, the lake populations of great cormorants have increased by 270%, and the current great cormorant diet exceeds fisheries catches by almost three-fold, which is a serious threat to all of lake fisheries. The current size of the great cormorant population poses a serious threat to the restoration of the eel population in Polish waters even with the proposed increase in eel stocking, which is already being implemented. Reducing the great cormorant population by one third of its current size is viewed as necessary, and even if this is done, the magnitude of the great cormorant diet will still exceed that of all other piscivorous animals combined. Despite European incentives, Poland has yet to develop the recommended Strategy for the Management of Cormorant Populations. Article 9 of the Birds Directive (Council Directive 79/409/EEC of 2 April 1979 on the conservation of wild birds) allows exceptions to be made if they prevent serious damage being done to other interests, such as fisheries. Unfortunately, in the face of strong pressure from some groups, attempts to use this possibility to reduce the great cormorant population in Poland have been negligible.

River basin	Number of pellets collected (indiv.)	Number of eel in pellets (indiv.)	Number of regurgitated eel (indiv.)	Mean body weight of eel (g)	Quantity of eel in overall great cormorant diet (indiv.)	Weight of eel in overall great cormorant diet (kg)	Total weight of great cormorant prey in the colony studied (kg)	Share of eel weight in great cormorant diet (%)
Oder	325	0	21	221.8	181	40	43 126	0.09275
	358	0	0	0	0	0	224 196	0.00000
	683	0	21	221.8	181	40	267 322	0.01496
Vistula	536	2	3	405.7	2186	887	413 263	0.21436
	103	0	0	0	0	0	138 516	0.00000
	81	0	4	163.6	133	22	147 941	0.01487
	259	0	0	0	0	0	242 760	0.00000
	330	1	1	293.0	2187	641	511 224	0.12539
	1309	3	8	297.2	4506	1550	3 638 544	0.04260
Coastal waters	280	0	0	0	0	0	44 000	0.00000

12 Other sampling

Evaluation of eel migration dynamics

Studies of the intensity and dynamics of eel migrations are realized using traditional fishing gears and other useful devices such as electric barriers.

Range of operations: during eel migrations in spring and fall the numbers and mass of migrating eel are recorded daily at designated sites for 35 days in spring and 35 days in fall. The studies will be conducted annually for six years at sites located on the Vistula and Oder rivers, and at two-year intervals at the remaining sites. The data obtained is used to estimate the overall number of migrating eel in the two river basins.

Hydroacoustic methods combined with monitoring catches could prove to be a quick and relatively precise method for evaluating the number and biomass of migrating eel in inland waters. Hydroacoustic methods are not yet used on a wider scale in shallow waters, mainly because of the difficulties linked to the proximity of the boundaries of the environment, i.e. the surface and the bottom, which can disrupt signals from fish. However, in the case of hydroacoustic data analysis for determining numbers of individual fish, and not aggregations of them, the impact of these disruptions is not that significant.

Scientific hydroacoustic measurements for monitoring purposes are performed with a SIMRAD EK-60 echosounder (Norway) at a frequency of 70 and 120 kHz at varying impulse ranges of 0.1 to 1.0 ms. The measurements are taken with a stationary beam with a horizontal split beam. This permits determining the direction and speed at which the eel are moving through the water column. Transmitters are deployed on specialized constructions that permit regulating and adjusting the angle of the beam axis relative to the water surface.

The hydroacoustic data collected are analyzed with Sonar 5 software. This permits obtaining data from selected water layers that are 15 to 20 cm in thickness. These results are used to determine the number of eel that swim through the zone monitored by the transmitter. The results of hydroacoustic analysis are verified by catches of eel made with set gear.

Acoustic signals registered from migrating eel in the Piaśnica River in the Vistula River basin.

Evaluation of mortality caused by technical constructions in waters

Eel encounter many barriers along migration routes to the sea. The majority of these are the result of technical constructions built in streams and rivers used as migratory routes. These barriers also include various types of weirs, sills, and water intakes.

Information has been collected regarding 15 000 technical constructions in waters. While their impact on fish migration is highly varied, virtually all of them pose difficulties of some degree for fish swimming upstream, but not all of them pose a problem for fish swimming downstream. The impact these constructions have on fish migration depends on many factors, the most important of which is the role of the construction; specifically, whether the water is used for producing hydropower power, for irrigation, for supplementing water pipelines or ponds, etc., whether the entire flow is exploited, and whether the fish have a way to avoid the turbines and pumps. These depend on the individual technical solutions used in each construction, and whether, when bypassing them, the fish are in danger of injury from falls, changes in pressure, etc.

Oder River basin

The desired impact can be achieved in various ways. One of the most rational of these must be making streams fully passable or the liquidation of small hydropower power facilities with an output of less than 100 kW, and decreasing fish mortality by half in the large hydropower plants in Table 12. The reduction in fish mortality can be achieved by constructing passes, periodically shutting down turbines, and/or reconstructing hydropower facilities or barriers. The choice of optimal solutions requires detailed analyses of the conditions at each barrier and the costs of implementing changes.

Vistula River basin

One of the practical conditions required to achieve the aim of the plan is to improve the passability of the barriers in Włocławek and Dębe. It appears to be theoretically possible and rational to make migration routes fully passable or to liquidate the small hydropower facilities in Table 13, and also to reduce eel mortality at the Dębe and Włocławek hydropower plants to a third of current mortality (estimated to be 30%). These improvements could be achieved through various measures, but the choice of concrete solutions must be preceded by detailed studies and technical analyses of each of the barriers.

An experiment employing telemetric methods based on acoustic and radio technology was performed in 2011 at the Smołdzino hydropower facility to estimate the mortality of silver eel migrating through its turbines.

The Smołdzino hydropower plant is located on the Łupawa River and has two vertical-axis Francis turbines. The turbine 1 throat takes in water at a rate of 4 m^3/s at 125 rpm, while turbine 2 is larger and takes in 8.25 m^3/s at 65 rpm. The rotor diameter of these turbines in 2140 m. The mean drop of the hydropower plant water barrage is 2.2 m. During the experiment from November 8 to December 13 2011, mainly turbine 2 was operational. Turbine 1 was put into operation on December 5 2011. The turbines ceased operation for one day on December 13. The upper water intake at turbine 1 is secured with 2.5 cm mesh, while that at turbine turbine 2 has 3 cm mesh.

Acoustic telemetry

On November 8 and 9, 15 silver eel individuals were fitted with Vemco coded transmitters. The fish were measured (Lt) and weighed. Eye diameter and pectoral fin length were also measured. The length of the tagged individuals ranged from 55.5 to 68.2 cm and the weight ranged from 363 to 568 g. The transmitters were placed inside the abdominal cavity while the fish were anesthetized. The site where the transmitters were placed inside the body was stitched and disinfected. The tagged eel were held for about 2 hours to recover and to eliminate possible mortality following the procedure. The fish were released into the reservoir upstream from the hydropower plant. Six Vemco VR2W acoustic receivers were distributed along the Smołdzino-Rowy segment of the river. The first was installed in the reservoir upstream from the hydropower plant close to the area where the fish were released. The next two receivers were located downstream from the hydropower plant flanking each bank of the river. The next receiver was deployed about 400 m downstream from the dam. The last two receivers were installed at the inflow of the Łupawa River into Lake Gardno and at the outlet canal of the lake that flows into the sea at the town of Rowy. Additionally, the movements of the tagged fish were tracked with a Vemco VR100 portable receiver as they migrated along the river segment from Smołdzino to Lake Gardno.

The experiment did not confirm that the turbines had any impact on the migrating eel. Of the 15 tagged individuals, 14 passed through the hydropower plant and migrated downstream from Smołdzino. Of these individuals, at least ten reached Lake Gardno. Only one individual remained above the hydropower plant, and was presumed dead. Unfortunately, because of the high water level in the canal that connects Lake Gardno with the sea, it was not possible to read the receiver located there; this would have permitted determining how many of the eel actually migrated into the sea.

Radio telemetry

On November 10 2011, 15 silver eel individuals measuring 57 to 73.8 cm in length and weighing from 351 to 691 g, were tagged with ATS radio transmitters using identical procedures to those used with the acoustic transmitters. The movements of the eel were tracked with four ATS R4500 automatic stations. Two of them were mounted on the hydropower plant building, with one directed upstream and the other downstream. The next station was placed in the headquarters of Słowiński National Park, and the last was deployed about 350 m downstream from the Smołdzino hydropower plant. Additionally, the fish were searched for systematically with active telemetry from a boat and from the river bank. All of the fish passed through the turbines and were noted to be downstream from the hydropower plant, and just one individual apparently did not survive passing through the turbine. Three individuals were caught by fishers in Lake Gardno, while five eel remained in the Łupawa River between Człuchów and the lake without migrating much until December 13 2011.

The deadline for making migratory routes passable for silver eel escapement in the Oder and Vistula river basins is planned for 2019.

13 Stock assessment

13.1 Local stock assessment

The stock dynamics of eel in both river basin districts was estimated using a version of CAGEAN model (Deriso *et al.*, 1985). The model was fitted to data covering period 1960–2011. It were a lot of gaps in the age structured data, and for some data only approximate or assumed values were available, so the model was fitted using simplifying assumptions. The available data included:

- Fishery and recreational catches covering whole period.
- Restocking numbers covering whole period.
- Age structure and weight-at-age for several years, but in most years these data were not available. The best covered by age and weight data period was since 2006.
- Predation on eels by cormorants.

In the CAGEAN model fishing mortality (F) was separated into year effect (fishing mortality at reference age in a year) and age effect (selection). As data for estimating year effect in F were too scarce, the F was presented as time dependent polynomial of 7th degree, and coefficients of such polynomial were estimated within the model. Predation mortality from cormorants was included, but it appeared to be low (usually at 0.01–0.02). Recruitment to the model was assumed as proportional to recruitment indices estimated using GLM by WGEEL (ICES, 2011) and coefficient of proportionality (Ralfa) was estimated in the model. Selection was estimated at ages 3–6, at others it was assumed at 1. Other parameter was Zini, total mortality used to estimate initial stock numbers (in 1960) from average recruitment at the beginning of simulation period.

The model was fitted by minimizing the sum of squared residuals between observed and modelled catch and observed and modelled catch-at-age in those years in which age distribution was available. The residuals were determined from logged values. Details of the model were presented in 2008 Polish eel management plan. The inverse of variance weighting was applied to weight terms of total sum of squared residuals. The estimated fishing mortality and Ralfa were inversely correlated and it was relatively little information in the data to select most representative estimate of Ralfa. Thus, the model was run for series of Ralfa values, and as a representative for eel dynamics it was selected such Ralfa, at which minimized sum of squared residuals showed low changes, while the total mortality was relatively close to mortality estimates from catch curve. Otherwise, the minimizing procedure tended to select high Ralfa and produced unrealistically low fishing mortality.

The model fit in 2012 differs from the model in 2008 for a few reasons:

- Recruitment indices were now taken from GLM estimates presented in WGEEL Report in 2011.
- Weight-at-age were updated and appeared to be much higher than previously used at younger ages.
- Data from 2008–2011 were included in the analysis.

As a result the biomass estimates now are similar to previous estimates at the beginning of series (1960s) and comparable at the end of series (after 2000), however in middle of the assessed period present biomass estimates are markedly higher from previously estimated.

13.2 International stock assessment

13.2.1 Habitat

Natural eel habitats in Poland are found in nearly all waters (Table 7), the only differences are in their importance for the occurrence of eel. Rivers are of the least importance to the occurrence of eel because they are routes for feeding and spawning migrations (silver eel escapement). The most important eel habitats have been and are transitional waters (Vistula and Szczecin lagoons) and lakes which comprise the lakelands situated in northern Poland.

Table 7. Surface areas of water categories in the EMUs (ha).

Types of waters	Oder EMU	Vistula EMU	TOTAL POLAND
Rivers, width >3 m	-	-	134 700*
Lakes, surface area >1 ha	163 000	118 400	281 400
Dam reservoirs	16 000	32 000	48 000
Transitional waters	45 700	32 800	78 500
Maritime waters**	646 450	344 100	990 550

*** length in km.**

**** maritime waters include the inner Gulf of Gdańsk, which nominally belongs to inner maritime waters.**

13.2.2 Silver eel production

13.2.2.1 Historical and current eel escapement

The description of the eel population model used to estimate potential escapement is in Section 13.1. The calculated values of potential escapement during the reference and current period are as follows:

Table 8. Estimated eel escapement for various assumptions in the 1960–1979 and 2009–2011 periods.

	Oder EMU	Vistula EMU
Eel mortality from hydroelectric barriers	30%	44%
Eel escapement numbers [thou. indiv.]		
1960–1979* period	1480	1234
2009–2011 potential	178	163
With hydroelectric barriers in 2009–2011	107	73
Target (40% of the 1960–1979 period)	592	493
Ratio of 2009–2011** to the target	0.18	0.15

***/ estimated from natural spawning, without exploitation or barriers.**

****/ hydroelectric barriers included.**

The parameters reflecting current and historical state of eel stock and mortality for Odra and Vistula river basin districts. B=biomass (tons), F=fishing mortality, H=anthropogenic mortality, A=F+H).

parameter	Odra	Vistula
B_0	1611	1343
B_{goal}	645	537
$B_{current}$	117	82
ratio$B_{current}/B_{goal}$	0.18	0.15
B_{best1}	75	62
B_{best2}	426	355
sumF	1.02	2.06
sumH	0.51	0.80
sumA	1.53	2.86

Remarks:

B_0 is based on average recruitment from reference period taken as 1960–1979;

B_{best1} is based on current recruitment (2009–2011);

B_{best2} is based on recruitment from those year-classes, which form current escapement of silver eel to spawn;

sumF, $B_{current}$, B_{best} are provided as averages in 2009–2011.

Two versions of B_{best} were provided, as it was not fully clear from the guidelines how B_{best} is defined. In addition, it is not clear how to calculate B_{best} from $B_{current}$, sumF and sumH, because to calculate B_{best}, the sumF referring to generations forming current escapement should rather be used instead of sumF from current years.

13.2.2.2 Impacts

Mortality in eel is caused by a number of factors, the most important of which include hydroelectric power facilities, fishery, cormorant predation, water pollution, parasite infection, and illegal catches.

Detailed study on impacts is currently ongoing (see chapter Other sampling), so the first results will be ready in 2013.

Table 9. Causes of mortality in eel other than fishing.

No.	Cause of mortality	Habitat type	Impact
6.1	Hydroelectric power facilities	All	Vistula EMU – 44% Oder EMU – 30% (Appendix 21)
6.2	Predation	All	Potentially substantial (research required)
6.3	Pollution	All	Quality data (low impact)
6.4	Diseases and parasites	All	Quality data
6.5	Illegal catches	All	No data (possible significant impact)

13.2.2.3 Stocking requirement eels <20 cm

ODER EMU

Of six management strategies analysed, the one chosen stipulates a stocking intensity of 6 million glass eels (2 tons). The equivalent number of reared eel fry with body lengths <20 cm *L.t.* would be 1 200 000 individuals.

VISTULA EMU

Of six management strategies analysed, the one chosen stipulates a stocking intensity of 7 million glass eels (2.33 tons). The equivalent number of reared eel fry with body lengths <20 cm *L.t.* would be 1 400 000 individuals.

14 Sampling intensity and precision

Since 2006, Poland has participated in the programme for collecting fisheries data, which includes sampling eel landings. Until 2008, the framework for data collection was set forth in Council Regulation (EC) No. 1639/2001. Thus far, samples have been collected in the Szczecin and Vistula lagoons and survey forms have been completed and entered into the SFI database.

The detailed ichthyological analysis of eel from landings follows standard procedure for population sampling, and includes recording parameters such as length, weight, sex, stomach fullness, and parasitic infection (nematode *Anguillicola crassus)*. Otoliths are also collected for later age and growth-rate determinations. Because commercial fisheries to not differentiate between yellow and silver eel, the metamorphosis stage is determined using the silvering index.

From 2009, there has been a shift in the framework for collecting dataset forth in Council Regulation (EC) No. 199/2008 concerning the establishment of a Community framework for the collection, management, and use of data in the fisheries sector and support for scientific advice regarding the Common Fisheries Policy.

Specifically, this is a move away from single-species sampling performed in the 2005–2008 period toward multispecies sampling based on métiers, or fleet segments. In the case of eel, sampling in 2010 will be introduced in inland waters as part of commercial and recreational catches. Although the framework for data collection in maritime fisheries is quite precisely described (Guidelines for the new DCR (SGRN-08-01), for inland fisheries there is just one short notation regarding the required number of fish analysed to determine age. The SFI planned a monitoring system that functions on similar principles to those of the marine system (Table 10). The catches sampled will be those made with gear groups that include up to 90% of the entire fishing effort. It is planned to analyse 200 fish from each river basin.

Table 10. Basic scheme for collecting marine fisheries data from eel catches in 2009–2010.

Choice of region(Baltic region; fishing grounds)	ICES SD 22-24 Oder EMU	ICES SD 25-32 Vistula EMU
Choice of métier (fleet segment) for eel	Pot and trap gear (FPO)	
Degree of sampling segment (landings + discards)	Minimum of one cruise per month	
Total number of sample	Depending on the variation coefficient CV, assumed CV=12.5% for eel	
Age analysis	100 yellow eel 100 silver eel	100 yellow eel 100 silver eel
Other biological parameters*	as above	as above

*** sex, silvering index – gonad maturity, degree of parasitic infection with *Anguillicola crassus*.**

The level of precision regarding age required by DCF regulations was not achieved. The numerous length and age classes would require performing age analysis on a thousand fish annually to achieve a CV coefficient of about 12.5%.

15 Standardization and harmonization of methodology

15.1 Survey techniques

See chapter “other sampling.”

15.2 Sampling commercial catches

Data regarding commercial fisheries are collected in fishing ports in which eel catches are reported. Measurements and analysis are performed at the SFI laboratory. Prior to analysis the fish are anaesthetized then sacrificed.

15.3 Age analysis

Age analysis is conducted at the SFI laboratory. Age is calculated based on the number of growth interval rings visible as dark rings and clearly differing from the light protein matrix on the surface of otoliths (Moriarty, 1983; Campana, 1992; Campana and Jones, 1992; Lecomte-Finiger, 1992; Tzeng *et al*., 1994). Two otolith preparation methods are used – the more common break and burn, and the less common section and stain. Thin sections are cut using a high-speed Acutom-50 micro-tome with a diamond blade.

15.4 Life stages

Eel life stage is determined using the method described in Durif *et al*. (2005).

15.5 Sex determinations

Eel sex is determined macroscopically according to established schema of ovary and core build.

16 Overview, conclusions and recommendations

Report on the eel stock and fishery in Portugal 2011/'12

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Reporting Period: This report was completed in August 2012, and contains data up to 2011 and some provisional data for 2012.

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2 Introduction

This report is an update of last year´s report but most of the information related to the EMP, despite having been presented in previous reports, was repeated because there is no new information for some chapters. It contains data for 2011 and some provisional data for 2012.

2.1 Eel fishery

The European eel occurs in different types of waterbodies that include coastal lagoons, estuaries and rivers but the presence of impassable dams, reduced the distribution area, which is now restricted to areas below obstacles in most river basins, especially in the largest. The commercial exploitation of eel includes glass eel fishery, exclusively in River Minho, and yellow eel fishery, all over the country.

The species has been traditionally exploited in Portugal, where it has a high gastronomic value, especially fried when small, and stewed when large. This preference restricts fishery as demanding for eels for human consumption, falls preferably in individuals of around 25 cm, which is the most appreciated size to fry. There are no fisheries for silver eels in Portugal, and given the lack of tradition to eat glass eels, glass eel fishery was non-existent until the early 1980s, except for the River Minho. Eel fishery is managed by DGPA (General Directorate of Fisheries and Aquiculture) with responsibility in coastal waters, and AFN (National Forestry Authority) with responsibility in inland waters. Both institutions are under the Ministry of Agriculture, Sea, Environment and Planning (MAMAOT), former Ministry of Agriculture, Rural Development and Fisheries (MADRP). The exception is River Minho because as an international river having a common stretch bordering both countries, there is a Commission (Standing Transboundary Commission of the River Minho) with representatives from both countries, setting specific rules that are applied to the fishery, in the international section of that river basin. Licences to fish in inland waters are issued by AFN, whereas licences to fish in transitional and coastal waters are issued by DGPA.

After a period of high fishing pressure and intensive poaching of glass eels, glass eel fishery was forbidden after the fishing season 2000/2001 (*Decreto Regulamentar* nº 7/2000) in all river basins, except in the River Minho where it is still permitted (Decree-Law nº 316, artº 55 of 26/11/81). Despite the enormous efforts of the authorities, which results in the confiscation of a large number of nets, poaching remains a problem all over the country, especially in the north and central parts of Portugal. Some investment has however been done to increase the fiscalization by the Authorities. An example is the establishment of a protocol between the Administration of the River Basin District from the Tagus (ARHTejo) and the SEPNA (Service of Nature and Environment Protection) from GNR (National Republican Guard) who can now use a boat and a car from AHR to monitor the river to guarantee compliance with the law.

Although landings do not separate yellow eels from silver eels, the fishing gears used are mainly directed to catch yellow eels, which is the dominant type in landings.

Yellow eel fishery is ruled by eleven specific byelaws applied to eleven fishing areas in coastal waters (estuaries and coastal lagoons) and nine other byelaws, which are applied to specific fishing areas called ZPPs (Zonas de Pesca Profissional / Professional Fishing Zones) (See Figure 2.1), which are the only areas where professional eel fishery is allowed in inland waters. These laws set the rules for types and characteristics of fishing gears and in most cases, limit the maximum number of gears per fishing licence. Fishing effort is not recorded. In inland waters, professional fishery is ruled by Law 2097/59 (6 June, 1959) in the stretches represented in green, whereas in the sections represented in yellow it is ruled by the byelaws (Figure 2.1a). Fisheries managed by DGPA have obligatory landing reports, while in inland waters, landing reports are obligatory in some fishing areas but in other areas only if requested by the Authorities. Minimum legal size is 22 cm in both areas of jurisdiction.

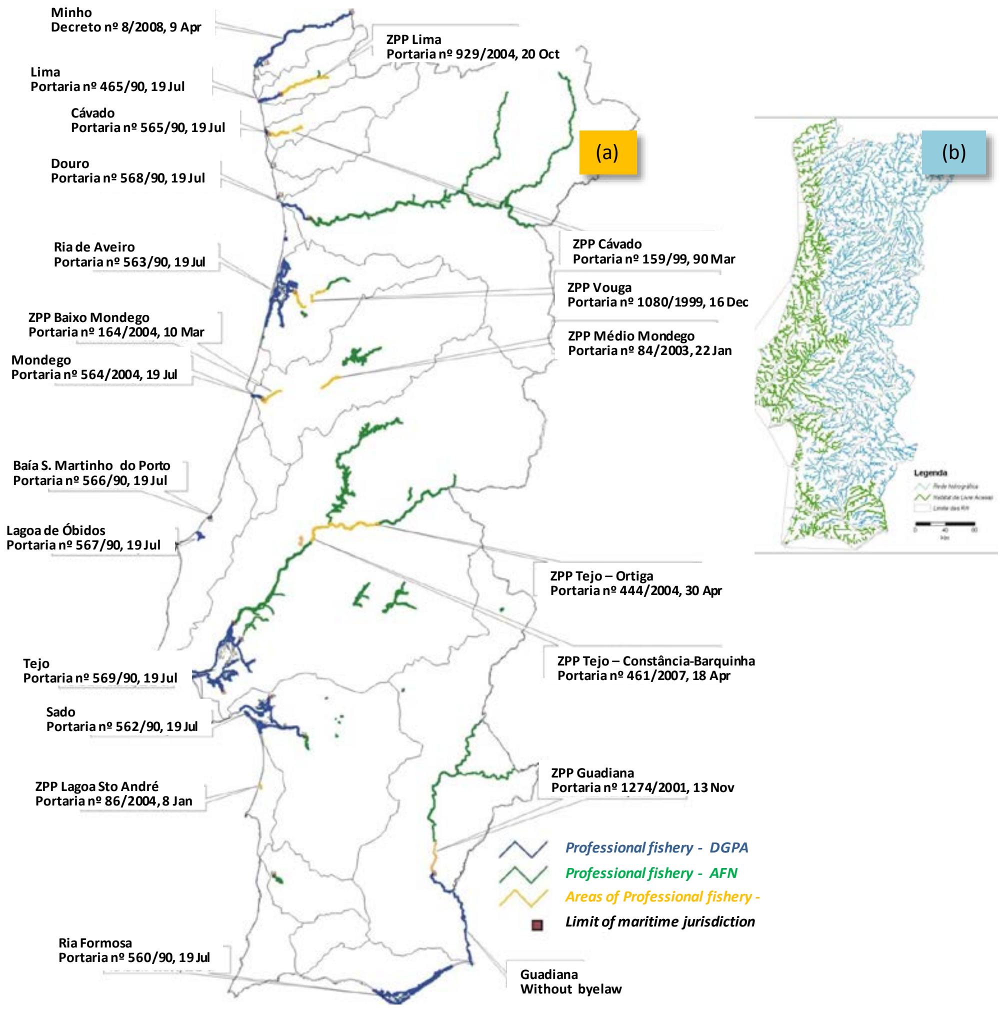


Figure 2.1. Map showing areas where professional fisheries can be conducted both in estuaries and coastal lagoons (jurisdiction of DGPA) and in inland waters (jurisdiction of AFN) (a). The limit of maritime jurisdiction and the byelaws that rule the fisheries at each area are presented in the map (a). (Source: AFN). The habitat that is accessible for the eel is also represented in green (b).

Eel fishery is permitted from January 1st until September 30th. A closed season of three months (October, November and December) has been set to increase escapement of silver eels. This prohibition was first set in 2010 for waters within the jurisdiction of DGPA, *i.e.* estuaries and coastal lagoons (Portaria nº 928/2010, from 20 September) and in 2012 for waters under the jurisdiction of AFN, *i.e.* inland waters (Portaria nº 180/2012, from 6 June). In River Minho the yellow/silver eel fishery is forbidden.

As a part of the government organizational reforms, DGPA (Directorate of Fisheries and Aquiculture) is designated by DGRM (General Directorate of Safety and Maritime Affairs) and AFN (National Forestry Authority) is designated by ICNF (Institute of Nature Conservation and Forests). However, they keep their responsibility in the same jurisdiction areas.

2.2 Portuguese Eel Management Plan

The Portuguese Eel Management Plan was approved by the European Commission on the 5th April 2011, following the delivery of the last revised version on the 19th November 2010.

In response to Regulation EC 1100/2007, Portugal has submitted an Eel Management Plan in December 2008. This plan was resubmitted in May 2009 and accepted by the EC in July 2009. The Portuguese Eel Management Plan was established to be implemented for the entire territory, which was designated as one eel river basin, *i.e.* the eel management unit, in accordance with Article 2, number 1. Madeira and Azores islands were excluded from the plan because anthropogenic impacts such as fishery and physical obstacles were considered of little or no importance, and similar to pristine conditions.

As mentioned above, the eel management unit for the purpose of the EMP is the entire territory. The designation of the entire territory as one eel river basin, originated from the generalised lack of information at the national level as well as from the fact that the entire territory can be considered as a potential habitat for the species. Data from the fishery are underestimated for coastal waters, and non-existent for inland waters, where catches are not reported. In addition, silver eels are not separated from yellow eels in landings and there are no scientific data on yellow and silver eel production neither in the present nor in pristine conditions.

Despite the existence of five river basins extending beyond Portugal (Minho, Lima, Douro, Tagus, and Guadiana; Figure 2.2a), and included in three different River Basin Districts (Figure 2.2b), it was agreed between both countries that the only Transboundary Eel Management Plan that should be considered was for River Minho, as it is the only international river where the river mouth is shared by both countries. As coordination between the two countries was delayed, it was not possible to consider it in December 2008, when submitting the Portuguese Eel Management Plan.

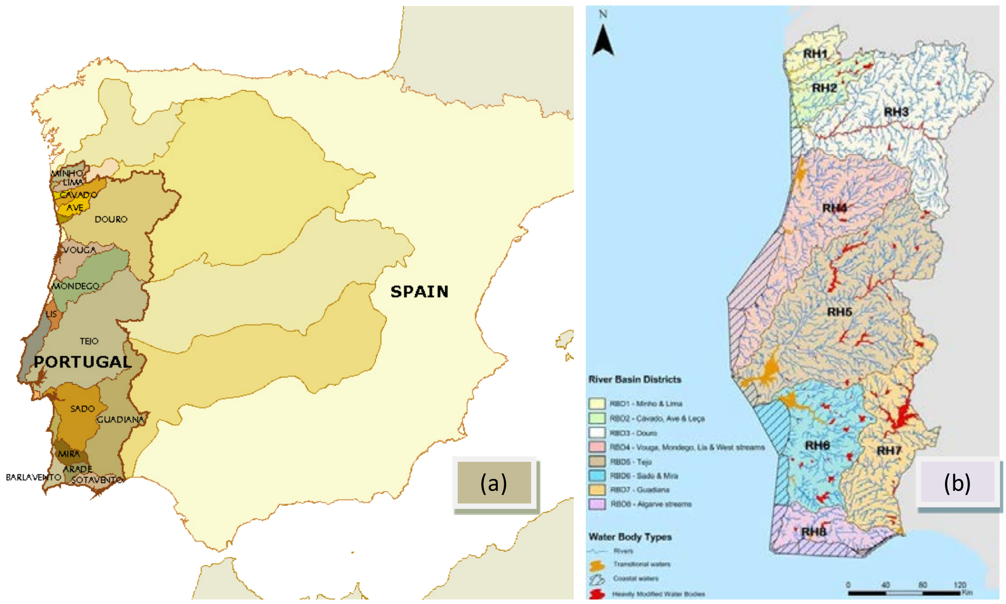


Figure 2.2. Map showing Portuguese River basins including the catchment area extending to Spain (a), and limits of the eight Portuguese River Basin Districts defined according to the Directive 2000/60/EC (b). RBD is labelled as RH in the map.

A project financed by INTERREG IV, "NATURA-Minho: Levantamento do habitat fluvial, os habitats de interesse comunitário, avaliação dos recursos migradores e ordenamento do seu aproveitamento no baixo Minho" which started by the end of 2009 and finished by the end of 2010 (with both countries as partners) was the support to prepare the Transboundary EMP for the River Minho, as one of the outputs of this project was the EMP for the River Minho.

Because the EMP for the River Minho was not delivered in time, Portugal had to reduce the fisheries effort until the implementation of the EMP in that river. Hence, several measures were taken to comply with the provisions of Article 4, number 4 *i.e.* to reduce fishing effort by at least 50% relative to the average effort deployed from 2004 to 2006. Those measures included reducing the number of fishing licences to fish glass eels, shrinking the authorized fishing zone for glass eels, shortening the fishing period, and banning fishery for eels.

A first version of the Transboundary EMP was sent to the European Commission in June 2011 followed by a revised version in November of the same year. The Transboundary EMP was approved by the European Commission on the 21st May 2012.

The first report on the implementation of the Portuguese EMP, which included a list of the measures that have been implemented, was sent to the European Commission in June 2012. Assessment of the effectiveness of those measures could not be estimated because of lack of data on stock assessment.

As for the report on the implementation of the Transboundary EMP for the River Minho it was not delivered to the European Commission because of its very recent approval (21st May 2012).

3 Time-series data

3.1 Recruitment-series and associated effort

3.1.1 Glass eel

In the River Minho, the monitoring of glass eel recruitment has been carried out since the mid-1970s based on professional fishermen catch values that have been annually reported to the authorities. Official fishery statistics have been kept by the responsible local authorities – *Capitania do Porto de Caminha* (Portugal) and *Comandancia Naval de Tuy* (Spain). Total annual statistics have been recorded since 1974. There is no recruitment monitoring of glass eels at the national level.

3.1.1.1 Commercial

The glass eel fishery is prohibited in all rivers of Portugal (*Decree Regulamentar* nº 7/2000 of May 30) with the exception of the River Minho (Decree-Law 316 artº 55 of 26/11/81). It was after the fishing season 2000/2001 that the fishery became prohibited in all other Portuguese rivers, except for aquaculture and restocking programmes.

Glass eel fishery in the River Minho has been permitted between November and April for many years, but in the last fishing seasons, mostly due to the eel population decline and the high fishing pressure, an agreement between the Portuguese and Spanish authorities, has been gradually reducing the fishing period. The fishing season is currently defined, to include four New Moons (the most profitable period). In the last fishing season (2011–2012) it occurred between the 18th November and the 1st March.

The fact that a fisherman has a licence to fish glass eels in a certain year does not necessarily mean that he will actually fish. The seasonal occurrence of other, relatively abundant species, like sea lamprey, influences the effort put in the glass eel fishery in an unpredictable manner.

Fishermen are obliged to report their catches to the local authorities.The official fishery statistics are kept by the responsible local Authority – *Capitania do Porto de Caminha.* Total annual statistics have been recorded since 1974 (Table 3.1). Between 1974 and 2005, 13.4 tons of glass eels were caught annually. However, it is estimated that values are 80% underestimated. A maximum of 50 tons was declared in 1980/81 followed by a second peak of 30.3 tons in 1984. In the period from 1985 to 1988 the official yield dropped to 9.5 tons with a peak of 15.2 tons in 1995. In 2000/2001 low catches were obtained, probably due to bad weather conditions that prevented fishing for three months. After the 2001/2002 fishing season and until 2007, the values decreased to 2.0 tons. For the 2008/2009 season there was a slight increase in the amount declared, which can be a consequence of a higher number of issued licences (see Table 3.1), rather than a real increase in recruitment. The same false increase in the yield from 2010 is probably related to changes in the new way to report catches as fishermen are obliged to fill in logbooks and report catches every three months. The amount declared will be compared to the quantity sold at auction. In case there is any false declaration there will be consequences, and their licences will not be renewed. A change in reporting catches has been introduced in the fishing season 2011/2012. Fishermen have to report their catches on a monthly basis filling in a logbook where they should register the amount caught in each fishing session.

Table 3.1. Glass eel recruitment in the River Minho (Portuguese and Spanish parts), 1974 to 2011 (Source: Capitania do Porto de Caminha, and Comandancia Naval de Tuy).

YEAR	PORTUGAL	SPAIN	TOTAL (tons)
1974	0.05	1.6	1.65
1975	5	5.6	10.6
1976	7.5	12.5	20
1977	15	21.6	36.6
1978	7	17.3	24.3
1979	13	15.4	28.4
1980	3	13	16
1981	32	18	50
1982	6.7	9.7	16.4
1983	16	14	30
1984	14.8	15.3	30.1
1985	7	6	13
1986	9.5	5.5	15
1987	2.6	5.6	8.2
1988	3	5	8
1989	4.5	4	8.5
1990	2.5	3.6	6.1
1991	4.5	2.4	6.9
1992	3.6	9.8	13.4
1993	2.9	2.1	5
1994	5.3	4.7	10

YEAR	PORTUGAL	SPAIN	TOTAL (tons)
1995	8.7	6.5	15.2
1996	4.4	4.3	8.7
1997	4.5	2.9	7.4
1998	3.6	3.8	7.4
1999	3	3.8	6.8
2000	1.2	6.5	7.7
2001	1.1		1.1
2002	1.443	7.8	9.243
2003	0.814	1.6	2.414
2004	1.17	1.3	2.47
2005	2.7	0.32	3.02
2006	0.905	1.14	2.045
2007	0.75	1.03	1.78
2008	1.35	1.33	2.68
2009	0.576	Not available	
2010	0.947	1.145	2.092
2011	1.085	Not available	

3.1.1.2 Recreational

Not applicable, as there is no recreational fishery of glass eels in the River Minho.

3.1.1.3 Fishery independent

No available data. There is no fishery-independent dataseries on glass eel recruitment.

3.1.2 Yellow eel recruitment

3.1.2.2 Commercial

There is no commercial dataseries on yellow eel recruitment.

3.1.2.2 Recreational

Not applicable. Catches are not reported.

3.1.2.3 Fishery independent

No available data.

3.2 Yellow eel landings

3.2.1 Commercial

No available data. There is no commercial data on yellow eel recruitment.

3.2.2 Recreational

Not applicable as there are no landings from recreational fishery and fishermen are not obliged to report their catches or sell the fish. In River Minho it is forbidden to catch eels by recreational fishing since 2010.

3.3 Silver eel landings

There is no separation between yellow and silver eels and fishing gears are not directed to catch silver eels, despite their occurrence in fykenets.

3.3.1 Commercial

No available data.

3.3.2 Recreational

Not applicable.

3.4 Aquaculture production

Aquaculture production of European eel is not significant in Portugal because there are no units of eel aquaculture in Portugal. In brackish water systems, production of eels is a byproduct in aquaculture systems directed towards extensive and semi-intensive seabass (*Dicentrarchus labrax*) and seabream (*Sparus aurata*) farming. In freshwater, there is no production of eels in aquaculture systems since 2000, despite the existence of four inactive production units. The difficulties in obtaining glass eels (after the prohibition to fish), the high price they reached, and water availability, might have been responsible for that interruption in production.

3.4.1 Seed supply

Not applicable as the semi-intensive and extensive ponds are naturally colonised by eels.

3.4.2 Production

The production of eels is presented in Table 3.2.

Table 3.2. Aquaculture production of eels (tons) between 1997 and 2011 (Source: DGPA).

Year	Production (tons)
1997	16.2
1998	13.2
1999	3
2000	6
2001	6.5
2002	4.2
2003	4.7
2004	1.5
2005	1.4
2006	1.1
2007	0.5
2008	0.4
2009	1.1
2010	n/a
2011	n/a

3.5 Stocking

There is no stocking of eels in Portugal.

3.5.1 Amount stocked

Not applicable.

3.5.2 Catch of eel <12 cm and proportion retained for restocking

Except for River Minho, it is forbidden to fish for glass eels in Portugal. River Minho is the only national exception where glass eel fishery is still permitted. Because River Minho extends to Spain, a stocking programme to stock 60% of the glass eels fished, in accordance with Article 7 of the Eel Regulation (EC Regulation 1100/2007) has been discussed by both countries. Because actual recruitment is considered above the carrying capacity of available habitat in the international section of the River Minho (River Minho EMP), glass eels caught in this area will be available to be used on stocking actions elsewhere, either in Portugal or Spain.

3.5.3 Reconstructed time-series on stocking

Not applicable. There is/was no stocking.

4 Fishing capacity

4.1 Glass eel

Glass eel fishery is only permitted in River Minho where fishery is regulated by Decree 8/2008, 9th April 2008. Fishery is operated with a stownet. This net has the following maximum dimensions: 10 m of floatline kept at the surface by 10–20 buoys, 8 m height, 15 m leadline, width of net end 2.5 m and wet mesh size >2 mm. Opening area is around 50 m^2. The net is anchored when the tide is rising, the end fastened to a boat, and glass eels are frequently scooped out with the help of a small dipnet. Glass eels can also be fished from the river bank with a dipnet of 1.5 m maximum diameter and mesh size of 2–5 mm.

The fishery, which depends completely on the rising tidal current, is always performed at night around new moon. Depending on the weather conditions, peaks may occur in winter or spring. Catches in summer months are usually very low (Domingos, 1992; Antunes, 1994a), although heavy rain during summer months can promote a more intense migration and higher catches (Domingos, 2002).

In 1983 there were 450 licensed fishermen in Spain and 750 in Portugal, corresponding to 300–400 nets in total. In 1988 approximately 600 boats in Portugal had permission to fish glass eels with one net each and in 1995, around 450 Portuguese boat inscriptions were recorded. In 1999, 251 Spanish fishermen were registered for the glass eel fishery. Number of fishing licences issued by *Capitania do Porto de Caminha* is presented in Table 4.1.

To reduce fishing pressure it was decided by the Standing Transboundary Commission of the River Minho that starting on the fishing season 2010/2011 the maximum number of fishing licences for each country would be 200, and also that the fishing zone for glass eels would decrease 25 km in the river length. In the last year a new change was introduced in the licensing process, as licences started to be given to the owners of the boats and not to fishermen, implying that the drop to 126 licences is a consequence of these changes rather than a real reduction in fishing pressure. As observed in Table 4.1., the fishing period has been progressively reduced since the fishing season 2006/2007.

Table 4.1. Number of fishing licences (stownets) issued by *Capitania do Porto de Caminha* to fish glass eels in the River Minho, 1987 to 2011 (Source: Capitania do Porto de Caminha).

Fishing season*	Nr. fishing licences
1987/88	721
1988/89	633
1989/90	565
1990/91	475
1991/92	435
1992/93	349
1993/94	327
1994/95	432
1995/96	426
1996/97	378
1997/98	387
1998/99	385
1999/00	320
2000/01	295
2001/02	224
2002/03	197
2003/04	236
2004/05	224
2005/06	209
2006/07 (1)	185
2007/08 (2)	200
2008/09 (3)	216
2009/10 (4)	200
2010/11 (5)	126
2011/2012 (6)	140

*** Licences for glass eel fishery are issued by fishing season (1 November to 30 April before 2006/07). In the five last fishing seasons (1) 1 November to last New Moon of March; (2) 1 November to 12 February; (3) 20 November to 01 March, (4) 9 November to 22 February; (5) 1st November to 1st February; (6) 18th November to 1st March.**

The Portuguese glass eel catches are mainly sold to Spain for human consumption and aquaculture. In general, the highest prices are attained before Christmas (on average 350 €/Kg, although they can be sold at 500 €/Kg). Despite forbidden all over the country, illegal glass eel fishery occurs in all estuarine areas due to the high economic value. The nets used are different from the type used in the River Minho, because there is no need to collect the eels with a dipnet, helping poachers to hide from the authorities. The net is fixed to the bottom by anchors that are attached to the wings, and fishing is conducted without the need to have fishermen close to the boat. These nets are conical and tied with a cable in the end of the cone. With the rising tide, the wings open and the net starts to fish the glass eels which get trapped inside the bag. There is no need to take the nets out of the water. The only thing to do is to pick up the end of the net, open it into the boat and release all the catches. Because these nets are left fishing in the water, they are extremely used in illegal fishery. The authorities (Maritime Police and SEPNA) make a tremendous effort to control the situation, but the confiscated nets are rapidly substituted by new ones.

The results obtained by SEPNA (a special unit from GNR, National Republican Guard) from monitoring illegal glass eel catches during the last two fishing seasons are presented in Table 4.2.

Table 4.2. Number of men and equipment used in monitoring glass eel poaching during the three last fishing seasons. The amount of glass eels confiscated is also presented (Source: SEPNA-GNR).

	FISHING SEASON 2009/10				FISHING SEASON 2010/11				FISHING SEASON 2011/12			
District	Men	Cars	Boats	Kg	Men	Cars	Boats	Kg	Men	Cars	Boats	Kg
AVEIRO	26	10	0	0	86	31	0	22	n/a	n/a	n/a	
BEJA	239	103	4	8.6	201	63	28	2.15	105	n/a	n/a	21
BRAGA	32	5	0	7	33	13	5	4	50	n/a	n/a	0
COIMBRA	149	54	0	0	209	79	0	1	42	n/a	n/a	0
FARO	8	3	0	0	23	8	0		30	n/a	n/a	0
LEIRIA	293	95	0	3.165	155	58	0	13.4	31	n/a	n/a	6.3
LISBOA	88	33	5	0.75	88	33	5	0.75	n/a	n/a	n/a	
PORTO	135	46	0	1.8	94	31	0	0	n/a	n/a	n/a	
SANTARÉM	106	40	0	3.12	106	31	7	14.12	47	n/a	n/a	0
SETÚBAL	22	10	0	3	19	8	0	2	34	n/a	n/a	0
V. CASTELO	46	17	0	0	57	23	0	0	n/a	n/a	n/a	
VILA REAL	56	19	0	0	53	23	0	0	n/a	n/a	n/a	
Total	1200	435	9	27.435	1124	401	45	59.42	339	n/a	n/a	27.3

As observed in Table 4.2, there was an enormous effort to control illegal fishing for glass eels, especially during the years following the delivery of the EMP.

SEPNA has among other competences, the obligation to monitor the illegal activities of fishing and can act on land. However, another special unit from GNR, the UCC acting close to the coast, obtained the results presented in Table 4.3 for the fishing season 2010/2011.

Table 4.3. Number of nets and weight of glass eels confiscated between 1st October (2010) and 31st July (2011) (Source: UCC- GNR).

	Kg	Nets
Lisboa	2.53	28
Figueira da Foz	98.71	94
Matosinhos	163.7	10
Total	264.94	132

The effort to control poaching of glass eels has been developed both by SEPNA and DGAM (Maritime police) as can be observed in Table 4.4.

Table 4.4. Number of fishing gears confiscated by the Maritime Police during the fishing seasons 2006/2007 to 2011/12 (Source: DGAM).

FISHING SEASONS			2006/07	2007/08	2008/09	2009/10	2010/11	2011/12
Nr. of operations			n/a	86	86	86	237	123
CONFISCATION		Nr. of fishing gears	310	729	521	492	707	302
		Glass eels (Kg)	198,40	67.25	54,5	21,15	55,98	166,55
MEANS	MEN	Nr. of men	297	372	471	387	841	494
	EQUIPMENT	Nr of Cars	92	121	106	136	127	126
		Nr of Boats	52	80	68	69	156	94

4.2 Yellow eel

Fishing capacity in inland waters is not known, and under the present legislation it is not possible to estimate the number of fishermen and eel fishing gears they owe/use. Professional and recreational fishermen must obtain a licence issued by AFN to fish in these waters but they are not obliged to report their catches. Licences for recreational fishery can be national or regional (North, Centre, South) and fishermen can fish where they choose to according to the type of fishing licence. Professional fishery is ruled by nine byelaws, which define the river stretches where fishermen are allowed to fish, and lay down the rules to fish (gears and mesh sizes, size limit of species, hour restrictions and species restriction).

The number of specific eel fishing licences issued by DGPA for local fishery in estuarine and coastal waters, grouped by gear type and RBD, is listed in Table 4.4. These licences are linked to fishing boats, together with other licences that are used for other species. The same fishing boat can be licensed to fish with more than one type of fishing gear. In some areas within the DGPA jurisdiction, there is a policy on maximum number of fishing gears permitted by licence. That does not imply fishermen use them all, but the number they use is unknown. The type, number and characteristics of eel fishing gears vary according to fishing area. There are eleven specific byelaws that set the rules for eleven fishing areas. However, for certain areas and/or fishing gears there is no restriction on the number permitted for each licence. These different rules and the lack of record on the actual number of fishing gears fishermen use, contribute as extra difficulties to estimate fishing capacity.

Table 4.4 presents a list of the number of licences issued by DGPA but to convert this to fishing capacity is impossible, as there is no record of the number of gears per type of fishing gear, and the maximum number of nets permitted by boat varies according to the fishing area. It should be noted that longlines directed to catch demersal fish species can be operated for several species and therefore, the number of licences issued may not reflect a real pressure on the eel stock, but has to be considered as potential fishery usage.

Table 4.4. Number of licences issued by DGPA to use eel fishing gears in transitional waters and coastal lagoons, 1998 to 2010 (Source: DGPA). * It only includes River Lima. Data from River Minho are not available.

River basin district	Fishing gear	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
RBD1*	Longline	3	3	3	3	3	4	5	5	6	7	7	1	2
	Fishing rod	5	5	4	3	3	3	3	3	3	4	4	3	4
RBD2	Longline	2	2	2	1	1	1	1	1	1	1	1	0	0
	Fishing rod	1	1	1	1	1	1	1	1	1	1	1	1	1
RBD3	Fykenet	1	2	2	2	2	2	1	1	1	1	1	0	0
	Sniggle	4	5	5	5	3	3	2	2	2	2	2	1	1
	Longline	58	57	56	51	42	42	43	43	45	42	42	24	24
	Fishing rod	0	0	0	0	1	1	1	1	1	10	20	29	34
RBD4	Fykenet	229	234	222	225	227	233	231	230	209	195	191	121	112
	Beach-seine	292	290	280	280	277	278	269	251	229	215	202	127	116
	Sniggle	206	208	205	206	205	209	206	215	209	202	197	123	119
	Longline	417	419	415	412	419	422	427	445	439	411	425	357	361
	Fishing rod	45	46	47	48	48	52	65	86	100	207	259	312	324
RBD5	Fykenet	119	113	113	122	114	123	122	110	113	103	101	86	81
	Longline	391	371	356	357	338	362	380	362	367	350	356	276	258
	Fishing rod	0	0	0	0	0	0	0	0	17	35	55	62	77
RBD6	Longline	160	158	154	146	139	139	132	129	128	122	123	37	38
	Fishing rod	0	0	0	0	0	0	0	0	0	4	11	22	26
RBD7	Longline	20	53	52	56	57	57	54	53	51	50	51	34	34
	Fishing rod	0	0	0	0	0	0	0	0	0	0	1	2	3
RBD8	Longline	70	66	63	62	65	66	74	80	92	90	93	67	68
	Fishing rod	1	1	1	1	1	4	8	16	25	25	38	41	44

The use of fykenets in the River Minho was banned by Decree 8/2008 (April 9th) and its application started on the fishing season 2008/2009. However, longlines are still permitted in the international part of the river (80 km) and eels are caught as bycatch of other fisheries.

4.3 Silver eel

Not applicable because there is not a fishery for silver eels.

4.4 Marine fishery

Not applicable. In coastal waters, eels are caught in estuaries and coastal lagoons, but there is not a fishery for eels in marine habitats.

5 Fishing effort

Fishing effort is not recorded in the Portuguese eel fishery.

There is a variety of fishing gears that are used to catch yellow eels, namely fykenets, sniggle, fishing rods, longlines and beach-seine nets. Longlines were included in Table 4.3 because despite being selective fishing gears mostly directed to catch demersal fish species, they can occasionally be used to catch eels.

In coastal areas, these are licensed and linked to boats, but their use by fishermen (number of fishing sessions and number of fishing gears used) is unknown. There is no registration of number of fishing gears per licence, although maximum number per fishing area is set by law. The boats used in local fisheries within the jurisdiction of DGPA (estuaries and coastal waters) are small (less than 9 m long) and they are not obliged to keep logbooks. Landings are obligatory but the only information that is kept is the name of the boat and total catches per species, without any record about type and/or number of gears used.

Having the jurisdiction of inland waters AFN introduced, in 2012, the obligation to report catches in seven of the nine ZPPs (Professional fishing zones) established in inland waters.

5.1 Glass eel

No available data.

5.2 Yellow eel

No available data.

5.3 Silver eel

No applicable. No fishery directed towards catching silver eels.

5.4 Marine fishery

Not applicable. There is no marine fishery for eels.

6 Catches and landings

6.1 Glass eel

Fishermen have always been obliged to report their total annual catches to local authorities. Official fishery statistics have been kept by the responsible local Authority – *Capitania do Porto de Caminha*. Total annual statistics have been recorded since 1974, and as observed in Figure 6.1 there were three periods in landings. Following a decline after 1986, there was a period of medium landings and a final decline was registered after 1999. Since 2000, total landings have remained in quite low levels, corresponding to less than 1.5 tons per year, with the exception of 2005, when catches were slightly higher.

In fishing season 2010/2011 a new regulation entered into force obliging fishermen to fill in a logbook and report their catches every three months and the regulation for fishing season 2011/2012 obliged fishermen to report their catches on a monthly basis.

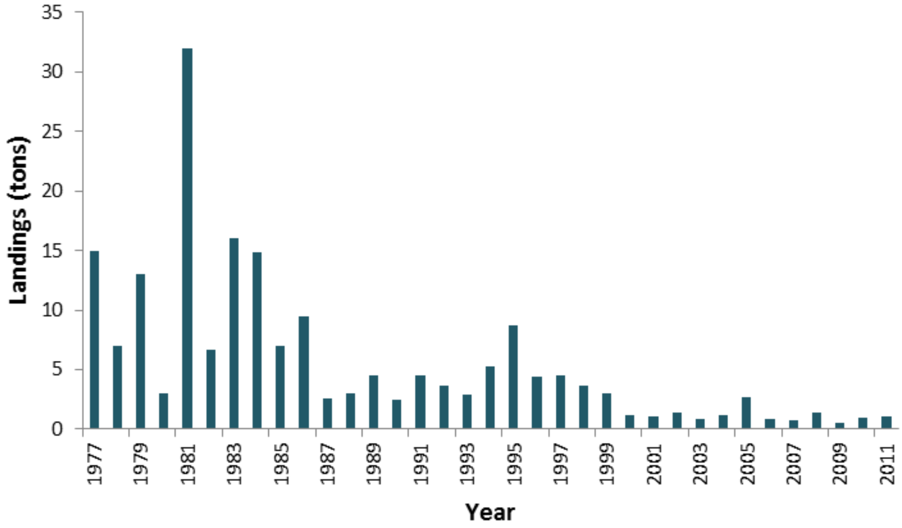


Figure 6.1. Annual landings of glass eel fishery in the Portuguese part of the River Minho, 1974 to 2011 (Source: Capitania do Porto de Caminha).

6.2 Yellow eel

There are no landings in inland waters and fishermen will be for the first time, this year, obliged to declare their catches in some ZPPs. Therefore, at present the only information on eel landings is provided by coastal fishery.

There is not a separation between silver eels or yellow eels, although silver eels are seldom caught by fishermen. Hence, landings from coastal fisheries (estuaries and coastal lagoons), presented in Figure 6.2, are mostly from yellow eels.

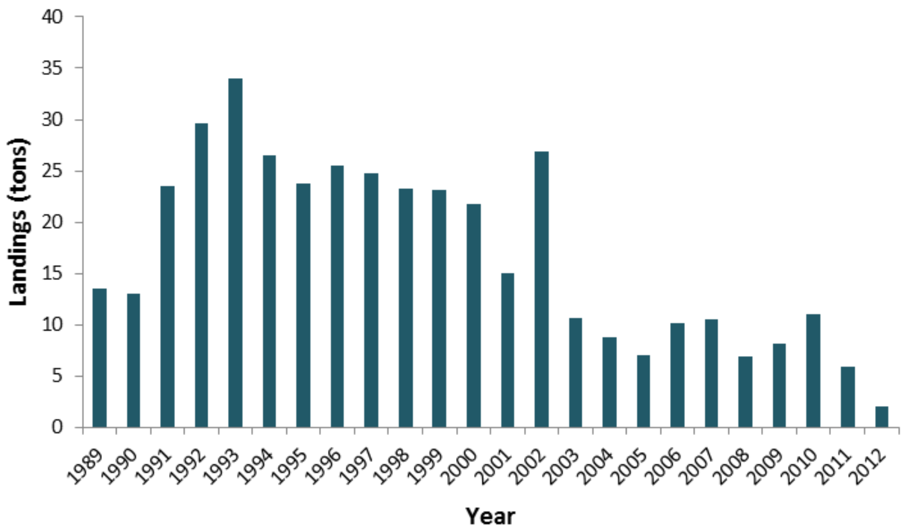


Figure 6.2. Total annual landings of yellow eel fishery in coastal waters (estuaries and coastal lagoons), 1989 to 2012 (Source: DGPA). (Data for 2012 include only seven months).

As shown in Figure 6.2, there was a decline in catches after 2000 which, despite a peak in 2002, has continued until today. However, it should be noted that a ban of three months (October, November and December), implemented in 2010 (Portaria nº

928/2010, from 20 September), might account for the decline observed in 2011. The changes if fishery regulations, derived from the implementation of the EMP, add as extra difficulties to evaluate the trend on the stock, based on landings.

The importance of eel landings varies across the country, as can be seen in Table 6.1. The highest landings were however, registered in RBD5 where 236.2 tons were landed between 1989 and 2012. RBD5 includes the Tagus estuary, undoubtedly the most important fishing area. The lowest landings occurred in RBD6 and RBD7. The catches of eels in Portugal are not enough to supply the needs as can be seen in Tables 6.2 and 6.3.

Table 6.1. Annual landings of yellow eel fishery in coastal waters (estuaries and coastal lagoons), by River Basin District and total, 1989 to 2012 (Source: DGPA and Capitania do Porto de Caminha).

	LANDINGS (Kg)								
YEAR	RBD1	RBD2	RBD3	RBD4	RBD5	RBD6	RBD7	RBD8	TOTAL
1989	3885	768	821	173	6311	306	84	1184	13 532
1990	2598	1081	721	1442	5720	300	128	1011	13 000
1991	3754	612	940	1410	12 371	3024	43	1331	23 486
1992	3675	878	1434	918	18 814	2163	256	1527	29 665
1993	5676	1173	1692	1232	20 767	830	604	1969	33 943
1994	1435	1765	1117	1029	18 215	801	401	1790	26 553
1995	1957	1499	863	3953	13 007	501	409	1520	23 706
1996	1472	2228	662	3177	16 210	378	301	1139	25 566
1997	1476	2099	662	2776	15 349	1007	342	997	24 707
1998	1981	767	1201	2752	15 429	81	421	646	23 277
1999	810	897	2137	2223	15 734	70	728	545	23 143
2000	898	641	1431	2667	15 598	18	221	299	21 772
2001	404	112	775	1517	12 095	1	57	43	15 003
2002	784	163	1226	3039	21 501	3	28	121	26 863
2003	1095	889	717	3174	4646	54	8	47	10 630
2004	1036	986	428	3254	3028	16		100	8848
2005	1281	1235	397	1612	2418	1	4	74	7022
2006	1970	1218	361	3382	2976	221	2	1	10 131
2007	2591	825	150	3953	2859	127	2	5	10 512
2008	1200	1150	345	1913	2333	0	6	7	6954
2009	1269	1175	333	1968	3363	2	0	59	8169
2010	2430	934	496	2706	4422	3	16	24	11 031
2011	1432	310	61	1606	2457	0	0	0	5889
2012(*)	554	33	95	797	552	0	0	0	2036

(*) Data for 2012, include the first seven months of the year.

The commercial circuit of importation (Table 6.2) and exportation (Table 6.3) shows that Portugal is in deficit of eels to supply the internal market as the amount imported largely exceeds the amount exported.

Table 6.2. Importation of eels: live; frozen; and fresh and refrigerated fish, 2009–2011 (Data from 2010 and 2011 are preliminary) (Source: INE).

	LIVE EELS		FROZEN EELS		FRESH & REFRIGERATED EELS	
Year	Origin	kg	Origin	kg	Origin	kg
2009	USA	30 010	CA	24 255	ES	70 013
	ES	31 538	USA	19 800		
	FR	37 881	ES	10 200		
			FR	47 523		
			NL	59 284		
Total		99 429		161 062		70 013
2010	CA	2987	USA	19 758	ES	55 921
	USA	21 600	ES	4790		
	ES	46 710	FR	11 412		
	FR	50 987				
	NL	790				
Total		123 074		35 960		55 921
2011	CA	1200	USA	19 755	ES	9560
	USA	21 580	ES	140		
	ES	36 977	FR	3860		
	FR	41 156				
	NL	3155				
Total		104 068		23 755		9560

Table 6.3. Exportation of eels: live; frozen; and fresh and refrigerated fish, 2009–2011 (Data from 2010 and 2011 are preliminary) (Source: INE).

	LIVE EELS		FROZEN EELS		FRESH & REFRIGERATED EELS	
Year	Destination	kg	Destination	kg	Destination	kg
2009	USA	5	FR	1	CA	12
	ES	5516		1	ES	59
	FR	439				
Total		5960		2		71
2010	USA	45	ES	72	CA	57
	DK	135	FR	10	ES	172
	ES	10 914				
Total		11 094		82		229
2011	USA	54	ES	549	CA	116
	ES	297	FR	1	ES	147
Total		351		550		263

The possible trade of glass eels in the data (they are not discriminated by the authorities in Portugal as it is done by Eurostat) may lead to a wrong interpretation when weight is analysed, when looking at the amount of frozen eels, which cannot be glass eels because they have not the same value or interest as when live, it is clear that the importation (221 tons) is much higher than exportation (634 kg). Additionally it is relevant to note that based on the origin of importation, and assuming European eels are not travelling to the American continent to come back to Europe, there is a trade of American eel to supply the internal market.

6.3 Silver eel

No available data as there is no distinction between yellow and silver eels.

6.4 Marine fishery

Marine fisheries are not directed to catch eels.

7 Catch per unit of effort

7.1 Glass eel

No available data.

Cpues could not be estimated because fishermen reported total catches for the entire fishing season and they were not obliged to keep a record on fishing intensity. With the implementation of the logbooks for glass eel fishery in River Minho, this information might become available for the future on a regular basis.

However, based on data obtained by IPIMAR from logbooks distributed to five fishermen who volunteered to cooperate, during the fishing season 2011/2012 the average cpue/gear/night was 627 g (5–6 days/New Moon).

7.2 Yellow eel

No available data. Cpue cannot be estimated because the number of eel fishing gears used per fishing licence is not recorded.

During a Pilot project under the DCF, IPIMAR distributed logbooks to four volunteer fishermen from Óbidos Lagoon and obtained a cpue varying from 0.112 eels/fykenet/day to 0.233, whereas in the Aveiro Lagoon the cpue varied between 0.343 and 0.485 eels/fykenet/day (two fishermen). IPIMAR is trying to establish records of catches based on data reported voluntarily by fishermen and in 2012 logbooks were distributed to ten fishermen in Óbidos Lagoon. Preliminary data show very low catches (0.06 eels/fykenet/day) in comparison with the results mentioned above. This fact might not be related to low abundance of eels but with disturbances in hydrodynamics at the interior of the Lagoon, with high currents and significant variations in the height of the water column, that negatively affects gear efficiencies. These changes were caused by human interventions in the connection between the Lagoon and the sea to improve the conditions offered to tourists in that area.

7.3 Silver eel

Not applicable. There is no fishery for silver eels.

7.4 Marine fishery

Not applicable. There is not an eel fishery in marine waters.

8 Other anthropogenic impacts

Anthropogenic impacts identified in the eel management plan were mainly related to fisheries. Although turbine activity is usually a major mortality factor especially for silver eels, in Portugal there is no passage for eels in the dams, which implies there is no mortality associated with turbines.

9 Scientific surveys of the stock

9.1 Recruitment surveys for glass eel

Experimental glass eel fishery in the Minho River was initiated in 1981, supported by grants and projects, and conducted for several purposes, with no fixed sampling sites in general (Weber, 1986; Antunes and Weber, 1990, 1993; Antunes, 1994a,b). Occasional studies in Lis River, Mondego River, Guadiana River and Lima River were conducted for short periods (Jorge and Sobral, 1989; Jorge *et al.*, 1990; Domingos, 1992; Bessa, 1992; Bessa and Castro, 1994, 1995; Domingos, 2003). Generally the information available from scientific studies includes fishing time, yield, bycatch, biometric parameters, pigmentation, relation with moon's phase and time of the year.

9.2 Stock surveys for yellow eel

No available data, as there are no current surveys of yellow eels.

9.3 Stock surveys for silver eel

No available data, as there are no current surveys of silver eels.

10 Catch composition by age and length

Commercial catch is reported as weight and there is no established sampling to collect data on age and length for the European eel in Portugal. However, IPIMAR has been collecting that information under the Data Collection Framework in the Aveiro Lagoon and in Óbidos Lagoon. Data on age have not been made available so far.

Length–frequency distribution of eels from commercial catches using fykenets both in the Óbidos Lagoon and in the Aveiro Lagoon is presented in Figure 10.1.

As shown in Figure 10.1 part of the catches are under the minimum legal size, *i.e.* 22 cm. Differences in the population structure are a consequence of differences in the mesh size of the fykenets used in both systems, which is smaller in the Aveiro Lagoon. Additionally, as observed in Table 10.1 some of the catches from the Aveiro Lagoon include silver eels, contrary to the Óbidos Lagoon where only one silver eels was caught.

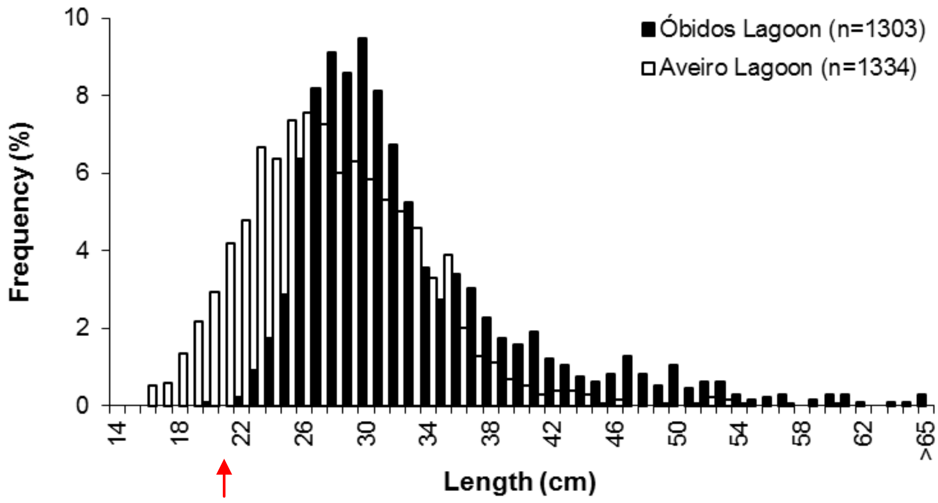


Figure 10.1. Percentage length–frequency distribution of eels sampled from commercial catches in the Óbidos Lagoon (n=1303) and Aveiro Lagoon (n=1319). ↑ Minimum legal size (22 cm).

Length and weight composition of commercial catches from Óbidos Lagoon and Aveiro Lagoon is presented in Table 10.1.

Table 10.1. Length and weight composition of commercial catches sampled in the Óbidos Lagoon and in the Aveiro Lagoon (Mean, maximum and minimum values).

Month	TL (mm)			TW(g)		
	Max	Min	Mean±sd	Max	Min	Mean±sd
Óbidos Lagoon	772	203	340.1 ± 77.3	986	14	75.0 ± 74.2
Aveiro Lagoon	535	160	279.8 ± 57.9	319	6	41.3 ± 31.4
Aveiro Lagoon (Silver eels)	443	298	352.2 ± 31.9	150	41	82.0 ± 22.9

In the River Minho, the capture of eels by electric fishing showed that 45.8% of the eels belong to the length class of 30–45 cm while only 8.7% are longer than 45 cm (Figure 10.2) (River Minho EMP).

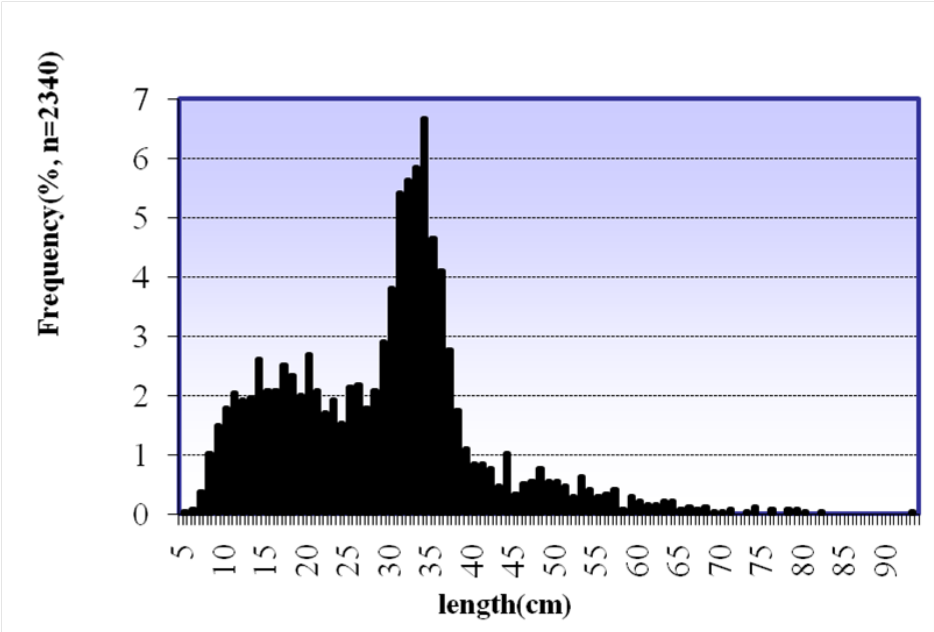


Figure 10.2. Length class distribution of the eels captured in the River Minho tributaries. Class interval=2 cm.

11 Other biological sampling

There was no routine programme to sample eels, except for a Pilot project under the Data Collection Framework, which started in 2009 and lasted for one year. The areas studied included two brackish water systems (Óbidos Lagoon and Aveiro Lagoon).

10.1 Length and weight and growth (DCF)

Results of eel growth under the DCF are not yet available. The length–weight relation for eel catches in Ria de Aveiro and Lagoa de Óbidos is given in Figures 11.1 and 11.2 respectively. Significant differences are depicted in the two relations, with eels from Ria de Aveiro being almost 10% heavier for a given size.

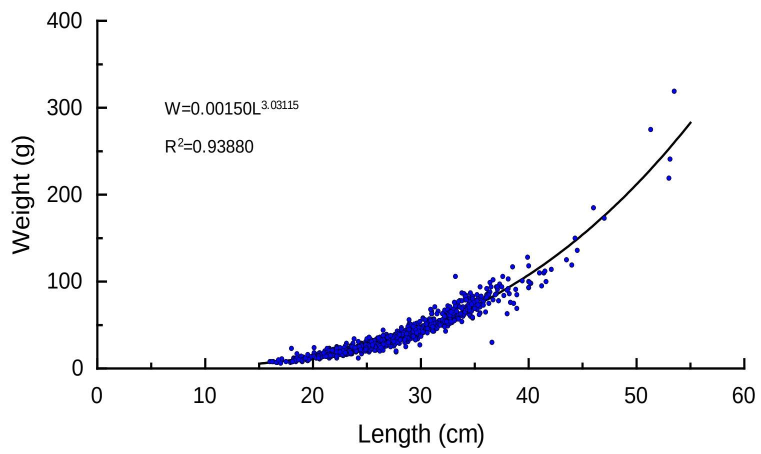


Figure 11.1. Length–weight relation of eels sampled from the the Aveiro Lagoon (n=830) between 2009 and 2010 (Source: DCF Report).

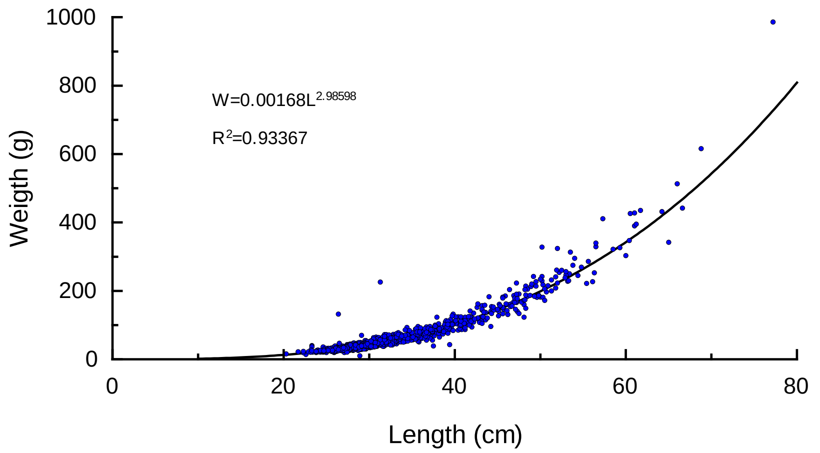


Figure 11.2. Length–weight relation of European eels sampled from Óbidos Lagoon (n=1222) between 2009 and 2010 (Source: DCF Report).

11.2 Parasites and pathogens

There is not a national programme to monitor parasites or pathogens. *Anguillicoloides crassus* is however probably spread throughout the country.

In a study conducted in 2008 in five brackish water systems (Aveiro Lagoon, Óbidos lagoon, Tagus estuary, Santo André Lagoon and Mira estuary) it was concluded that *A. crassus* was spread in all the surveyed systems except in Óbidos lagoon, which was probably related to the higher salinity observed in this lagoon, similarly to what happens in one sampling site (Barreiro) (Neto *et al*., 2010) located in the lower part of the Tagus estuary. Prevalence values ranged from 0 to 100% and intensity values ranging from 0.4 to 5.8 (unpublished data). More recently, within the DCF programme, the parasite was found in the swimbladder of seven among the 404 eels examined for the Óbidos Lagoon. The low prevalence found (1.73%) reinforces the idea that the infection rate is very low in areas with higher salinity, as it is the case in this lagoon. The presence of the parasite had already been reported for the River Minho (Antunes, 1999) and River Mondego (Domingos, 2003), which suggests the parasite is probably widespread in Portugal. The map shows the locations where this parasite has been reported so far.

River Minho

Aveiro Lagoon

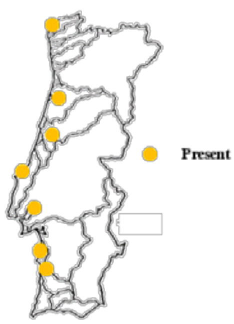
River Mondego

Óbidos Lagoon

River Tagus

Santo André Lagoon

River Mira



11.3 Contaminants

Samples of eels caught from five brackish water systems (Aveiro Lagoon, Óbidos Lagoon, Tagus estuary, Santo André Lagoon and Mira estuary), were analysed for some trace metals (Hg, PB, Zn, Cu, Cd) revealing low contamination loads when compared to their European congeners (Passos, 2008; Neto, 2008; Neto *et al.*, 2011a). The most contaminated eels were obtained from the Tagus estuary. However, in this estuary no clear relationships could be established between contaminant concentrations in eel tissues (liver and muscle) and in sediment, probably because of the general heterogeneity in environmental conditions (Neto *et al.*, 2011b).

A comparative study about the effects of pollution on glass and yellow eels from the estuaries of Minho, Lima and Douro rivers was developed by Gravato *et al.* (2010). Fulton condition index and several biomarkers indicated that eels from polluted estuaries showed a poorer health status than those from a reference estuary, and adverse effects became more pronounced after spending several years in polluted estuaries.

11.4 Predators

No new data on predators was available for 2011. However, some information is available for previous years.

Apart from the fish species Lusitanian toadfish (*Halobatrachus didactylus*) that can predate on eels (Costa *et al.*, 2008) and the European eel, which can display cannibalistic behaviour (Domingos *et al.*, 2006), the main predators of eels in Portuguese aquatic systems include the great cormorant, *Phalacrocorax carbo*, and the European otter, *Lutra lutra*. The eel is present in the diet of otters and cormorants throughout the year, but they become more important in spring and summer when the water level is lower (Trigo, 1994; Cerqueira, 2005; Dias, 2007). The impact of predation on the eel population is unknown but eels represented 25.4% of the diet of otters from Ria Formosa (Cerqueira, 2005), a shallow coastal lagoon, located in the south of the country, and 7% of the diet of cormorants from Minho estuary (Dias, 2007). The real impact of this predation on the eel stock in Portuguese waters is unknown, despite the increase in the population of the great cormorant and the European otter in recent years.

12 Other sampling

No other sampling data was available.

13 Stock assessment

13.1 Local stock assessment

There is no stock assessment.

11.2 International stock assessment

11.2.1 Habitat

Eels inhabit all types of habitats, although in some catchments extensive areas have become inaccessible, due to the presence of obstacles lacking fish passages or where fish passages, despite present, are inefficient. Estuarine areas are important and represent a high portion of habitat with complete free access, as there are no dams in tidal areas. The estimated wetted area of free access for the eel is clearly dominated by transitional and coastal habitats in all river basin districts (RBD), except for RH2 (Table 13.1). Total riverine habitat is 43 757 ha, whereas 91 730.2 ha, include transitional and coastal areas. Total wetted area accessible for production is therefore 135 487 ha.

Table 13.1. Estimated total wetted areas (ha) for each river basin district (RBD) accessible for the eel. Riverine habitat is separated from coastal and transitional waters.

RBD	Riverine	Coastal & Transitional waters	TOTAL
RH1	7769	3898.5	11 667
RH2	1742	744.0	2486
RH3	2308	830.8	3139
RH4	4165	13 811.5	17 976
RH5	20 486	36 911.0	57 397
RH6	1489	21 919.4	23 409
RH7	5297	3579.4	8877
RH8	501	10 035.5	10 536
Total	43 757	91 730.2	135 487

13.2.2 Silver eel production

The estimates of silver eel production presented in the revised version of the Portuguese EMP and in this section are simply exploratory and require validation, which is intended to be improved as data on the population is obtained.

13.2.2.1 Historic production

In the absence of data on historic production of silver eels in Portugal it was necessary to make some extrapolations and use information from other countries to estimate this parameter.

The way historic production was calculated is presented in the revised version of the Portuguese EMP (April 2010). The pristine production estimated varied between 47.2 kg/ha and 15.7 kg/ha, assuming that actual escapement varies between 10% and 30% of historical levels based on information obtained from the *Plan de Gestion Anguille de la France- Volet National*.

13.2.2.2 Current production

The methodology used to estimate current silver eel production is presented in the revised version of the Portuguese EMP (April 2010). Lack of data concerning silver eel estimates, requires the use of alternative approaches to meet the demands of Council Regulation 1100/2007 (ICES, 2008). Hence, yellow eel proxies were used to determine silver eel production.

The density of yellow eels was based on data from France (Rhône-Mediterranée http://www.onema.fr/IMG/paf/PAF-rhonemediter) because data from our neighbouring country were not available. The production was then calculated considering the wetted area up to the first obstacle to migration. A distinction between brackish water and freshwater systems was included in those estimates, which resulted in mean values for brackish water systems and riverine habitats in each river basin. A mean value for riverine and brackish water systems was then obtained for each river basin.

Assuming that 5% of yellow eels become silver (Plan de Gestion Anguille de la France – Volet National) and that the mean weight for silver eels in Portugal is 71 g

(Mondego and Tagus rivers, unpublished data) the current production of silver eels in Portugal is 640 tons at the national level, with differences among river basins as shown in Table 13.2.

Table 13.2. Current production ($B_{current}$) of silver eels from Portuguese River Basin Districts (RBD). Data reported in the revised version of the Portuguese EMP or estimated from there.

RBD	Total production (ton)	Relative production kg/ha
RH1	38	3.3
RH2	9	3.6
RH3	11	3.5
RH4	95	5.3
RH5	254	4.4
RH6	138	5.9
RH7	30	3.4
RH8	64	6.1
Total	639	4.7

In the River Minho EMP the silver eel production was estimated considering the wetted area up to the first dam (wetted area=1678,88 ha) resulting in a value of 5,52 Kg/ha.

13.2.2.3 Current escapement

The actual current escapement from the Portuguese river basins is not known. However, given the reduced impact of fisheries on the stock (8 tons reported in landings compared to the 640 tons estimated for production) and the null influence of hydropower installations on escapement (hydropower dams are impassable barriers to migration), it is presumed that escapement is very close to production estimates. Additionally, silver eels are seldom caught in fisheries reducing the direct impact on silver eels. It should however, be mentioned that reported fisheries include only brackish water systems.

For the River Minho, the estimated percentage of escapement of silver eels was 25.41%, representing 9268 kg (River Minho EMP).

13.2.2.4 Production values e.g. kg/ha

Production values are presented in Table 13.2 (see Section 13.2.2.2.). They vary between 3.3 kg/ha and 6.1 kg/ha across the RBDs and the mean value, at the national level, is 4.7 kg/ha.

13.2.2.5 Impacts

No available data. The impacts of anthropogenic activities on the stock namely, poaching of glass eels, contaminants, parasitism and dams were identified in the EMP, but not quantified. As written in the last version of the Portuguese EMP (April 2010), these data will be obtained in the near future.

An inventory of natural and artificial obstacles present in the tributaries of the international area of the River Minho was made for the project NATURA-Minho: *Levantamento do habitat fluvial, os habitats de interesse comunitário, avaliação dos recursos* *migradores e ordenamento do seu aproveitamento no baixo Minho*". These results are presented in Figure 13.1.

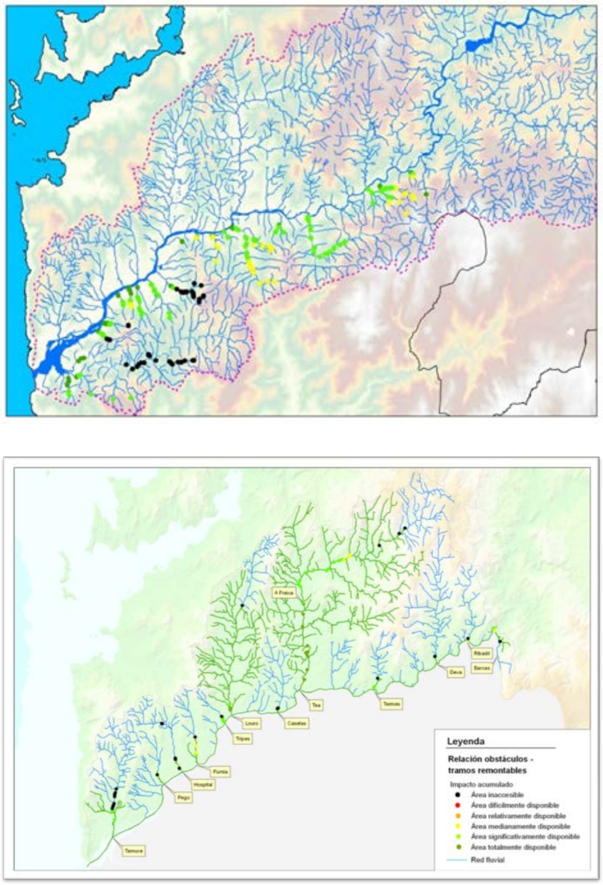


Figure 13.1. Obstacles in the tributaries of the international River Minho, before the first dam (80 Km from the river mouth). Black dots represent impassable obstacles for fish (River Minho EMP).

13.2.3 Stocking requirement eels <20 cm

The Portuguese EMP does not include a programme of stocking in the measures proposed to recover the population. The same applies to the River Minho because actual recruitment is considered above the carrying capacity of available habitat in the international section of the River Minho (River Minho EMP).

13.2.4 Summary data on glass eel

The quantity of glass eels caught in the commercial fishery from the River Minho is presented in Table 13.3.

The destination of these glass eels is probably Spain because glass eels are not eaten in Portugal or used for any other purpose, and fishermen usually sell them to the neighbour country. Despite having no information on sales (amount and buyer), it is assumed that all glass eel catches have been sold to Spain, which means they can be used for stocking elsewhere. Their final use is however, unknown.

Table 13.3. Quantity (kg) of glass eels caught in the River Minho between 2009 and 2011.

YEAR	QUANTITY (kg)
2009	576.10
2010	947.25
2011	1085

13.2.5 Data quality issues

No information.

14 Sampling intensity and precision

There is no consistent sampling design employed in Portugal.

15 Standardisation and harmonisation of methodology

There are no protocols applied in Portugal to sample eels. In fact, so far, eels have not been sampled from commercial catches. The methodologies used in scientific studies, have varied according to author, sampling site and objectives of the work.

15.1 Survey techniques

Electric fishing has been the method used in eel surveys in freshwater habitats, which has been conducted either from the river banks, in large and deep river stretches, or across the river stretch when water level is low (Costa, 1989; Domingos, 2003). In estuaries and coastal lagoons, fykenets or beam trawls have been the sampling methods most used (Costa, 1989; Domingos, 2003; Gordo and Jorge, 1991). A stownet has been used in most of the glass eel surveys.

15.2 Sampling commercial catches

Eel sampling is part of the routine sampling of DCF.

Glass eel monitoring will be conducted through the project "Pilot study for glass eel (*Anguilla anguilla*) 2011–2013", which was also proposed within the DCF Framework. The objective is to establish monitoring sites for recruitment, related to the commercial fisheries in the River Minho and to a fishery-independent dataseries from the 1990s in the River Lis.

15.3 Sampling

Sampling of eel follows the legal requirements to deal with animals, implying that to sacrifice them it is necessary to kill them by an overdose of anaesthetic.

15.4 Age analysis

In studies of eel age which have been conducted in Portugal, *sagitta* otoliths have been removed, cleaned with water, stored dry, and cleared in 70% alcohol (Vollestad, 1985) for 24 hours before being examined under a stereoscope microscope. The otoliths were read by more than one person (Gordo and Jorge, 1991), or by the same person who read them twice (Costa, 1989; Domingos, 2003). In the lack of agreement between both readings, a third reading was performed and if inconsistent, otoliths were excluded from analyses.

INRB/IPIMAR will follow the recommendations of the ICES Workshop on Eel Age WKAREA 2009.

15.5 Life stages

Pigmentation stages of glass eels analysed in some studies were determined according to Elie *et al*. (1982) by Casimiro (1988) and Antunes (1994b). In a study conducted in the River Mondego, silver eels were identified by Domingos (2003) based on the eye index, colour of back and belly, colour of pectoral fins and state of lateral line according to Pankhurst (1982).

In the River Minho some differences were obtained when comparing the classification of silver eels based on the criteria established by Pankhurst (1982) or Durif *et al*. (2005) (River Minho EMP).

15.6 Sex determinations

In Portugal, the determination of sex in scientific studies has been performed by dissection and macroscopic analysis of gonads or under a dissecting microscope, for smaller individuals (Costa, 1989; Domingos, 2003; Neto, 2008; Passos, 2008). More recently, Quintella *et al*. (2010) have sexed silver eels by length, to avoid sacrificing animals, considering eels larger than 45 cm as females.

INRB/IPIMAR is determining sex by macroscopic analysis under the Data Collection Framework.

16 Overview, conclusions and recommendations

Portugal has delivered two EMPs to comply with the needs set by the Eel Regulation 1100/2007. One of those plans was established at the national level for the entire country, and the other one was the transboundary EMP for the international part of the River Minho. This latter was produced by the Portuguese and Spanish authorities, sent to the European Commission at the beginning of 2011 (after a reduction of 50% in fishing effort), revised in November, the same year and only recently approved (May 2012).

The Portuguese EMP was approved by the European Commission on the 5th April 2011, following the delivery of the last revised version on the 19th November 2010. The lack of information on the eel stock in Portuguese waters has been responsible for the delay in its approval.

Some management actions included in the Portuguese EMP have already started. Most of them concentrated on reducing the fishery.

The implementation of a programme to collect data on the eel stock in Portuguese waters, that was considered a priority during the development of the Portuguese EMP, was set in the plan as one of the measures to cope with the need to measure the effectiveness and outcomes of management actions, in line with Article 9 of the Eel Regulation 1100/2007. This programme has not commenced so far.

Portugal submitted a national progress report with regard to the implementation of the Portuguese EMP in June 2012. This report included a list of measures that have been implemented. However, there was no data to make an assessment of the stock.

It is therefore, strongly recommended that the programme to collect data on the stock starts the earliest possible, to comply with the needs set by Article 9.

17 Literature references

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Report on the eel stock and fishery in Spain 2010/2011

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Reporting Period: This report was completed in September 2012, and contains data up to 2011 and some provisional data for 2012.

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2 Introduction

2.1 Spanish EMUs

Spanish River Basin Districts (RBDs), charged of the design of the hydrological plan and the management of continental waters, were defined after the approval of the Royal Decree 125/2007 by which the territorial limits of the RBDs were fixed (Figure 1).

All the territory of the RBDs of Guadalquivir, Galicia Costa, Basque Country Inner basins, Catalonia Inner basins, Canary Islands basins, Balearic Islands basins and Atlantic and Mediterranean basins of Andalucía belongs to a single autonomous region (Figure 2) and are managed by the autonomous region they belong to. On the contrary, Segura, Júcar, Miño-Sil, Cantábrico, Duero, Tajo, Guadiana, Ebro and Guadalquivir RBDs extend over different autonomous regions and are managed by the Spanish Ministry of the Environment and Rural and Marine Affairs (MARM) through eight hydrographical confederations. Additionally, the Miño, Duero, Tajo and Guadiana RBDs are shared with Portugal, whereas the Ebro RBD is shared with France.

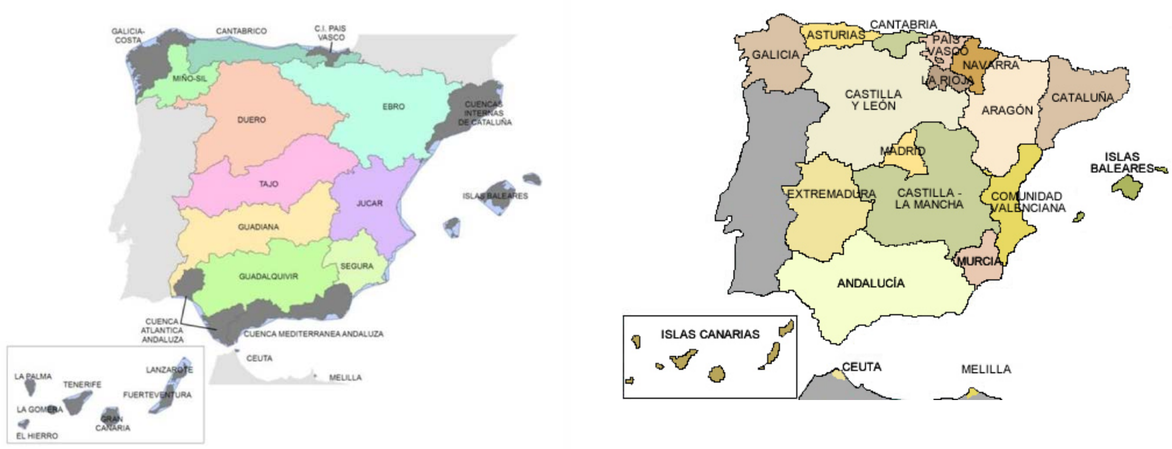


Figure 1. RDBs and autonomous regions of Spain.

The main characteristics of the River basins included in this report are:

Autonomy	RBD	River Basin	Latitude	Longitude	Drainage area (km²)	River length (km)
Basque	B. Inner	Bidasoa	43º19'	1º58'W	700	69
	B. Inner	Oria	43º16'	2º06'W	882	77
	B. Inner	Urola	43º17'	2º14'W	342	65
	B. Inner	Deba	43º19'	2º26'W	530	60
	B. Inner	Artibai	43º21'	2º29'W	104	26
	B. Inner	Lea	43º22'	2º35'W	99	26
	B. Inner	Oka	43º21'	2º40'W	183	27
	B. Inner	Butrón	43º23'	2º56'W	172	44
	B. Inner	N. Ibaizabal	43º19'	3º00'W	1798	72
	B. Inner	Barbadun	43º17'	3º07'W	128	27
Asturias	Cantábrico	Nalón	48º17'	5º23'W	4866	142
Galicia	G. Coast	Ferrol	43º27'	8º08'W	27	17
	G. Coast	Eo	43º4'	7º05'W	819	78
	G. Coast	Vigo	42º09'	8º36'W	176	33
	G. Coast	Pontevedra	42º15'	8º41'W	145	23
	G. Coast	Arousa	42º26'	8º46'W	230	33
	Miño	Miño	41º5'	8º52'W	9775	308
Murcia	Segura	Mar menor	37º 41 N	00º 50' W	170	
Valencia	Jucar	Albufera lagoon	39º22'	0º18' E	738	
	Segura	El Hondo lagoon	38º11N	0º46'W	23.9	
	Segura	Santa Pola	38º11N	0º37'W	25.0	
Catalonia	Ebro	Ebro	40ª41′	0º44′E	85 362	910
	C. Inner	Muga	42º14,2′	3º7,6E	758	
		Fluvià	42º12,2′	3º6,7E	974	
		Ter	42º1,4′	3º11,7′E	2955	

2.2 Review of the main regional characteristics of the eel fishery in Spain

The autonomous regions are in charge of the management of the fishery in inner waters (including coastal waters). This causes great differences among the autonomous regions:

- The amplitude of the historical dataseries is variable among the autonomous regions, depending on the date in which the regulation of each autonomous region was issued.
- In some of the autonomous regions, the same regulation is applied to all the River basins while in others, each basin or even a particular zone within the same basin has its own regulation. Additionally, even in the same autonomous region, the fishery is regulated for some River basins but not in others.
- In some of the autonomous regions, fishermen are professional and have to sell their catches to the fish market, while in others, they are non-professional. In this sense, the accuracy of the information related to catches and landings differs greatly among those autonomous regions.
- Each autonomous region has its own way of managing the stock: different fishing techniques are allowed.
- In many cases, the organizations that are involved in the management of the eel could differ within the same autonomous region, depending on the eel development stages.

In the 2008 year report, a table detailing eel fishery in Spain was included which contained the legislation in force at that time. The management plans include some fishery restrictions. In Spain the glass eel fishery exists in all the RBDs. In the Atlantic, the most important glass eel fishery River basins are the Miño (Miño-Sil RBD), the Asturian River basins (Cantabrico RBD), the Basque River basins (Basque inner RBD) and the Guadalquivir. In the Mediterranean, the most important glass eel fishing points are the Delta of the Ebro River (Ebro RBD) and the Albufera (Júcar RBD) from Catalonia and the C. Valenciana respectively. In addition to that, there is an important yellow and silver eel fishery in Galicia, C. Valenciana and Catalonia.

As explained above, the available information from each autonomous region is variable: Below, information available from the different autonomous regions has been summarized.

BASQUE COUNTRY: There is not a professional yellow or silver eel fishery in the Basque Country. Recreational fishery catches were historically insignificant and the fishery was forbidden in 2009.

Glass eel fishery is a very traditional fishery in the Basque Country and affects to zones associated to River mouths, including beaches, estuaries and River banks. Glass eel fishery is located in most of the River basins of Bizkaia (Artibai, Lea, Oka, Butrón and Nervión- Ibaizabal) and Gipuzkoa (Bidasoa, Oiarzun, Urumea, Oria, Urola, and Deba). Basque fishermen cannot sell the catches and therefore they should be classified as non-professional. Although being the glass eel fishery very traditional, there was not any management plan for glass eels until 2001, when the Basque Government with the advice of AZTI, launched a fisheries monitoring plan. In 2003, a new regulation for glass eel fisheries was issued. It stated that there must be only one licence per person and fishing basin and that it is mandatory to fill in the Daily Catches report with catches and effort data.

There are a lot of little River basins in the Basque Country. The River mouths of those basins are included in the Basque Inner River basins district (Basque Inner RBD), but the upper parts of some of these Rivers are included in Cantabrico RBDs (Figure 1).

CANTABRIA: There is not a professional yellow or silver eel fishery, and the catches of recreational fishery are insignificant. On the contrary, both, professional and recreational glass eel fishery exists in Cantabria, mainly located in the Nansa, Pas and Campiazo River basins. Recreational fishermen must have the maritime fishing recreational licence and their catches are not for sale. Professional fishermen sell their catches in the market or in other licensed establishments. Fishermen fish in land and they are only allowed to use one sieve (≤1.2 m^2) by fishermen. Since 2005, fishermen report their catches.

ASTURIAS: There is not a professional yellow or silver eel fishery in Asturias, and the recreational fishery was forbidden in 2007.

Glass eel fishery, on the other hand, is a very traditional fishery in this area and affects to zones associated to river mouths, including beaches, estuaries and river banks. The Fisheries General Direction of Asturias has provided the data concerning the number of issued licences and the glass eel sales data in Asturias using fish auctions. There are 18 fishermen guilds in Asturias; in the San Juan de la Arena fisherman guild data are available since 1952 and for the other 17, data are available since 1983. In the 2006 report (ICES, 2006), all the catches from Ribadesella fishermen guild were attributed to the Sella River which is the closest one. However, fishermen from other eastern Rivers of Asturias sell their catches in Ribadesella also, and therefore it is not correct to attribute all the sales of Ribadesella to the Catches of the Sella. In fact, until now, the origin of the sold glass eel must be identified only in the fishermen guilds corresponding to the Nalón River (San Juan de la Arena and Cudillero). Besides that, the catches of the Nalón are sold only in the San Juan de la Arena and Cudillero fish markets. So, it is perfectly possible to identify the glass eel from the Nalón. For that reason, from the 2007 report on, the fishery data is split into the Nalón and the "Other Rivers" from Asturias. In October 2010, a new regulation was implemented in the Nalón River (*Resolución de 7 de octubre de 2010, de la consejería de Medio Rural y Pesca, por la que se regula la campaña 2010/2011 de pesca de la angula y se aprueba el Plan de explotación de la Ría del Nalón*; BOPA No 241, 18-10-2010). This regulation limits the number of boat and land licences in the Nalón River to 45 and 55 respectively. The gear type is also limited to a sieve no bigger than 200x60 cm. Boat dimensions and power together with fishing effort has also been regulated in this area. The rest of fishermen guilds are asked to record the glass eel catches and the fishing effort data of the free zone. It will enable comparing catches and sales as in the exploitation plan. In Asturias there are many little River basins and all of them are included in the Cantábrico RBD (Figure 1).

GALICIA: Only one management unit has been defined in the Galicia-Costa RBD, in which non-professional fishing activity has been completely forbidden. Yellow and silver eel fishery activity has been split. It is a boat fishery where the number of gear types is limited per boat. The boats need a specific licence for the fishing gear that will be used in each fishing trip. They might have more than one fishing gear licence, but only one of them can be used in each fishing operation. According to the resolution that allows eel fishing in the Arousa, Ferrol and Vigo Rivers ("Resolución do 23 de decembro de 2010, da Dirección Xeral de Ordenación e Xestión dos Recursos Mariños, pola que se autoriza o plan de pesca de anguía para as confrarías de pescadores das rías de Arousa, Ferrol e Vigo" publicado no DOG nº 251 de 31 de diciembre de 2010), the maximum number of sieves is 80, and the fishing period is limited from the 1st of February to the 29th of October. Nowadays, there are 66 boats allowed to fish using the 'butrón' sieve, but only 37 of them are active nowadays. Regarding the 'anguila' sieve, there are 41 boat licences but this gear has been practically abandoned, and there is only one boat currently working with it.

As mentioned in the introduction, Miño-Sil RBD is one of the most important eel fishing areas in Spain. The Miño River is the most important fishing point. There is both, professional and non-professional glass eel and yellow and silver eel fishery in this RBD. The lower part of the Miño River limits the border of Spain and Portugal and for that reason the permanent International Commission of the Miño is responsible for the management of this part of the river. In the present report, the information collected by the Galician autonomous region regarding the Galicia-Costa RBD is included together with the data from the Miño RBD. The catches are established using auctions data from the different fishermen guilds, which are assigned to a determined river basin. In the Galician fishermen guilds, yellow and silver eel catches are not split up. The estuaries are considered basins themselves because of their size, and are managed as basin units. In this way, the estuaries listed below contain catches data from the following fishermen guilds:

- Arousa Estuary: Cambados, Carril, and Rianxo fishermen guilds.
- Eo River: Asturians fishermen guilds.
- Ferrol Estuary: Barallobre, Mugardos and Ferrol fishermen guilds.
- Pontevendra Estuary: Pontevedra fishermen guilds.
- Vigo Estuary: Arcade and Redondela fishermen guilds.

Data from the Ulla River are collected by Ximonde Center for Fishing Preservation. This information belongs to the Galician Coast RBD and it is obtained from the web of the Galician Government (www.pescagalicia.com) and UTPB (Unidade Técnica Pesca Baixura).

The other river basins mentioned in this report belong to the Miño Basin (Figure 2). Data from this river are collected from the Miño River Command. Two thirds of the river basin drainage area is located inside the autonomous region of Galicia. The rest of the area is located among Asturias and Castilla-León autonomous regions of Spain, whilst a little part of the lower basin belongs to Portugal. Eel fishing is regulated according to the autonomous region where fishing is carried out. There is an international stretch of Miño between Spain and Portugal. There, the eel fishing is professional and land fishing is allowed only if sieves are used. The conic tackle was allowed only for two years after the publication of the regulation of the international stretch of Miño and until the sand barrier of the Miño estuary is dredged that will facilitate the entry of the migratory species.

ANDALUCIA: A new regulation is in force in Andalucía since November 2010, in which several measures have been established in order to implement a recovery plan for the European Eel (*DECRETO 396/2010, de 2 de noviembre, por el que se establecen medidas para la recuperación de la anguila europea (Anguilla anguilla)*). A complete closure of the eel fishery has been issued. Only some aquaculture factories will get a permission to fish and then grow a certain amount of eel per year. At least 60% of this catches should be directed to restocking activities, whereas the rest of the eels could go to the market.

MURCIA: Eel fishery is professional and the minimum landing size for eel is set at 38 cm. The number of boats varies between 30 and 40 per year. Eels are fished using a "paranza" (a fixed box made with net or/and canes) or bottom-set longlines. This fishery takes place in the Mar Menor and catches are sold through the "Lo Pagán" guild.

C. VALENCIANA: Glass eel fishery is a professional fishery while the yellow and silver fishery is both, professional and recreational.

There are two types of professional yellow/silver fisheries depending on the province. In Valencia, there are 4 fishing associations: in the Albufera, El Palmar, Silla, Catarroja associations exercise their rights to exploit the yellow and silver eel around the Albufera which is a 2100 ha. Coastal lagoon between Turia and Júcar Rivers; on the other hand, Molinell association operates in Pego-Oliva fen which constitutes an agrarian landscape with a traditional economic activity. The fishermen community of El Palmar is the fishing organization with the major tradition and number of members, and the only one that is allowed to fish in fixed places in the lagoon. Eel fishery in the Albufera has its own regulation and two types of fishing are considered: the fixed place fishing (named "redolins") and the traveling fishing.

Regarding glass eel fishery, there are six professional associations of glass eel fishermen distributed between the provinces of Valencia and Castellón, with 168 fishing licences and 89 fishing points ("postas"). In the Albufera Perelló-Perellonet fishing association has the exploitation rights. Fishermen of the Albufera fish in different "Golas"; channels that connect the Albufera with the sea. In the province of Alicante, professional fishery occurs in eleven fishing preserves located between the El Hondo wetlands (Elche) and the salt flats of Santa Pola. In the fishing preserve of Alicante, a maximum number of fishing tackles (named "mornells") is allowed. The fishermen guilds and associations give their catches data to the territorial service of each province responsible for the continental fishing. In the case of glass eel, they also report the fishing days.

CATALONIA: There are two RBDs in Catalonia: the Catalonia Inner River basins, which include small and medium Rivers, and the Ebro RBD, which is the second largest River basin in Spain. The delta of the Ebro River is the most important eel fishing point in Catalonia regarding the number of active fishermen with licence and eel catches. The glass eel fishery is professional in the Ter, Muga and Fluviá Rivers (province of Gerona) and the delta of the Ebro River (province of Tarragona). Adult eel recreational fishing is only allowed with rods, except from the lagoons of the Delta, where a professional yellow and silver eel fishery exists.

BALEARIC ISLANDS: There is not any glass eel fishery in the Balearic Islands. Professional eel fishery (>40 cm) is allowed only in Menorca, although there is only one licence. Fishermen fish using a conic pot called "gánguil". In the Albuferas of Mallorca recreational fishery is allowed, but catches are very low. Nowadays, there are 1000 licences for River fishing and it is estimated that only from 10 to 20% of them are devoted to recreational eel fishery.

Spanish government does not compile eel catches data recorded in the different autonomous regions, and there is not any official statistics about landings in Spain. Different autonomous regions have contributed to the present report providing their data.

2.3 Spanish EMPs

The Ministry of Environment, and Rural and Maritime Environment (MARM), responsible for fisheries and environmental issues, submitted the Spanish Eel Management Plan in December 2008. In May 2009 it submitted the clarifications and additional information required by the commission. Spanish EMP was revised in October 2009 by ICES, and the commission asked MARM to modify the Spanish EMP according to that evaluation. The revised version of the Spanish EMP was sent to the commission on June 2010, and was approved in October 2010. **Spain and Portugal made the Miño international River plan that was approved in May 2012** (all the plans available at http://www.magrama.gob.es/es/pesca/temas/planes-de-gestion-y-recuperacion-de-especies-pesqueras/planes-gestion-anguila-europea/).

The Marine Secretary from MARM has coordinated the plan. *Anguilla anguilla* is a native species in Spain, whose population has undergone a significant decline in recent years as in the rest of Europe. The construction of large dams since the 1960s has led to its disappearance from most of the inland river basins of the Iberian Peninsula, leaving the current populations confined to the coastal areas (Figure 2). Some individuals can be found in the interior due to restocking.

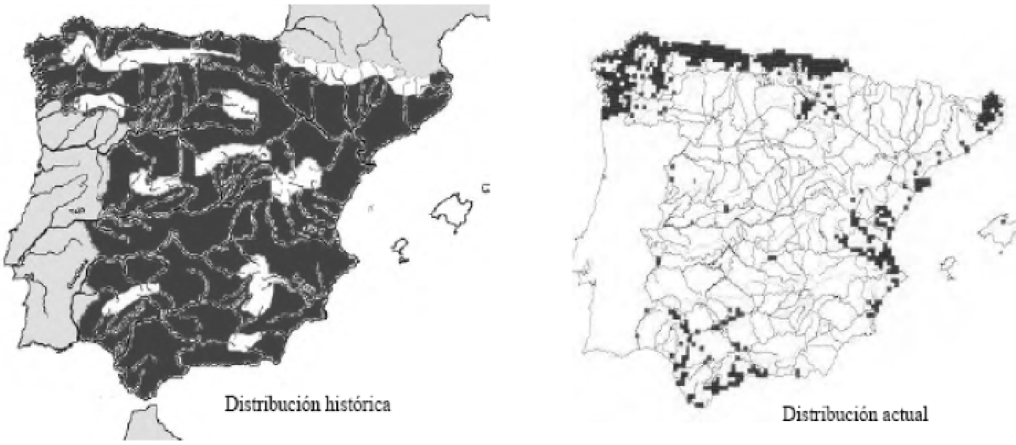


Figure 2. Historic and present distribution of eel in Spain according to Doadrio *et al.* (2001).

Given Spain's national and regional structures, the Spanish management plan is based on a **National Eel Management Plan (EMP) and twelve specific EMPs** (eleven EMPs for the Autonomous Communities with eel populations that can complete their life cycle in these basins, and one EMP specific for the Ebro River Basin also with eel populations):

1) EMP of Galicia;

2) EMP of Asturias;

3) EMP of Cantabria;

4) EMP of Basque Country;

5) EMP of Navarra;

6) EMP of Catalonia;

7) EMP of the Ebro RBD (only Catalonia);

8) EMP of C. Valenciana;

9) EMP of Castilla La Mancha, only for the eels in the upper part of the Jucar and in coordination with C. Valenciana;

10) EMP of Murcia;

11) EMP of Balearic Islands;

12) EMP of Andalucía.

The National EMP defines the structure and methodology, the monitoring and evaluation measures and the objectives at national level. It also contains a summary of the twelve specific EMPs. Each participating Autonomous Community – with exclusive competences on eel fisheries - has been defined as an **Eel Management Unit** (EMU) that shall undertake an Eel Management Plan, in accordance with Article 2(1) of Council Regulation (EC) 1100/2007. According to the Spanish EMP**,** the selection of the EMUs and of the areas that currently have natural occurrence of eel is based on the scientific data available. There are large differences between the monitoring and evaluation, available data and the capacity for action between the inner regions with no current eel populations and the coastal regions that still have them. Those autonomous regions where the eel disappeared many years ago and that have no data or criteria for action cannot put forward effective measures in the short term according to the Spanish EMP. However, a commitment at national level was adopted within the Sectorial Environmental Conference on 7th June 2010 between the Ministry of Environment, Rural and Marine Affairs (MARM) and the Regional Ministers of Environment of the Autonomous Communities, allowing for effective measures to take place in the medium term to deliver the 40% silver eel escapement target in the Spanish territory.

This should be achieved by a two phase rolling plan:

- **In the first phase (2010–2015)** the coastal autonomous communities that had data available and management measures prior to the drafting of the plan will implement their proposed measures. These measures are based on the best available estimates of the pristine and current situation of the European eel in Spain. They aim to achieve 40% escapement in their area of competence, within the overall aim of reaching the 40% national escapement target. In the inland River basins, a series of commitments and specific measures will be adopted at national level such as the elimination of barriers, habitat improvement, monitoring, study and assessment of the eel population and more accurate definition of pristine habitat in order to develop specific measures. In addition to that, working groups comprising representatives of all the public administrations involved in the eel management and scientific experts will be created. Estimates of the pristine and current situation of the European eel in Spain will be updated on that base. At the end of this first phase, the new data will allow to reassess the stock situation and to launch the second phase from 2016 on, with specific regional measures to strengthen and improve the plan's objectives across the potential surface defined.
- **The second phase (2016–2050)** kicks off in 2016 and will coincide with the timescale for reviewing the River Basin Management Plans as set out in the Water Framework Directive to take account of further measures needed to meet the Directive objectives. Therefore, it makes sense to review the EMPs in parallel.

This two-step approach will be carried out without prejudice of the periodic evaluation of the proposed measures in the EMPs, both at regional and national level.

The measures provided for in the National EMP and in the specific EMPs aim to ensure the protection and sustainable exploitation of European eel and to restore the escapement levels of eel at national level, by the year 2050. In those autonomous communities where fishing for eel <12 cm is authorized, the reserve percentages of glass eels for restocking provided for in Article 7 of the Regulation are also met. In general, there is a clear difference between the measures proposed by the regions of the north of the Peninsula, with their waters flowing to the Atlantic, and those of the Mediterranean. The first ones propose the reduction of fishing effort by up to 50% compared to reference periods as the main measure to comply with the objectives of the regulation. The last ones mainly focus on restocking measures and maintaining the fishing management measures already set in their legislation. In certain cases, these last ones also propose measures to reduce fishing effort or to ban certain fisheries. As a general rule, stricter control and catch monitoring measures to control illegal fishing or poaching are proposed.

Finally, Spain presented a post evaluation report in July 2012 as required by the commission which includes the revision of the eel habitat area and the silver eel biomass estimations for some of the autonomous regions.

3 Time-series data

3.1 Recruitment-series and associated effort

3.1.1 Glass eel

3.1.1.1 Commercial

All the data in this section is obtained from auctions or fishermen guilds. There are four historical dataseries for glass eel catches in Spain (Table 1), which are updated yearly:

- San Juan de la Arena fish market in Asturias: It includes almost all the catches from the Nalón River. Since 1995, the administration of Asturias also compiles data from the rest of the fish markets in Asturias. Until the 1970s only land fishing existed, then fishermen started to fish in boats, and the catches increased notably.
- The Albufera in C. Valenciana. In the 1949–2000 period data were collected from fishermen guilds corresponding to two fishing points (Golas of Pujol and Perellonet). From 2001 on, the administration of C. Valenciana also compiles data from other fishing points in the Albufera, and the rest of C. Valenciana. To maintain the coherence of the dataseries, the Pujol and Perellonet data will be taken into account for the historical dataseries.
- The Delta del Ebro lagoons in Catalonia. Data are obtained from the fish markets in the area. Since 1998, the administration from Catalonia compiles data for the fish markets corresponding to the Ebro River mouth, obtaining total catches in the Ebro. Additionally, since 1998 it compiles information from the rest of Catalonian Rivers also.
- The Miño. As this RBD is shared with Portugal in includes data from both, Spain and Portugal. The Miño River command compiles these catches data.

Table 1. Glass eel professional catches in Spain (kg), 1949 to 2012.

	San Juan de la	Asturias*	Puchol Perellonet**	Albufera	Delta del Ebro lagoons	Ebro RBD ***	Catalunya Inner Basins	Miño Spain	Miño Portugal	Miño RBD
1949			9319							
1950			3828							
1951			2093							
1952										
1953	14 529		2535							
1954	8318		5910							
1955	13 576		906							
1956	16 649		884							
1957	14 351		2833							
1958	12 911		402							
1959	13 071		6637							
1960	17 975		9453							
1961	13 060		16 731							
1962	17 177		11 088							
1963	11 507		7997							
1964	16 139									
1965	20 364									
1966	11 974				4651					
1967	12 977				4937					
1968	20 556				8858					
1969	15 628				2524					
1970	18 753				2947					
1971	17 032				2022					
1972	11 219				1261					
1973	11 056				1129					
1974	24 481				1354					
1975	32 611				2466			1600	50	1650
1976	55 514				5626			5600	5000	10 600
1977	37 661				-			12 500	7500	20 000
1978	59 918				3400			21 600	15 000	36 600
1979	37 468				4177			17 300	7000	24 300
1980	42 110				3514			15 400	13 000	28 400
1981	34 645				3800			13 000	3000	16 000
1982	26 295		1309		2636			18 000	32 000	50 000
1983	21 837				2327			9700	6700	16 400
1984	22 541		2387		1815			14 000	16 000	30 000
1985	12 839		2980		1690			15 300	14 800	30 100
1986	13 544				301			6000	7000	13 000

	San Juan de la	Asturias*	Puchol Perellonet**	Albufera	Delta del Ebro lagoons	Ebro RBD ***	Catalunya Inner Basins	Miño Spain	Miño Portugal	Miño RBD
1987	23 536		2845		2027			6539	9500	16 039
1988	15 211		4255		-			5600	2600	8200
1989	13 574		2513		-			7359	3000	10 359
1990	9216		1321		1108			3962	4500	8462
1991	7117		1079		897			5743	2500	8243
1992	10 259		830		323			2835	4500	7335
1993	9673		355		799			4893	3600	8493
1994	9900		303		350			2068	2900	4968
1995	12 500		199		190			4701	5300	10 001
1996	5900	7751	271		409			6523	8700	15 223
1997	3656	7329	366		847	3033		4283	4400	8683
1998	3273	6514	1348		939	3379		2878	4500	7378
1999	3815	7113	615		465	1983	346	3812	3600	7412
2000	1330	3058	323		112	3373	401	3812	3000	6812
2001	1285	2732	569		1383	7425	368	1519	1200	2719
2002	1569	3105	574	574	922	3315	77	1427	1100	2527
2003	1231	2770	358	411	1558	4571	357	1755	1400	3155
2004	506	1351	232	320	564	1504	285	1562	800	2362
2005	914	2875	208	237	298	1805	134	1331	1292	2623
2006	836	2175	166	208	557	1209	147	320		
2007	615	2265	258	292	611	611	148	1140		
2008	871	2379	118	125	445	1170	79	1333		
2009	272	749	58	78	411	1511	0	1332		
2010	1089	2612	95	125	501	1536	131	2000	320	
2011	1231	2055	112	179	419	1426	101	1307		
2012	612	1812	123	151	1158	2048		995		

*** Includes San Juan de la Arena fishmarket.**

**** Albufera includes catches from Pujol and Perellonet.**

***** Includes lagoons and river mouth catches.**

The historical dataseries clearly demonstrate the glass eel catches drop (Figure 3).

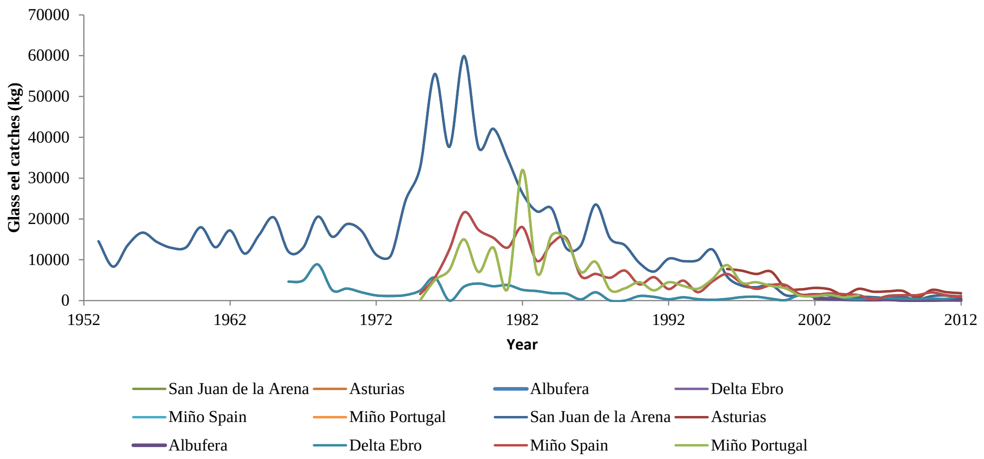


Figure 3. Glass eel catches (kg) time series in Spain.

3.1.1.2 Recreational

In the Basque Country glass eel fishing is recreational. It is obligatory to fill in the Daily Catches report with data regarding catches and effort (Table 2). In Cantabria the recreational fishermen report their data to the local administration.

Table 2. Glass eel recreational in Spain (kg), 2004 to 2012.

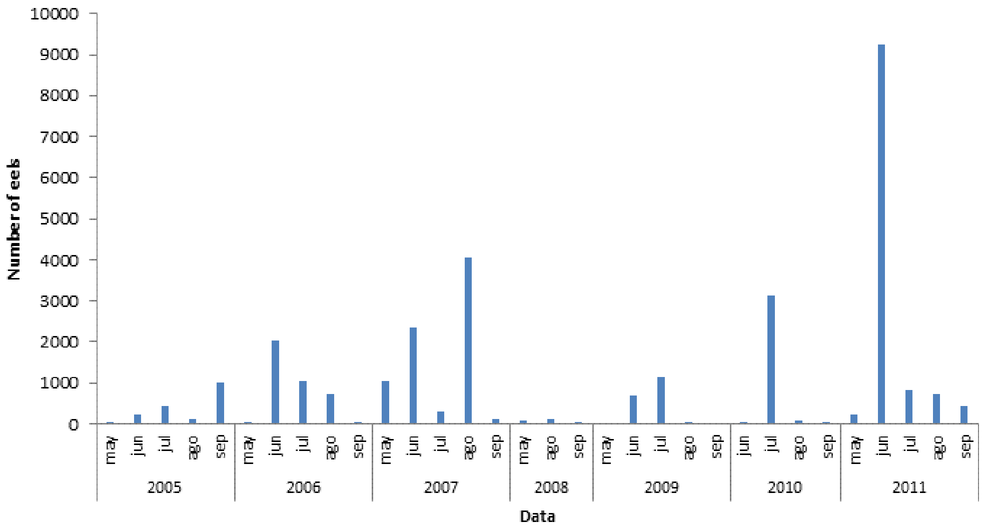
	Basque inner basins RBD	Cantabria
2004	858	
2005	1181	
2006	1282	398
2007	687	341
2008	1205	94
2009	212	0
2010	614	65
2011	376	13
2012	1082	21.7

3.1.1.3 Fishery independent

No historical data are available: however some experimental fishing is being carried out in the Guadalquivir (Sobrino *et al*., 2005), Nalón and Oria Rivers.

3.1.2 Yellow eel recruitment

Upstream migration data has been collected since 2005 in the Oria River in a trap located in the tidal limit. Excluding 2008, when the trap did not work properly, 2009 data were the lowest number of the historical series, which could be related to the very low recruitment in that year. But, apparently, recruitment has been increasing from then on, reaching one of the higher numbers of eel in the time-series during 2011 (Figure 4).



Year	2005	2006	2007	2008	2009	2010	2011
Nº eels	2656	3868	8957	233	1823	3244	11 466
Day with >1000 eels			August			July	June
Nº eels			3978			2033	4485

Figure 4. Number of eels collected in the Orbeldi trap (River Oria, Basque Country).

3.1.2.1 Commercial

Eel catches are only split up into yellow and silver in Albufera and Miño (see Section 3.2.1).

3.1.2.2 Recreational

No data available.

3.1.2.3 Fishery independent

All the autonomous regions carry out multispecific electrofishing samplings. However, data are not compiled at a national level.

3.2 Yellow eel landings

3.2.1 Commercial

Eel catches are only split up into yellow and silver in the Albufera (Table 3). Additionally, aggregated information exits for other RBDs (Table 4). The data source is described in the introduction.

Table 3. Yellow eel catches (kg), 1951 to 2012.

	Albufera
1951	30 000
1952	38 000
1953	30 200
1954	40 400
1955	30 400
1956	30 260
1957	40 000
1958	40 000
1959	40 000
1960	30 000
1961	30 040
1962	20 200
1963	22 400
1964	18 000
1965	12 300
1966	15 000
1967	59 500
1968	16 000
1969	11 200
1970	12 600
1971	11 612
1972	18 300
1973	12 428
1974	11 210
1975	6570
1976	5300
1977	4668
1978	
1979	
1980	
1981	6848
1982	9126
1983	7697
1984	3577
1985	3464
1986	2871
1987	3611
1988	2098
1989	
1990	1843
1991	

	Albufera
1992	2330
1993	2349
1994	2155
1995	2897
1996	3105
1997	2123
1998	2563
1999	2503
2000	2047
2001	1995
2002	2126
2003	2598
2004	2138
2005	1472
2006	1479
2007	1911
2008	2245
2009	4640
2010	2029
2011	1543
2012	1634

Table 4. Yellow and silver eel catches (kg), 1951 to 2011.

	Albufera	C.Valenciana *	Galician Coast RBD	Ebro lagoons	Ebro RBD **	Miño Spain	Miño Portugal	Miño RBD	Balearic Islands RBD	Murcia
1951	90 000									
1952	102 200									
1953	80 200									
1954	97 700									
1955	102 900									
1956	106 120									
1957	80 000									
1958	115 000									
1959	100 000									
1960	98 000									
1961	95 340									
1962	90 700									
1963	95 400									
1964	91 500									
1965	76 300									
1966	79 000			30 662						
1967	79 500			36 026						
1968	65 600			45 327						
1969	56 500			52 046						
1970	42 850			81 864						
1971	44 012			102 839						
1972	43 800			52 591						
1973	33 028			45 853						
1974	24 822			49 685						
1975	17 190			54 872						
1976	13 560			46 469						
1977	11 020									
1978										
1979										
1980										
1981	19 117									
1982	15 971									
1983	14 094									
1984	10 972									
1985	14 477					2027	2000	4027		
1986	12 114					1334	4200	5534		
1987	14 839					1282	3000	4282		
1988	9796					1227	3400	4627		
1989						1368	3100	4468		
1990	3843							4037	503	

	Albufera	C.Valenciana *	Galician Coast RBD	Ebro lagoons	Ebro RBD **	Miño Spain	Miño Portugal	Miño RBD	Balearic Islands RBD	Murcia
1991						1037	3000	5075	691	
1992	5330					1275	3800	3313	526	
1993	5349					813	2500	4126	556	
1994	4155					1126	3000	4960	385	
1995	4497					1460	3500	6866	214	
1996	6065					1266	5600	2843	380	
1997	4907			17 393		1543	1300	2296	534	
1998	5663	6864	17 641	14 367		796	1500	1980		
1999	4903	5977	3789	14 790	16 522	780	1200	1580		12 470
2000	3584	4084	4298	13 587	17 921	830	750	2503		15 504
2001	3279	4147	15 794	32 044	35 317	903	1600	1254		35 491
2002	3558	4375	50 544	23 391	26 095	604	650	1474		30 802
2003	6640	8550	39 698	15 679	18 626	614	860	918		32 672
2004	7729	8770	31 341	12 127	16 081	598	320	935		22 248
2005	5517	7439	35 373	12 269	13 710	265	670	1277	212	32 682
2006	5111	6481	31 702	16 369	17 361	277	1000	-	190	25 631
2007	6187	7352	63 109	19 893	22 640	149		-	140	22 790
2008	7155	10 108	28 277	-	-	447		-	44	20 314
2009	11 582	15 409	32 768	20 793		277		-	-	23 962
2010	5717	10 657	45 498	12 016	12 016	149	-	-	-	-
2011	4410	8481	28 408	18 555	19 138					18 661
2012	5872	11 067	31 889	17 652						19 470

*** Includes catches from Albufera.**

**** Includes lagoons and river mouth catches.**

3.2.2 Recreational

No data available.

3.2.3 Fishery independent

No data available.

3.3 Silver eel landings

3.3.1 Commercial

The data from the Albufera are detailed in Table 5. The source of the data is the same detailed above for glass eel catches in Albufera and the Miño and Ebro Rivers (Table 1).

Table 5. Silver eel catches (kg), 1951 to 2011.

	Albufera
1951	60 000
1952	64 200
1953	50 000
1954	57 300
1955	72 500
1956	75 860
1957	40 000
1958	75 000
1959	60 000
1960	68 000
1961	65 300
1962	70 500
1963	73 000
1964	73 500
1965	64 000
1966	64 000
1967	20 000
1968	49 600
1969	45 300
1970	30 250
1971	32 400
1972	25 500
1973	20 600
1974	13 612
1975	10 620
1976	8260
1977	6352
1978	
1979	
1980	
1981	12 269
1982	6845
1983	6397
1984	7395
1985	11 013
1986	9243
1987	11 228
1988	7698
1989	
1990	2000
1991	
1992	3000
1993	3000

Albufera	
1994	2000
1995	1600
1996	2960
1997	2784
1998	3100
1999	2400
2000	1537
2001	1284
2002	1432
2003	4042
2004	5591
2005	4045
2006	3632
2007	4276
2008	4910
2009	6942
2010	3688
2011	2497
2012	3822

3.3.2 Recreational

Yellow and silver eel recreational data is only allowed in Valencia and the Balearic Islands, but historical data do not exist in these regions.

3.3.3 Fishery independent

No data available.

3.4 Aquaculture production

There are six fish farms in Spain that produce eel:

- Two in C. Valenciana, one of them ("C. Valenciana de Acuicultura") produces yearly around 300 tons of eel, and is the main eel producer in Spain. The other one ("Puchades") was created in 2008 with a capacity to produce 150 tons of eel per year.
- A fish farm in the Delta del Ebro (Cataluña) that produces around 60 tons of eel per year.
- An eel farm in the Basque Country, with capacity to produce 60 tons of eel per year.
- A fish farm in Andalucía in the Guadalquivir basin.

Additionally, in the Basque Country, in Aginaga (Oria River basin) there are six companies dedicated to the commercialization of glass eels.

3.4.1 Seed supply

The fish farms from Cataluña buy glass eel to local fishermen and the one from C. Valenciana mainly to the Delta del Ebro, Guadalquivir, Galicia, Asturias fishermen and to a lesser extent to UK and Morocco. Even though they plan to give especial licences for fish farms in Andalucía, the glass eel fishery has been completely closed since November 2010 and there is not any agreement at the moment.

The companies from the Basque Country have hatcheries in Asturias, C. Valenciana, Catalonia and the Atlantic coast of France to maintain the glass eels they buy to local fishermen until they are transported to the hatcheries in Aginaga.

There is no quantitative data available.

3.4.2 Production

The production is detailed in the Table 6.

Table 6. Aquaculture production (kg) in Spain per autonomous region until 2011 (source: Spanish Ministry of Agriculture, Food and Environment).

	Basque Country	Cataluña	C. Valenciana	Andalucía	Total
2002		130 000	260 200	34 538	424 738
2003		41 000	264 800	33 077	338 877
2004		63 600	316 600	43 673	423 873
2005		63 600	301 470	61 855	426 925
2006	55 000	63 600	233 150	51 055	402 805
2007	65 000	60 000	325 000	27 962	477 962
2008	65 000		385 364	11 000	461 364
2009	80 000		370 151	0	450 151
2010	31 450		380 071	0	411 521
2011			391 229		

In Spain the production of eel is stabilized in 400 tons, which are mainly locally commercialized.

3.5 Stocking

In Spain different restocking experiences have been carried out:

- In Navarra stocking is carried out in the Ebro River but only as a measure of artificial maintenance of the presence of eel in the Rivers. 385 075 young eels, acquired in farms from C. Valenciana, France, and Gipuzkoa had been stocked between 1984 and 2008.
- Since 1988, C. Valenciana fishermen from the Albufera and from the Bullent and Molinell Rivers must give a percentage of their glass eels catches for restocking. These glass eels are raised in the public Centre for the Production and Experimentation of Warm Water Fishes until they reach a weight of 8–10 g. Fattened eels are released up in the River waters and wetlands of C. Valenciana and even in other autonomous regions. The EMP of C. Valenciana contains a detailed stocking plan.
- In Asturias, the Head Office of Fishery purchased 6 kg and 8 kg of glass eel that were released in Sella and Nalón Rivers in 2010 and 2011 respectively. The Price per glass eel kg was 531.8€ in 2010 and 577.8€ in 2011. But there is not any type of monitoring programme for these individuals.

- In Catalonia Inner River Basins and the Ebro RBD, different restocking experiences have been carried out since 1996. During the 1998–2007 period fishermen gave 5% of their seasonal glass eel catches approximately for restocking in the Fluvia, Muga, Ter and Ebro Rivers; restocked eels had an average weight between 0.15 and 0.33 g.

  During the 2005–2006 and 2006–2007 seasons, a pilot study was carried out by the government of Cataluña and the IRTA (Insitut de Reserca i Tecnlogia Agroalimentâires). Eel fishermen provided 38 276 eels with an average weight between 0.65–0.70 g. The initial biomass was 25.7 kg, and after fattening, the biomass was 1617 kg. So biomass increased in 1591.8 kg, and glass eel–yellow eel survival rate in the farm was 71.4%. This work has continued during the 2008–2009 and 2009–2010 seasons, and a total of 1300 of these individuals have been used this year (2011) for restocking in the Ter River. All these individuals have been tagged for future monitoring experiences. The results of this pilot study will be used in the following years aiming to increase the success rate of the restocking operations.

- In Cantabria, a 40% of the total glass eel landings of the 2010–2011 season has been used for restocking. Some of the catches were kept alive in tanks by the Consejería de Medio Ambiente and stocked weekly along the fishing period in different River basins depending on the source of landings. The rest of glass eels were cultured and stocked in different stages of their life cycle, aiming to assess the efficiency of each of the methods.
- In the Basque Country, a new pilot study started in the Oria River in 2011. In a first phase, 2400 young eels trapped in the Orbeldi trap (in Usurbil, Gipuzkoa) were translocated up to the Ursuaran River (in Idiazabal, Gipuzkoa). Both Rivers belong to the same River basin (Oria River basin). During the summer (2011), different electric fishing operations have been carried out aiming to monitor the restocked individuals. During 2012, and within the same project, an 2,8 kg of glass eels from the fishery were stocked directly in the Oria River and another amount was kept for fattening in an eel farm; 1.7 kg of on-grown glass eel were stocked after.

3.5.1 Amount stocked

3.377 kg of eel have been stocked during the 2008–2012 period (Table 7).

Table 7. Amount of eels stocked during 2008–2012 period.

Year	Region	Origin	Quantity	Density (n/ha)	Mean size (g)	Mean size (cm)
2008	Asturias	Ongrown cultured	14.82	2964		20
	Navarra	Ongrown cultured	101		8	
2009	Asturias	Ongrown cultured	50			20
	Asturias	Ongrown cultured	50			15
	Navarra	Ongrown cultured	102		10	
	Catalunya	Wild silver eel-fishery	380		359	40–60
	Valencia	Ongrown cultured	318		203	
2010	Navarra	Ongrown cultured	90		7	
	Valencia	Ongrown cultured	141		429.7	
2011	Asturias	Ongrown cultured	15	3000		15
	Asturias	Ongrown cultured	9.5	1900		15
	Cantabria	Wild glass eel-fishery	4.9			
	P. Vasco	Wild bootlace-trap	5.1	5807	2.1 (0.2–7.7)	11.5
	Navarra	Ongrown cultured	88		7	
	Catalunya	Wild silver eel-fishery	273		210	20–50
	Catalunya	Wild silver eel-fishery	630		210	20–50
	Catalunya	Wild bootlace-fishery	30		4.7	12_15
	Catalunya	Wild bootlace-fishery	14		4.7	19_15
	Valencia	Ongrown cultured	180		10.6	
	Andalucía	Ongrown cultured	12	75		12
	Andalucía	Ongrown cultured	5.7	75		<12
	Andalucía	Forfeitured	131			100
2012	Cantabria	Wild glass eel-fishery	12.35			
	P. Vasco	Wild glass eel-fishery	2.8	5.800–6.800	0.3	7.03
	P. Vasco	Ongrown cultured	1.7	3000	0.36	6.7
	Catalunya	Forfeitured	41			6–9
	Catalunya	Forfeitured	16			6–9
	Catalunya	Forfeitured	24			6–9
	Catalunya	Forfeitured	24			6–9
	Catalunya	Forfeitured	33			6–9
	Catalunya	Forfeitured	114			6–9
	Catalunya	Forfeitured	114			6–9
	Catalunya	Forfeitured	114			6–9
	Catalunya	Forfeitured	33			6–9
	Catalunya	Forfeitured	16			6–9
	Catalunya	Wild bootlace-fishery	72		2.9	6_14
	Catalunya	Wild silver eel-fishery	80		632	34–74
	Valencia	Ongrown cultured	34		3.1	

3.5.2 Catch of eel <12 cm and proportion retained for restocking

The only available information is regarding the eels that have been stocked in Spain; the destination of the rest is not known (Table 8).

Table 8. The amount of glass eel used for different destination.

			National				EU Countries			
		Catches (kg)	Stocking (kg)	% Stocking	Human consumption (kg)	Aquaculture	Stocking (kg)	% Stocking	Human consumption (kg)	Aquaculture
2009–2010	P. Vasco*	613	0	0	613	0	0	0	0	0
	Cataluny a	1535	380	24.7	ND	ND	ND	ND	ND	ND
	Valencia	167	42	25	ND	ND	ND	ND	ND	ND
2010–2011	Cantabria	58	5	9	53	0	0	0	0	0
	P. Vasco*	376	0	0	376	0	0	0	0	0
	Cataluny a	1426	947	66	ND	ND	ND	ND	ND	ND
	Valencia	256	55	22	ND	ND	ND	ND	ND	ND
2011–2012	Asturias	1813	18	1	ND	ND	ND	ND	ND	ND
	Cantabria	63	12	19	51	0	0	0	0	0
	Cataluny a	2241	152	7	ND	ND	ND	ND	ND	ND
	Valencia	274	53	19	ND	ND	ND	ND	ND	ND

*** Recreational fishery.**

ND: no data available.

3.5.3 Reconstructed time-series on stocking

Table 9. Stocking of cultured and wild eel in Spain since 1948.

	Ongrown cultured				Wild glass eel (n)				
	Ebro (Navarra) (n)	C. Valenciana (n)	C. Valenciana (g)^	C. Valenciana (Kg)	Sella & Nalón (n)*	Fluvia**	Muga**	Ter	Ebro (Cataluña)
1948									
1984	16 400								
1985	1200								
1988	45 000								
1989		55 419	9	528					
1990		26 488	10	248					
1991		56 948	12	387					
1992		57 488	9	459					
1993		167 450	6	1021					
1994		121 314	6	749					
1995		215 539	5	927					
1996	15 000	95 692	9	789					66 290
1997		143 370	10	1278					74 934
1998		86 382	11	891		16 408	18 846		79 119
1999		44 219	9	381		66 369			94 637
2000	38 600	54 295	10	561					
2001	24 500	62 169	9	544		12 750			
2002	113 000	43 038	9	396					
2003	18 750	64 373	7	351					
2004	100 000	64 923	8	542		35 769	35 769		
2005		119 647	7	392					
2006		1760	11	19					
2007		20 804	9	186				26997	
2008	12 625	43 352	8	358	30 000				
2009	10 200	19 843	16	318					
2010	12 856	4577	31	141	45 000				
2011	12 572	16 394	11	180	60 000	2900 ***			
2012		20 449	2	34		37 620	37 620	37620	26 730

^Average weight.

*** 4 kg, 6 and 8 kg in total.**

**** 0.15–0.33 gr.**

***** 273 kg of eel from the 2008–2009 and 2009–2010 fishing seasons and kept in the IRTA (Instituto de Investigación y Tecnología Agroalimentaria).**

4 Fishing capacity

4.1 Glass eel

Table 10. Number of glass eel fishing licences or boats per basin.

		Recreational		Commercial				
		P. Vasco	Cantabria	Asturias	Valencia	Ebro	Catalunya	Cantabria **
2005–2006	Boat	54		50				
	Land	363		271	89		15	
2006–2007	Boat	50		47				
	Land	367		234	89		15	
2007–2008	Boat	42		45				
	Land	284		205	89	283	15	
2008–2009	Boat	366		45				
	Land	44		219	89			
2009–2010	Boat	46						
	Land	348			89			
2010–2011	Boat	47		43				
	Land	349	35	183	89		10	
2011–2012	Boat	45		37				5
	Land	363	64	169	89			

****Number of boats.**

4.2 Yellow eel

The available information is shown in Table 11.

Table 11. Number of yellow and silver eel fishing licences per basin.

Year	Galicia *	Asturias “	Murcia ^	Valencia ¨	Islas Baleares “
2005–2006		2		4	76
2006–2007		2		4	36
2007–2008		2		4	52
2008–2009		1		4	41
2009–2010		1		4	
2010–2011	62,5	1	40	4	
2011–2012		1		4	

Number of * tackles, “licences, ^boats and ¨posts.

4.3 Silver eel

See Section 4.2 above.

4.4 Marine fishery

There are not data available; however, this is not a target fishery, and the only catches are accidental.

5 Fishing effort

5.1 Glass eel

Table 12. Number of hours (Basque Country) or days (Asturias, C. Valenciana and Catalonia) dedicated to glass eels fishing since 2005–2006 fishing season.

		Recreational	Commercial		
		P. Vasco *	Asturias ^	Albufera ^	Catalunya *
2005–2006	Boat	3229			
	Land	8132			
2006–2007	Boat	2667	952		
	Land	7551	321	110	
2007–2008	Boat	3231	861		
	Land	7502	376	220	
2008–2009	Boat	909	588		
	Land	2973	393	200	
2009–2010	Boat	1894			
	Land	5337		105	
2010–2011	Boat	1271	963		
	Land	4227	2547	134	
2011–2012	Boat	3016,1	931		
	Land	5938,1	3501	123	770 700

***Hours.**

^Days.

5.2 Yellow eel

Data for yellow and silver eel in Marjal Pego-Oliva (C. Valenciana, Jucar RBD) fishing is given in Table 13. No information available for the rest of Spain.

Table 13. Number yellow and silver eel fishing days in Marjal Pego-Oliva during the 1998–2011 period.

Season	Fishing days
1997–1998	53
1998–1999	55
1999–2000	23
2000–2001	26
2001–2002	42
2002–2003	73
2003–2004	33
2004–2005	39
2005–2006	44
2006–2007	46
2007–2008	82
2008–2009	57
2009–2010	34
2010–2011	44
2011–2012	50

5.3 Silver eel

See Section 5.2 above.

5.4 Marine fishery

There are not data available; however, this is not a target fishery, and the catches are accidental.

6 Catches and landings

6.1 Glass eel

Table 14. Glass eel catches (kg) in Spain during the last three seasons.

		Cantabria	P. Vasco	Asturias Nalón	Asturias Total	Valencia Albufera	Valencia Total	Catalunya Ebro	Catalunya Total
	Boat		555	993	993				
2005–2006	Land		666	329	1182	209		1209	1356
	Boat		321	706	706				
2006–2007	Land		452	233	1559	292	341	611	148
	Boat		475	1054	1054				
2007–2008	Land		683	331	1325	118	157	1170	79
	Boat		54	213	213				
2008–2009	Land		142	153	536	78	117	1511	87
	Boat		252						
2009–2010	Land		362	1562	2612	125	167	1536	1667
	Boat		128	815					
2010–2011	Land		248	416	2054	179	276	1426	1528
	Boat			628	628				
2011–2012	Land	42	324	249	744	151	193		2241

6.2 Yellow eel

Table 15. Yellow and silver eel catches (in tons) in Spain.

	Galicia Coast *	Valencia Albufera ^	Valencia Total	Catalunya Ebro *	Murcia*	Islas Baleares	Asturias*^
2005	30.1	5.52	7.44	1.66	32.7		
2006	63.1	5.11	6.48	1.98	25.6		653
2007	28.3	6.19	7.35		22.8		225.2
2008	32.8	7.16	10.11	22.6	20.3		159
2009	45.5	11.58	15.41		23.9		142
2010	28.4	5.72	10.66	12	-		11 680
2011	31.9	4.41	8.48	19	18.7		248
2012	24.4”	5.87	11.07	17.6	19.5	275	

***Source: Auctions.**

^Source: Catches reports.

“Until August 2012.

6.3 Silver eel

See Section 6.2 above.

See Section 3.3 above.

6.4 Marine fishery

There is not data available; however, this is not a target fishery, and the only catches are accidental.

7 Catch per unit of effort

7.1 Glass eel

Table 16. Glass eel cpues in Spain.

		Cantabria professional *	Cantabria recreational *	P. Vasco ^	Asturias Nalón *	Asturias Total *	Valencia Albufera *	Valencia Total *
	Boat			0 .429	0 .750			
2005–2006	Land			0 .588	0 .720		1 .758	1 .578
	Boat			0.344	0 .740			
2006–2007	Land			0 .409	0 .730		2 .536	1 .846
	Boat			0 .147	1 .180			
2007–2008	Land			0 .090	0 .880		0 .431	0 .543
	Boat			0 .052	0 .360			
2008–2009	Land			0 .034	0 .460		0 .473	0 .443
	Boat			0 .115	0 .360			
2009–2010	Land			0 .062	0 .460		0 .879	0 .742
	Boat			0 .085	0 .840			
2010–2011	Land			0 .055	0 .600		1 .275	1 .019
	Boat		0 .210	0 .193		0 .670		
2011–2012	Land	0 .400		0 .068		0 .210	1 .172	1 .129

***Kg/day.**

^Kg/hour.

Table 17. Temporal trends in catches of glass eel per fishing place and day in C. Valenciana.

	Albufera	Rest of Valencia
1999		0 .026
2000		0 .303
2001		0 .222
2002	0 .222	0 .254
2003	0 .176	0 .369
2004	0 .175	0 .287
2005	0 .093	0 .211
2006	0 .161	0 .304
2007	0 .191	0 .225
2008	0 .029	0 .156
2009	0 .039	0 .101
2010	0 .068	0 .137
2011	0 .141	0 .148
2012	0 .204	0 .245

7.2 Yellow eel

Table 18. Catches of yellow and silver eel per day of fishing in Marjal Pego-Oliva.

	Catches (kg)	Fishing days	kg/fishing day	kg/fishing day/fishing place
1998	1201	53	22,7	7,6
1999	1074	55	19,5	6,5
2000	500	23	21,7	7,2
2001	868	26	33,4	11,1
2002	817	42	19,5	6,5
2003	1910	73	26,2	8,7
2004	1041	33	31,5	10,5
2005	1922	39	49,3	16,4
2006	1370	44	31,1	10,4
2007	1165	46	25,3	8,4
2008	1413	82	17,2	5,7
2009	1079	57	18,9	6,3
2010	1375	34	40,4	13,5
2011	1369	47	29,1	9,7
2012	995	50	19,9	6,6

7.3 Silver eel

See Section 7.2 above.

7.4 Marine fishery

There are not data available; however, this is not a target fishery, and the only catches are accidental.

8 Other anthropogenic impacts

Major impacts are described in the Spanish EMP but no quantitative data is available. The Basque Country post-evaluation report includes a theoretical study, based in the mortality rates per turbine type from bibliography, and silver eel population estimates. The result is that the cumulative mortality among eels passing throw the turbines is between 51, 9 and 81, 0 % in the Oria River.

9 Scientific surveys of the stock

There is not any national eel specific survey programme in Spain; all the autonomous regions have multispecific electrofishing surveys. Additionally, some of the autonomous regions have eel specific monitoring programmes. In the Basque Country, for example, glass and yellow recruitment and potential escapement are monitored in a yearly basis in the Oria River and there are glass eel experimental fishing of glass eel in the Guadalquivir and Nalon Rivers. Some punctual studies have been done by Spanish researches; however a collaborative study to exchange knowledge and methodologies is lacking. Some autonomous regions had promoted punctual studies too, but these data are not gathered anywhere. However, the autonomous regions envisage making silvering eel specific surveys in their management plans.

9.1 Recruitment surveys, glass eel

Glass eel recruitment in the Oria River is sampled in a yearly basis. During 2011–2012 fishing season, Asturias has performed experimental fishing in order to analyse the recruitment and it is planned to continue in the following years.

9.1.1 Stock surveys, yellow eel

All the autonomous regions make periodic multispecific electrofishing surveys for the WFD, but until now, none of them has been directed exclusively to eel. There is not any agreed protocol for sampling, and there is not any compilation of this information at the national level. Some of the autonomous regions envisage making eel specific surveys in their management plans.

Yellow eel recruitment in the Oria River is sampled on a yearly basis in a fish pass in the tidal limit.

9.2 Silver eel

The Basque management plan, will determine the spawning potential according to Durif *et al*. (2003; 2005) in the different basins every five years. The spawning potential has already been determined in the Deba and Oria Rivers since 2007.

Some of the autonomous regions envisage making silvering eel specific surveys in their management plans.

10 Catch composition by age and length

No data available.

Until 2011, the DCF was not applied for eel in Spain, and in that year only glass eel catches from the Basque Country (recreational) were reported. Some of the autonomous regions have measured age and length punctually.

11 Other biological sampling

Biological parameters are not sampled routinely in the autonomous regions, although the autonomous regions envisage sampling them in their management plans.

11.1 Length and weight and growth (DCF)

No data recorded for the DCF or any other programme. Murcia made a study to analyse length and age in the catches from the Mar Menor. In Galicia, catch length is monitored yearly. In Valencia, one hundred and twenty European eel females were captured in their reproductive migration from the Albufera Lagoon. Otoliths were extracted and processed, and fish age was determined by counting annual otolith rings (annuli).

11.2 Parasites and pathogens

There are not new data or is not available. See previous Spanish Country Report 2011.

11.3 Contaminants

There is not new data or is not available. See previous Spanish Country Report 2011.

11.4 Predators

In Catalunya fishing competitions have been made to remove for fish species like bullhead, perch, pikeperch and black bass. Potential predators like American mink (*Neovison vison*) are controlled by trap in Catalunya. The cormorant (*Phalacrocorax carbo*) and heron (*Ardea cinerea*) populations are monitored and controlled, although predation on eel is practically non-existent.

A recent study in Andalucía showed that the impact of cormorants on eel population is not significant.

12 Other sampling

No data available.

13 Stock assessment

13.1 Local stock assessment

There is not stock assessment in Spain at a national level. Each autonomous region has assessed the stock for the management plan in a different way. The management plan of each autonomous region has its own objectives, methodology and structure.

In Spain, each autonomous government is in charge of the control, regulation and management of eel fishery and population. Thus population assessment is made at the autonomous region level, and the methodology data requirement and monitoring methods depend on the autonomy. Almost all the autonomies compile eel fishery data; but each autonomous region has its own methodology to compile fishery data. AZTI-Tecnalia made the first data compilation for eel in Spain for the WGEEL report (2006). After, another compilation of data was made for the EMP and for the Postevaluación of the plan (2012). But all these three, were data compilations since there is not any study or sampling program at the national level to compile eel information in a coordinate way (fishery data, biological information, etc.

Similarly, there are some research projects going on in Spain, but there is not any that includes researchers from different regions. Finally, most of the autonomies made electric fishing surveys in the WFD framework; but only a few make eel specific electrofishing surveys.

In this way, the objectives of the different EMUs depend on the region (available in : http://www.magrama.gob.es/es/pesca/temas/planes-de-gestion-y-recuperacion-de-especies-pesqueras/planes-gestion-anguila-europea/); therefore, some of the regions have focused in restocking (mainly in the Mediterranean) since others have focused in fishery and other in environment measures.

Regarding the assessment of the current eel population in the post-evaluation report there is a great variability among EMUs. There have been three different situations:

1) **Total lack of data in the EMU:** those EMUs have applied reference area production values from bibliography or for similar close habitats.
2) **EMUs with electrofishing surveys:** those EMUs have their own production values, and they have extrapolated these values to areas of similar habitats without surveys.
3) **EMUs with fishery data and surveys**: They have calculated productivity based in this data.

As pristine production is concern, some EMUS have used reference values, and others have applied a conversion factor to current production. Finally, to calculate B_{best}, fishing mortality has been added to $B_{current}$, since other anthropogenic mortalities have not been quantified; thus B_{best} is underestimated.

Table 19. Approaches used by the Spanish autonomies to determine the 3 Bs.

EMU	B_0	$B_{current}$	B_{best}
P. Vasco	Area production rate	EDA Extrapolation of area production rate	
Navarra	Area production rate	Extrapolation of area production rate	
Cantabria	Apply a conversion factor to $B_{current}$	Extrapolation of area production rate	
Asturias	Apply a conversion factor to $B_{current}$	Extrapolation of area production rate	
Galicia	Surveys	Surveys	
Andalucía	Area production rate	Extrapolation of area production rate	$B_{current}$ + F
Murcia	Apply a conversion factor to $B_{current}$	Based on fishery data and surveys	
C. La Mancha	Area production rate	No current production	
Valencia	Area production rate	Area production rate from Bibliography	
Catalunya	Area production rate	Extrapolation of area production rate	
Illes Balears	Apply a conversion factor to $B_{current}$	Based on fishery data and surveys	
Inner s	Area production rate	No current production, inaccessible habitat	

13.2 International stock assessment

There is a high variability regarding eel population among the different EMUS (Figure 5), ranging from the 0% to the 66.7% of the target (Table 20). $B_{current}$ escapement is 13% of the pristine one. Regarding anthropogenic mortality, only the fishery one has been considered in the analysis, so B_{best} is underestimated.

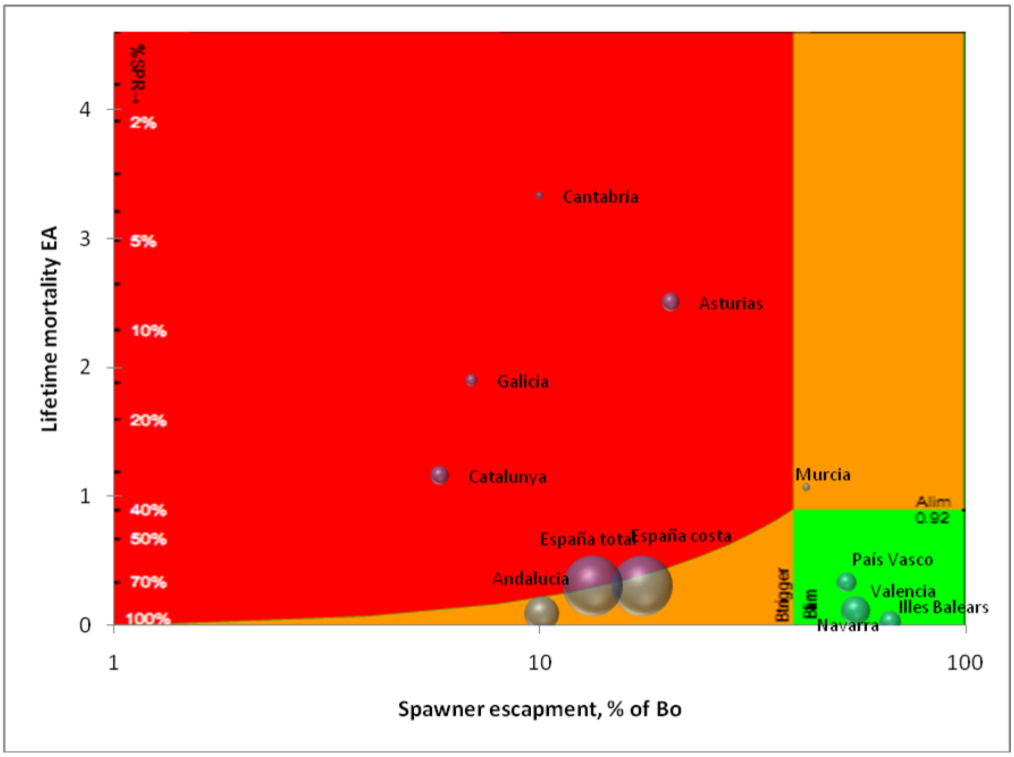


Figure 5. Modified Precautionary Diagram (ICES 2012).

13.2.1 Habitat

The Spanish EMP includes a series of calculations to define the pristine habitat and escapement, and to compare it with the current situation. As the exact definition of the pristine habitat was unknown and due to the lack of complete sets of data or harmonized methods to estimate escapement levels, a series of general criteria were assumed, based on the data available in each region and on scientific literature consulted. This initial data will be reviewed and improved before the end of the first implementation phase of the EMPs (2015) to begin the second phase with more accurate estimates. In fact, these calculations had been improved and reported in the 2012 post-evaluation report.

The criterion generally adopted for the definition of the **pristine habitat** was to consider the natural habitat of eel as the watercourses to a height of 800 m in basins with little slopes and 600 m in those of greater slopes, provided that there were no natural obstacles in levels below these heights. For the internal basins (without EMP in the 1st phase, see Section 2.3), data on surface water layer has been used, with a series of technical criteria provided by the Hydrographic Confederations. The autonomous communities with EMP in the 1st phase have defined a more detailed estimate of their habitat, which may mean that the inland habitat area is underestimated in comparison to the coastal one. The current habitat has been quantified as the previous one, but only taking into account the habitat before the first artificial impassable obstacle.

13.2.2 Silver eel production

In the initial version, of the EMP (2010) an average pristine productivity of 20 kg/ha was assumed in the internal basins (without EMP in the 1st phase, see Section 2.3) in the inland water areas and 50 kg/ha in transitional waters (ICES, 2001). The autonomous communities with EMP in the 1st phase took a different approach, based on the information available that best matches their specific environmental and ecological conditions (Table 20). A more detailed explanation might be find is the EMP of each EMU. Some of the regions have improved their estimations, in the 2012 post-evaluation report: they have obtained new current productivity values, and they have calculated historic values applying a conversion factor (table).

13.2.2.1 Historic production

Table 20. Pristine wetted area and escapement of the EMUs according to the Spanish EMP post-evaluation report.

	Pristine wetted area (ha)				Bo	
	Fluvial	Transitional	Lagoons	Total	Fluvial	Total
P. Vasco	1434	2616		4050	28 672	245 040
Navarra	272			272	5448	5448
Cantabria	1936			1936	9680	9680
Asturias	2437	1337		3774	44 923	64 042
Galicia	2906	1436		4342	87 174	130 257
Andalucía	25 377	101 100		126 477	507 549	5 562 526
Murcia	219		13 519	13 737	4371	26 271
C. La Mancha	1174			1174	23 488	23 488
Valencia	12 499	1457	4261	18 217	249 979	698 026
Catalunya	39 398	910		40 308	858 759	858 759
Illes Balears			4253	4253		330 883
Coastal regions	87 652	107 420	23 469	218 540	1 820 043	7 954 421
Inland regions	66 868	21 657		88 525	1 337 355	2 420 205
Total Spain	154 520	129 077	23 469	307 065	3 157 398	10 374 626

13.2.2.2 Current production

Only the impact of fisheries has been considered since the other anthropogenic impacts have not been quantified.

Table 21. B_{best} of the EMUs according to the Spanish EMP post-evaluation report.

	B_{best}
P. Vasco	178 638
Navarra	2305
Cantabria	28 063
Asturias	159 130
Galicia	60 392
Andalucía	610 396
Murcia	31 525
C. la Mancha	0
Valencia	427 984
Catalunya	159 542
Illes Balears	222 662
Coastal regions	1 880 637
Inland regions	0
Total Spain	1 880 637

13.2.2.3 Current escapement

Table 22. Current escapement of the EMUs according to the Spanish EMP post-evaluation report.

	Current wetted area (ha)				B_0	
	Fluvial	Transitional	Lagoons	Total	Fluvial	Total
P. Vasco	1375	2616		3991	12 215	129 164
Navarra	231	0		231	2305	2305
Cantabria	615			615	1294	1294
Asturias	1268	1337		2605	6834	12 584
Galicia	1656	1436		3092	4885	9122
Andalucía	13 550	53 539		67 089	27 346	562 732
Murcia	219		13 500	13 719		11 170
C. la Mancha	0	0	0	0		0
Valencia	12 499	1457	4261	18 217	30 773	385 175
Catalunya	984	676		1660	50 420	50 420
Illes Balears			4253	4253		220 561
Coastal regions	32 396	59 624	23 450	115 470	136 073	1 384 526
Inland regions	0	0	0	0	0	0
Total Spain	32 396	59 624	23 450	115 470	136 073	1 384 526

13.2.2.4 Production values e.g. kg/ha

Table 23. Silver eel productivity according to the Spanish EMP post-evaluation report.

	Pristine productivity (kg/ha)			Current productivity (kg/ha)		
	Fluvial	Transitional	Lagoons	Fluvial	Transitional	Lagoons
P. Vasco	20	82.7		5.0–14	44.7	
Navarra	20			10		
Cantabria	20			0.8–7.4		
Asturias	8.6–20	14.3		2.4–8.7	4.3	
Galicia	30		30	3.0		3.0
Andalucía	20	50		0.5–2.9	10	
Murcia	20		1.62			0.8
C. la Mancha	20			0		
Valencia	20	80	77.8	33.75	78.75	56.25
Catalunya	20		77.8	0.8–65.1		51.9
Illes Balears			77.8			51.9

13.2.2.5 Impacts

Only fisheries impact has been considered, although they are mentioned in the reports, other anthropogenic impacts have not been quantified; only the Basque EMU reports gives a theoretical cumulative mortality among eels passing throw the turbines between 51.9 and 81.0% in the Oria River.

13.2.3 Stocking requirement eels <20 cm

In Catalonia, fishermen must give 5% of their catches for restocking. Following the regulation, a 45% of the average value of the total catches of the last three fishing seasons will be restocked.

In C. Valenciana both, glass eel and eel fishermen must give a percentage of their catches for stocking. Additionally, they will restock with individuals of all the sizes (and not only <20 cm as required by the regulation). In order to reach the percentages that should be destined to stocking according to the EU regulation, they will use EEUs (Equivalent Units of Eel). To calculate this they will take into account the rate of survival in the form of eels of different size. In this way, they have estimated that the 35% of catches of glass eel in 2009 will correspond to 369.238 EEU and the 60% in 2013 to 632.980 EEU. See 2011 Spanish CR for more details.

13.2.4 Summary data on glass eel

See Table 8.

13.2.5 Data quality issues

No data available.

14 Sampling intensity and precision

As mentioned in previous section the DCF was not applied for eel until 2009, when only glass eel catches in the recreational glass eel fishery from the Basque Country were reported. Also there is not any sampling programme at the national level, thus is not possible to analyses sampling intensity and precision.

15 Standardisation and harmonisation of methodology

Since there is not a national survey or sampling programme, standardizations and harmonization have been not studied until now.

15.1 Survey techniques

15.2 Sampling commercial catches

15.3 Sampling

15.4 Age analysis

15.5 Life stages

15.6 Sex determinations

16 Overview, conclusions and recommendations

As mentioned above, in Spain, each autonomous government is in charge of the control, regulation and management of eel fishery and population. The only information that is compiled routinely corresponds to fishery. In addition to that, each autonomous region has its own methodology to compile fishery data. In this way, the assessment of the general eel status in Spain is a very complicated task. Apart from the present report, and the management plan, there is not any global study or sampling programme to compile information (fishery data, biological information, etc.) in Spain in order to give a Spanish national overview of eel situation. Similarly, there are some research projects going on in Spain, but there is not any that includes researchers from different regions.

All the above-mentioned, makes a very complicated task to compile the data required in the report, and also, the one necessary to be able to make a proper assessment of the eel population.

In this way, it is essential to compile eel data as required by the DCF. Additionally, the different autonomous regions should coordinate their data collection and management and research plans. Thus, it is recommended to **create a Spanish eel group,** including autonomic administrations, River Basin Districts, and researchers. Also, in those River basin districts that extend over different autonomous regions, the different local administrations should make an effort to coordinate their work in the basin, both concerning management and research.

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Report on the eel stock and fishery in Sweden 2011/'12

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Reporting Period: This report was completed in August 2012, and contains data up to 2011 and some provisional data for 2012. Data given in an annex is available on request from ICES Advisory Programme.

Data availability: All data presented in this Country Report have been made available in electronic format to the working group meeting.

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2 Introduction

2.1 Background

Most of the information presented in this introduction is based on the Eel Management Plan (EMP) Sweden delivered to the EU (COM) in 2008.

The Swedish EMP involves measures in four principal areas:

- Reduction of the fishery;
- Improved possibilities for downstream migration (reduced turbine mortality);
- Stocking of glass eel;
- Control.

2.2 Quantification of the measures

The overall target for the national management plan (EMP) is that 90% of all silver eel that at present would have been produced in Swedish water without anthropogenic mortality shall survive and escape to contribute to reproduction. This shall be achieved by regulation of the fishery, reduction of turbine mortality and increased stocking of imported glass eel. The relative contribution of the different measures is shown in the following table (Table SE.1). The sign indicates extraction (-) or addition (+) to the production without anthropogenic impact.

Table SE.1. Overview of the quantities of eel produced, and the management actions planned in the EMP.

	Silver eels (*1000)	Per cent of production
Present natural production of silver eels in Sweden	2870	
Loss in the fishery before measures	-1470	-51%
Loss in hydroturbines before measures	-280	-10%
Addition from earlier stockings	+210	7%
Reduction of fishing due to regulation 2007	+390	14%
Continued regulation of fishery	+550	19%
Reduction of turbine		
Mortality	+140	5%
Increased stocking	+185	6%
Net anthropogenic mortality after measures	-275	-10%

2.3 Eel fisheries

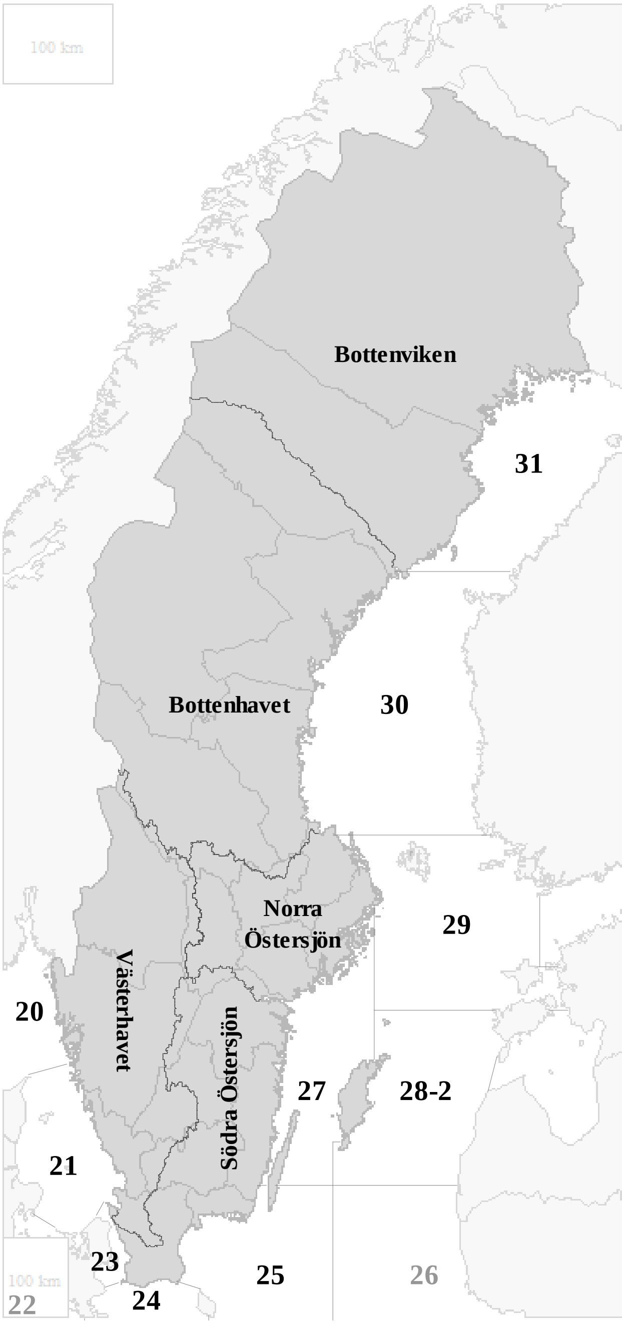

Figure SE.1. ICES subdivisions in coastal waters, and the River Basin Districts in inland waters. County borders are indicated in grey

The eel fisheries in Sweden can be described as four different types. One is a fykenet fishery for yellow eels along the West Coast of Sweden, i.e. in RBD 5 (Figure SE 1.). **This fishery is closed from 2012**. In the southernmost parts of the country, the Öresund straits included, there is a traditional fishery heading for migrating silver eels only. That is in RBD 4. On the East Coast, i.e. in RBD 3 and 4 there is a combined fishery, heading mainly for silver eels, but also large yellow eels and other species are caught. In some 20 freshwater lakes, eels are caught in a similar combined pound net fishery, catching not only eels but also other fish species as pike perch, perch, pike, etc.

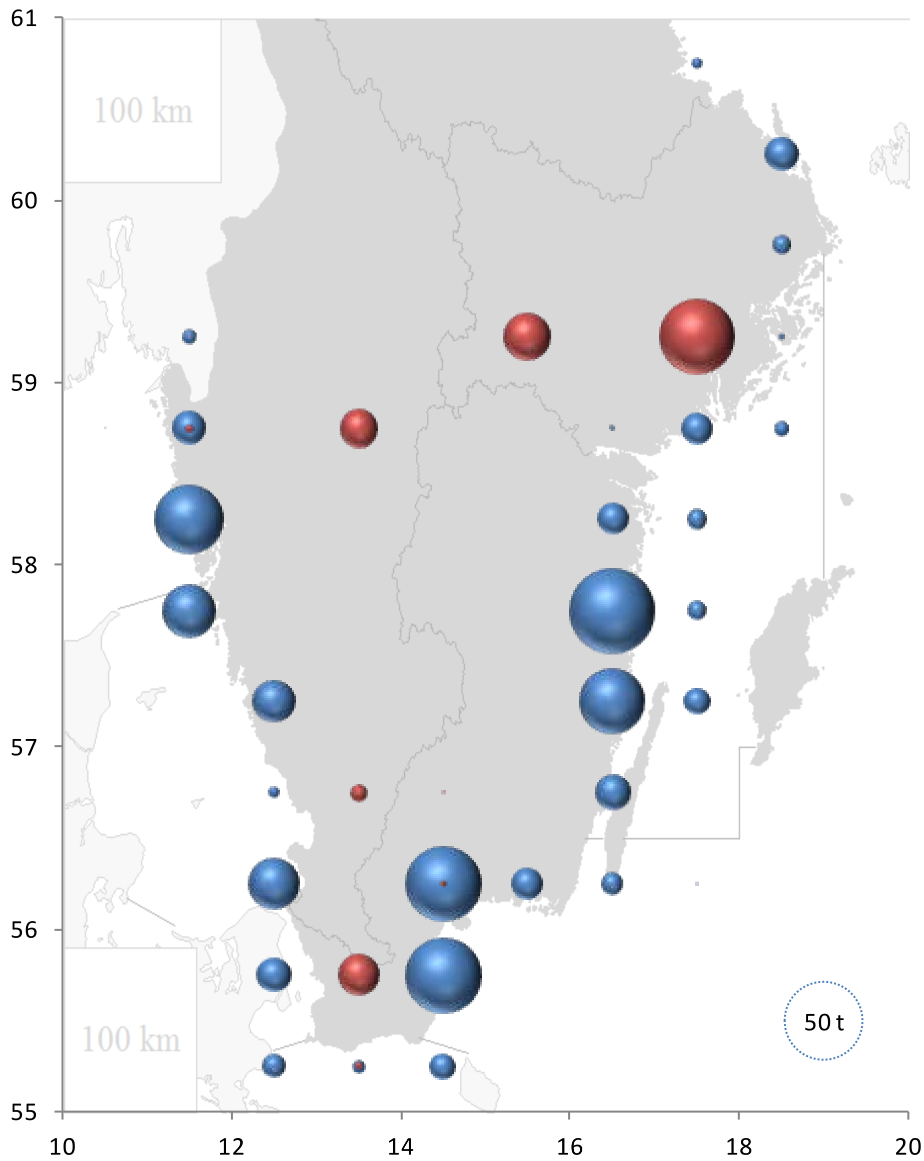

Figure SE. 2. The commercial catch in lakes and coastal areas in 2011 expressed per ICES statistical rectangle. The sizes of the circles are proportional to the catch.

In 2007 eel fishing in general became prohibited, unless with a special permit. The issuing of licences was based upon landings during a reference period 2003–2005. Licences were given to fishermen that landed 400 kg eel yearly or who had significant income from eel fishery. Exemption from the 400 kg eel per year were given if the fishery was established during the reference period or if fishing had not been possible during the reference period.

In 2008 the legislations was revised so that only licence holders from 2007 could apply for a new eel fishing licence and the application contained information on number and types of gears and fishing area.

In 2009 fishing effort was limited in Kattegat and Skagerrak to between 1 of May and 14 of September and the fykenet fishery limited to 400 single or double fykes. In the

Baltic Sea fishery was limited to the same time period or within a continuous 90 days period and in freshwater the fishery was limited to a 120 days continuous period. In 2009 the licence were given on a two year basis (2009/2010) such that the effect of the regulation could be evaluated when the eel management plan is evaluated. Today's licences are valid for 2012–2013.

In Kattegat south of the latitude 56°25'00 N (Kullaberg, the border between ICES Subdivision 21 and 23) the allowed fishing period for fixed gear (poundnets) as well as for mobile ones (as double fykes) has decreased to 60 days in 2011. Fishing for eel north of Kullaberg is prohibited since spring 2012.

3 Time-series data

3.1 Recruitment-series and associated effort

3.1.1 Glass eel

3.1.1.1 Commercial

No available data (as fishing for glass eels is prohibited).

3.1.1.2 Recreational

No available data (as fishing for glass eels is prohibited).

3.1.1.3 Fishery independent

The abundance of glass eels (truly unpigmented) in the open sea (Kattegat and Skagerrak) are surveyed by trawling with either an Isaacs–Kidd Midwater trawl (IKMT) or with a modified Methot–Isaacs–Kidd Midwater trawl (MIKT). The former trawl is used in a fixed position in the intake canal for cooling water to the condensers at the Ringhals Nuclear Power Station (e.g. Westerberg, 1998 a & b). The latter method is used from RV Argos during ICES-International Young Fish Survey (Hagström and Wickström, 1990), (since 1993 called the International Bottom Trawl Survey (IBTS Quarter 1). When the glass eels have settled they and larger eels can be monitored on soft and shallow bottoms using a "Drop Trap" technique (Westerberg *et al.*, 1993; ICES, 2009a). This was successfully done during a number of years, and an attempt is now made to restart similar series, extending over a considerable stretch of the west Coast. From all three methods recruitment-series could be compiled and two of them are shown below.

Recruitment of glass eel (truly unpigmented) to the Swedish west coast is monitored at the intake of cooling water to the nuclear power plant at Ringhals in the Kattegat (Figure SE.3 and Table SE.2). The time of arrival of the glass eels to the sampling site varies between years, probably as a consequence of hydrographical conditions, but the peak in abundance normally occurred in late March to early April. Abundance has decreased by 93% if the recent three years are compared to the peak in 1981–1983.

The sampling at Ringhals is performed twice weekly in February–April, using a modified Isaacs–Kidd Midwater trawl (IKMT). The trawl is fixed in the current of incoming cooling water, fishing passively during entire nights. Sampling is dependent on the operation of the power plant and changes in the strength of the current may occur.

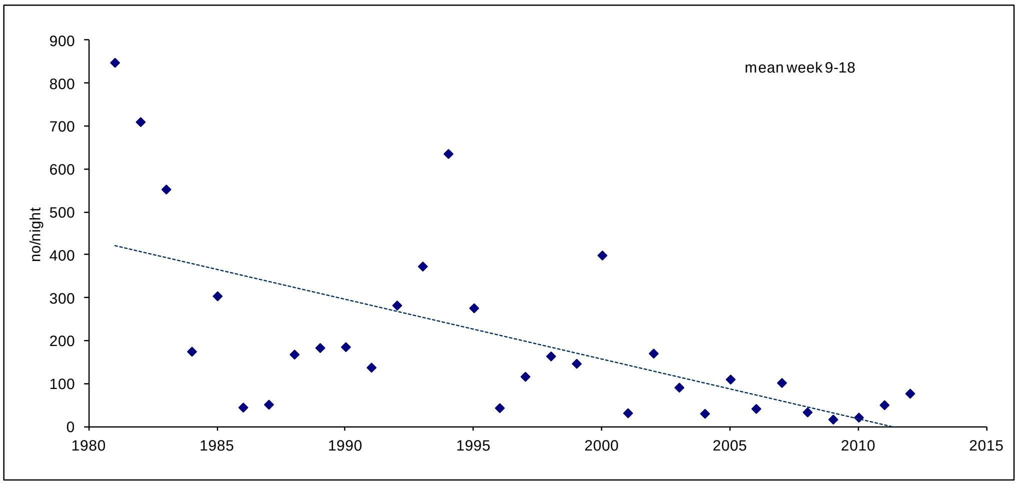

Figure SE. 3. Time-trend in glass eel recruitment at the Ringhals nuclear power plant on the Swedish Kattegat coast (the 2012 value is preliminary).

Table SE. 2. Annual indices of glass eel recruitment at the intake canal for cooling water to reactors 1 and 2 at the Ringhals nuclear power plant. Weekly means (n/night) of numbers of glass eels collected with a modified Isaacs–Kidd Midwater trawl during March and April (weeks 9–18). Data were corrected for variations in water flow (the 2012 values are preliminary).

week no	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
3	3													1			
4	0							17			1			4			
5	4							8		15	14	18	30	5	4	0	0
6								28		27	13	56	45	7	11	0	1
7								6		22	9	85	331	7	41	0	22
8	1							34		57	3	44	57	8	48	11	3
9	187		51			3		36	342	185	3	160	55	3	172	0	68
10	199	24				2		80	372	150	15	471	118	7	224	4	200
11	250	130	528	176		4		19	129	150	88	290	130	610	333	13	198
12	374	806	835	289	14	6	2	16	107	145	42	469	535	400	569	25	60
13	1886	1258	265	122	109	1	0	72	291	251	110	562	495	1430	331	60	42
14	2093	1335	469	181	0	3	31	149	121	351	138	151	403	1236	625	33	77
15	1849		878	112	878		141	603	67	284	414	298	540	1145	91	128	201
16			925		476		69	416	42	120	254	142	527	619	64	73	49
17	804		477	171	350		6	127		37	193	231	564	278	80	56	44
18	0					297	114				124	55					230
mean 9-18	849	711	553	175	305	45	52	169	184	186	138	283	374	636	277	44	117

week no	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
3															
4		0													
5	1	0	74	2	27	6	0	20	0	10	0	0	0		0
6	1	0	142	0	86	5	1	12	2	42	8	1	0		0
7	9	8	267	3	154	2	2	62	3	4	27	0	0	1	0
8	50	12	115	5	327	5	0	22	2	12	17	4	0	0	0
9	125	62	344	5	117	5	1	15	6	11	10	3	0	1	14
10	100	121	377	3	200	10	3	10	2	29	31	2	2	3	9
11	8	72	533	22	366	44	3	39	1	81	114	3	4	4	109
12	177	158	214	24	530	53	18	162	13	382	38	15	8	34	348
13	220	2	479	16	59	185	35	153	17	186	30	36	4	37	104
14	448	314	942	22	185	192	65	162	55	101	43	37	34	70	27
15	237	377	154	45	184	151	55	202	97	191	26	25	24	179	29
16	96	79	299	25	53	74	90	286	132	20	13	23	91	57	48
17	202	141	257	128	8	158	32	66	62	18	2	11	23	73	10
18	31				9	46	8	10	36	7			28		
mean 9-18	164	147	400	32	171	92	31	110	42	102	34	17	22	51	77

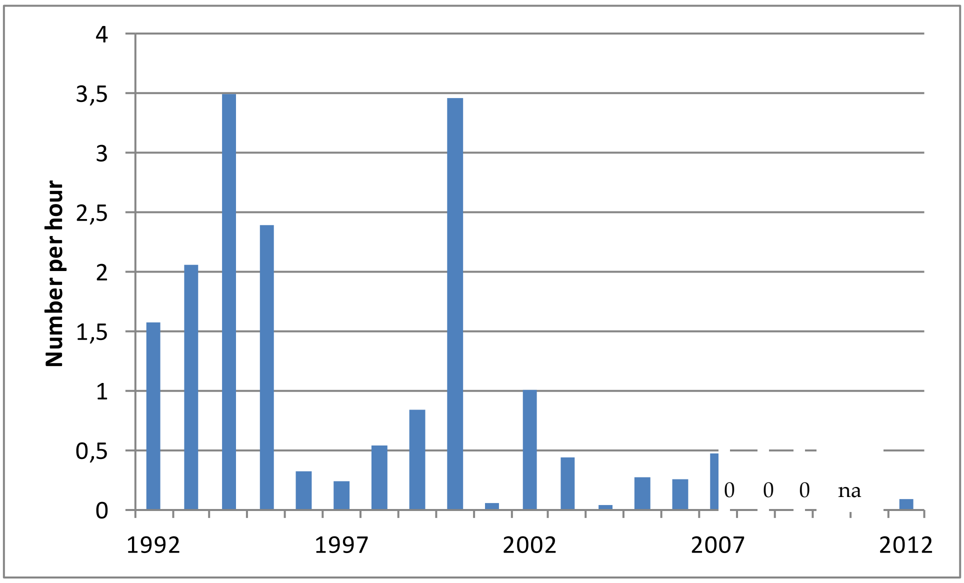

Figure SE. 4. Catch of glass eels by a modified Methot–Isaacs–Kidd Midwater trawl (MIKT) in the Skagerrak-Kattegat 1992–2012. Data expressed as total numbers per hour of haul. No glass eels were caught in 2008, 2009 and 2010. In 2011 there was no sampling due to technical problems.

3.1.2 Yellow eel recruitment

3.1.2.1 Commercial

3.1.2.2 Recreational

No available data (as fishing for eels smaller than the minimum legal size is prohibited).

3.1.2.3 Fishery independent

The ascent of young eels is monitored in a number of rivers along the Swedish coasts. In the 1970s, these data came from some 20 rivers, but today most of the sites are closed due to lack of eels and therefore lack of interest. The recruitment indices used today are based on the amount of ascending eels in eight rivers from Göta Älv on the Skagerrak coast to River Dalälven on the Baltic Coast. Data are presented both as absolute amounts in weight and as indices based on yearly proportions compared to a common reference period (1971–1980). In most rivers the recruits belong to several age classes, but in River Viskan situated on the West Coast most eels are young-of-the-year recruits, i.e. originates from glass eels arriving at the coast in the same year.

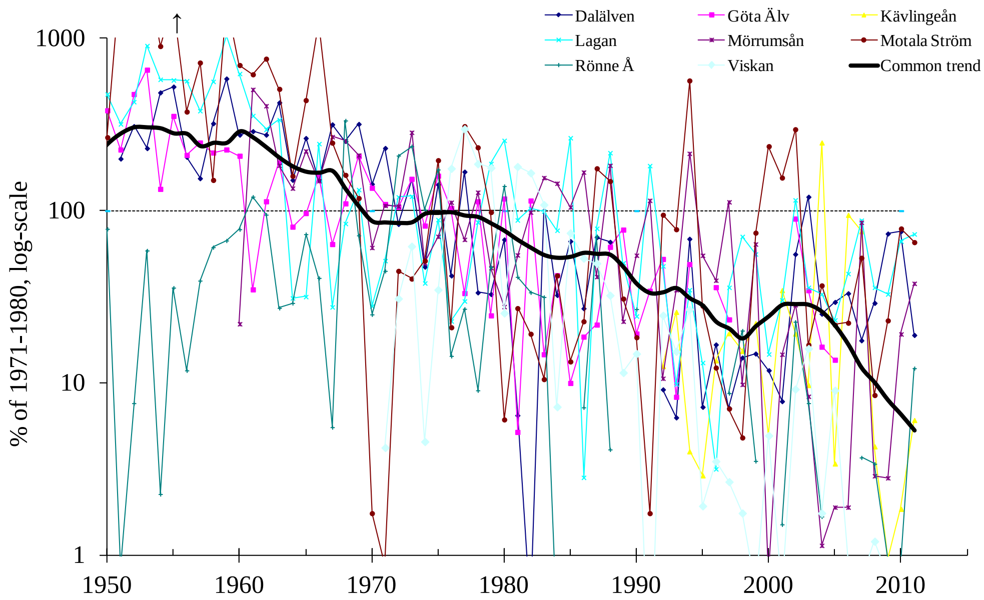

Figure SE. 5. The ascent of young eels in seven Swedish rivers (logarithmic scale).

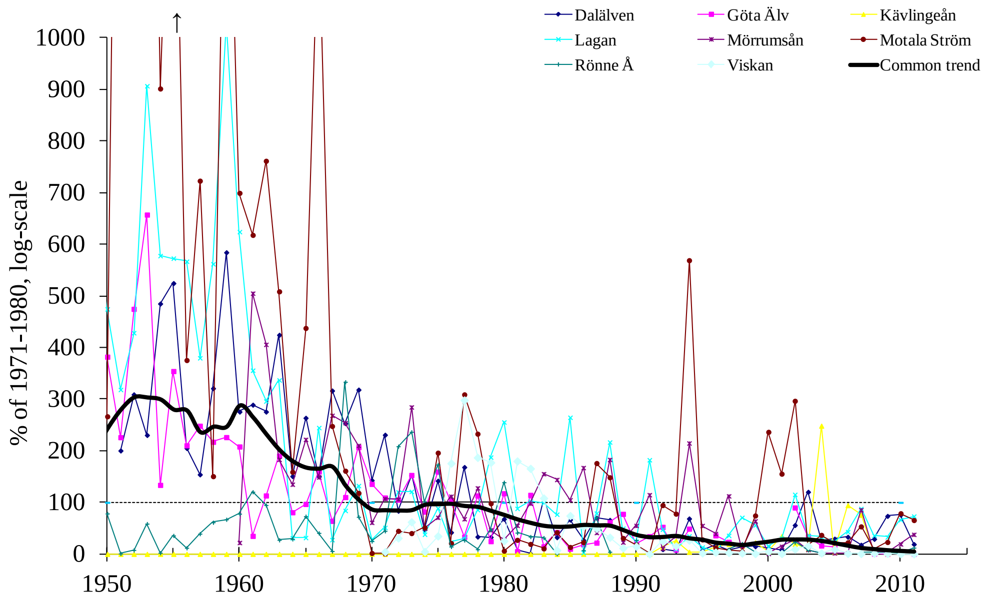

Figure SE. 6. The ascent of young eels in seven Swedish rivers (linear scale).

3.2 Yellow eel landings

3.2.1 Commercial

No reliable data on yellow eel separately.

3.2.2 Recreational

No updated figures are available as recreational fishing is prohibited since 2007. In previous reports an estimate based on a statistical survey was presented.

3.3 Silver eel landings

3.3.1 Commercial

No reliable data on silver eel separately.

3.3.2 Recreational

No updated figures are available as recreational fishing is prohibited since 2007. In previous reports an estimate based on a statistical survey was presented.

3.4 Aquaculture production

3.4.1 Seed supply

In 2012, 1200 kg were imported from River Severn in the UK.

3.4.2 Production

Of the imported glass eels (elvers) in 2012, 71% (2 561 774 individuals) were used for stocking in Sweden and 177 000 were sent off for stocking in Finland. The remaining 29% were used for further culture. The production for consumption in 2011 was 94 tons.

3.5 Stocking

3.5.1 Amount stocked

3.5.1.1 Standardising restocking units

Restocking seed material has varied from imported glass eels freshly recruited from the ocean to legally sized eel of approximately six years old, caught in the commercial fishery on the West Coast. Historical records indicate the source and size of the seed material in most cases, expressed in numbers and/or total weight, but neither of these units makes the different types of seed material comparable to each other (numbers going down with age, while total weight goes up). In order to standardize restocking quantities, all units have been expressed in "glass eel equivalents", following the line of reasoning of Knösche *et al*. (2004).

The glass eel equivalent is defined here as the number of (true) glass eels that would need to be restocked, if (true) glass eels had been used instead of the actual seed material, assuming an average growth and mortality rate in-between the glass eel stage and the actual size used. For a bootlace eel of age *a*, it is assumed that the initial number of glass eels $N_{glass\ eel}$ has declined by natural causes, down to N_a, where

$$N_a = N_{glass\ eel} \times exp^{-a \times M}$$

And hence

$$equivalency\ factor = \frac{N_{glass\ eel}}{N_a} = exp^{+a \times M}$$

Converting data on all types of restocking into numbers, and multiplying by the relevant equivalency factor, all restockings are then expressed as the equivalent number of glass eels. Using these data in an analysis of stock dynamics, these glass eel equivalents should be treated as if they were indeed restocked as glass eel, in year *t-a*, where *t* is the year of restocking. Hence, the stock dynamics analysis will assume that in the first *a* years of their life, they have grown and aged according to the above formula, leaving exactly N_a eels of age *a* in year *t*. That is: the conversion from restocked numbers to glass eel equivalents is exactly undone. Note that growth and mortality estimates should be equal in the equivalency conversion and the stock dynamics analysis.

In most cases, only the size of the seed material is known (length or weight), and a rough estimate of the corresponding age has been made; see Table SE. 3, below. A constant natural mortality rate of M=0.138 was assumed (i.e. 75% mortality over ten years, as assumed by Dekker, 2000).

Note that a bootlace eel is equivalent to more than two glass eels, that is: if equal numbers would be restocked, the bootlace would be expected to result in more than double the production. At the same time, however, the individual weight of bootlace eels is 90 gr on average, compared to 0.3 gr for the glass eel. Taking into account the mortality, a single glass eel (equivalent) is assumed to yield nearly 40 gr of bootlace eel biomass. Hence, stocking equal biomasses of glass eels and bootlace eels, the glass eel would be more than 100 times as effective.

Imported glass eels have never been restocked directly into outdoor waters in Sweden, but have been and still are being quarantined in indoor facilities. During their stay indoors, they are fed and they grow. After a few weeks, they are released to outdoor waters, at an average size of 10 cm and 1 gr. At that moment in time, these quarantined elvers have a true age of only a few weeks, but the size of a half year old eel (taking the glass eel stage as the hypothetical age zero). The larger size is assumed to give them a head-start in comparison to true glass eels of the same real age, and therefore these quarantined elvers have a glass eel equivalent of 1.07. That is: for calculating the number of glass eel equivalents, the age is used of a locally wild animal of the same size.

Table SE. 3. Types of restocking seed material, their size and age, and the corresponding number of glass eels.

Stage	L (cm)	W (gr)	age	$a \times M$	N_a	Glass eel equivalent	Total biomass (gr)
Glass eel	7	0.3	0	0	1.000	1.000	0.30
Elver (yngel)	9.5	1	0.5	0.069	0.933	1.071	0.93
Trollhättan eel	15	5	2	0.276	0.759	1.318	3.79
Bootlace (sättål)	40	90	6	0.828	0.437	2.289	39.32

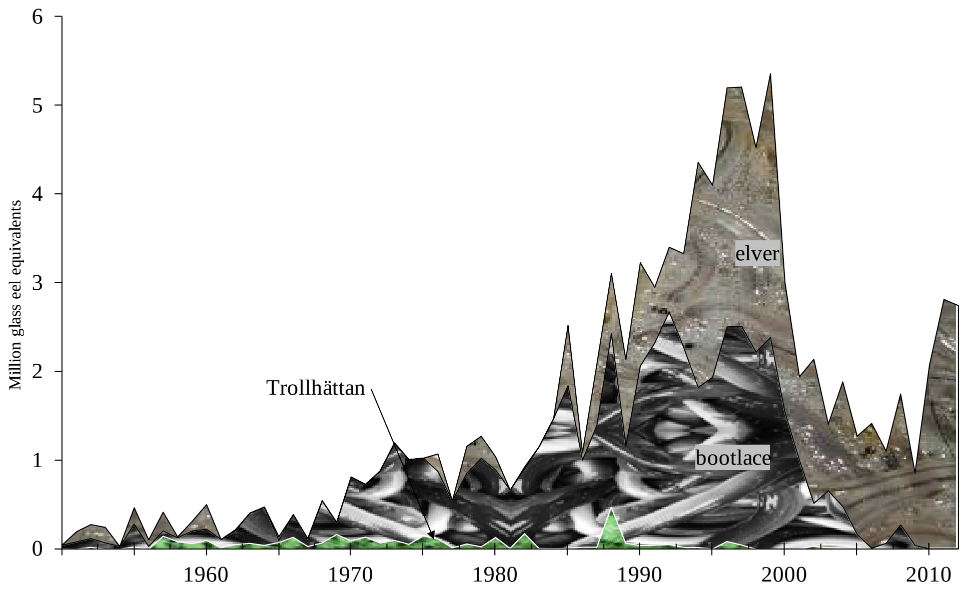

Figure SE. 7. Quantity and composition of the eel used for restocking since 1950.

Until the 1990s, the transport of eels from the west coast to the east coast (bootlace, sättål) has dominated the restocking programmes; recently, quarantined glass eel (elver, yngel) restocking is the only action left. Trollhättan eel (from Göta Älv) has always been a small quantity, and this transport has ended completely in 2005.

Figure SE. 8 shows the trend in restocking inland waters. Until 1970, less than 0.5 million glass eel equivalents were restocked. From 1970 to 1990 the quantity gradually increased to 1.5 million, reached 2–3 million in the 1990s, and then went rapidly down to about 1 million again. In 2010 and 2011, nearly 2 million equivalents were restocked. The quantity of eels being taken from west coast rivers (in Trollhättan) has been very small in comparison to the total quantities being restocked in these rivers.

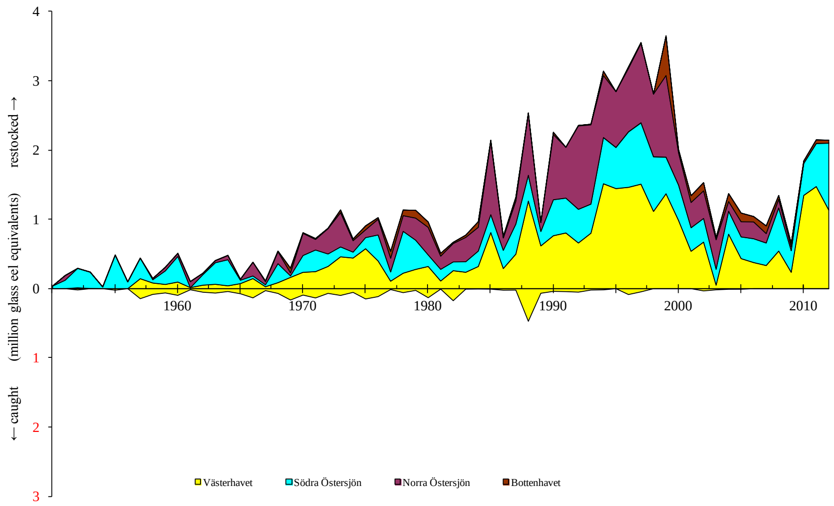

Figure SE. 8. Restocking in inland waters, by river basin district. Note that the catch of eels for restocking (in fact Västkusten – west coast only) is shown below the horizontal axis, while release of eels is shown above.

In coastal waters (Figure SE. 9), bootlace eels were caught along the west coast and restocked mostly along the east coast. Since 2000, this transport has come to a halt, and net restocking into coastal waters along the east coast is now small in comparison to the inland restocking.

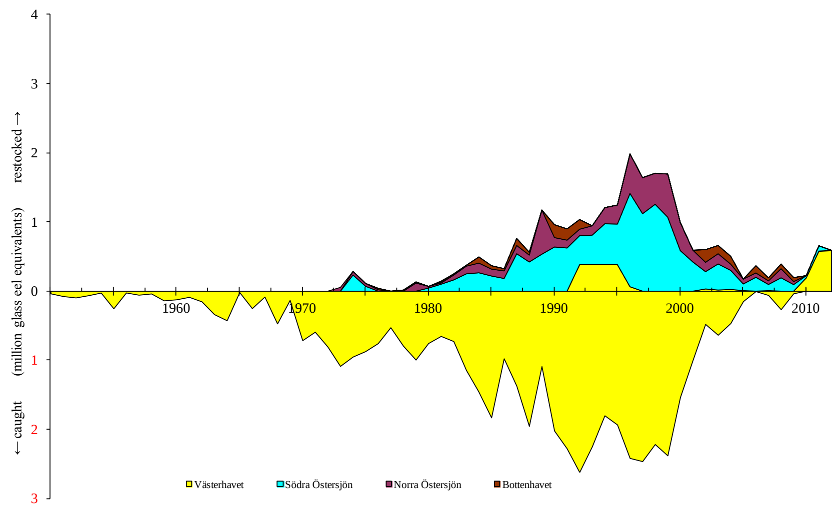

Figure SE. 9. Restocking in coastal waters, by river basin district. Note that the catch of eels for restocking (in fact Västkusten – west coast only) is shown below the horizontal axis, while release of eels is shown above.

In 2012 glass eels (elvers) were again imported from River Severn in the UK. From those eels, 71% (2 561 774 individuals) were used for stocking in Sweden and 177 000 in Finland. As there is a mandatory quarantine period of about 8–10 weeks before stocking, the eels released in nature are about 1 gram each when stocked, i.e. slightly ongrown.

Bootlace eels are no longer used for restocking, but ascending yellow eels of different sizes are in some rivers assisted in their upstream migration.

3.5.2 Catch of eel <12 cm and proportion retained for restocking

Catch of eels smaller than the minimum legal size is not allowed.

3.5.3 Reconstructed time-series on stocking

Table SE. 4.

	Local Source				Foreign Source			
Year	Glass Eel	Quarantined Glass Eel	Wild Bootlace*	On-grown cultured	Glass Eel	Quarantined Glass Eel	Wild Bootlace	On-grown cultured**
1973	0	0	475 466	0	0	0	0	10 200
1974	0	0	416 594	0	0	0	0	0
1975	0	0	382 040	0	0	0	0	0
1976	0	0	331 515	0	0	0	0	183 769
1977	0	0	231 064	0	0	0	0	0
1978	0	0	347 384	0	0	0	0	284 060
1979	0	0	435 371	0	0	0	0	232 667
1980	0	0	330 874	0	0	0	0	138 454
1981	0	0	286 093	0	0	0	0	0
1982	0	0	318 392	0	0	0	0	20 000
1983	0	0	500 407	0	0	0	0	0
1984	0	0	638 699	0	0	0	0	0
1985	0	0	800 962	0	0	0	0	633 500
1986	0	0	427 426	0	0	0	0	79 600
1987	0	0	599 811	0	0	0	0	647 936
1988	0	0	854 506	0	0	0	0	637 100
1989	0	0	476 597	0	0	0	0	913 678
1990	0	0	883 803	0	0	0	0	1 089 095
1991	0	0	996 136	0	0	0	0	585 783
1992	0	0	1 145 798	0	0	0	0	680 886
1993	0	0	983 944	0	0	0	0	987 000
1994	0	0	787 693	0	0	0	0	2 370 653
1995	0	0	845 449	0	0	0	0	2 021 145
1996	0	0	1 056 990	0	0	0	0	2 516 567
1997	0	0	1 077 106	0	0	0	0	2 517 676
1998	0	0	969 285	0	0	0	0	2 153 960
1999	0	0	1 040 824	0	0	0	0	2 778 463
2000	0	0	671 909	0	0	0	0	1 372 655
2001	0	0	437 875	0	0	0	0	876 492
2002	0	0	210 234	0	0	0	0	1 516 372
2003	0	0	278 598	0	0	0	0	701 866
2004	0	0	204 692	0	0	0	0	1 312 493
2005	0	0	66 158	0	0	0	0	1 037 331
2006	0	0	2 850	0	0	0	0	1 313 978
2007	0	0	27 067	0	0	0	0	971 507
2008	0	0	117 168	0	0	0	0	1 379 946
2009	0	0	16 478	0	0	0	0	763 214
2010	0	0	0	0	0	0	0	1 936 510
2011	0	0	0	0	0	0	0	2 625 984
2012	0	0	0	0	0	0	0	2 561 774

* In more recent years, bootlace eels were about 90 grams each and

**** On-grown cultured about 1 gram.**

According to the Swedish EMP about 2.5 million glass eels (in practice on-grown cultured eels) will be stocked annually. However, nothing is decided for how long.

4 Fishing capacity

4.1 Glass eel

No available data (as fishing for glass eels is prohibited).

4.2 Yellow eel

See below.

4.3 Silver eel

See below.

4.4 Marine and inland fishery

The number of licences issued yearly has decreased by 43% since the regulation was implemented in 2007. This decrease is mainly explained by the closure in 2012 of the yellow eel fishery on the west coast.

Table SE. 5. Number of licences issued yearly for coastal and freshwater fishery.

	TOTAL	COASTAL	COASTAL & FRESHWATER	FRESHWATER
2007	434			
2008	408	336	3	69
2009/2010	387	316	3	68
2011	360	285	3	72
2012	248	175	2	71

5 Fishing effort

5.1 Glass eel

No available data (as fishing for glass eels is prohibited).

5.2 Yellow eel

See below.

5.3 Silver eel

See below.

5.4 Marine and inland fishery

Since 1999, coastal fishermen submitted monthly reports on their activities. These reports do not allow reconstructing fishing capacity and/or effort, but the number of companies actually landing eel can be counted. Figure SE. 10 shows these trends per river basin district. In recent years, the number of companies has gone down, primarily in Västerhavet and in Bottenhavet. Since 2006, a minimal landing of 400 kg per year is required to obtain a licence. This increased the number of companies reporting, especially in Södra Östersjön, but otherwise, the number of companies shows a downward trend here too. The fishery in Kattegat and Skagerrak was closed in 2012, corresponding to a 40% decrease in coastal licences.

For inland waters, no reliable time-series on fishing capacity or effort exist (cf. Table SE. 5).

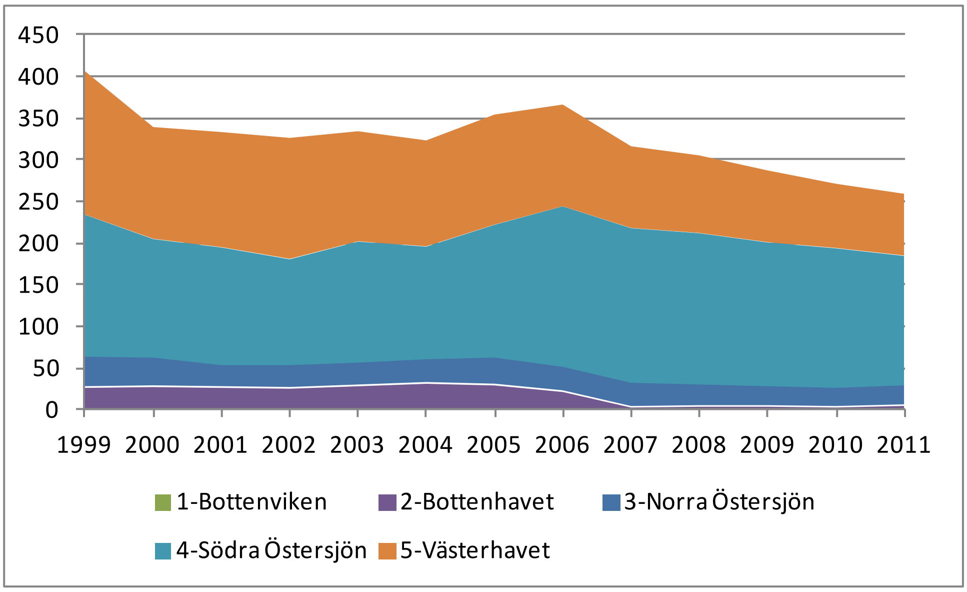

Figure SE. 10. Time trend in the number of fishing companies landing eel from coastal waters, by river basin district.

6 Catches and landings

6.1 Glass eel

No available data (as fishing for glass eels is prohibited).

6.2 Yellow eel

See below.

6.3 Silver eel

Freshwater fishery

The proportion of yellow eels is investigated from 2010 on as part of the DCF-programme for eel in freshwater. The eel fishery in freshwater is looking to catch migrating silver eels and is mainly conducted using fixed fishing gears such as poundnets. The results from the analysis of 2010 and 2011 sample catches showed that 0.8 and 4.8 % respectively were classified as yellow (residential) according to the silver index (SI) of Durif *et al*., 2005. The rest were either classified as premigratory or migratory eels. A comparatory classification according to Pankhurst, 1982 was also performed on the materials. Analysis showed that 23 and 29% (2010 and 2011 respectively) were classified as yellow according to Pankhurst eye index. However, the commercially catch of eels from freshwater is normally presented as silver eels.

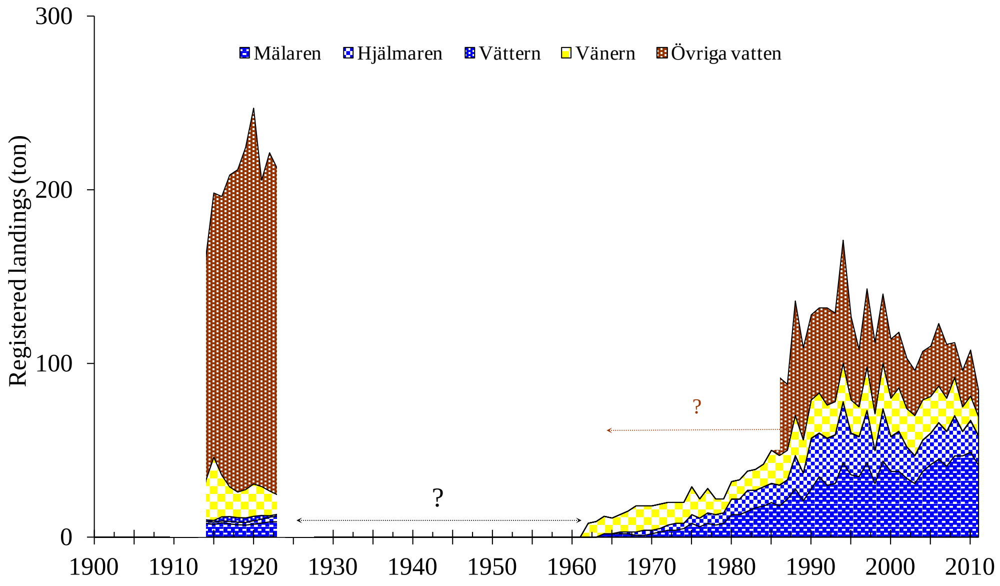

Figure SE. 11. Landings from inland waters, for each of the great lakes, and for the sum of all smaller lakes ("Övriga vatten"). The statistics were collected by the Statistics Sweden (SCB), based on reports by county fisheries officers; since 1999, statistics are based on monthly reports or logbooks, reported by fishers to the Swedish Board of Fisheries and now to The Swedish Agency for Marine and Water Management; for the in-between period, no records exist. Landings from the smaller lakes ("övriga vatten") were not reported until 1986 and onwards. Official data for 2011 is probably incomplete.

6.4 Marine fishery

Total eel catches reported to the logbook system averaged 494 tons in 1999–2011. As the system allows reports of undefined eel catches, the relation between life stages is not exactly known. Before 2005 shares of silver and yellow eel were equal and the undefined part was small (3%). Silver eel proportion tend to increase in 2005–2007 and probably also in 2008 (when the undefined part was 30%), as an increase in landings was recorded in the Baltic proper after 2004.

The Baltic eel fishery is strongly dominated by a poundnet fishery for silver eel. The duty to present logbooks was not mandatory for fishing on private waters until 2005 (private ownership of fishing rights are common in both inland waters as along the coast). This implies that catches in the Baltic Sea silver eel fishery were underestimated. The degree of underestimation is not known. In addition, the new legislation requiring license for eel fishing in 2007 has probably reduced underestimation of catches. In 2009–2011 approximately 70% of the landings were silver eel, mainly due to a reduction of yellow eel landings.

Logbooks contain information on a daily basis on catches (kg), gears used (number and type) and the fishing time (hours). In the journals information is given on a monthly basis with catches (kg), and effort (nr of gears*days). Both types of data are administrated and stored by the Swedish Board of Fisheries (since 1 July 2011 by the Swedish Agency for Marine and Water management). The Baltic Proper and the Kattegat-Skagerrak area strongly dominate the landings and the share for the Baltic was higher in recent years than in the preceding period (Figure SE 12). A significant decline in the total landings is seen in 2007–2011 (linear regression, $p<0,01$) and for the first time in modern history the Swedish eel landings from the sea-fisheries were below 400 tons.

Recreational fishery is prohibited since 2007.

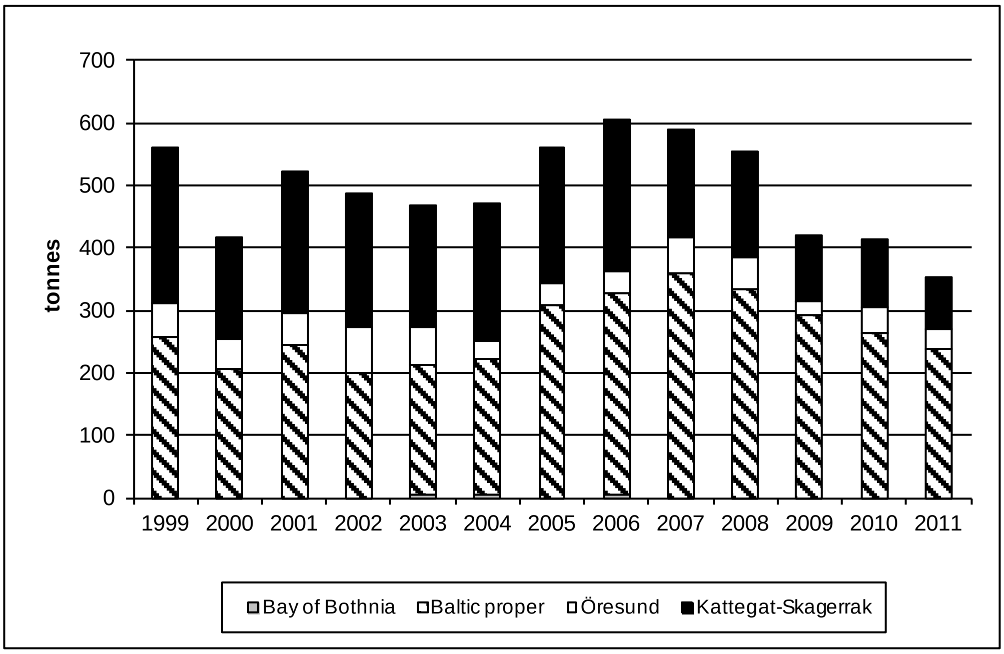

Figure SE. 12. Total commercial landings in coastal fishery by main basin.

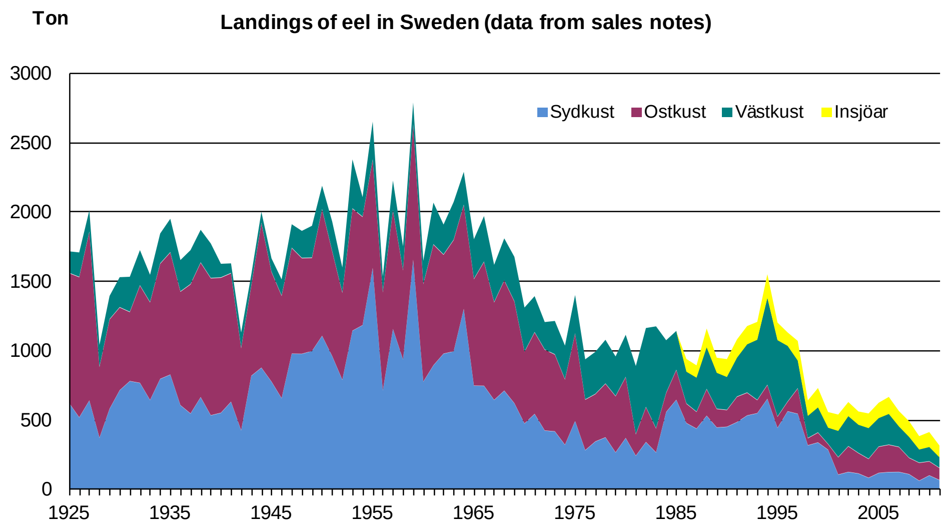

Figure SE. 13. Landings as reported through the sales notes system.

There is a discrepancy between the data derived from the traditional sales notes system and the more recent logbook system. During the most recent years this difference was considerable, as in 2011 when sales notes report 238 tons, while the logbooks say 355 tons (all from the marine areas). This discrepancy for 2011 (49%) is presented in the official statistics as a “completion increment” (SCB, 2012).

7 Catch per unit of effort

7.1 Glass eel

No available data (as fishing for glass eels is prohibited).

7.2 Yellow eel

See below.

7.3 Silver eel

See below.

7.4 Marine fishery

Fishermen in the central Baltic have provided detailed records of their catches for several decades, as part of a monitoring programme related to the nuclear power plant in Oskarshamn. On one site in southern Östergötland archipelago (Figure SE. 14), no change in the catch of yellow or silver eel per unit of effort has been observed since the mid-1970s, though the fishing effort in the 1990s was considerably lower than before. No such decline in effort occurred on a site in northern Kalmar County; no significant change in yellow eel catch occurred here, but catches of silver eel have increased. This might be related to an increased focus on silver eel in recent years.

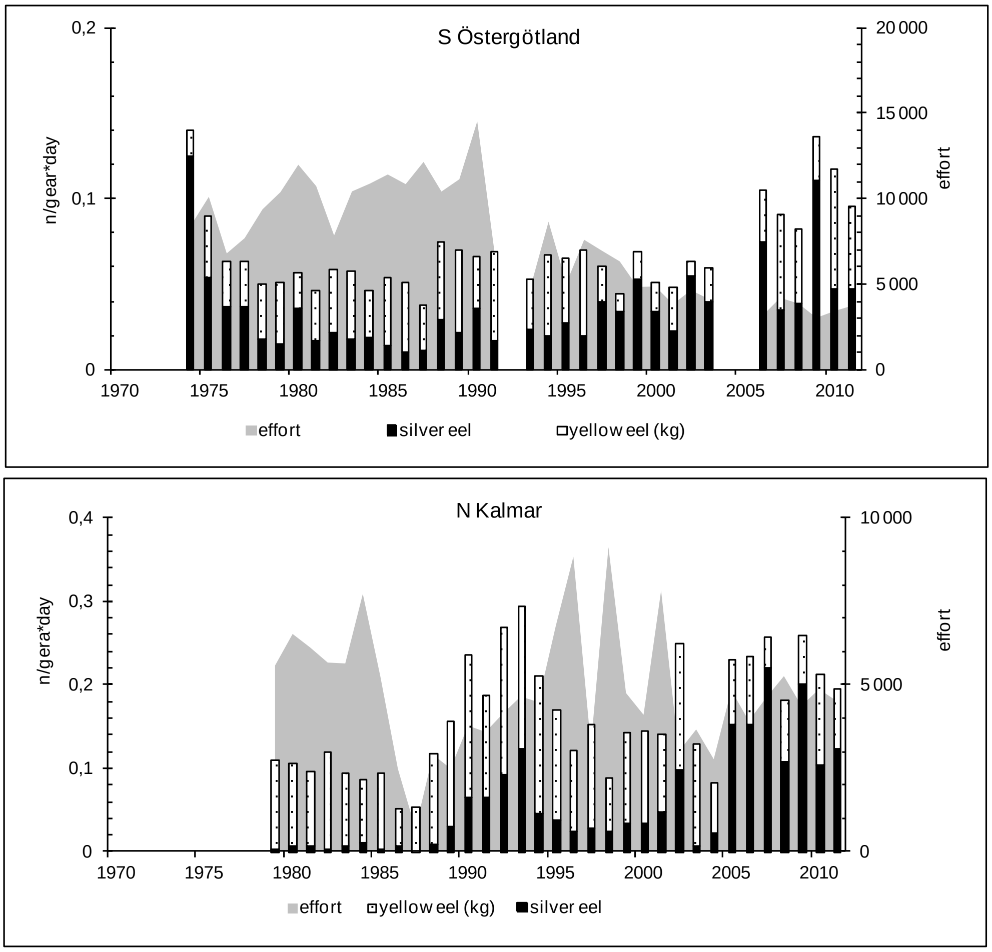

Figure SE. 14. Catch per unit of effort for yellow and silver eel, and total annual fishing effort, in fisheries with (small) fykenets in two areas in the central Baltic.

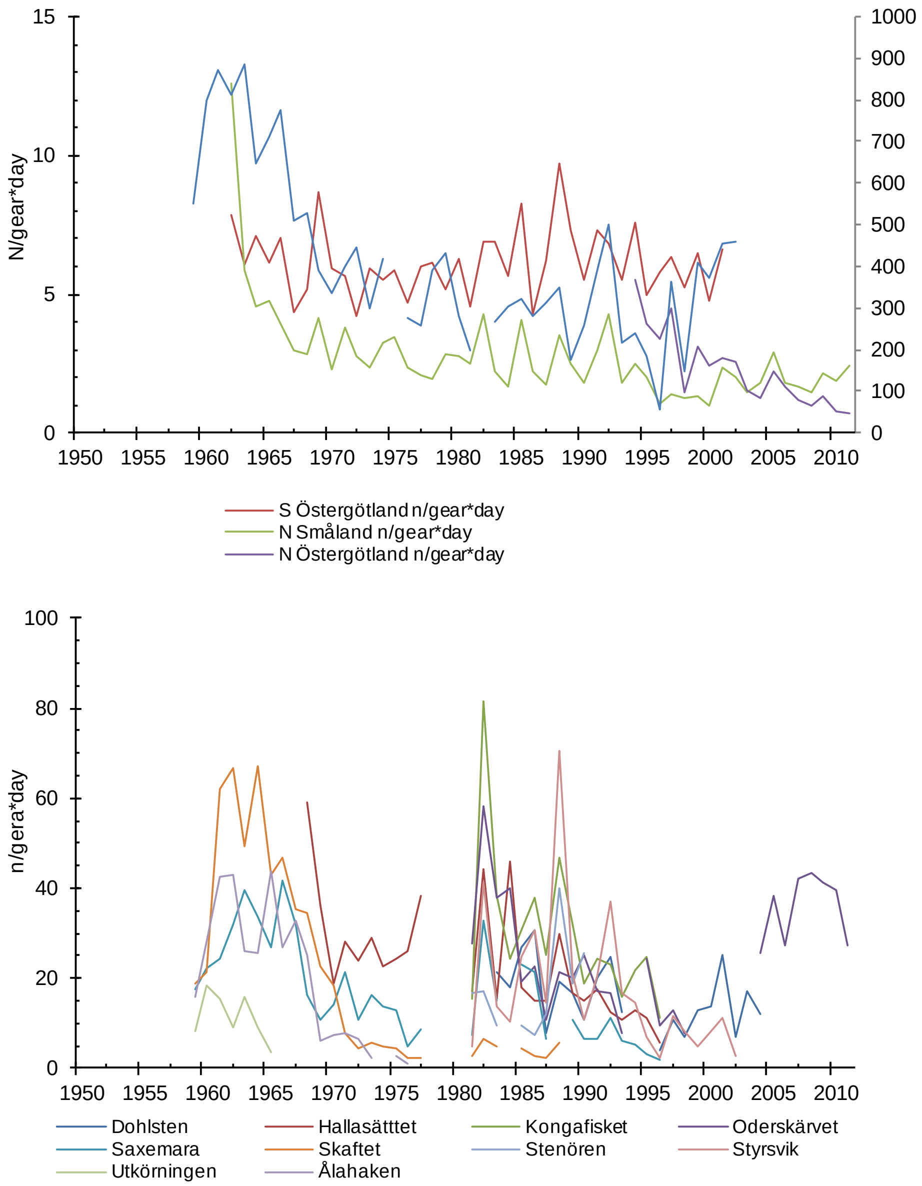

Figure SE.15. Catch per unit of effort in the poundnet fishery for silver eel at four sites in the central Baltic (top) and ten sites in Hanöbukten (below).

The catch per unit of effort for the poundnet fishery on silver eel in the central Baltic has declined considerably in the 1960s (Figure SE. 15), but has stabilized thereafter. Two of the series ceased around 2000, and the same happened to some of the series in Hanöbukten in the 1990s. In recent years, however, some of the original series resumed, and catches at these sites have been relatively high recently, compared to the 1980s. Note however, that the data presented only represent part of the poundnet fishery in this area.

8 Other anthropogenic impacts

There is a programme running, aiming at a reduction in hydropower induced mortalities from assumed high levels down to less than 60% in total (looking at Sweden as one management unit). However, no relevant data besides what is presented in Chapter 13 are available.

9 Scientific surveys of the stock

9.1 Recruitment surveys, glass eel (includes yellow eel in Scandinavia)

Recruitment is mainly studied as described above (3.1), i.e. by monitoring ascending young eels in a number of rivers but also by trawling studies in the open Kattegat-Skagerrak area as well as in the cooling water intake to the Ringhals Nuclear Power Plant. To this come extensive data collected by electro-fishing mainly for salmonids in streams all over Sweden. (Figures SE. 16–19). From 2010 onwards we add to these sites a smaller number of electro-fishing stations in areas with a nonsufficient coverage. Some resting series with drop-trapping (ICES 2009a) data has also been reopened and extended from 2010, in order to improve the coverage of samples and quality of recruitment data.

9.1.1 Electro-fishing surveys

In inland waters, electro-fishing surveys have been held in running waters, and data have been compiled in a central register (SERS, Swedish Electrofishing Register, Swedish University of Agricultural Sciences, Department of Aquatic Resources, Örebro). Time trends can be shown from 1990 onwards. From SERS the following kind of data were extracted.

9.1.2 Data on occurrence

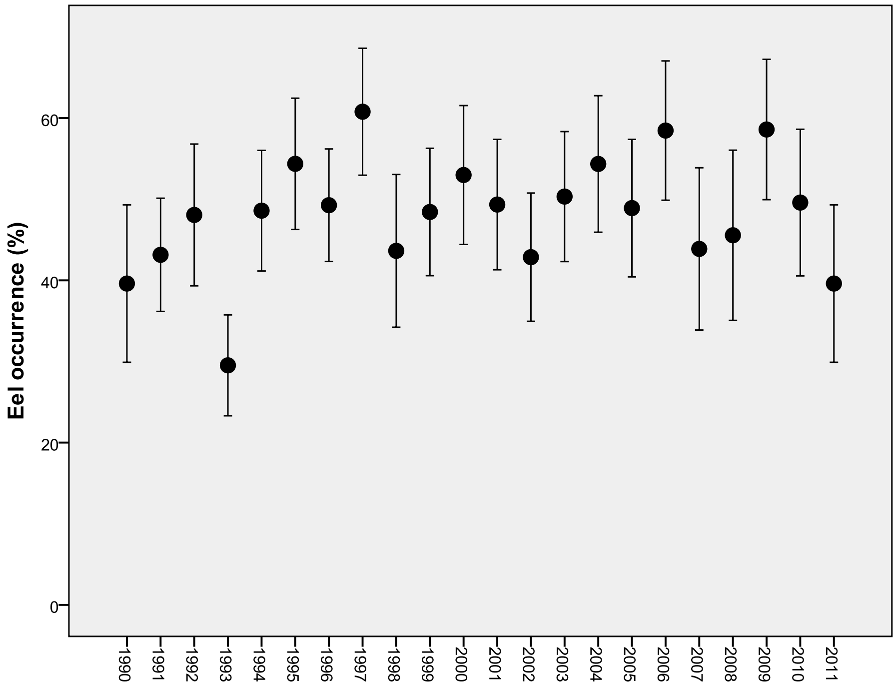

Figure SE. 16. Proportion of electro-fished stations (%) with eel occurrence (+/- 95% CI) along the west coast (only the county of Halland). The stations fished in 1990–2011 are situated from 0 to 100 m altitude. Note that local abundance is not given here, only presence/absence. Data from SERS (Swedish Electrofishing Register). The trend is not significant (Pearson correlation, n=22, r=0,251, p=0,26).

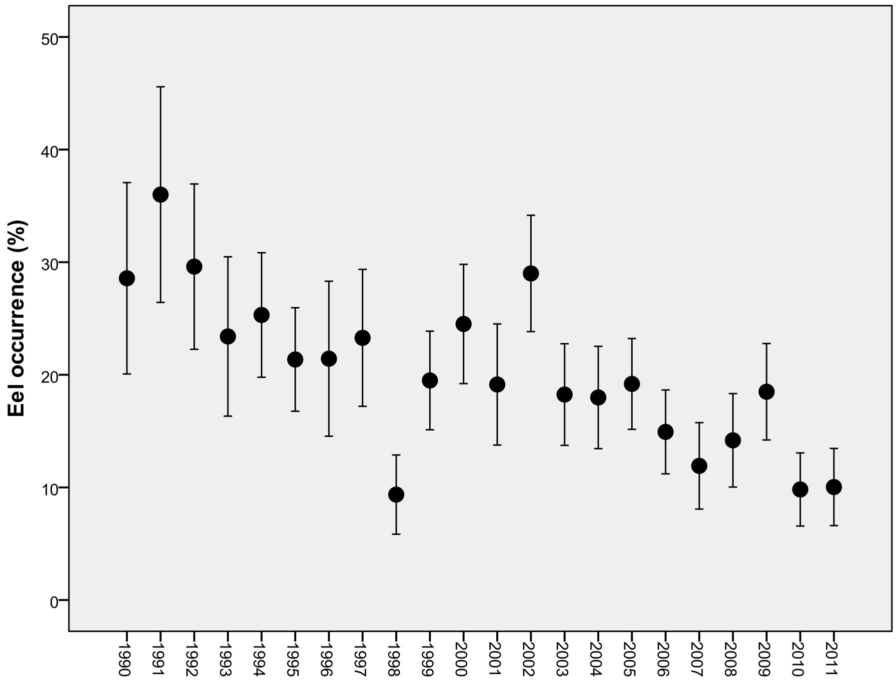

Figure SE. 17. Proportion of electro-fished stations (%) with eel occurrence (+/- 95% CI) along the east coast. Stations fished in 1990–2011 in this figure are situated from 0 to 100 m altitude in seven counties along the Baltic Sea coast. Note that local abundance is not given here, only presence/absence. Data from SERS (Swedish Electrofishing Register). The negative trend is significant (Pearson correlation, n=22, r=-0,759, p=<0,001).

9.1.3 Data on abundance

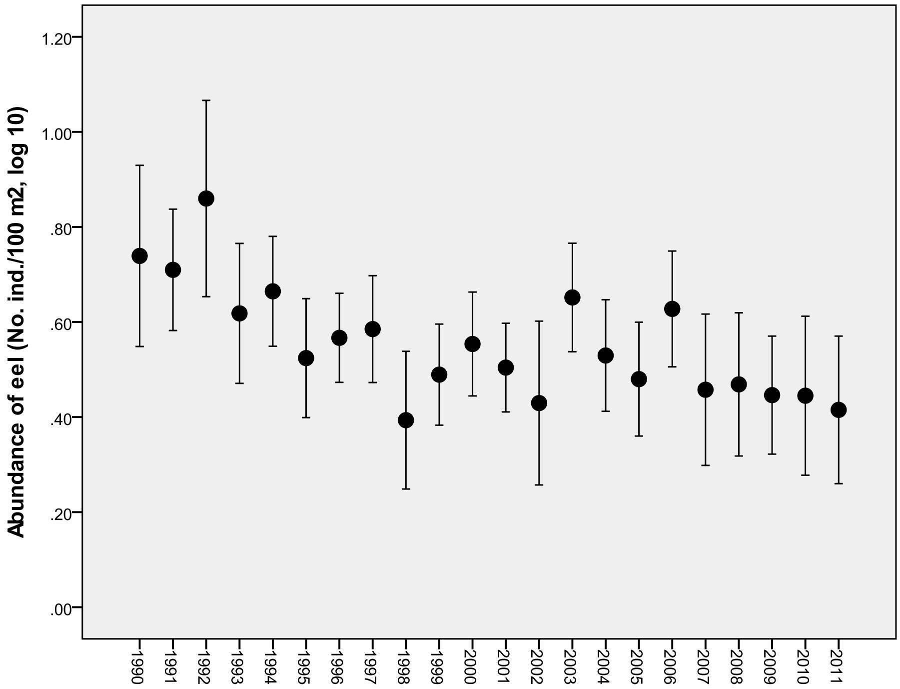

Figure SE. 18. Abundance of eel (No. ind./100 m², log 10) along the west coast (only the county of Halland). The stations fished in 1990–2011 are situated from 0 to 100 m altitude. Data from SERS (Swedish Electrofishing Register). The negative trend is significant (Pearson correlation, n=22, r=-0,7, p=<0,001).

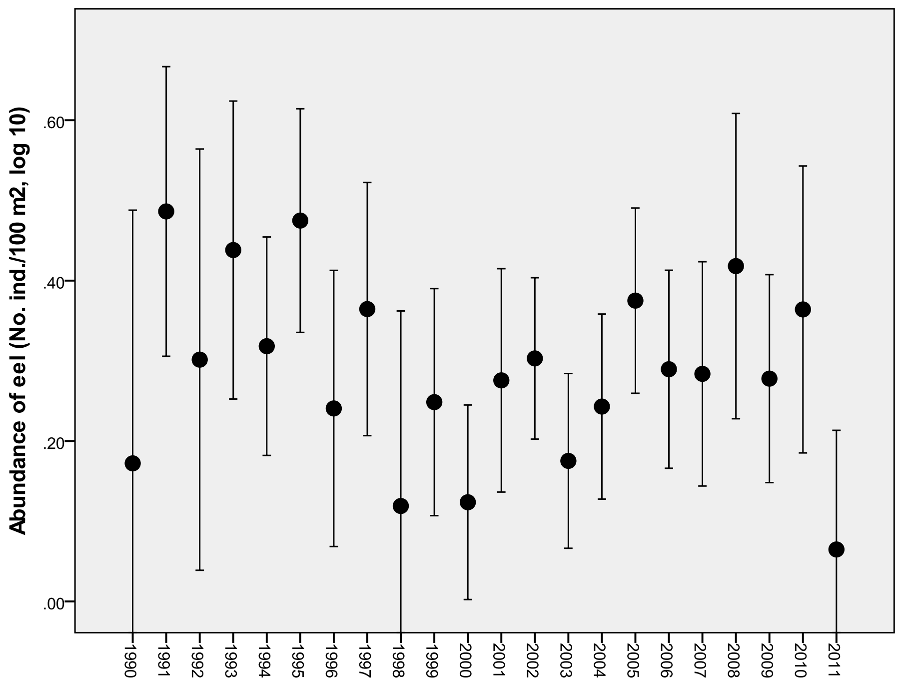

Figure SE. 19. Abundance of eel (No. ind/100 m², log 10) along the east coast. Stations fished in 1990–2011 in this figure are situated from 0 to 100 m altitude in seven counties along the Baltic Sea coast. Data from SERS (Swedish Electrofishing Register). The negative trend is not significant (Pearson correlation, n=22, r=-0,220, p=0,326).

As part of the DCF fishery-independent monitoring for recruiting young eels, some old electrofishing sites and series along the Swedish West Coast have been revived from 2010. Furthermore the "Drop Trap" technique (Westerberg *et al.*, 1993) has been employed in shallow coastal areas along the same coast. A few attempts using "lamprey pots" were initiated in small rivers in 2011. The catch from drop-trapping and the lamprey pots were both low. If this is due the techniques used or reflects very low abundances of young eels is not yet known.

9.2 Stock surveys, yellow eel

The coastal fish communities on the Swedish west coast are monitored by standardized fishing with fykenets in shallow water (2–5 m). Yellow eel is among the dominating fish species in August most years. The trend for the longest time-series from Vendelsö in N Kattegat is significantly positive (Figure SE. 20). No trend exists in the other long time-series from Barsebäck in the Öresund, nor in other areas, although the tendency is negative in some areas in recent years. The magnitude of cpue though, was similar to that of the longer series. The interannual variations in cpue were influenced by water temperature at the time of sampling. Cpue at Vendelsö and at Barsebäck was positively correlated with seawater temperature at Vendelsö in the period with available data (1988–2011) (Vendelsö p<0,01, r2=0,31; Barsebäck p<0,05, r2=0,19). However, no time-trend in temperature was observed for this period.

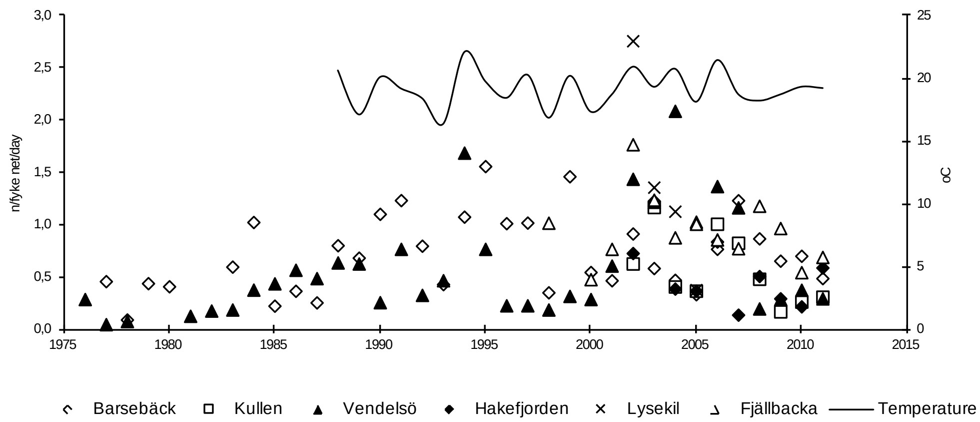

Figure SE. 20. Time-trend in the yellow eel catches in coastal fish monitoring with fykenets in August on the Swedish west coast. Annual mean water temperature at the fishing gears is presented for the Vendelsö area in central Kattegat.

9.3 Scientific surveys of restocked eels

As part of our national eel research programme some stocked eel populations are since many years continuously studied mainly by test-fishing or by the use of permanent outlet traps (cf. Westin, 2003 and Wickström *et al.*, 1996). In some cases the stocked eels were marked or tagged with $SrCl_2$, Alizarin Red and PIT-tags, respectively. In e.g. Lake Mälaren 5000 glass eels were marked with Alizarin Complexone in 1997 and a few years later marked eels dominated the catch in an experimental test fishing with fykenets at that site (Figure SE. 21). More than 10% of the marked eels have been recaptured so far, a figure that will increase as only few have yet become silver.

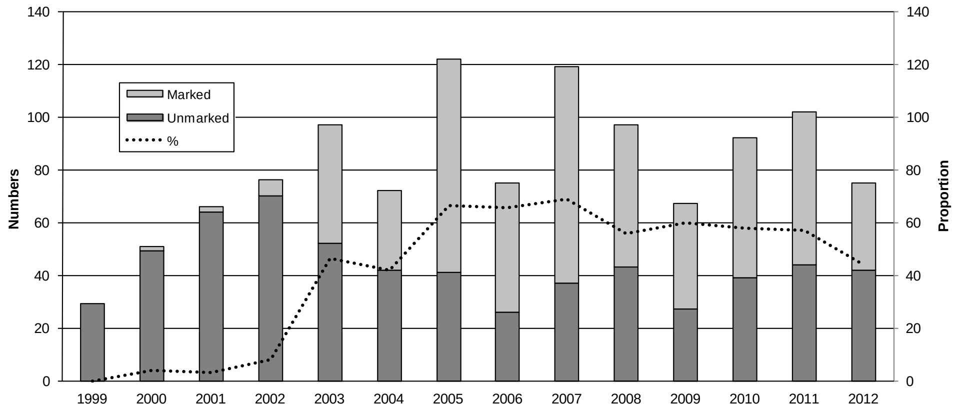

Figure SE. 21. Proportions of marked stocked eels in Lake Mälaren.

Besides that all eels used for stocking in Sweden since 2009 are marked with $SrCl_2$, some 2000 glass eels were in 2011 marked also with $BaCl_2$ before being stocked at the same site as in 1997. A preliminary check indicates a marking success of 87%.

Eels stocked 1999–2001 in Lake Ymsen were tagged with passive transponders (PIT-tags). All eels taken from that lake are screened for PIT-tags by a local fisherman who controls the whole eel fishery. Until 2011, 159 eels were recaptured, corresponding to a recapture rate of 6,1%. Most of them were quite large silver eels with growth rates of about 60 mm/year.

From Lake Fardume Träsk (cf. Wickström *et al.*, 1996) where eels were stocked in 1989 there is still a considerable run of silver eels. In spring 2012, i.e. after 23 years in that lake they were 797 mm in length and 872 g in weight, to compare with e.g. 2007 when the corresponding figures were 732 mm and 681 g, respectively.

9.4 Silver eel

Nothing to report (cf. section on mark–recapture).

10 Catch composition by age and length

Length compositions of fykenet catches sampled in the 2000s along the west coast and in the Öresund are quite comparable (Figure SE. 22): the interval between 40 and 50 cm dominates the catch, and frequencies decline with length to almost zero around 70 cm. The difference between the early and the late 2000s in Skagerrak area and in Öresund might have been related to a change in legal size, changing sampling sites, or be real. Sampling in the central Baltic focused on unsorted catches. Here, the most abundant size class is 50–60 cm, and larger eels are considerably more abundant than on the west coast, while the smaller eels (< 40 cm) are relatively scarce.

For the average size of silver eels, there is a clear trend going from the central Baltic towards Öresund, finding smaller and smaller sizes. In the central Baltic, few eels are shorter than legal size (65 cm in 2010), while in Skåne, 40% of the catch is below legal size; here, they are even a bit shorter than in the (northern) Öresund, while in Öresund a legal size of 40 cm applied (2010).

Catches in inland waters consist predominantly of silver eels; their lengths vary from the legal size (65 cm at that time) to 100 cm or more. There is a slight tendency for northern lakes to produce larger eels, but otherwise, the length composition varies from lake to lake without any clear pattern.

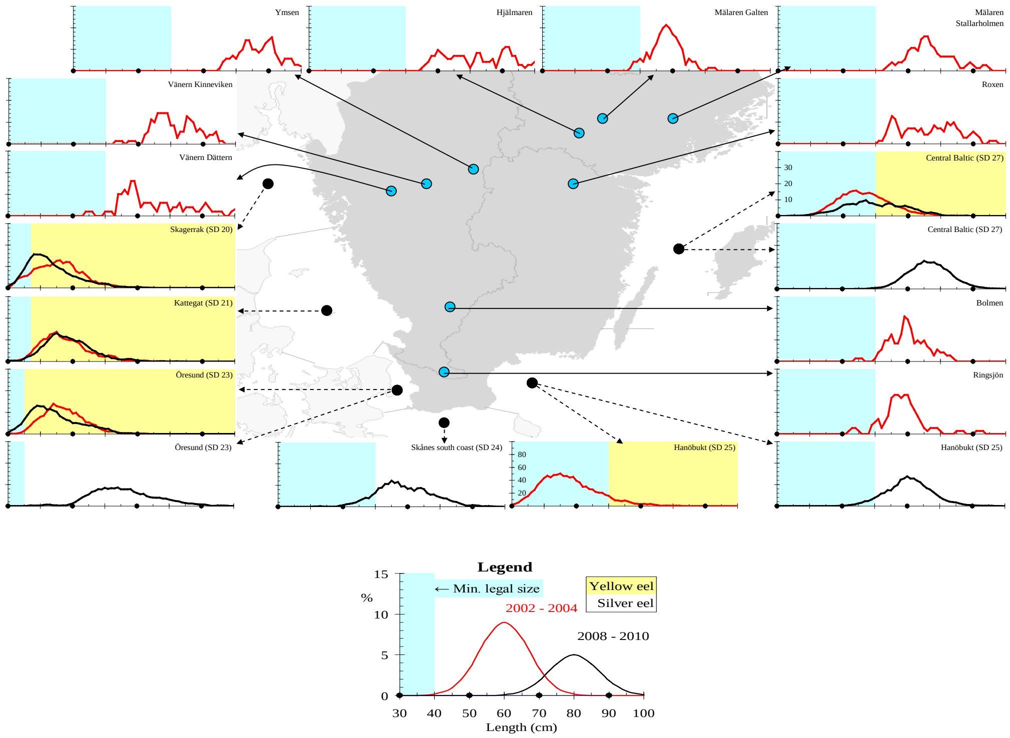

Figure SE. 22. Length composition of (sorted or unsorted) commercial catches. All observations have been scaled to 100% over the length classes above the local legal size. The shadowed area marks the legal size. Moving averages over 3 cm; vertical scales for all plots 0–15%, except where otherwise indicated.

For yellow eel, the age composition from commercial catches does not show marked differences between coastal areas (Figure SE. 23). Most yellow eels are between 5 and 15 years old, all between the inner Baltic and the Skagerrak coast. Differences between years of sampling are small too. Only in Öresund were much younger eels observed than in the other areas.

For silver eel, the age composition varies considerably between the Baltic and Öresund (Figure SE. 23). Samples from pound nets taken in the 2000s have shown eels between five and 25 years old. In the central Baltic and Hanöbukten, ages vary between ten and 20 years, while along the southern coasts of Skåne and in Öresund the eels are a bit younger. A relatively large share of the eels from Öresund was ten years or younger, in both sampling periods.

Silver eel age in inland waters is dominated by age groups between ten and 20 years old, but the oldest eels can be up to 30 years or more.

In over 6000 yellow eels sampled in 2006–2010, females were absolutely dominating. Males lacked completely in the central Baltic. The relatively largest share of males was found along Skagerrak coast, where approximately 4% of 2500 yellow eels analysed were male. In the other areas, less than 1% was male.

In nearly 5000 silver eels sampled in 2007–2010, only 19 males were found, most of them in Öresund, making 3.8%. This will be an overestimate, since sampling in recent years was length-stratified, with a fixed number of eels per cm. Only three males were found along the Baltic coast, all on Skåne's south coast. In a material of silver eels leaving the Baltic Sea in 2003 (Clevestam and Wickström, 2005), 5.25% were males.

In inland waters, catches consist of female eels only, which will relate to the high legal size (males rarely become bigger than 50 cm, legal size is 70 cm (previously 65 cm). In scientific surveys, a small number of males have been observed, but the total number is extremely low.

Silver eel age in inland waters is dominated by age groups between 10 and 20, but the oldest can be up to 30 years or more. Mean ages from the 2010 DCF silver eel collections in four lakes vary between 12.8 and 18.7 years (total average 15.9, n=599).

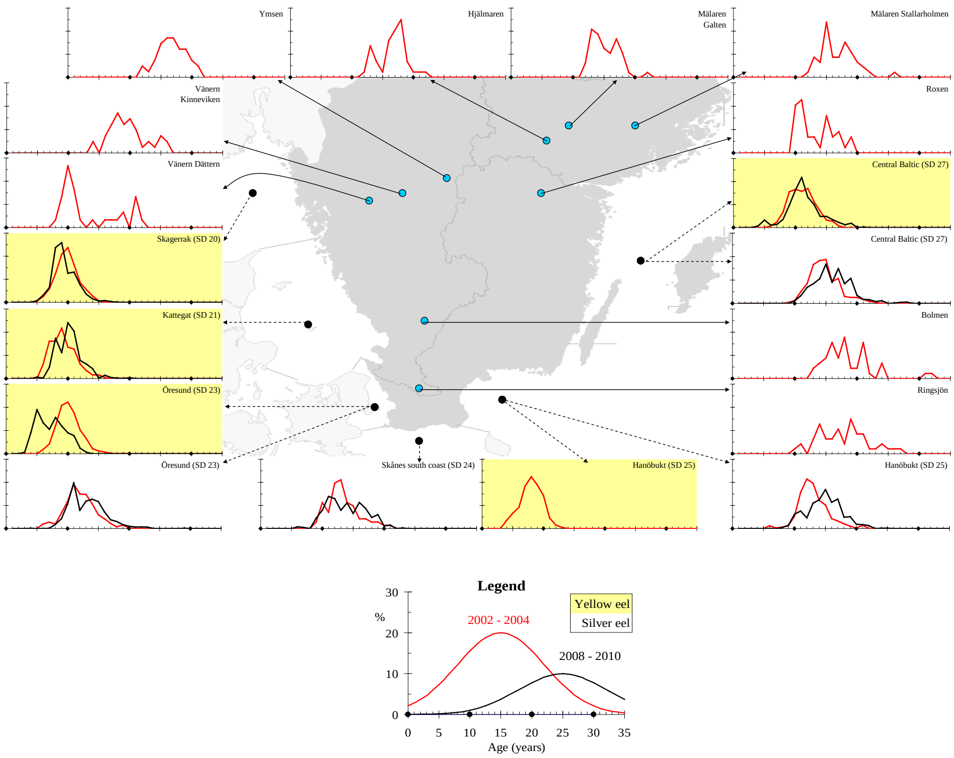

Figure SE. 23. Age composition of yellow and silver eel from commercial catches, taken from poundnets. Most samples were unsorted for the legal size. (No moving average; vertical scale for all plots 0–30%).

11 Other biological sampling

11.1 Length and weight and growth (DCF)

Annual growth for the yellow eel stage has been calculated as the difference between the final length and the glass eel length, divided by the number of years in between, and averaged over all eels being sampled. In coastal waters, annual growth varied between 45 and 52 mm per year, with a tendency to grow a bit faster in the Baltic proper (Figure SE. 24).

For silver eel, it is less certain than for yellow eel that locally observed average growth rate indeed reflects the local circumstances, since the silver eels might have come from different places. Observed growth rates showed little variation along the east and south coasts: mostly around 50 mm per year, which most closely resembles the growth rate of yellow eel in the Baltic proper.

Silver eel age in inland waters is dominated by age groups between 10 and 20, but the oldest can be up to 30 years or more. Mean ages from the 2010 DCF silver eel collections in four lakes vary between 12.8 and 18.7 years (total average 15.9, n=599).

Growth of silver eel in inland waters varies between 36 and 55 mm per year, without a clear trend: growth can vary from lake to lake. In inland waters, local circumstances apparently determine the growth, even in silver eel.

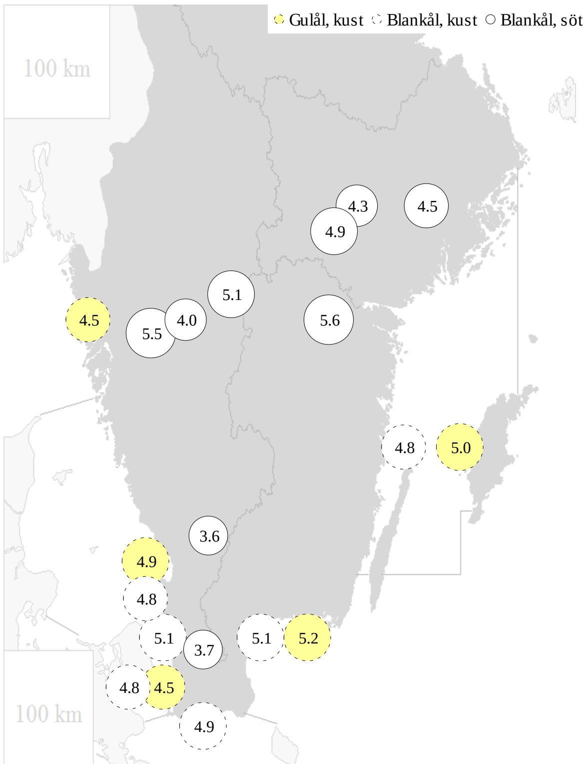

Figure SE. 24. Average growth in cm per year, for yellow and silver eel, in fresh and coastal waters.

From the DCF programme in freshwater the following data on length, weight and age were found (Table SE. 6). Growth of silver eel in four inland waters varies between 36 and 58 mm per year.

Table SE. 6.

Lake	N	Mean length (std)	Mean weight (std)	Mean age (std)	K	*A. crassus* Prevalence	*A. crassus* Intensity
Hjälmaren							
2010	125	876 (65)	1566 (361)	16,1 (2,9)	0,23	61,6	**4,0 (4,7)**
2011	111	882 (70)	1552 (361)		0,22	53,2	**3,6 (4,3)**
Mälaren							
Galten 2010	125	748 (46)	846 (153)	16,7 (2,5)	0,20	79,8	**3,7 (3,4)**
Galten 2011	125	766 (37)	939 (135)		0,21	84	**4,6 (4,4)**
Mälaren							
Prästfj. 2010	129	825 (76)	1315 (390)	18,7 (2,9)	0,23	82,9	**6,1 (4,9)**
Prästfj. 2011	127	807 (78)	1183 (375)		0,22	85	**5,5 (5,1)**
Ringsjön 2011	124	678 (64)	620 (183)		0,19	79	**12,8 (14,4)**
Vänern S							
2010	129	783 (61)	1016 (301)	12,8 (3,1)	0,21	81,4	**8,6 (8,3)**
2011	131	823 (75)	1158 (362)		0,20	79,2	**7,1 (7,3)**
Vänern N							
2010	126	784 (72)	1019 (334)	15,3 (3,2)	0,20	81	**6,0 (6,2)**
2011	**126**	**779 (77)**	**950 (323)**		**0,19**	**89,7**	**8,3 (8,8)**

11.2 Parasites and pathogens

The prevalence of swimbladder parasite *Anguillicoloides crassus* has been monitored in samples taken from commercial catches, in fresh waters and coastal areas. The prevalence in yellow eel was generally lower in marine areas along the west coast, going up to 6% in Skagerrak and 13% in the southern Kattegat, while more than 50% of the yellow eels had parasites in both Baltic areas (Figure SE. 25). Silver eels were less infected in general, and differences between sites were smaller. In inland lakes, prevalence was generally much higher (79–90%), although only 57% of eels in Lake Hjälmaren were infected in 2010–2011.

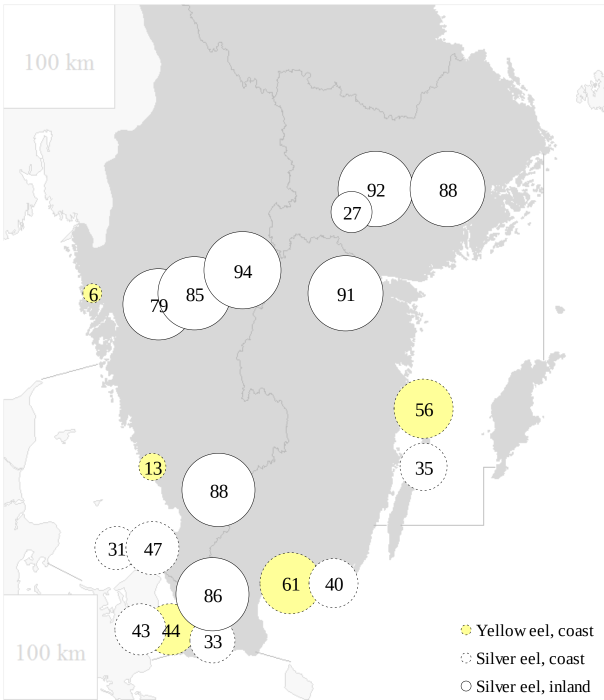

Figure SE. 25. Prevalence (%) of the swimbladder parasite *Anguillicoloides crassus* in yellow and silver eel, in the 2000s.

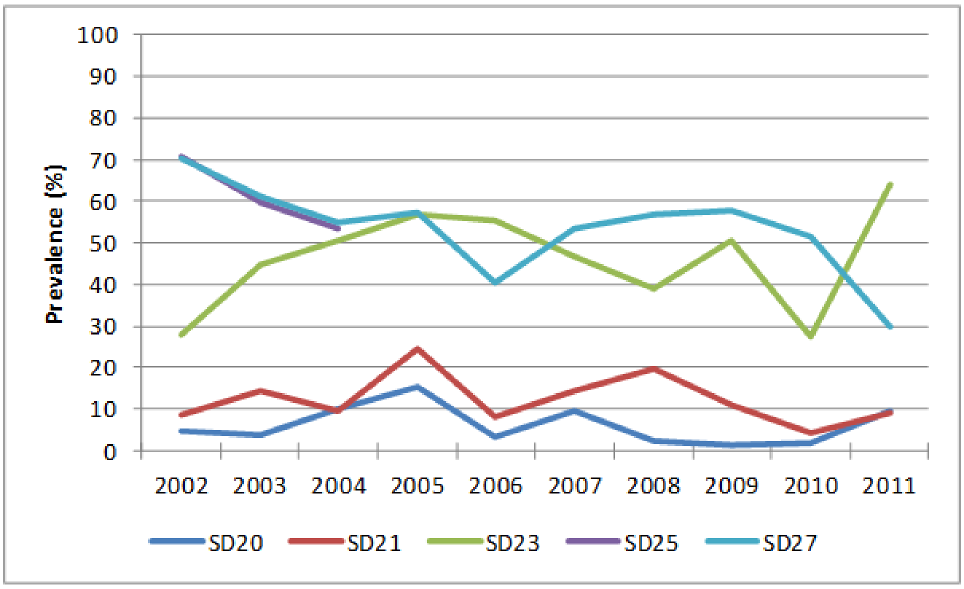

Figure SE. 26. Time trends in prevalence of *A. crassus* in yellow eels in Swedish coastal areas (ICES Subdivisions 20, 21, 23, 25 and 27).

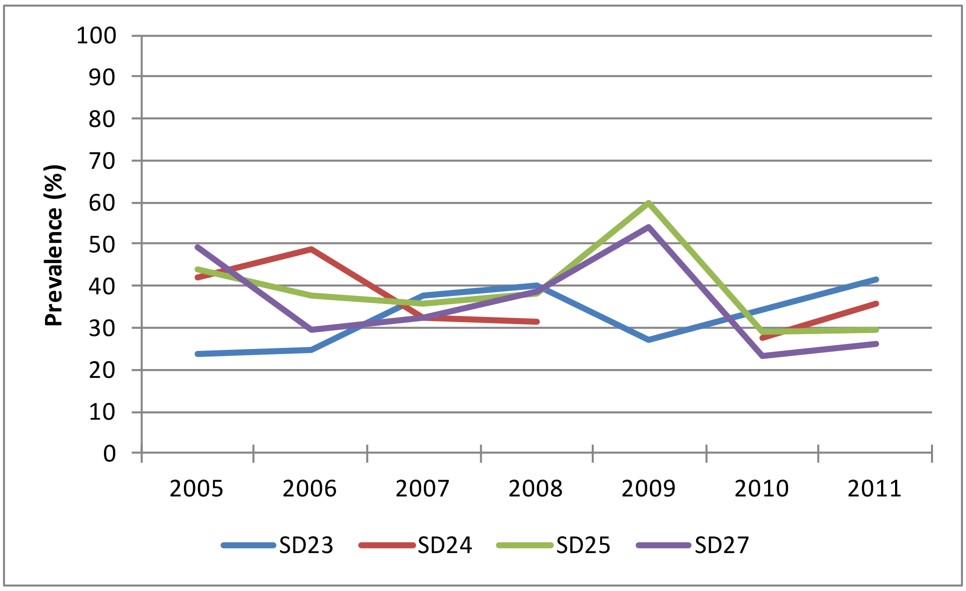

Figure SE. 27. Time trends in prevalence of *A. crassus* in silver eels in Swedish coastal areas (ICES Subdivisions 23, 24, 25 and 27).

From eels sampled from freshwater within the DCF programme, also prevalence and intensity of *A. crassus* were analysed.

Table SE. 7. Prevalence and intensity of *A. crassus* in migrating eels from the commercial fishery in four lakes.

LAKE/Site	N	Prevalence (%)	Intensity (sd) (no parasites/infected)	Note
HJÄLMAREN				
2010	125	61.6	4.0 (4.7)	
2011	111	53.2	3.6 (4.3)	
MÄLAREN				
Prästfjärden				
2010	129	82.9	6.1 (4.9)	
2011	127	85.0	5.5 (5.1)	
Galten				
2010	125	79.8	3.7 (3.4)	
2011	125	84.0	4.6 (4.4)	
RINGSJÖN				
2011	124	79.0	12.8 (14.4)	17% yellow eels
VÄNERN				
North				
2010	126	81.0	6.0 (6.2)	
2011	126	89.7	8.3 (8.8)	
South				
2010	129	81.4	8.6 (8.3)	
2011	131	79.2	7.1 (7.3)	

Two time-series from Lakes Mälaren and Ymsen, respectively show quite stable prevalence of *A. crassus* during last years.

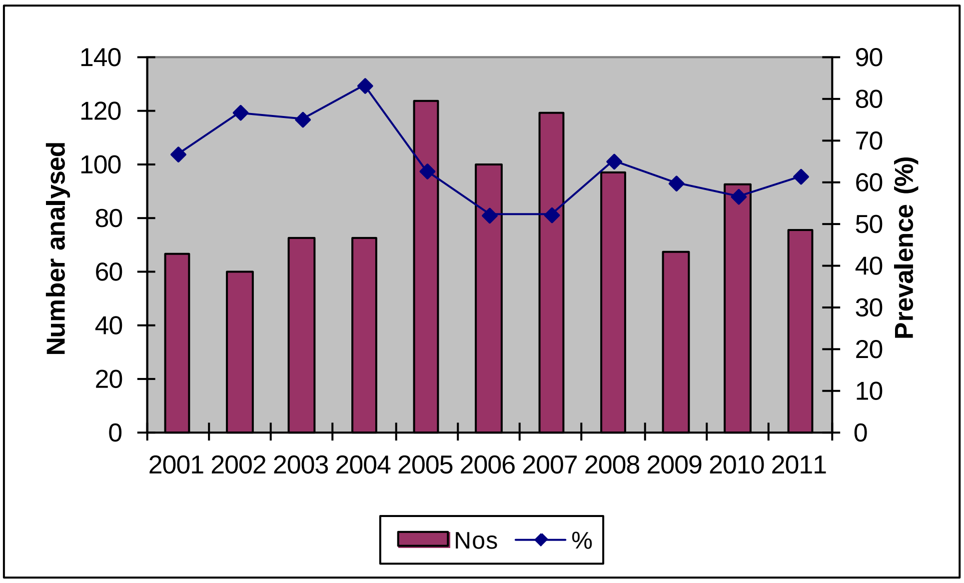

Figure SE. 28. ***Anguillicoloides crassus*** **in eels from Lake Mälaren.**

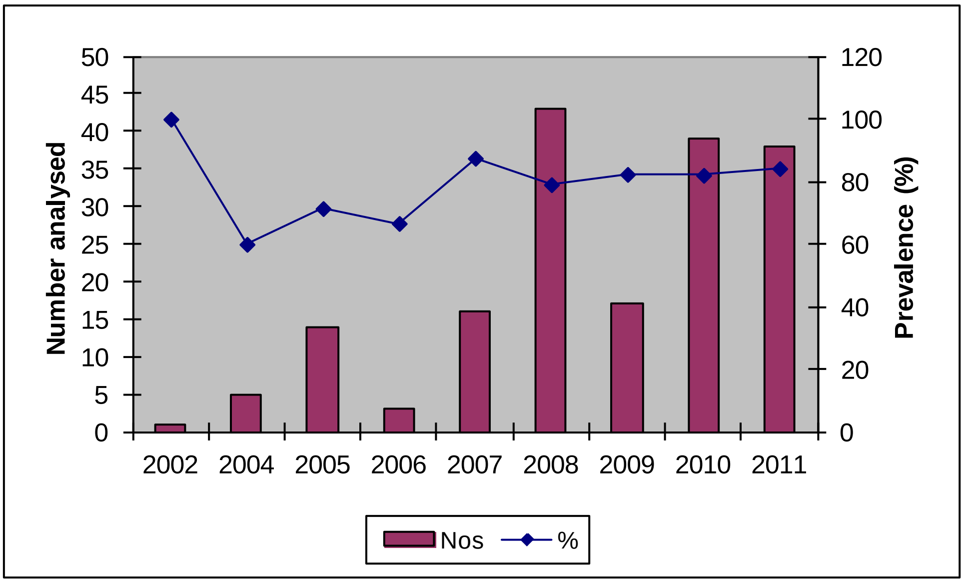

Figure SE. 29. ***Anguillicoloides crassus*** **in eels from Lake Ymsen.**

11.3 Contaminants

No analyses for dioxins and PCB have been performed since 2010. Since 1st of January 2012 there are no longer any "action levels" for dioxins and PCB in fish, including eel, from the wild (Recommendation 2011/516/EU). Also the allowed maximum values have been slightly changed, both in values (lowered), as well as the use of toxic equivalents (from WHO TEF 1998 to WHO TEF 2005) (Regulation (EU) nr 1259/2011).

This information was kindly submitted by Frida Broman at the National Food Agency.

11.4 Predators

11.4.1 Predation by cormorants

Analyses of stomach and pellet contents of cormorants shows considerable differences in diet between areas and seasons (Boström *et al*., 2012 a&b; Östman *et al*., 2012). In a sample of 467 stomachs analysed from the west coast (unpublished), eel made up only 1% of the consumed biomass outside the cormorant breeding season, and around 3% in the cormorant breeding season. The latter value, however, relates to only 10% of the total number of stomachs analysed. The highest percentages of eel were found in 44 stomachs collected in winter time in the coastal area around Karlskrona, in 2009 and 2010. In that material, eel made up ca. 25% of the stomach content, and some eels up to 70 cm in length were observed. Unlike the west coast, eels did not occur in samples collected during the cormorant breeding season here. In Mönsterås, northern Kalmarsund, only a single eel was found in nearly 200 stomachs being sampled, that was ca. 2% of the diet outside the cormorant breeding season.

To assess the impact of cormorant predation on eel, detailed information on abundance and seasonality of the cormorant stock is required. That information is currently not (yet) available. According to the Swedish Ornithological Society, 45 000 breeding pairs occurred in 2006, and each bird consumed 0.3–0.5 kg of fish food per day. Using these figures, the total fish consumption by cormorants is considerable, and even a small percentage of eel in the diet would already constitute a significant impact on the eel stock, possibly in the order of 100 t or more.

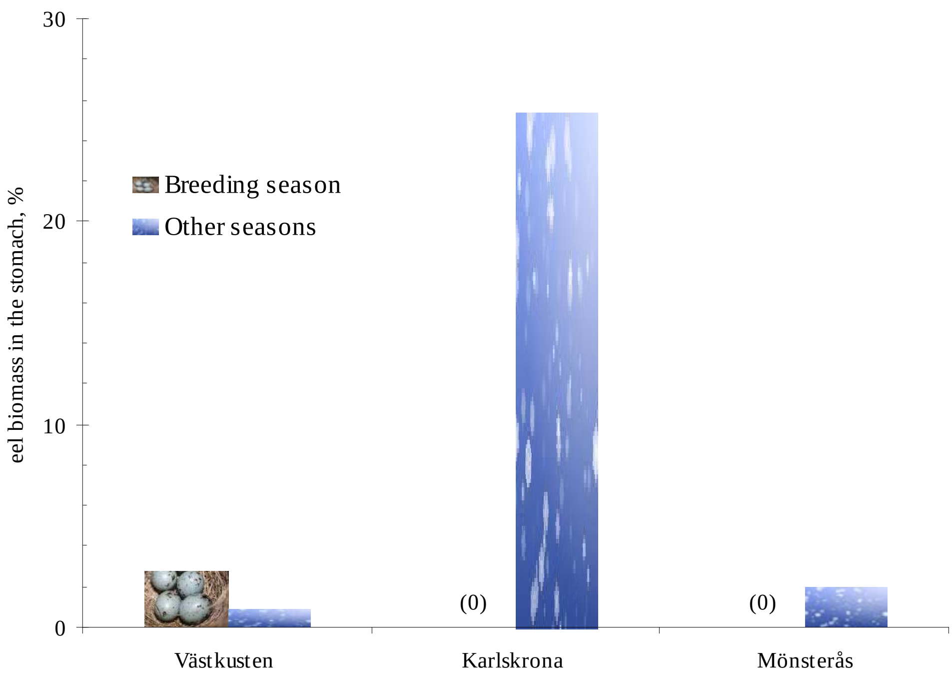

Figure SE. 30. The fraction of eel in the diet of cormorants, collected during breeding season and other parts of the year, respectively in coastal areas in 1999–2010 (preliminary data from Swedish Board of Fisheries, Coastal Institute).

11.4.2 Predation by seals

Continuous monitoring of the diet of grey seals in the Baltic Sea has been carried out since 2001 (Lundström *et al.*, 2007; Lundström *et al.*, 2010). Previous investigations of the diet of grey seals in Swedish waters are limited to material collected in the late 1960s and early 1970s (Söderberg, 1972; Söderberg, 1975). Up to now the diet composition has principally been estimated from prey remains in the digestive tracts of hunted and bycaught seals. Eel has been proved to occur in the prey choice of Baltic grey seals in all studies done (Table SE. 8), but the consumption of eel seems to be connected to seals visiting fishing gear, rather than a more general feeding pattern. Of the seals examined since 2001, all that had consumed eel (n=19) were collected from fishing gear, and at least ten were drowned in fishing gear specifically targeting eel (settraps and fykenets). Hence, there is a risk for overestimation of the average proportion of eel in the diet of the grey seal population. On the other hand, there is also a risk of underestimation of eel in the seal diet when estimating the diet composition solely on undigested prey remains. Since 2010, subsamples of prey remains in the grey seal digestive tracts are collected for subsequent DNA analysis, in order to get a picture of the prey choice independent of undigested prey remains. Information about the diet of harbour seals off the Swedish west coast is limited to studies based on faecal scats collected in the 1970s and 1980s (Härkönen, 1987; Härkönen, 1988; Härkönen and Heide-Jørgensen, 1991) in which eel contributed to less than 0.1% by weight to the diet. Current harbour seal data are however lacking. Further studies on the feeding patterns of both grey seals and harbour seals are in progress, focusing on areas of certain interest (K. Lundström, pers. comm.).

Table SE. 8. The occurrence of eel (proportion of the examined seals containing eel) in the diet of Baltic grey seals, collected between 1968–1971 (Söderberg, 1975); 2001–2005 (Lundström *et al.*, 2010) and 2008–2011 (K. Lundström, unpublished data).

	Frequency of occurrence		
	1968-1971	**2001-2005**	**2008-2011**
Gulf of Bothnia	2% (n_{tot}=42)	0.9% (n_{tot}=113)	0.6% (n_{tot}=169)
Baltic Proper	7% (n_{tot}=102)	7% (n_{tot}=117)	7% (n_{tot}=130)

11.5 Miscellaneous

11.5.1 Trap and transport

As part of the programme initiated by a Memorandum of Understanding between the six largest hydropower companies and the Swedish Board of Fisheries, a Trap & Transport program commenced in 2010. In 2011 about 7000 silver eels were transported to downstream areas with open access to the sea. There is a superficial check for health and quality in those eels and a more detailed monitoring for quality; including maturity (from external criteria) is planned for 2012.

11.5.2 Marking eels for stocking with strontium

Since 2009 all eels stocked in Sweden, and as a consequence of being imported via Sweden, also eels stocked in Finland, are marked with strontium in their otoliths. Eels intended for Sweden are given one treatment and the ones to be sent to Finland two treatments, inducing one and two rings of elevated Sr-concentration in their otoliths, respectively. This marking programme will facilitate a post evaluation of our stocking measures. Already in 2011 young recruits caught in coastal areas along the Swedish west coast were separated into wild and stocked ones by analysing their otoliths for Sr.

11.5.3 Mark–recapture studies

Since the early 1900s, information on the silver eel migration and fisheries has been obtained by means of mark–recapture experiments. Tagging has been performed irregularly over time. In 2012 Sweden starts recurring monitoring of silver eel fishery within EU Data Collection Programme (DCF) using the conventional external tagging technique. Silver eels are caught, a Carlin-type of tag is inserted in their back, and then eels are released again. Text on tag informs the fishers to contact the office of Swedish fish tagging, and will get a reward. Figure SE. 37 shows the areas where recent releases have been done and Figure SE. 38 shows the trend in the number of tags released since 1900.

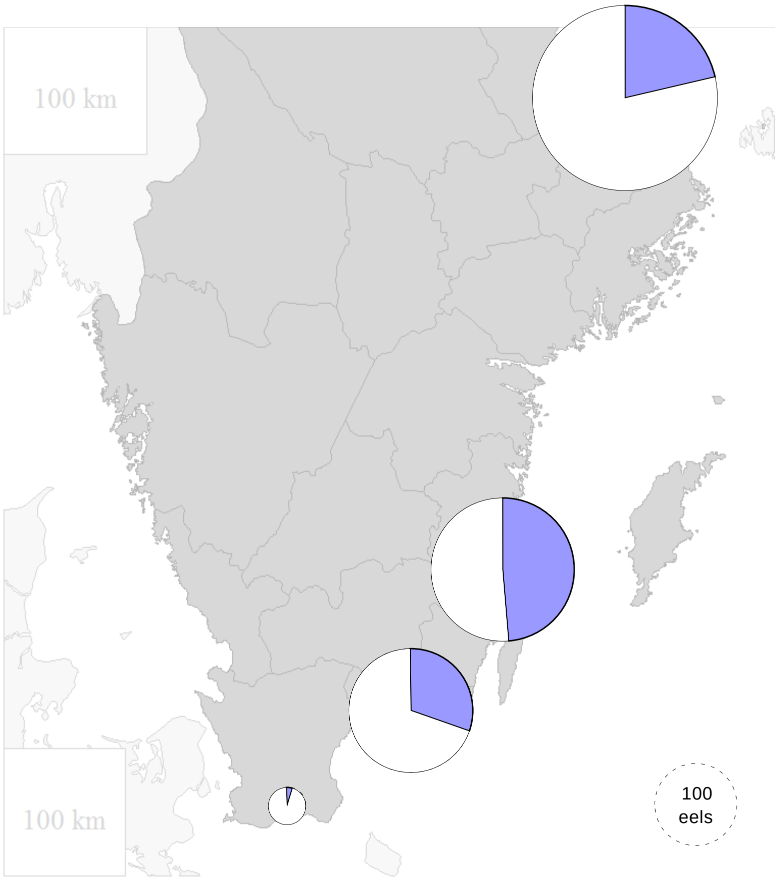

Figure SE. 31. Number of silver eels tagged (bubble size) and number recaptured (blue sector) by county in which they were released. This map shows the number of eels being tagged since the year 2000.

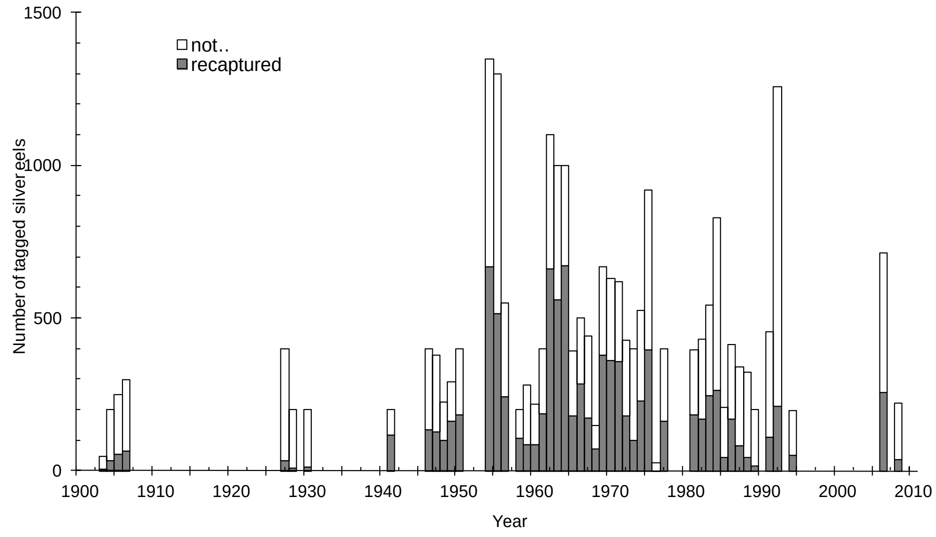

Figure SE. 32. The time trend in the number of silver eels tagged and recaptured.

11.5.4 EELIAD

As part of the EELIAD project (http://www.eeliad.com/) as well as of national projects, silver eels are tagged and followed both in Lake Mälaren, in the Baltic and in the Kattegat-Skagerrak area. From the use of Data Storage Tags (DST) we learn about the migration of silver eels with respect to time, depth and temperature. Within the Eeliad project 170 silver eels from Sweden have been tagged with different kinds of Data Storage Tags. Results from long records of active migration all show a similar diurnal diving behaviour; shallow, in some cases immediately at the surface, in the nighttime and deeper during daylight. The maximum depth was 400 to 600 meters for all eels. The migration route for eels outside the Baltic Sea was along the Norwegian Trench into the Norwegian Sea and then southwest into the Atlantic west of Scotland. Migration pattern shows no differences due to origin (stocked as elver/bootlace or naturally immigrated).

12 Other sampling

Nothing to report.

13 Stock assessment

In preparation of the EMP 2009, stock abundance and anthropogenic impacts have been assessed; mostly using data for the period 2000–2006. In spring 2012, a new assessment has been prepared (Dekker, 2012). This chapter summarises those latter results.

13.1 Local stock assessment

According to the Swedish Eel Management Plan, the whole Swedish national territory constitutes a single management unit. Several management actions, however, and most of the anthropogenic impacts differ between geographical areas: inland waters and coastal areas are contrasted and West Coast versus East Coast. Anthropogenic impacts include barriers for immigrating natural recruits, restocking recruits, yellow and silver eel fisheries, hydropower related mortality, Trap & Transport of young recruits and of maturing silver eels; etcetera.

The assessment in Dekker (2012) is broken down along geographical lines, also taking into account the differences in impacts, resulting in four blocks, with little interaction in-between. These blocks are:

1) West Coast – natural recruitment and restocking, fishery on yellow eel. The Swedish EMP presents an assessment, based on catch curve analysis. By 2012, fishing restrictions have been implemented, including a reduction in effort and a raise in minimum size. In the years 2009–2012, the stock is expected to have declined (trend in recruitment) and recovered (reduced impacts), but in 2012, these effects will have had only little effect yet. The West Coast fishery being closed as of spring 2012, a rather simple re-assessment was made: assuming that the stock remained almost stable, fishing mortality and landings will have developed proportionally. A major problem arises in the calculation of B_0. Between the 1950s and the 2000s, catches rose and then declined, to end close to the starting level. It is unclear, whether the 1950s stock was equally abundant as today's (implying equal fishing impact) or whether, the stock declined proportionally to recruitment (implying a very low impact in the 1950s). Depending on that assumption, B_0 comes at either 1154 ton or 11 540 ton; $B_{current}$ is either 1% or 1‰ of B_0; A_{lim} is either 0.0230 or 0.0023. This uncertainty on B_0, however, appears to be almost irrelevant; to come within sustainable limits, a major reduction in fishing impact is required and the fishery has been closed as of spring 2012.

2) Inland waters – natural recruitment and restocking, fishery on yellow and silver eel, impact of hydropower generation. In inland waters, the information sources are restricted to the youngest (recruitment, restocking) and the oldest (silver eel fishing, hydropower impact) life stages; inland surveys have not yet been analysed for yellow eel. The assessment presented in the EMP essentially analysed the relation between production (i.e. landings) and habitat characteristics (carrying capacity). However, today's stock is depleted (low recruitment) and for 90% dominated by man-made restocking. Therefore, a re-analysis was made: first, given the known restockings, the expected production x years later is calculated; then, the impact of fishing (known landings) and hydropower (assumed impact of 70% per station) is assessed. No ground-truth information exists, to verify the result. Surprisingly, actually observed landings derived from past restocking indicate that natural mortality M must have been extremely low (5–10%), much below conventional estimates (15–20%). In the absence of independent verification, estimates are presented for two values: M=0.05 and M=0.10.

3) Trap & Transport of silver eel – not related to a standing stock, recruitment or other anthropogenic impacts. The eels for Trap & Transport are taken from the fishery; hence, that impact is already covered. Under this heading, only the release of the silver eel is covered. Calculated escapement is simply set equal to the biomass released; no (negative) mortality is calculated, since the release is not linked to any particular part of the standing stock.

4) East Coast – natural recruitment and restocking, fishery on silver eel. The East Coast stock is a mix of local production and (mostly) immigrants from elsewhere in the Baltic- and probably a mix of restocked and natural eels. In the absence of an assessment of the corresponding yellow eel stock, the

impact of the Swedish silver eel fishery has been assessed on the basis of historical mark–recapture experiments (Dekker and Sjöberg, submitted and above (11.5)). The fishing mortality in the years 2000–2008 was estimated at 0.1; the effects of later restrictions to the fishery were extrapolated on the basis of the trends in landings (implying that the exploited stock did not change).

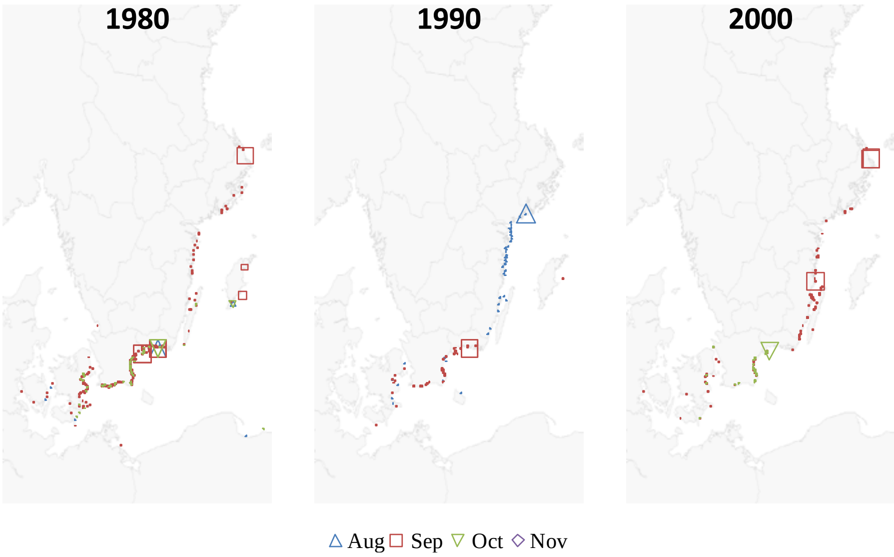

Figure SE. 33. Spatial distribution of the releases and recaptures, by decade (panel) and month of release (symbol). The size of the symbols is proportional to the number of eels involved and their size in the legend given represent one hundred eels each. The smallest symbols represent recaptures of a single eel; all larger symbols represent releases. A number of 17 eels in June and 44 in July have been omitted.

13.2 International stock assessment

13.2.1 Habitat

An overview of the available habitats is given in Table SE. 9 and Figure SE. 34. These present the total habitat. In coastal areas, eel stock density declines with depth; in both coastal and inland areas, eel density declines with latitude, and very few eels are found north of RBD 3.

Table SE. 9. Habitat area by River Basin District, for inland and coastal waters. For coastal waters, habitats have been broken down by depth zone.

	Inland	Coastal, by depth zone (m)				
River basin district		≤3	≤6	≤10	≤15	≤20
1 - Bottenviken	1 088 044	80 320	67 820	92 110	66 580	50 210
2 - Bottenhavet	1 038 815	30 890	20 900	28 330	15 260	16 670
3 - Norra Östersjön	326 388	61 180	40 120	28 760	39 810	42 490
4 - Södra Östersjön	487 262	98 080	78 160	108 840	116 170	40 760
5 - Västerhavet	985 737	40 450	22 200	30 880	2 030	1 470

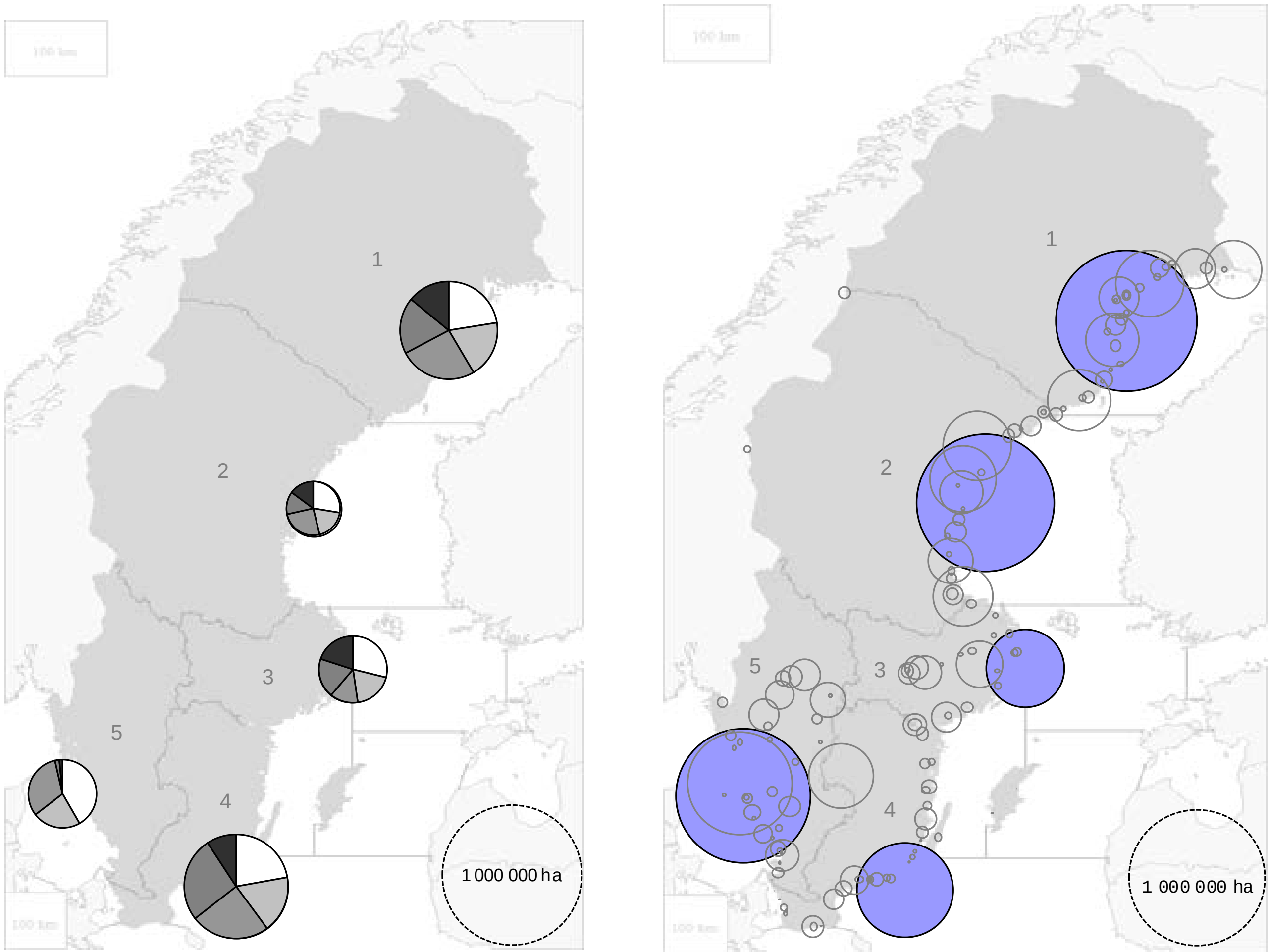

Figure SE. 34. Surface area of habitats by river basin district. Left: coastal habitats by depth zone, right: inland waters, colour=river basin district totals, gray=individual catchments.

13.2.2 Silver eel production

In recent years, management restrictions have been applied to reduce anthropogenic impacts on the eel stock, resulting in declining anthropogenic impacts. In most cases, however, the expected recovery of the stock will take place over a range of years; mortality has indeed changed due to management measures, but the stock has only just begun to restore. Except for the inland restocking, only an over-simplified assessment of this recovery trajectory is presented.

Table SE. 10 summarises anthropogenic mortalities by area, from the range of years reported in the Swedish Eel Management Plan until the last data year. A country-wide lifetime mortality rate is added, using the calculation procedure of Dekker (2010)[1]. The range of years covered in this table corresponds to the shortest range for

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[1] Delayed effects of a changing anthropogenic mortality regime are directly taken into account for ΣA, while $B_{current}$ shows the actual trend, in which delayed effects gradually come through (ICES, 2011). The anthropogenic mortality averaged over the whole country is calculated using the relation between %SPR and ΣA [ΣA=-ln(%SPR)], the

each of the constituting parts; notably that for the East Coast fishery. Medium-term projections are based on an assumed continuation of the *status quo* concerning anthropogenic impacts. However, it is rather unlikely that the *status quo* is indeed continued without further change: both the stock and the anthropogenic impacts are likely to develop. Hence, the medium-term projections give an indication of delayed effects of current management measures, but otherwise will not adequately represent the future. For that reason, projections beyond 2012 have been omitted from the table.

Table SE. 11 summarises the biomass indicators for the year 2011. For the East Coast, the indicators reflect the impact of the Swedish fishery only; impacts in other areas affecting the earlier life stages of these eels have not been included. The indicators in this table do take into account both naturally recruited eels and restockings, since there is no way to separate one from the other consistently. Restocked eels dominate in inland waters, but they make a marginal contribution to the country-wide totals.

The first precautionary diagram (Figure SE. 35) shows the status of the stock, as in 2011; the bubbles are scaled in accordance with the abundance of the stock (B_{best}) in each of the areas. The second diagram (Figure SE. 36) shows the recent trend in stock indicators; for readability, the bubbles have been left out here. Additionally, the second diagram shows the delayed effect current management actions will have in the coming years; a medium-term projection (dotted lines). In both diagrams, two inland estimates are given, for M=0.05 and M=0.10 respectively, reflecting a low and a high assumed natural mortality level. For the country-wide Total, only one estimate is given (for M=0.10, the conservative estimate resulting in a higher level of precaution). Due to the relatively small contribution of the inland stock to the total stock, the inland stock has a minor influence on the country total. The country-wide total estimate based on M=0.05 would almost completely overlap with the one given.

In 2000, the impact of the West Coast fishery exceeded sustainable limits considerably. Fishing restrictions have since reduced the impact to approximately ΣA=0.93 in 2011, almost exactly the ultimate value of A_{lim}=0.92, had the silver eel escapement not been below the targeted 40% level. The closure as of spring 2012 brings the fishing impact down to zero (the downward dashed line); a recovery of the stock is expected in the coming years (horizontal dashed line). The West Coast stock contributes to the country-wide total for about 10%; the indicator for the country-wide total in Figure SE. 36 is projected to follow a parallel trajectory (immediate downward, followed by a recovery in the coming years), but at a smaller scale.

The inland stock is dominated by restocked eel, and a shift in the spatial distribution of the restocking has had a major impact on the status of the inland stock. From the year 2000 until the mid-2000s, the anthropogenic impacts on the inland stock declined, but returned to higher values since. Overall, the anthropogenic impacts on the inland stock have been above sustainable limits in all years. The most recent shift in spatial distribution of the restocking seems to deteriorate this situation. The current Trap & Transport programme is far too small to reverse this trend.

The East Coast fishery has a low impact (7%), on a large part of the total Swedish stock (ca. 70% of the total), and a moderate contribution to the total catch. Recent fishing restrictions have reduced the impact from 10% to 7%. The impact is estimated to

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averaging procedure of Dekker (2010) [average %SPR is the B_{best}-weighted average of the %SPR's of the constituting parts], and finally back-converting the average %SPR to a mortality ΣA for the whole country.

be well within sustainable limits, but it should be stressed that this covers only the Swedish part of the lifetime anthropogenic impacts.

The trend in stock indicators for the country-wide total has largely followed the East Coast trend up to 2011 (the East Coast being the bigger part of the total stock), but the total closure of the West Coast fishery is expected to take over in the coming years (the bigger change). The estimated indicators for the country-wide total are within the mortality limits of this Precautionary Diagram.

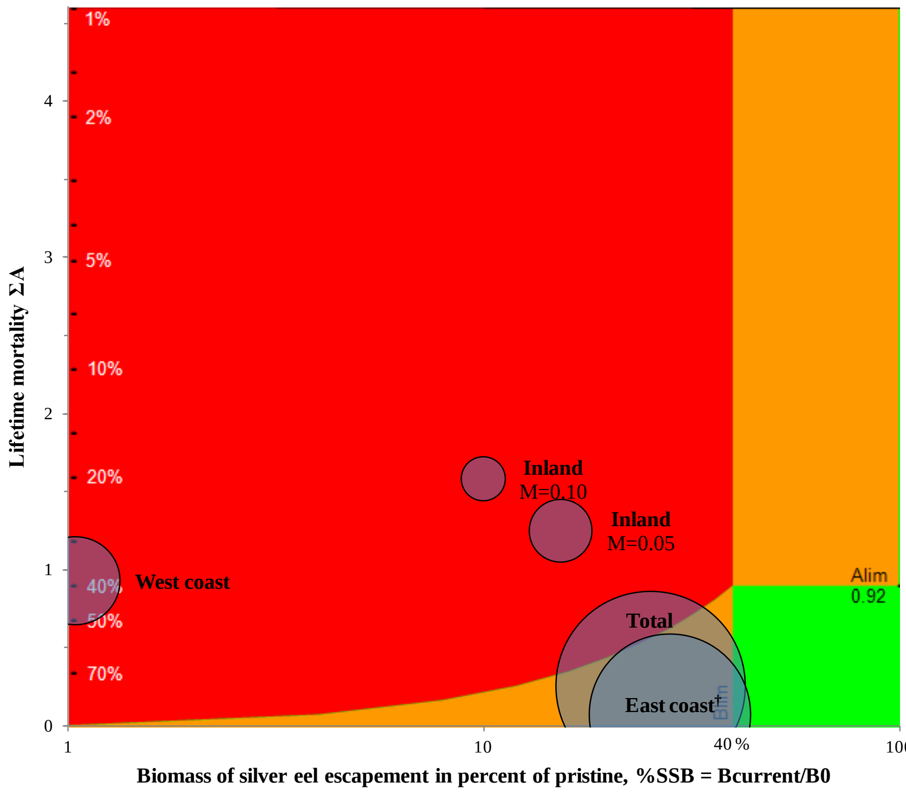

Figure SE. 35. Precautionary Diagram for the Swedish eel stock, as in 2011. The size of each bubble is proportional to B_{best}, indicating what part of the stock is found in each area. The location of each bubble quantifies the status of the stock (horizontal, in percentage of the notional pristine stage) and the magnitude of anthropogenic impacts on the eels in each area (vertical). The vertical axis is expressed as mortality rate (outside) and corresponding survival (inside the axis) relative to the un-impacted state. For the inland area, two separate estimates are given, assuming a low (M=0.05) respectively a high (M=0.10) value for natural mortality.

† For the East Coast, only the impact of the Swedish silver eel fishery is included; impacts on other life stages, in other areas/countries are not.

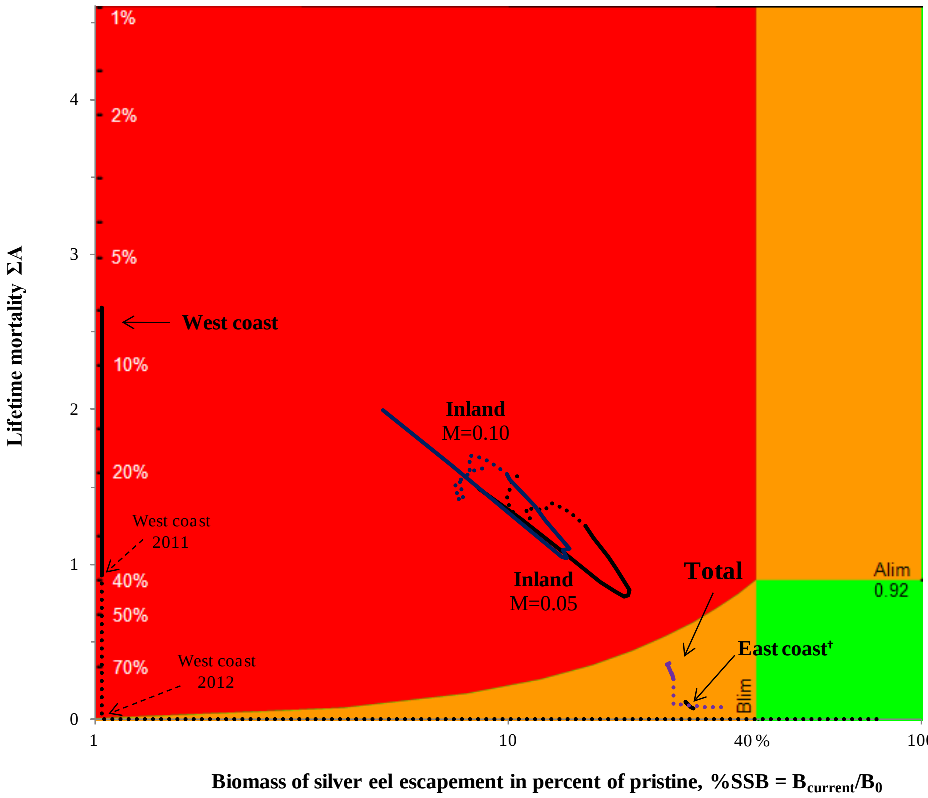

Figure SE. 36. Precautionary Diagram for the Swedish eel stock: trend in status and anthropogenic impacts from 2000 until 2011 (drawn lines) and predicted trend in the coming years, under a *status quo* assumption (dotted lines). See Figure SE. 35 for further explanation.

† For the East Coast, only the impact of the Swedish silver eel fishery is included; impacts on other life stages, in other areas/countries are not.

Table SE. 10. National stock indicators: temporal trend in total anthropogenic impact ΣA by area and year. For inland waters (and the country total), estimates are given for a low (left) or high (right) assumption on natural mortality M.

Year	West Coast	Trap & Transport	Inland waters M=0.05	Inland waters M=0.10	East Coast	Total M=0.05	Total M=0.10
2005	2.39	undefined	0.79	1.04			
2006	2.66		0.80	1.09	0.10	0.37	0.36
2007	1.91		0.84	1.10	0.11	0.36	0.35
2008	1.86		0.97	1.28	0.10	0.36	0.35
2009	1.19		1.05	1.38	0.08	0.30	0.29
2010	1.20		1.17	1.55	0.08	0.31	0.29
2011	0.93		1.25	1.58	0.07	0.29	0.26
2012	0		1.32	1.64	0.07	0.13	0.10

Table SE. 11. National stock indicators for the year 2011. Note that in this table, indicators do not distinguish natural from restocked eels.

	West Coast	Trap & Transport	Inland waters M=0.05	Inland waters M=0.10	East Coast	Total M=0.05	Total M=0.10	units
Catch/kill	84	-	411	223	271	766	578	ton
Catch/kill	0.5	-	0.12	0.12	0.29	0.92	0.92	million
$B_{current}$	12	7	165	58	3499	3683	3576	ton
$N_{current}$	0.02	0.007	0.22	0.08	3.71	3.97	3.83	million
B_{best}	586	0	576	280	3770	5500	5204	ton
N_{best}	1.7	0	0.92	0.46	4.0	6.62	6.16	million
B_0	1154–11 540	0	1076	580	12 500 §	14 730	14 234	ton
N_0	1.7–17	0	0.80	0.49	25.00	16.25	15.94	million
ΣA	0.93	undefined	1.25	1.58	0.075 †	0.29	0.26	rate
%SPR	40%	undefined	29%	21%	93% †	75%	77%	%
%SSB	1–0.1%	-	15%	10%	28%	25%	25%	ton/ton, %
%SSB	2–0.2%		28%	16%	27%	24%	24%	# / #, %

† Partial estimate; covers the Swedish silver eel fishery only.

§ B_{best} in 1950–1970 is estimated at ≈5000 ton. It is assumed that historical B_{best} = 40% of B_0.

13.2.3 Stocking requirement eels <20 cm

The Swedish EMP calculates with a doubling of the present level of stocking, i.e. a proposed total of 2.0–2.5 million glass eels. This level was considered as realistic although the actual need to fully utilise all suitable areas for eel production is much higher. In 2012 more than 2.5 million eels were stocked, i.e. the pragmatic level from the EMP was reached. However, it must be stressed that the true requirement is much higher.

13.2.4 Summary data on glass eel

No catch of glass eels is allowed and therefore no export to e.g. Asia.

In 2012, 1200 kg were imported from River Severn in the UK. Of those 71% were used for stocking, corresponding to 2.56 million eels.

29% of the glass eels imported in 2012 were used for further culture.

No glass eels were consumed direct.

The mortality during the first 100 days was estimated to 4,9%.

13.2.5 Data quality issues

Nothing to report.

14 Sampling intensity and precision

Nothing to report.

15 Standardisation and harmonisation of methodology

15.1 Survey techniques

As described above the "drop trap" technique (Westerberg *et al*., 1993) has been taken up again. The aim is to improve our estimates of the recruitment to coastal areas.

15.2 Sampling commercial catches

No new information available.

15.3 Sampling

No new information available.

15.4 Age analysis

No new information available.

15.5 Life stages

In addition to eye size also fin lengths are now measured in all eels handled at the Institute of Freshwater Research. This allows using the silver index described by Durif *et al*., 2009. However, it seems this silver index gives quite different stage classifications compared to the traditional Pankhurst eye index (Pankhurst, 1982).

15.6 Sex determinations

No new information available.

16 Overview, conclusions and recommendations

Comparing the overall status of the national Swedish eel stock to the management targets, it is concluded that:

1) Criteria of the Swedish Eel Management Plan have been fulfilled almost exactly;
2) Biomass escaping is about one-fourth of pristine escapement, below the minimum target of 40% set in the EU Regulation; and

3) The 2011 anthropogenic impacts are about half the allowable maximum following the current closure of the west coast fishery, the impacts will reduce to one-quarter of that allowable maximum.

The 2012 assessment on the west coast is based on the analysis of past commercial landings. The fishery being closed as of spring 2012, future assessments will need to be based on survey sampling, already going on. For the inland part of the stock, the assessment is essentially a prediction based on past restockings; ground-truth on the standing stock can be derived from (available but un-analysed) electro-fishing data. Hydropower impacts in the current assessment are based on little available evidence; incoming field-data will need to be incorporated. Mark-recapture experiments on the east coast silver eel fishery are being re-continued in 2012.

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Report on the eel stock and fishery in United Kingdom 2011/'12

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Reporting Period: This report was completed in August 2012 for the ICES/EIFAAC WGEEL 2011, held in Copenhagen, Denmark in early September. It must be noted that most of the data relating to 2012 are provisional and will not be finalised until complete catch data are obtained and records can be fully validated. In compiling the report, some of the provisional data for 2010 and 2011 presented in previous reports have been updated. Where revisions have been made from earlier reports, this is indicated in the text and tables.

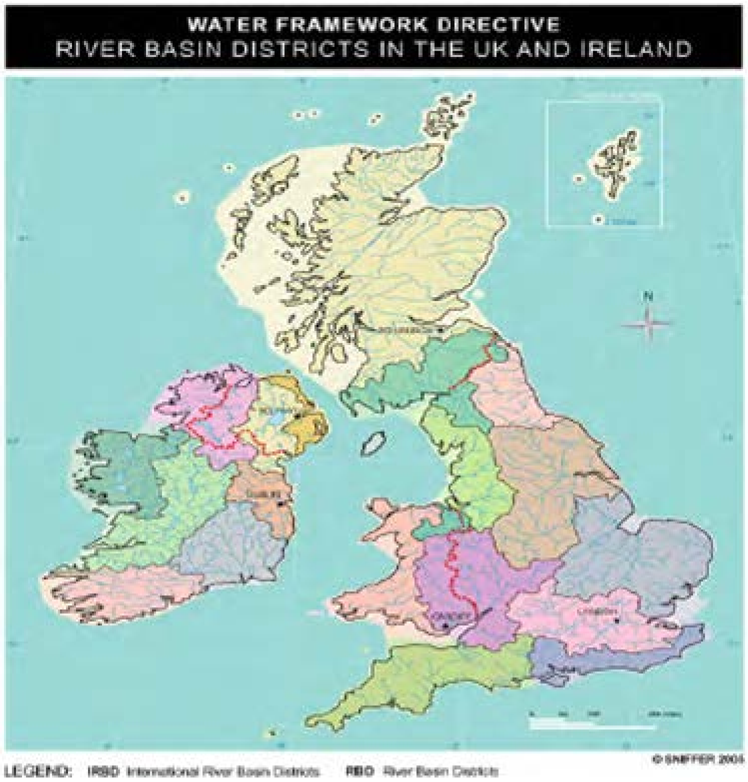
2 Introduction

2.1 UK overview

Eel are widespread throughout estuaries, rivers and lakes of the UK, with the possible exception of the upper reaches of some rivers, particularly in Scotland, due to difficulties of access.

There are eleven Eel Management Plans (EMPs) for England and Wales, including one shared with Scotland, one for the remainder of Scotland, and three in Northern Ireland including one shared with the Republic of Ireland (Figure 1). Most of the UK EMPs have been set at the River Basin District (RBD) level, as defined under the Water Framework Directive. The RBDs in Northern Ireland deviate slightly from those defined for the WFD, owing to their transboundary nature. The North Western International EMP is a transboundary plan with the Republic of Ireland.

Figure 1: Map of River Basin Districts for the UK and Northern Ireland



2.2 England and Wales

The Environment Agency is responsible for the management of eel fisheries in England and Wales. All fishing for eel requires authorisation, which is subject to standard national conditions that control seasons, methods, apply geographic restrictions and other measures to protect bycatch species.

Standard conditions allow the use of four instrument types for eel fishing: permanently fixed traps (e.g. weir or rack traps and 'putts'); moveable or temporary nets or traps without leaders or wings and with a maximum diameter of less than 75 cm; moveable or temporary nets or traps with leaders or wings with a maximum diameter of less than 100 cm (usually fykenets); and elver (glass eel) dipnets. Recreational angling is permitted using rod-and-line but all rod-caught eels must be returned alive to the waters from where they were caught. Appendix 1 in the 2007 UK report provides a summary description of netting and trapping methods used to catch eels in England and Wales.

Conditions also stipulate that all eel (apart from glass eel) less than 300 mm in length must be returned to the water, that no part of any net, wing or leader shall be made of a mesh greater than 36 mm stretched mesh, and that monofilament material is prohibited (except for an elver dipnet or fishing with rod-and-line). It is also a requirement that nets set in tidal waters should not dry out, unless they are checked just before they do so, and that nets should not cover more than half the width of the watercourse, or should not be set closer than 30 m apart (apart from in stillwaters and tidal waters). All fykenets must be fitted with an otter guard (a 100 mm square mesh hard plastic frame, fitted in the mouth of the first trap, to prevent otters becoming trapped in the nets). No fishing is allowed within 10 m upstream or downstream of any obstruction. Elver dipnets must be used singly, by hand and without the use of nets, chains, or boats. Small wingless traps and winged traps (fykes) can be used across the whole of England and Wales unless local byelaw restrictions apply.

Since 2010, the yellow and silver eel fisheries have been limited to those individuals who were already licensed, and these individuals are limited to the number of nets that they can apply for based on previous effort. Applications from newcomers are considered, but only for scientific studies, stock monitoring or for personal consumption. Thus, commercial fishing is effectively capped to existing fisherman who can use up to a maximum number of nets.

The glass eel fishery is restricted to two zones: in parts of South Wales and Southwest England, and in parts of Northwest England.

Every authorised instrument must carry an identity tag issued by the Environment Agency and it is a legal requirement that all eel and elver fishermen submit a catch return. Eel fishers are required to give details of the number of days they have fished, the location and type of water fished, the total weight of eel caught and retained or a statement that no eel have been caught. Annual eel and elver net authorisation sales and catches are summarised by instrument type and Agency region (soon to be River Basin Districts (RBDs)) and reported in the "Salmonid and Freshwater Fisheries Statistics for England and Wales" series (www.environment-agency.gov.uk/research/library/publications/33945.aspx).

2.3 Northern Ireland

Lough Neagh in Northern Ireland is the largest freshwater lake in the UK. Prior to 1983, estimates of annual recruitment of glass eel to the Lough consistently exceeded 6 million and averaged in excess of 11 million (based on a mean weight of 3000 glass eel per kg). Productivity is such that the Lough sustains a large population of yellow eel and produces many silver eels that migrate via the out-flowing Lower River Bann.

The system sustains the largest remaining commercial wild eel fishery in Europe, producing 16% of total EU landings and supplying 3.6% of the entire EU market (wild caught + aquaculture) in 2007. Fishing rights to all eel life stages are owned by the Lough Neagh Fishermen's Co-operative Society (LNFCS). The fishery is managed to enable the capture of approximately 250–350 t of yellow eel and 75–100 t of silver eels annually, with an escapement of silver eels at least equivalent to the catch of silvers. Whilst it is illegal to fish for glass eels in N. Ireland, provision is made whereby LNFCS staff is allowed to catch glass eels using dragnets below a river-spanning sluice gate, which creates a barrier to upstream juvenile eel migration, for onward placement into L. Neagh. Elvers are also trapped at the same location and placed into the Lough.

The yellow eel fishery (May–September, five days a week) supports 80–90 boats each with a crew of two men using draftnets and baited longlines. Eels are collected and marketed centrally by the cooperative. Silver eels are caught in weirs in the Lower River Bann. Profit from the less labour-intensive silver eel fishery sustains the management of the whole cooperative venture, providing working capital for policing, marketing and stocking activity and an out-of-season bonus payment for yellow eel fishermen at Christmas.

Natural recruitment has been supplemented since 1984 by the purchase of glass eel from outside the RBD. Approximately 91 million (30.3 t) additional glass eel have been stocked by the LNFCS. Reviews on the fishery, its history and operation can be found in Kennedy (1999) and Rosell *et al.* (2005).

The cross-border Erne system is comparable in size to L. Neagh and produced a fishery yield in the region of 33 t of eels per year. Within N. Ireland, Upper and Lower Lough Erne sustained a small-scale yellow eel fishery, which was closed in 2010 under the terms of the NWIRDB Eel Management Plan (EMP). There has been no commercial silver eel fishery on the Erne since 2001, but a trap and truck conservation silver eel fishery was instigated in 2009. Elvers are trapped at the mouth of the River Erne using ladders placed at the base of the hydroelectric facility that spans the Erne, and trucked upstream into the Erne lake system. A comprehensive study into the structure, composition and biology of the eel fisheries on the Erne was conducted by Matthews *et al.* (2001).

Overall policy responsibility for the supervision and protection of eel fisheries in Northern Ireland, and for the establishment and development of those fisheries rests with the Department of Culture, Arts and Leisure (DCAL). The Agri-Food and Biosciences Institute for N Ireland (AFBI) are employed by DCAL to provide the scientific basis for eel management in Northern Ireland.

2.4 Scotland

There have been no regulated eel fisheries in Scotland for the past several decades, and new legislation has been introduced in 2009 to require that anyone wishing to fish for eel in Scotland must seek a licence from the Secretary of State.

3 Time-series data

3.1 Recruitment-series and associated effort

3.1.1 Glass eel

3.1.1.1 Commercial

England & Wales

The glass eel fisheries of England and Wales are prosecuted by hand-held dipnets, in estuaries draining into the Bristol Channel, in particular from the Rivers Severn, Wye and Parrett, with smaller fisheries elsewhere, such as that in Morecambe Bay, Cumbria.

Those authorised to fish for glass eel in England and Wales are obliged to report their annual catch by weight, effort in terms of days and gears fished, location and water type (coastal, river, stillwater). Catches reported to the Environment Agency have historically been aggregated and reported to the WG as the catch for England and Wales. In addition to these catch returns, annual trade statistics from Her Majesty's Revenue & Customs (HMRC) provided an alternative indication of catches, for the period 1979–2006. Trade reports did not discriminate by eel size or stage, and therefore a procedure was developed to estimate glass eel trade into and out of the UK, and hence nett export trade; see the 2010/11 UK Country report for further details. Comparison between the catch reported to the EA and the nett exports HMRC data for 1979–2006 suggested a significant but variable level of under-reporting to the Agency, by between five and 15 times.

In 2009, legislation was introduced to improve the traceability of eel caught, such that there are now three sources of data:

1) Catch returns to the Agency.

2) The quantity of glass eel bought by the dealers from the fishermen (consignment notes).

3) The quantity of glass eel exported from the UK or stocked within the UK.

Updating the provisional data reported to WGEEL in the UK Country Report 2010/11 (2011: Table 1), the final catch reported to the Environment Agency for 2011 was 2.24 t of glass eel. The quantity of glass eel bought by the dealers was 3.64 t, and 3.28 t was exported or used internally (within UK), representing a loss (mortality or weight loss) between capture and sale by dealer of 9.0% by weight.

For 2012, the provisional data (as of 25th July) are catch reported to the Environment Agency of 2.35 t, the quantity bought by the dealers was 3.82 t, and 3.61 t was exported or used internally (within UK), representing a loss (mortality and shrinkage) of 5.5% by weight.

Table 1 also presents data for catch per unit of effort (cpue) based on catch (kg) and effort (days fished) returns to the Environment Agency (see Table 15 for regional data). Though underreporting of catch and effort are recognised, the consistency in the data collection over the time period (2005–2011) allows an evaluation of the trend in stock over this time period. Over the last three years, there has been an increase in glass eel recruitment from the low of 2008 and 2009, and the increase in reported catch of 4.9% compared to 2011, is thought to reflect a true increase in the availability of glass eel to the fishery during the last two years. However, the catch of UK glass eel remains at the very low levels observed (reported) since the late 1990s (Table 1).

Table 1. Time-series of 'UK' glass eel commercial fishery catch, as reported to Environment Agency and predecessor Agencies, and as estimated from HMRC nett export trade reports. 'n/a' = no data available.

Year	Catch reports to Agency (t)	HMRC nett trade (to 2006) or Consignment Notes (t)	Dealers purchase (t) 2010 onwards	Cpue (kg/day) Agency returns 2005 onwards
1972	16.7	n/a		
1973	28.2	n/a		
1974	57.5	n/a		
1975	10.5	n/a		
1976	13.1	n/a		
1977	38.6	n/a		
1978	61.2	n/a		
1979	67	40.1		
1980	40.1	32.8		
1981	36.9	n/a		
1982	48	30.4		
1983	16.9	6.2		
1984	25	29		
1985	20	18.6		
1986	19	15.5		
1987	21.3	17.7		
1988	21.4	23.1		
1989	20.6	13.5		

Year	Catch reports to Agency (t)	HMRC nett trade (to 2006) or Consignment Notes (t)	Dealers purchase (t) 2010 onwards	Cpue (kg/day) Agency returns 2005 onwards
1990	20.9	16		
1991	1.1	7.8		
1992	5	17.7		
1993	5.73	20.9		
1994	9.5	22.3		
1995	11.9	n/a		
1996	18.8	23.9		
1997	8.7	16.2		
1998	11.2	20.1		
1999	n/a	18		
2000	n/a	7.6		
2001	0.809	5.4		
2002	0.521	5.1		
2003	1.715	10		
2004	0.97	14.4		
2005	1.701	8.8		0.26
2006	1.274	8.2		0.12
2007	2.07	n/a		0.29
2008	0.816	n/a		0.13
2009	0.29	0.45		0.06
2010	1.24	1.72	1.89	0.37
2011	2.24	3.28	3.64	0.31
2012*	2.35*	3.61*	3.82*	0.29*

*** Note that the 2012 reported catch is provisional, as of 25th July 2012. From 2010 export data are derived from consignment notes.**

Regional indices for England and Wales

Catches are now reported per "nearest waterbody" and, as such, new time-series are being developed reporting catches to basin or more likely River Basin District (Table 2).

Table 2. Commercial catches (kg) of glass eel from England and Wales RBDs reported to the EA, 2005 to 2012. Note that the 2011 catches are updated from the provisional data reported in the 2011 report, the 2012 catches are provisional (as of 25th July 2012), and that no glass eel fisheries operate in the other RBDs, i.e. Northumbria, Humber, Anglian, Thames and Solway-Tweed.

Year	Northwest	Dee	West Wales	Severn	Southwest	Southeast
2005	166.2	39	87	784.8	626.5	0
2006	116.1	5.5	37	631.3	482.7	1.5
2007	200	6.3	26	1172.5	669	0
2008	91.6	2	3.8	370.7	348.6	0
2009	19.6	0.5	0	76.8	194.5	0
2010	30.3	4.8	1.1	531.7	756.5	0
2011	75.8	12.9	2.5	897.5	1249.8	0
2012	33.8	16.9	0	925	1371.7	0

Northern Ireland and Scotland

There are no commercial glass eel fisheries in Northern Ireland or Scotland.

3.1.1.2 Recreational

There are no recreational fisheries for glass eel in the UK.

3.1.1.3 Fishery independent

England & Wales

New time-series of glass eel recruitment are being developed for several regions of England and Wales, notably the Somerset Levels, Thames and Anglian rivers. Upstream migrating glass eel and elvers are caught in pass-traps, which are operated in the spring and early summer. However, the existing sampling protocols do not allow for a robust enumeration of recruitment.

Northern Ireland

The LNFCS catch glass eels using dragnets with an area of 0.94 m^2, fished below a river-spanning sluice gate, which creates a barrier to upstream juvenile eel migration on the River Bann. A record of total catch per night is recorded, but not catch per individual net. These, and elvers trapped at the same location, are transported upstream to be stocked into the Lough. These catches provide a time-series of 'natural' recruitment into the Lough (Table 3). Recruitment has shown an overall downward trend to only 16 kg (approximately 48 000 glass eel) in 2011, which was the lowest catch on record. However, the catch is up in 2012, reaching 189.3 kg by August: the recruitment is almost over for 2012 and the final value is not expected to be much more than this.

Table 3. Glass eel recruitment to the River Bann, Northern Ireland, 1960 to 2012.

Year	Natural elver run (kg)	Year	Natural elver run (kg)	Year	Natural elver run (kg)
1960	7408.55	1978	5034.4	1996	2667.93
1961	4938.69	1979	2088.8	1997	2532.6
1962	6740.46	1980	2485.93	1998	1283.33
1963	9076.7	1981	3022.6	1999	1344.93
1964	3136.92	1982	3853.73	2000	562.8
1965	3801	1983	242	2001	315
1966	6183	1984	1533.93	2002	1091.53
1967	1898.77	1985	556.73	2003	1155.93
1968	2524.9	1986	1848.47	2004	334.6
1969	4008.3	1987	1682.8	2005	930
1970	3991.63	1988	2647.4	2006	456
1971	4157.07	1989	1567.53	2007	444
1972	2905.27	1990	2293.2	2008	24
1973	2524.2	1991	676.67	2009	158
1974	5859.47	1992	977.67	2010	68
1975	4637.27	1993	1524.6	2011	16
1976	2919.93	1994	1249.27	2012	189.3
1977	6442.8	1995	1402.8		

The elver run to the River Erne is monitored by capture at a box at the foot of the dam of Cathaleens Fall hydropower station (at tidal head) and transported to upper and lower Lough Erne. This RBD is transboundary between Northern Ireland and the Republic of Ireland. The glass eel fishery operates in the Republic of Ireland, but upstream transport of that catch is distributed to both countries. The elver run to the Erne was 50.5 kg in 2009, 83.5 kg in 2010, 73.0 kg in 2011 and 132.1 kg in 2012 (as of July). The full time-series index of glass eel recruitment to this basin is reported in the Republic of Ireland Country Report.

Scotland

There are no measures of glass eel recruitment in Scotland.

3.1.2 Yellow eel recruitment

3.1.2.1 Commercial

There are no commercial fisheries for larger 'yellow' eel recruits, and therefore no time-series data.

3.1.2.2 Recreational

There are no recreational fisheries for larger 'yellow' eel recruits, and therefore no time-series data.

3.1.2.3 Fishery independent

There are no long-term, fishery-independent surveys of yellow eel recruitment. Traditionally, eel recruitment in the UK is considered to be at the glass eel stage only, or at least for eels <12 cm. However, studies of eel migrating into freshwater from the Thames and Severn Estuaries in the mid-1980s, and monitoring by the EA (Anglian and North West RBDs), Royal Society for the Protection of Birds (RSPB, North West RBD) and Zoological Society of London (Thames RBD) since 2000 reveals that larger eels (typically up to about 30 cm) also recruit into freshwater throughout spring and summer. However, as no attempts have been made to quantify such recruitments, the results are not presented here.

A short time-series is available of yellow eel recruitment from the mainstem River Dee into a single small catchment in north east Scotland, the Girnock Burn. An upstream trap approximately 50 km from the sea catches upstream migrating yellow eels (length range 96–254 mm) and these are manually counted. There is uncertainty about how representative these counts are of the total upstream migration, because although there is a substantial barrier to migration at the site, eels can find alternative routes upstream. The annual counts of upstream migrants, and mean length, are presented in Table 4.

Table 4. Yellow eel recruitment to the Girnock Burn, a tributary of the River Dee, northeast Scotland, from 2008 to present, noting that 2012 data are provisional.

Year	Count	Mean length (mm)
2008	572	156
2009	370	155
2010	89	156
2011	48	158
2012*	263*	158*

3.2 Yellow eel landings

3.2.1 Commercial

England & Wales

The yellow and silver eel catches reported to the Environment Agency have historically been reported to the WG as a single catch for England and Wales (see Table 12). Since 2005, catches have been recorded according to the "nearest waterbody" and reported separately for yellow and silver eels. As such, new time-series will be developed for future reports providing yellow eel catches to basin or more likely RBD level.

Northern Ireland

The supplementary stocking of glass eel and the operation of a market driven quota system for yellow eel fishing in Lough Neagh, means that the yellow eel catch data are not suitable as an index time-series of yellow eel production. However, the catch data are useful for scientific understanding of eel production processes and are presented in Table 13.

Scotland

There are no commercial fisheries for yellow eel in Scotland.

3.2.2 Recreational

There are no recreational fisheries specifically targeting eel for consumption in the UK. Eel are caught as bycatch by recreational anglers, and must be returned to the water alive but these catches are not reported. However, no data are available on post-release mortalities, and this is recognised as an area that warrants research.

3.3 Silver eel landings

3.3.1 Commercial

England & Wales

As noted in Section 3.2.1, the yellow and silver eel catches reported to the Environment Agency have historically been reported to the WG as a single catch for England and Wales (Table 12). Since 2005, catches have been recorded according to the "nearest waterbody" and reported separately for the two eel 'stages'. As such, new time-series will be developed for future reports providing silver eel catches to basin or more likely RBD level.

Northern Ireland

The supplementary stocking of glass eel in Lough Neagh means that the silver eel catch data are not suitable as an index time-series of unassisted silver eel production, for present purposes. However, the catch data are useful for scientific understanding of eel production processes, and are presented in Table 14.

On the Erne system in the Northwestern International RBD, the trap and truck conservation fishery caught approximately 10 t in 2009, 19.3 t in 2010 and 25.3 t in 2011.

Scotland

There are no commercial fisheries for silver eel in Scotland.

3.3.2 Recreational

There are no recreational fisheries targeting silver eel in the UK.

3.4 Aquaculture production

3.4.1 Seed supply

Although there is no eel aquaculture in the UK, glass eel are exported to aquaculture facilities in other European countries. No data are available on the ultimate fate of glass eel exported from the UK (i.e. restocking or aquaculture for consumption), but implementation of the registration of trade required by the new European Aquatic Animal Health Directive is expected to provide the relevant information in the near future.

3.4.2 Production

There is no aquaculture production of eel in the UK.

3.5 Stocking

3.5.1 Amount stocked

Note that the following all refer to stocking with glass eel. There is no stocking of ongrown eel anywhere in the UK.

England & Wales

Glass eel from the UK fishery are stocked into river systems of England and Wales: 53.6 kg in 2010, 50.1 kg in 2011 and 20.5 kg in 2012 (to date).

Northern Ireland

Recruitment of glass eel and elver to Lough Neagh has been supplemented by stocking of purchased glass eel since 1984 (Table 5), and these eel have been sourced from the UK glass eel fishery. However, in 2010 the 996 kg of glass eel purchased from UK Glass Eel Ltd originated from fisheries in San Sebastian, Spain and the west coast of France: no glass eels from UK waters were purchased. In 2011 and 2012, glass eel from UK and French sources were stocked into Lough Neagh though all were purchased from UK Glass Eels Ltd. Glass eel are not routinely quarantined before stocking into Lough Neagh, but arrive from UK Glass Eels Ltd with a Veterinary Health certificate. However, following the recent purchases from outside the UK, 1 kg of each new delivery is held in tanks and survival rates monitored for several weeks.

Table 5. Weight (kg) of glass eel stocked into Lough Neagh, 1984 to 2012.

Year	glass eel (kg)	Year	glass eel (kg)
1984	1334.67	1999	1200
1985	3638.51	2000	150.33
1986	5935.16	2001	0
1987	4584.07	2002	1007
1988	2107	2003	1368.03
1989	0	2004	427.09
1990	0	2005	718.67
1991	0	2006	330
1992	785.87	2007	1000
1993	0	2008	428
1994	771.87	2009	215
1995	686	2010	996
1996	33.19	2011	1035
1997	70.47	2012	1300
1998	17.27		

Scotland

There has been no recorded stocking of eel in Scotland.

3.5.2 Catch of eel <12 cm and proportion retained for restocking

There are no long-term time-series of data for this section. The catch is that reported in Section 3.1.1.1 (Table 1), but there are historic issues of underreporting the catch which mean that it is not appropriate to derive a proportion stocked from historical data. New measures to accurately record catch and proportion retained for stocking are being implemented as part of the EMPs.

In 2012, of the 3.82 t of UK caught glass eel that was bought by dealers, 84.7% were subsequently used in stocking and 10.5% for aquaculture (Table 6).

Table 6. Percentage of glass eel caught in the UK and used for stocking, aquaculture or direct consumption. [Note these percentages may not add up to 100% because of mortality and weight loss after capture].

	2009	2010	2011	2012
Stocking	100	53.8	43.9	84.7
Aquaculture	0	36.5	45.3	10.5
Direct consumption	0	0	0	0

3.5.3 Reconstructed time-series on stocking

Table 7. Reconstructed time-series of eel stocking (kg) in Lough Neagh; no data are available on occasional small quantities of UK sourced glass eel stocked in England and Wales. Note that "Local" is taken to represent UK sourced eel.

	Local Source				Foreign Source			
Year	Glass Eel	Quarantined Glass Eel	Wild Bootlace	On-grown cultured	Glass Eel	Quarantined Glass Eel	Wild Bootlace	On-grown cultured
1984	1334.67				0			
1985	3638.51				0			
1986	5935.16				0			
1987	4584.07				0			
1988	2107				0			
1989	0				0			
1990	0				0			
1991	0				0			
1992	785.87				0			
1993	0				0			
1994	771.87				0			
1995	686				0			
1996	33.19				0			
1997	70.47				0			
1998	17.27				0			
1999	1200				0			
2000	150.33				0			
2001	0				0			
2002	1007				0			
2003	1368.03				0			
2004	427.09				0			
2005	718.67				0			

	Local Source				Foreign Source			
Year	Glass Eel	Quarantined Glass Eel	Wild Bootlace	On-grown cultured	Glass Eel	Quarantined Glass Eel	Wild Bootlace	On-grown cultured
2006	330				0			
2007	1000				0			
2008	428				0			
2009	215				0			
2010	0				996			
2011	321				714			
2012	900				400			

4 Fishing capacity

4.1 Glass eel

England & Wales

As glass eel fishing in England and Wales is by hand-held dipnets, the potential fishing capacity is recorded as the number of licences/authorisations sold by the EA each year (Table 8). The glass eel fishery is restricted to two zones: in parts of South Wales and Southwest England, and in parts of Northwest England.

Table 8. Numbers of dipnet fishing licences sold or authorised by the Environment Agency or predecessors for commercial fishing for glass eel in England and Wales, 1980 to 2012.

Year	Agency dipnet Licences	Year	Agency dipnet Licences/Authorisations
1980	1367	1997	2450
1981	1303	1998	2480
1982	1288	1999	2207
1983	1537	2000	2100
1984	1192	2001	838
1985	1026	2002	899
1986	917	2003	922
1987	1162	2004	957
1988	918	2005	812
1989	1087	2006	719
1990	1169	2007	705
1991	960	2008	656
1992	969	2009	484
1993	1000	2010	369
1994	1058	2011	446
1995	1530	2012	489
1996	1682		

Northern Ireland

The capture of glass eel and elvers is prohibited in Northern Ireland, except under licence from the Department of Culture, Arts and Leisure (DCAL) to help with upstream migration past in-river obstacles on the River Bann.

Scotland

There are no fisheries for glass eel in Scotland.

4.2 Yellow eel

England & Wales

Since 2010, authorisations for yellow and silver eel fisheries have been limited to those individuals who were already licensed, and these individuals are limited to the number of nets that they can apply for based on previous effort. Applications from newcomers are considered, but only for scientific studies, stock monitoring or for personal consumption. Thus, commercial fishing is effectively capped to existing fisherman who can use up to a maximum number of nets.

No distinction is made between fishing for yellow or silver eels in the authorisations and most gears, with the exception of fixed traps on weirs, can be used to catch either stage. Therefore, fishing capacity in England and Wales is reported as licences/authorisations sold for commercial fishing for yellow and silver eels combined (Table 9).

Table 9. Numbers of yellow/silver eel fishing licences/authorisations sold by the EA, 1983 to 2011. Note that licences/authorisations are for gears and not per person but the number of licensees is available for 2009 onwards.

Year	Agency Licence sales	Number of Licensees	Year	Agency Licence/authorisation sales	Number of Licensees
1983	1523		1998	1825	
1984	2085		1999	1670	
1985	2624		2000	n/a	
1986	1994		2001	1991	
1987	2168		2002	1992	
1988	2443		2003	1831	
1989	2041		2004	1600	
1990	1589		2005	2369	
1991	1704		2006	2679	
1992	1724		2007	2818	
1993	1859		2008	2799	
1994	2647		2009	3120	225
1995	2648		2010	2970	158
1996	2752		2011	2777	130
1997	2602				

Northern Ireland

In Northern Ireland, longlines and draftnets are authorised fishing instruments for yellow eels (the 2007 UK Report: Appendix 1 provides a description of netting and trapping methods).The use of fykenets as a fishing engine for catching eels was banned in 2010 under the terms of all EMPs in Northern Ireland.

There are no eel fisheries in the Northeast or Northwestern International RBDs.

Neagh/Bann RBD

Lough Neagh/River Bann comprises a 400 km^2 lake-based system, which produces all of the commercial eel harvest in Northern Ireland.

Eel fishing on Lough Neagh is controlled by the LNFCS who licence the fishery to 180 fishermen, though in 2012 this number has ranged from 166 to 180 fishermen operating at different times during the fishing season. Around 1990, there were 200 boats (400 fishermen) fishing the Lough, but this number has steadily declined to the present day number of 80 to 90 boats as a result of an ageing fisher population, availability of alternative employment and falling market prices for eel. Boat size on L. Neagh is restricted to 8.6 m long and 2.7 m wide. Information on licence applications, number of boats, fishing activity, recruitment to the fishery and the catch of yellow and silver eels from L. Neagh is collected and maintained by the LNFCS with several aspects of these data spanning 45 years. This information is made available to DCAL and AFBI for scientific analysis and the provision of management advice.

Thirty percent of the Lough Neagh yellow eel catch is derived from draftnets, the other 70% from longline fishing using a maximum of 1200 standard sized hooks baited with earthworms, fish fry or the larvae of the flour beetle (meal worm). The fishery is run on a market-driven quota-based system (usually 50 kg per boat per day) and a log is kept of each individual boat's daily (Monday–Friday) catch, though this normally just records "quota achieved". New technologies such as hydraulic draft net haulers have been introduced over the last 15 years, thereby reducing the labour needed in the fishery or enabling fishermen to fish for longer if required.

In 2009, fishermen began reporting an increase in the effort required to fulfil daily quotas. Similar reports have been made in the following years, but the mild and wet weather associated with the late spring and summer of 2012 has made for steady fishing conditions throughout this year.

Scotland

In Scotland, historic commercial fisheries for yellow eels were largely based in low-lying productive lochs, the eels being sold mainly to local smokehouses. There is no tradition of eel consumption in Scotland. During the 1960s–1970s, eel catches in Scotland were estimated at around 10–40 t per annum. In 1989, 17 eel fisheries were operating, with catches ranging from 0.25 to 10.76 t (total: 23 t) (I. McLaren, Marine Scotland (Science), unpublished data). Correspondence with proprietors of eel fisheries in 2003 indicated a catch of less than 2–3 t per annum, chiefly yellow eels. The last known fishery closed in 2005. Since January 2009, a licence has been required to conduct any form of eel fishing. No licence applications have been received to date (August 2012).

4.3 Silver eel

England & Wales

See Section 4.2 for silver eel fishing capacity in England and Wales.

Northern Ireland

Northeast RBD

There are no silver eel fisheries in this RBD.

Northwestern International RBD

There are no silver eel fisheries in this RBD. The fisheries using large coghillnets at fixed weirs on Lower Lough Erne has been suspended since 2005, and closed since 2010 as part of the implementation of the EMP for this RBD.

Neagh/Bann RBD

Silver eel from Lough Neagh are caught in the River Bann using coghillnets fished on three weirs at two locations. The number of coghillnets fished depends on weather and river flow conditions, and normally ranges from 2-4 nets per fishing night. The record of nightly catch is estimated at the time (though rarely accurate). True daily catch is only obtained if the catch is processed and sold the following day. Otherwise, catches are retained in tanks and sold as and when market conditions are more favourable. Therefore, a 'single' catch sale record may be a total for several nights fishing.

Scotland

Correspondence with proprietors of eel fisheries in 2003 indicated a catch of silver eel less than 100 kg, mostly from traps in mill-races. Although there are few comprehensive records, data for one silver eel fishery show a 90% decline in catches between the early 1990s and 2002, although a yellow eel fishery was established in the upstream loch during the same period. The last known commercial silver eel fishery in Scotland ceased operation in late 2006. Since January 2009, a licence has been required to conduct any form of eel fishing. No licence applications have been received to date (August 2011).

4.4 Marine fishery

England & Wales

In England and Wales, the EA authorisations extend to targeted eel fishing in the coastal waters of RBDs. There are some authorised fisheries operating off the Anglian and south coasts of England, but these are not distinguished from inland fisheries in terms of fishing capacity (see Section 4.2). Eel are occasionally landed as a bycatch by marine-registered vessels, but these vessels are not reported here as a fishing capacity.

Northern Ireland

There are no marine fisheries for eel in Northern Ireland.

Scotland

There are no marine fisheries for eel in Scotland.

5 Fishing effort

In each EMP for England and Wales, the size of the glass, yellow and silver eel fisheries is presented in terms of the number of licensed instruments as opposed to the number of licensed (now authorised) net fishers. This is because licences are issued for gears rather than to named individuals: one authorised fisherman is able to set many traps and/or fykes. The only fishing gears operated by a single person are dip-nets, fixed traps, and Gloucester wingnets. As a consequence, fishery size according to number of gear licences should better reflect potential effort. However, as the administrative management unit for eel gear licensing is the EA Region rather than the RBD, it is not possible at present to provide a definitive description of fishing effort for several RBDs. For example, it is believed that >90% of the UK glass eel catch is derived from the Severn RBD, but this RBD extends over three EA Regions.

Prior to 2005, no specific effort data were associated with the reported catch data, and catch per licence has been the only proxy for cpue available to eel fishery managers. However, comparison of catch data with information on nett eel exports for England and Wales from HM Revenue & Customs (HMRC) suggested a significant level of underreporting, by between five and 15 times for glass eel and about six times for yellow and silver eel combined, with rates differing from year to year. As such, these data could only provide proxy estimates of recruitment and of home and international market trends (Knights *et al.*, 2001; Knights, 2002). The underreporting of catches is being addressed and the quality of data improved, through the use of further reporting from dealers.

5.1 Glass eel

England and Wales

Since 2005, glass eel fishermen have been required to annually report the number of days fished as part of their catch return, and these data are being used to develop time-series of fishing effort (Table 10).

Table 10. Commercial glass eel fishing effort reported to the EA as days (nights) fished across England and Wales, for 2007 to 2012. 2010 and 2011 data are updated from the provisional data reported in the 2011 UK Report. * = Note that the 2012 data are provisional as the deadline for catch returns was mid-August.

Year	Days fished	Licence sales	No. catch returns	% returns
2007	7380	705		
2008	6346	656	539	82
2009	4552	484	401	83
2010	3491	369	353	96
2011	7176	446	428	96
2012*	8001*	489*	364*	74*

Northern Ireland

There are no glass eel fisheries in Northern Ireland.

Scotland

There are no glass eel fisheries in Scotland.

5.2 Yellow eel

England & Wales

Since 2005, yellow and silver eel fishers are now required to annually report the number of days fished as part of their catch return, and these data allow the development of a time-series of fishing effort. Note that there is no separation of effort into that targeting yellow vs. silver eel. Also, the same regional reporting issues for glass eel catches and effort extend to yellow eel catch reports.

Fewer instruments were licensed/authorised to fish for yellow and silver eel in England and Wales in 2011, but effort increased by 83.0% (Table 11).

Table 11. The number and type of instruments licensed/authorised to fish for yellow and silver eel in England and Wales, and the fishing effort reported, between 2009 and 2011.

Type of instrument	2009	2010	2011
Permanent traps	14	6	7
Small Wingless Trap <75 cm per group of 10	740	850	375
Winged Traps/Fykes <1 m opening	2168	2114	2395
Total instruments	2922	2970	2777
Total effort (codends or traps x days)	121 813	100 355	183 660

Northern Ireland

Fishing effort in Lough Neagh is only represented as capacity, which is reported in Section 4.2.

Scotland

There are no yellow eel fisheries in Scotland.

5.3 Silver eel

England & Wales

See Section 5.2.

Northern Ireland

Silver eel fishing effort at the outflow of Lough Neagh is only represented as capacity, which is reported in Section 4.3.

Scotland

There are no silver eel fisheries in Scotland.

5.4 Marine fishery

Not applicable; see Section 4.4.

6 Catches and landings

6.1 Glass eel

England & Wales

Across England and Wales, the glass eel catch is only reported by weight, so number or length–frequency data are not available. The annual catch reported to the EA is presented in Table 1.

Updating the provisional data reported to WGEEL in the UK Country Report 2010/11 (2011: Table 1), the final catch reported to the Environment Agency for 2011 was 2.24 t of glass eel. The quantity of glass eel bought by the dealers was 3.64 t, and 3.28 t was exported or used internally (within UK), representing a loss (mortality or weight loss) between capture and sale by dealer of 9.0% by weight.

For 2012, the provisional data (as of 25th July) are catch reported to the Environment Agency of 2.35 t, the quantity bought by the dealers was 3.82 t, and 3.61 t was exported or used internally (within UK), representing a loss (mortality and shrinkage) of 5.5% by weight.

Northern Ireland

There are no commercial glass eel fisheries in Northern Ireland.

Scotland

There are no commercial glass eel fisheries in Scotland.

6.2 Yellow eel

England & Wales

Across England and Wales, yellow eel catch is only reported by weight, so number or length–frequency data are not available.

Prior to 2005, catches were only reported as 'yellow and/or silver eel' and therefore it was not possible to separate catches by stage. Since 2005, licensees have been required to report separate catch returns for yellow and silver eels, and these data are available from 2007 (Table 12).

The reported yellow eel catch for 2011 was 36.25 t, an increase of 49% compared to 2010, and 143% of the average annual catch since 2005 (25.41 t).

Table 12. Time-series of yellow and silver eel catches (t) for England and Wales reported to the EA or predecessor agencies, and derived from HMRC trade data. n/a = data not available.

	HMRC nett export (t)	Agency returns (t)		
Year	Yellow + Silver	Yellow + Silver	Yellow	Silver
1979	162			
1980	196			
1981	229			
1982	273			
1983	270			
1984	283			
1985	283			
1986	274			
1987	381	60.41		
1988	456	280.58		
1989	376	80.63		
1990	277	48.74		
1991	358	38.26		
1992	234	35.63		
1993	232	46.62		
1994	384	86.79		
1995	514	103.76		
1996	540	100.51		
1997	526	68.04		
1998	306	58.31		
1999	294	n/a		
2000	113	n/a		
2001	207	48.62		
2002	122	24.06		
2003	46	25.44		
2004	171	9.58		
2005	110	42.26	28.19	14.07
2006	62	35.91	24.91	11
2007	n/a	23.32	17.24	6.08
2008	n/a	31.31	25.37	5.94
2009	n/a	27.29	21.6	5.69
2010	n/a	26.5	24.31	2.2
2011	n/a	40.56	36.25	4.32

Northern Ireland

There are no eel fisheries in the Northeast or Northwestern International RBDs.

Neagh/Bann RBD

Yellow eel catches in L. Neagh in 2011 amounted to 342 t, only marginally greater than 2010 and essentially continuing the general downward trend since the late 1990s

(Table 13), associated with reducing effort in the yellow eel fishery as a function of falling boat numbers (Section 4.2). This is a significant cause of the long-term decline in catches and a response to alternative work/low prices available for yellow eels, rather than declining stocks. Catches per boat per day in the longline and draftnet fisheries continue to meet daily quotas imposed by the Cooperative, implying that sufficient stocks are maintained for the reduced number of boats fishing in the Lough, but fishermen have commented that it takes longer to catch their quota (Section 4.2).

Table 13. Catches of yellow eel in the Lough Neagh fishery, Northern Ireland, from 1965 to 2011 (catches rounded to nearest 1000 kg, 2005 onwards). Note that a daily quota system operates per boat in this fishery.

Year	Yellow eel catch (kg)	Year	Yellow eel catch (kg)
1965	236 759.1	1989	643 395.5
1966	284 772.7	1990	613 231.8
1967	327 281.8	1991	578 868.2
1968	382 327.3	1992	533 240.9
1969	368 677.3	1993	535 150
1970	516 504.5	1994	597 418.2
1971	610 909.1	1995	659 050
1972	509 090.9	1996	594 045.5
1973	562 481.8	1997	554 750
1974	587 904.5	1998	531 968.2
1975	576 354.5	1999	556 213.6
1976	481 886.4	2000	486 595.5
1977	455 350	2001	451 309.1
1978	544 695.5	2002	432 313.6
1979	702 609.1	2003	413 763.6
1980	668 945.5	2004	363 522.7
1981	681 545.5	2005	317 800
1982	705 759.1	2006	242 000
1983	662 709.1	2007	351 000
1984	807 672.7	2008	290 000
1985	616 668.2	2009	345 000
1986	522 359.1	2010	337 000
1987	503 777.3	2011	342 000
1988	503 236.4		

Scotland

There are no yellow eel fisheries in Scotland.

6.3 Silver eel

England & Wales

Across England and Wales, the silver eel catch is only reported by weight, so number or length–frequency data are not available.

Since 2005, licensees have been required to report separate catch returns for yellow and silver eels, and these data are available from 2007 (Table 12).

The reported silver eel catch for 2011 was 4.32 t, an increase of 96% compared to 2010, but only 61% of the average annual catch since 2005 (7.04 t).

Northern Ireland

There are no silver eel fisheries in the Northeast or Northwestern International RBDs.

Neagh/Bann RBD

Silver eel catches in L. Neagh in 2011 totalled 73 t, the lowest on record (Table 14).

Table 14. Catches of silver eel in the River Bann flowing from Lough Neagh, Northern Ireland, from 1965 to 2011 (catches rounded to nearest 1000 kg, 2005 onwards).

Year	silver eel catch (kg)	Year	silver eel catch (kg)
1965	329563.6	1989	152436.4
1966	332800	1990	123600
1967	242727.3	1991	121381.8
1968	204618.2	1992	148036.4
1969	238327.3	1993	90327.27
1970	237345.5	1994	95200
1971	233309.1	1995	138581.8
1972	124945.5	1996	112290.9
1973	162400	1997	109418.2
1974	178872.7	1998	104545.5
1975	187527.3	1999	113054.5
1976	144872.7	2000	101963.6
1977	236690.9	2001	84000
1978	280727.3	2002	95963.64
1979	341163.6	2003	114327.3
1980	245272.7	2004	99636.36
1981	228690.9	2005	117000
1982	209890.9	2006	104000
1983	203636.4	2007	76000
1984	165890.9	2008	78000
1985	135054.5	2009	88000
1986	129854.5	2010	97000
1987	121345.5	2011	73000
1988	150981.8		

Scotland

There are no silver eel fisheries in Scotland.

6.4 Marine fishery

There are no marine fisheries targeting eel outside the EMUs in the UK.

7 Catch per unit of effort (cpue)

7.1 Glass eel

England & Wales

Data on fishing effort, in terms of days fished, are only available since 2005. Therefore, the trend in glass eel cpue based on catch and effort returns to the EA since 2005 is shown in Table 15. Though underreporting of catch and effort are recognised (see Table 1 and associated text), the consistency in the data collection over the recent time period allows an evaluation of the trend in stock (i.e. recruitment). The data suggest an increase in recruitment in the last three years, compared to the low of 2008 and 2009. The provisional data for 2012 suggest similar levels of recruitment to 2011 in all RBDs except Northwest.

Table 15. Cpue (kg/day) of glass eel caught by the commercial fisheries by RBD [based on catch and effort returns to the EA] [+]provisional as of July 10 2012.

	2005	2006	2007	2008	2009	2010	2011	2012
Anglian		0						
Humber	0	0	0					
Southeast		0.1			0			
Southwest	0.33	0.08	0.27	0.17	0.14	0.64	0.4	0.38
Severn	0.17	0.14	0.26	0.09	0.03	0.23	0.23	0.22
West Wales	4.35	1.06	1	0.21	0	0.05	0.18	
Dee		0.19	0.19	0.2	0.04	0.34	0.56	0.52
Northwest	0.97	0.6	0.98	0.47	0.14	0.37	0.8	0.36
England & Wales	0.26	0.12	0.29	0.13	0.06	0.37	0.31	0.29

Northern Ireland

There is no commercial fishing for glass eel in Northern Ireland. No standardised cpue data are available for glass eel fishing on the River Bann, which is for local assisted migration purposes only.

Scotland

There are no glass eel fisheries in Scotland.

7.2 Yellow eel

England & Wales

As it is not possible to differentiate between fishing effort targeting yellow vs. silver eel in England and Wales, it is not possible to derive cpue separately for either stage. Therefore, the cpue for the combined yellow–silver eel fishery is reported in Table 16, both per RBD and for the fishery as a whole.

The cpue for the national yellow and silver eel fishery in 2011 was 0.22 kg per trap per day, which is similar to the values from 2007 onwards, but only 68% of the cpue from 2005 and 2006. This reduction suggests that the stock is currently lower when compared with the estimates in 2005 and 2006, but has remained steady over the last five years (Table 16).

Table 16. Cpue (kg/trap-day) of combined yellow and silver eel fisheries by RBD [based on catch and effort returns to the EA].

Year	Northumbria	Humber	Anglian	Thames	South East	South West	Severn	West Wales	Dee	North West	Solway Tweed	England & Wales
2005	0.06	0.12	0.35	0.37	0.90	0.33	0.44	0.42	0.29	0.36	0.00	0.35
2006	0.03	0.14	0.27	0.23	0.59	0.34	1.66	0.18	0.26	0.44	0.00	0.30
2007	0.00	0.74	0.16	0.21	0.21	0.16	0.18	0.77	0.28	0.00	0.00	0.23
2008	0.48	0.13	0.22	0.24	0.17	0.25	0.78	0.69	0.13	0.12	0.00	0.21
2009	0.33	0.03	0.17	0.36	0.34	0.25	0.23	0.03	0.40	0.35	0.00	0.22
2010	0.91	0.46	0.22	0.41	0.29	0.16	0.68	1.07	0.47	0.42	0.00	0.26
2011	0.00	0.26	0.19	0.36	0.38	0.22	0.37	0.47	0.23	0.12	0.00	0.22

Northern Ireland

A market driven quota-based catch management system, combined with varying boat numbers on L. Neagh (on an almost daily basis) means, it is impossible to calculate an accurate cpue for the yellow eel fishery. However a comparison of catch against average boat numbers produces a mean catch of 2830.1 kg boat^{-1} in 2006–2008 and 3788.9 kg boat^{-1} in 2009–2011, (increase of 33.9%). Analysis of the Lough Neagh data reveals no relationship between cpue and time lagged input stock density. This is most likely because (i) two different gears are operated (nets and baited longlines) with very different catch vs. effort limitations and with catch reported as a combined daily catch for both gear types, and (ii) there is a variable market related daily cap on the amount of eel that fishermen are allowed to catch.

Scotland

There are no fisheries for yellow eel in Scotland.

7.3 Silver eel

England & Wales

Effort data for the silver eel fishery is reported in combination with the yellow eel fishery (see Table 16 above).

Northern Ireland

There are no silver eel fisheries in the East or Northwestern International RBDs.

Given that a night's catch from the silver eel fishery in the River Bann may not be marketed the next day, but is combined with several night's capture (with this reported at the time of sale as the "catch"), it is difficult to calculate a cpue for the silver eel fishery that would provide a meaningful indicator of stock abundance. However, attempts will be made to analyse catch by number of nights when such "holding" for market purposes occur in 2012, to progress towards a useful measure of cpue.

Scotland

There are no fisheries for silver eel in Scotland.

7.4 Marine fishery

There are no marine fisheries targeting eel outside the EMUs in the UK.

8 Other anthropogenic impacts

The main sources of anthropogenic mortality outside the fishery are considered to be (listed in no particular order): 1) tidal flaps or gates; 2) pumping stations; 3) surface water abstraction points and 4) hydropower facilities, although the distribution of these factors varies considerably across the UK.

The following describes the manner in which these impacts have been assessed. RBD-specific assessments are presented in the UK EMP Review 2012, which will be published later this year.

8.1 Tidal flaps/gates

England and Wales

A total of 1048 tidal flaps/gates (also known as sluices) exist within England and Wales. A study was undertaken to produce a nationally consistent, prioritised list of tidal outfall structures in England and Wales where upstream and/or downstream fish passage is adversely affected (HIFI, unpublished). The decision of which sluices to assess was initially made on the basis of channel width, with the narrowest water-courses (those <5 m wide) rejected because these are unlikely to provide large quantities of habitat for eel (even if channel length is long). This reduced the number of structures from 1048 to 449, which were prioritised based on (1) fish stock status; (2) passage efficiency; (3) channel length; (4) channel width and (5) habitat quality.

In the absence of site-specific information on impacts, a conservative approach was taken to assume total loss of eel production upstream of the top 10% of tidal structures (i.e. B_{best} production (kg/ha) * total wetted area upstream), and no loss of production from the remainder.

Northern Ireland

Tidal flaps/gates are not considered to impact eel production in Northern Ireland.

Scotland

Tidal flaps/gates are not considered to impact eel production in Scotland.

8.2 Pumping stations

England and Wales

In England and Wales, there are 321 pumping stations identified as having the greatest potential to impact on eel, based on: 1) distance from head of tide (shorter distance = greater impact) and 2) the predicted presence of eel. In addition the list of sites was quality assured following local consultation.

To estimate the impact it has been assumed that all the area upstream of the pumping station is lost to eel production (i.e. B_{best} production (kg/ha) * total wetted area upstream).

Northern Ireland

Pumping stations are not considered to impact eel production in Northern Ireland.

Scotland

Pumping stations are not considered to impact eel production in Scotland.

8.3 Surface water abstraction sites

England and Wales

Surface water is abstracted at 29 863 sites in England and Wales. A subset of 772 sites was identified as posing the greatest potential to impact on eel were identified using the following criteria:

- distance from head of tide;
- size of the abstraction;

- predicted presence of eel;
- the sensitivity of the waterbody to abstraction; and,
- quality assured by consultation.

A study of eel entrainment and mortality conducted at twelve surface water abstraction sites, revealed an average annual entrainment rate of 627 eel, with mean age two years (~150 mm). The equivalent in terms of silver eel biomass is estimated to be 0.03 kg per entrained eel, which equates to an annual entrainment loss per abstraction of 18.81 kg. This rate was applied to the most critical surface water abstraction sites across England and Wales.

Northern Ireland

Surface water abstractions are not considered to impact eel production in Northern Ireland.

Scotland

Surface water abstractions are not considered to impact eel production in Scotland.

8.4 Hydropower

England and Wales

In England and Wales, there are 212 hydropower facilities in operation (Table 20) affecting 11 158 ha of eel producing habitat. The impact of each hydropower facility is estimated according to the B_{best} production (kg/ha) for the relevant RBD, the area of habitat upstream, the presence or absence of screens (preventing eel entrainment) and the type of turbine. For those sites with screens, the proportion of eel entering the turbine(s) was assumed to be zero if the spacing between the bars/mesh was <15 mm, 50% if the spacing was between 16–29 mm and 100% if > 30 mm: 27.6% of hydropower schemes (excluding Archimedes screws) are adequately screened to prevent the entrainment of eel (i.e. spacing was <15 mm). The estimates of turbine mortality were taken from the WGEEL 2011 report and were; Archimedes screw 0%, Francis Turbine 32%, Kaplan turbine 38%. All hydropower facilities have some form of bypass channel that provides an alternative route for fish around the turbine. On this basis, it has been assumed that approximately 50% of the silver eels produced upstream of a turbine will become entrained therein.

On those river systems where there is more than one hydro facility, the loss of production from the upstream turbine(s) has been accounted for in estimating the potential impact of turbines further downstream, i.e. the cumulative impact of all turbines has been calculated.

Northern Ireland

There are no hydropower installations in the Neagh/Bann or Northeast RBDs that impact on silver eel escapement.

In the Northwestern International RBD, there are two hydroelectric turbine stations at the outflow of the Erne system into the Atlantic. Their impact on silver eel escapement has been assessed and is reported in the Country Report of the Republic of Ireland.

Scotland

In the Scotland RBD, the estimate of production lost due to hydropower is based on the assumption that production is directly related to the proportion of total wetted area that hydro schemes either exclude eels from using, or where a fish pass allows eels access, it is assumed that zero escapement occurs from upstream. The total area of habitat from which eels are either excluded by hydro schemes or from which they are exposed to turbine mortality represents 20.6% of total freshwater habitat (24.3% of stillwater, and 10.1% of running water). These percentages of area lost to eels from hydropower are reduced markedly when taking account of the distribution of natural barriers to eel migration (assuming barriers to salmon are barriers to eel): to 3.4% (all freshwater), 8.1% (stillwater) and 1.3% (running water). These figures seem relatively low given the land area upstream of hydro scheme barriers, and are currently being reviewed. One possible reason for the low values is a consequence of the siting of some hydro schemes immediately below substantial natural barriers (i.e. waterfalls) to eel migration (in order to utilise the hydraulic head).

9 Scientific surveys of the stock

9.1 Recruitment surveys for glass eel

England & Wales

The EA is now monitoring glass eel and elver recruitment at a number of sites. The trapping protocols will allow for the development of qualitative time-series of glass eel and elver recruitment in these systems. However, the methods used do not allow for quantitative assessments of recruitment size.

Gollock *et al*. (2011) describe the monitoring of upstream migration of juvenile eels in the Thames catchment and the implications for populations of the species. Traps based on the design of Naismith and Knights (1988), were located on two tributaries of the Thames; River Darent (Acacia Weir) and River Roding (Redbridge roundabout) and one site on the Thames itself (Molesey Lock, East Molesey). Where possible the traps were run during the expected period of upstream elver migration, i.e. from early April to late September, but this was dependant on weather conditions and water temperature (Naismith and Knights, 1988).

Naismith and Knights (1988) provide relevant information on total catches of eels from the River Darent between 1985 and 1987 caught over a similar seasonal sampling period (Figure 2). The total number of eels caught decreased by 99.8% between 1985 (n = 895) and 2009 (n = 2). The catches since 2005 eel numbers have fluctuated considerably but remained at very low levels relative to the catches in the 1980s.

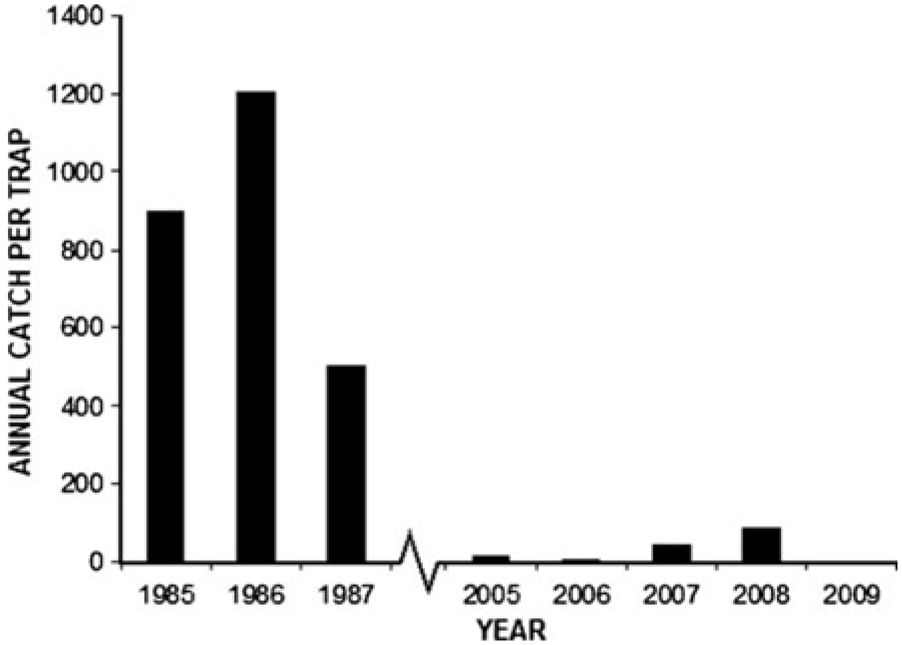


Figure 2. Total *A. anguilla* caught within the River Darent from 1985 to 2009. Data presented for 1985–1987 (Naismith and Knights, 1988) were halved in order to compensate for the increased effort of using two traps; 2005–2011 data were collected with a single trap. Methods and trap location are directly comparable between studies despite this increased effort (Gollock *et al.*, 2011; Gollock, Short and Mowat, unpublished data.).

Northern Ireland

In addition to the yearly glass eel surveying undertaken at the Cutts on the River Bann for the Neagh/Bann RBD, annual investigations of the timing of glass eel arrival and recruitment strength are undertaken within southeastern regions of the North-east RBD (primarily Carlingford Lough). Glass eel/elvers are sampled twice a month from their arrival in February/March through to April (subject to availability). A sample of 50 juveniles is removed for morphometric analysis, calculation of number per kilo and length–frequency analysis. Glass eel arrival is noted at other sites within this EMU but not intensively monitored.

Several sites around the Northern Ireland coastline were examined for glass eel in February and March of 2004, 2005 and 2006, using hoop and dragnets. Three of the sample sites were in the Northeast RBD area: Carlingford Lough/Newry Canal, (South Down coastal) Quoile barrage (which soon proved to be too hazardous to fish and was dropped) and Shrigley River (Strangford Lough). In addition, glass eel were sampled at the tidal limit of the River Lagan, at Stranmillis, Belfast, in 2005 and 2006. Samples of the catch were measured for length and weight, and reported in previous UK Country Reports.

The work demonstrated that glass eels were still arriving annually to Northern Ireland's east coast, from Belfast southward. Some sites, particularly Carlingford Lough at the mouth of Newry Canal, had locally significant quantities of glass eel arriving, but as outlined above, this has not been the case in recent years.

Despite the fact that monitoring of glass eel immigration involves working at night in potentially hazardous conditions, this work has continued annually on an *ad-hoc* basis; at the Carlingford site in particular. While not quantitative, it indicates that there is still annual glass eel supply to this coast. It is recommended that glass eel spot sampling continues, and resources permitting, is structured to improve the long-term value of the data. There could be merit in fitting permanent structures or traps for counting glass eel and elver where tidal head sluices with a fall exist (e.g. Lagan) for use in annual monitoring and to avoid hazardous night sampling. This work was not undertaken in 2011 because of staff illness, but was reinstigated in 2012, when fortnightly surveys were undertaken from January through to May. However, though insufficient numbers of glass eel were collected for morphometric analysis, the usefulness of this site as an additional monitoring site was proven.

Scotland

There are no scientific surveys of glass eel recruitment in Scotland.

9.2 Yellow eel stock surveys

England & Wales

The EA conducts annual multispecies surveys of fish populations in rivers, lakes and estuaries throughout England and Wales. Prior to 2001, eels were not a target species for these surveys, but some records of presence/absence or more quantitative data are available. From 2001 to 2006, at least the presence/absence of eels was recorded on all surveys. Routine electric fishing surveys for coarse fish and salmonids conducted by the Environment Agency (EA) from 2001 to 2012 show eels are present in nearly all river systems in England and Wales. There are some areas where eels are scarce or absent, particularly the upper reaches of rivers, though some lower reaches of rivers appear devoid of eel whilst the species is present further upstream. This may result from different survey techniques being utilized across a catchment. Eel were present in 43–51% of the survey samples during this period.

More intensive, eel-specific electric fishing surveys have been conducted in a number of river basins (22 with ten sites per river sampled quantitatively), yielding more accurate estimates of survey site population biomass, density and length–frequency distributions over a number of years (see Section 9.3). In addition, fykenet surveys have been conducted in stillwaters and estuaries, yielding length and weight data for eels along with catch per unit of effort indices.

Northern Ireland

The North South Shared Aquatic Resource (NSSHARE) Project covers three River Basin Districts; Northwestern International River Basin District, Neagh/Bann River Basin District and Northeast River Basin District. One of the main outcomes of the project is to develop ecological classification tools for assessing water quality under the Water Framework Directive using three biological quality elements; aquatic flora, benthic invertebrate fauna and fish fauna. The fish fauna biological quality element must include species composition, abundance and age structure. Eels are recorded as part of the species composition element (see Table 6 from 2008 UK Country Report).

The NSSHARE Fish in Lakes team was set up to develop an ecological classification tool using fish fauna, suitable for monitoring and classification of lakes under the requirements of the Water Framework Directive. This involved developing a standard methodology for sampling fish populations in lakes, and 83 lakes have been surveyed to date. The ecological classification tool is currently under development.

Northeast RBD

Eel are known to be present throughout this RBD but there are limited scientific data. Three lakes in this region have been selected as potential fish monitoring sites in the trial implementation phase of the Water Framework Directive. These lakes were sampled with a standardised (CEN) gill netting method supplemented with fykenets specifically for eel. Yellow eel populations are present in every lake examined thus far, though there were significant differences between two of these sites in length and age distribution.

There is clearly a difference between the eel population of the Clea Lake (Strangford Catchment) and Castlewellan Lake (South Down coastal). The Castlewellan eels are larger and older, probably reflecting the different characteristics of the two lakes. Castlewellan is further from the sea, and at higher altitude, whereas Clea is close to the sea and lowland, and perhaps biologically more productive. Furthermore, it is probable that the Castlewellan eel population is affected by natural impacts on access for recruits and emigrating silver eels. Clea Lake is a better index site for the catchment area and reflects continuing recruitment to at least 1992.

The age–length profiles of eels from a silver eel weir on the Quoile River from 1983 and 1984 confirm the view that the Castlewellan lake eels may well be partially landlocked, with restricted emigration potential resulting in long residence in freshwater.

Data are available for a sample of Quoile River yellow eel from 1969. This is important data in that it relates to a period before the opening of the upper of two barrages. This upper barrage may have restricted access upstream and retained eels within a brackish impoundment between the two barrages, especially to the small eel (less than 50 cm). However, the Quoile River system is now more accessible to eel than at any time since 1950, as the fish pass gates in the Lower Barrage between the estuary and the sea were renovated for eel and other fish passage in 2005.

Eel are present and widespread through the Quoile and Lagan river systems, though stock densities are not known. During electrofishing by Hodgson (2001) for trout, small numbers of eels were noted in the Annacloy and the Glasswater tributaries of the Quoile. They were absent from the majority of sites, but eel habitat may not have been adequately covered in a survey focussed on trout.

A recent survey undertaken in a small group of mixohaline lakes at Strangford netted 240 yellow eels. Length–frequency analysis indicated a much more normal distribution of eel lengths in comparison to other parts of the RBD previously surveyed such as the Quoile: with the length ranges were similar but mean length was much larger in Strangford (52.1 cm). Such differences illustrate that eel in this part of the system have unimpeded access to good eel habitat. This was further confirmed following analysis of the total eel biomass for the lakes surveyed, which was calculated at 71.6 kg, giving a standing stock of 17.9 kg ha^{-1}.

A PhD research project (Kenneth Bodles, Queens University, Belfast) has carried out an intensive sampling programme in regions of the Northeast RBD using fykenets. Results have been incorporated into the reviewed EMP for this RBD in 2012.

Only one additional site is required to complete eel monitoring for the RBD, i.e. a new site representing a lake on the Lagan system. This is planned for September 2012. Additional surveying of four small lakes within this RBD was undertaken in August 2011, mainly to assess the potential impacts of barriers to migration along riverine stretches. Whilst not abundant, eels of all expected size and age classes were recorded in each of the lakes sampled, illustrating migration throughout the catchments.

The first reporting round collating eel data from WFD and SMP monitoring was completed for the first review of this EMP in 2012.

Northwestern International RBD

A recent intensive fykenet survey into the yellow eel population of Lower Lough Erne has just been completed with samples and results awaiting analysis. The results of this survey will be compared with those of the Erne Eel Enhancement Programme (Matthews *et al*., 2001) and viewed against the closure of the yellow eel fishery in this RBD in July 2010.

Neagh/Bann RBD

Eels are sampled regularly as part of a long-term research programme which investigates all life stages throughout the year. Yellow eel catches are sampled weekly over 20 weeks (from May to September). A sample of 20 eels is chosen to reflect all size ranges caught, and analysed for age and length. In addition, the entire, ungraded landing of two fishing crew on one day each month is sampled, usually comprising 400–600 eels captured by longline and a similar number by draftnet, to enable comparison between methods. Every eel is measured for length and the total catch recorded.

Preliminary analysis indicates that a larger proportion of small eels (<40 cm) are captured by draftnets (34%, compared to 21.4% on longlines), whereas more of the larger eels (>60 cm) are taken on longlines. Furthermore, there was significant variation in the numbers of small eels captured by longlining dependent upon bait type (earthworms caught more) and hook size (larger hook caught fewer small eels).

Scotland

Electrofishing surveys by the Fisheries Trusts in Scotland (from 1996–2006) indicate that the eel is widespread, though absent from the upper reaches of many rivers, likely due to difficulties of access. Data are currently available only for the Scotland RBD (excluding areas of Galloway and the Tweed in the South). A total of 6651 electrofishing visits were made to 3645 sites. Eels were present at 39.7% of visits, and recorded as present on more than one visit at 44.3% of sites. As these surveys were primarily targeted at salmonids, they likely underestimated local eel abundance and therefore are reported here only in terms of the presence/absence of eels.

The Marine Scotland, Science, Freshwater Laboratory has two long-term, but intermittent, datasets on yellow eels, both from small, upland tributaries. A fish trap has operated on the Girnock Burn, a tributary of the River Dee in northeast Scotland, since the mid-1960s. The Girnock Burn rises at an altitude of 500 m and flows northwards, joining the River Dee some 70 km above the tidal limit. The stream channel has a largely open aspect, and is typically <5 m wide, depths ranging from a few cm to 0.5 m. Annual trap catch and electrofishing data were collected between 1967 and 1982 and again in 2004 and 2005. Since 2004, eels >200 mm have been PIT-tagged in order to determine movements and growth rates.

Analysis of these data (Chadwick *et al.*, 2007) shows that, in the late 1960s, the Girnock Burn eel population was comprised of relatively high densities of small (140–180 mm) males and with few females (320–360 mm). Growth rates are currently estimated to be between 8.7 and 17.4 mm y^{-1}, with growth occurring chiefly in the summer months. Small eels leave the system in late spring/early summer, larger eels in late summer/early autumn. Due to construction of a major barrier to immigration (plus the effects of recruitment declines since the 1980s), the estimated standing stock and declined from 1968 to 2005 by about 80%. The mean population density declined between 1968 and 2005 from 16 to 3 eels per 100 m^2, and biomass from 256 g to 71 g per 100 m^2. Thus, current densities are about 19% of the 1968 level, biomass about 28%. An updated analysis incorporating data from 2005–2009, but excluding winter electrofishing surveys due to their lower capture efficiencies suggests that the decline in density has been less marked than estimated by Chadwick *et al*. (2007) (Marine Scotland, unpublished data). The new analysis suggests peak mean minimum densities of 17.3 eels per 100 m^2 during the period immediately after the barrier to migration was introduced, falling to 9.2 eels per 100 m^2 in the period immediately prior to the recruitment collapse, and standing at 5.5 eels 100 per m^2 from 2004–2009. This amounts to a total decline of 68% since the barrier was introduced, and a decline of only 40% since the period prior to the recruitment collapse. Biomass has probably fallen more slowly than density because the average body length has increased 11% over the 37 year time-series, possibly due to lower in-river densities reducing competition and density-dependent mortality.

The other site monitored by Marine Scotland, Science is the Allt Coire nan Con Burn, which is situated in the Strontian region of western Scotland and drains into the River Polloch, an inflow to Loch Shiel. The catchment covers 790 ha and its altitude falls from 756 m to 10 m at the sampling point, where the river is 5–6 m wide and features riffle interspersed with glides which can be deep. Riparian vegetation at the sampling sites is predominantly mature deciduous woodland. Annual electrofishing surveys show no clear evidence of declines in yellow eel densities since 1992 (source: P. Collen, unpublished data).

The establishment of Fisheries Trusts and the Scottish Fisheries Co-ordination Centre has allowed the coordination of a number of electrofishing surveys, which now represent the principal source of information. The earliest of these data are from 1996, but spatial coverage is adequate only from 1997 onwards. It should be noted that there is considerable variation amongst the reports from individual Trusts in the level of detail that are recorded. Some of the data were collected with funding from Scottish Natural Heritage (SNH) and are their property. Otherwise all data are the property of the relevant Fisheries Trusts which have kindly allowed their use here. There are substantial areas of Scotland RBD for which data are not available, including the catchments of the Rivers Clyde, Don, Ythan, Nairn, Ugie, as well as the entire islands of Skye, Orkney and Shetland, (these latter two island groups are omitted from subsequent maps for reasons of space and clarity).

There are a number of problems with the interpretation of these data because of the variety of survey methods employed and inconsistency in efforts to capture and record eels. As such, a number of assumptions have been made in analysing the data. All these assumptions are likely to be violated to some extent, compromising the confidence that can be placed in the density estimates and strong confidence can only be placed in the presence/absence data.

The data show no consistent trend in reported eel abundance class over the period 1996–2005. In contrast, an analysis of the percentage of sites where eels were absent on the adjacent Solway Tweed RBD suggests this increased from 12% in 1972–1988, to 24% in 1992–1996, to 44% 1997–2001 and to 46% 2002–2005 (B. Knights, unpublished data), but it is possible that this represents a change in methodology in the early 1990s rather than a genuine decline in distribution.

There was considerable spatial variation in the distribution of eels, with eels being much less likely to be absent from sites in the northwestern parts of Scotland RBD. In the Western Isles, West Sutherland and Wester Ross, eels were absent at approximately 20% of sites, compared with 55% in Scotland RBD as a whole. This probably reflects the proximity of the northwest of Scotland RBD to the continental shelf (Knights *et al.*, 2001).

There is weak evidence that eel densities in Scotland may have declined since 2002. It is possible that this is a spatial rather than a temporal effect, however, because the distribution of sites differed between years, both locally and regionally. A similar pattern of decline in recent years was evident for several individual regions of Scotland RDB for which data was available, but was not universal; in particular West Sutherland in the northwest showed a trend for an increase in population density.

Since 2008, the Scottish Environment Protection Agency (SEPA) has begun routine electrofishing surveys for all fish species, including eels. In 2008, 48 sites were fished, eels were present at 39 sites (80%), and three of the nine sites where they were not found may have been affected by natural barriers to migration. This suggests that the SFCC data significantly overestimates the number of sites at which eels are absent. Minimum density of eels estimated from three pass electrofishings at the 39 sites where they were found ranged from 0.3–23.7 eels per 100 m^2, giving a mean minimum density across the RBD of 6.7 eels per 100 m^2 (or 5.4 eels per 100 m^2 including those sites from which eels were absent).

9.3 Silver eel surveys

England & Wales

There were five assessments of silver eel escapement undertaken in England and Wales during 2009-2012.

1) River Leadon (Severn RBD); a hydro-acoustic (DIDSON) assessment in 2009 and 2010.
2) River Leven (Northwest RBD); an estimate from the resistivity counter.
3) River Stour (Southwest, RBD); a mark–recapture study was undertaken in 2010, during which a total of 194 eel were tagged and 14 were recaptured (7.4%). In 2011 a total of 87 eel were tagged and 25 were recaptured (28.7%).
4) River Fowey (Southwest, RBD); an estimate from the resistivity counter.
5) The SMEPII model was used to estimate silver eel escapement (kg/ha) on a number of rivers in all RBD, based on yellow eel densities and length frequencies derived from scientific surveys.

The results of these assessments will be reported as soon as the UK EMP Review 2012 is published.

Northern Ireland

Northeast RBD

No current surveys of silver eels.

Northwestern International RBD

Surveys on the migrating silver eel stock on the Erne system began in 2009, as an integral component of a conservation fishery designed to trap and transport silver eels around hydropower plants within this RBD. The results of this survey work will be presented in the National Report of Ireland.

Neagh/Bann RBD

Samples of ten eels chosen to reflect all size ranges in the catch are removed every week over a twelve week period and analysed for age and length. At weekly intervals the previous night's haul is measured for length. The number analysed can vary widely but on average covers at least 400 fish within a night's catch of >1 t. In addition the weekly silver eel samples are also analysed for weight, sex, prevalence and intensity of *Anguillicoloides crassus*, stomach contents, and gastrointestinal endohelminths. Sex ratio of the silver eel population is also examined by counting the numbers of individuals contained in the graded (depending upon size) 15 kg boxes. The fishery records the number of boxes of small (male) and large (female) eels sold, and from this the sex ratio and number of silver eels can be estimated.

Scotland

Downstream migrating silver eels have been trapped at three sites in Scotland: the Girnock Burn and Baddoch Burn (two adjacent tributaries of the river Dee, emptying ultimately into the North Sea), and the Shieldaig (an entire small catchment on the western seaboard). The biomass of migrating silver eels for each available year have been converted to area production rates (kg/ha) and are reported in Table 17.

Table 17. Silver eel escapement from three catchments in Scotland ($kg.ha^{-1}$). * minimum estimate from incomplete data.

Year	Girnock	Baddoch	Shieldaig	Year	Girnock	Baddoch	Shieldaig
1966	0.53	-	-	1990	-	-	-
1967	0.44	-	-	1991	-	-	-
1968	1.42	-	-	1992	-	-	-
1969	1.02	-	-	1993	-	-	-
1970	0.86	-	-	1994	-	-	-
1971	1.25	-	-	1995	-	-	-
1972	0.84	-	-	1996	-	-	-
1973	1.59	-	-	1997	-	-	-
1974	1.07	-	-	1998	-	-	-
1975	2.23	-	-	1999	-	-	0.57
1976	1.91	-	-	2000	-	-	-
1977	1.42	-	-	2001	-	-	-
1978	1.25	-	-	2002	-	-	0.69
1979	1.07	-	-	2003	1.05	-	0.51
1980	0.61	-	-	2004	-	-	-
1981	1.02	-	-	2005	0.86	-	-
1982	-	-	-	2006	-	0.32	1.59
1983	-	-	-	2007	0.51	0.35	0.63
1984	-	-	-	2008	0.42	0.57	0.55
1985	-	-	-	2009	0.44	0.53	1
1986	-	-	-	2010	-	0.1	0.53
1987	-	-	-	2011	0.30	0.47	0.34
1988	-	-	-	2012	0.79*		
1989	-	-	-				

10 Catch composition by age and length

England & Wales

In England and Wales, the commercial catch is reported only as weight, so no age and/or length data are available. Some subsampling of the catch is undertaken however, and data from River Stour samples in 2010 and 2011 are presented in Table 18.

Table 18. Mean length and weight of silver eel caught on the River Stour.

Year	Length ± SE (mm)		Weight ± SE (g)	
	Female	Male	Female	Male
2010	634.3±3.6 (n = 309)	389.1±2.8 (n = 70)	493.3±10.9 (n = 194)	No sample
2011	628.2±4.7 (n = 247)	No sample	427.1±17.7 (n = 87)	No sample

The mean length, weight and age of silver eel caught in the River Avon in 2010 are shown in Table 19.

Table 19. Mean length, weigh and age of silver eel from the River Avon in 2010.

Parameter	Mean	SE	Range	Number
Length	591.8	5.94	410–845	200
Weight	382.8	12.7	132.4–1120.0	201
Age	18.8	0.27	13–31	188

Since 2007, the Environment Agency fish surveys have recorded the lengths of all eel >100 mm, and counted all the eels <100 mm. Cefas research surveys of eel in Poole Harbour estuary have measured length and weight of all eel captured using fykenets. In both cases, the eels are returned to the waters alive and therefore no age data have been collected. Cefas research sampling of silver eel runs from the Piddle, Stour (Hants) and yellow eels from the Thames Estuary has included the collection of otoliths for age determination and chemical analyses, but these data are not available at this time.

Northern Ireland

There are no eel fisheries to monitor in the northeast or northwestern International RBDs. In the Neagh/Bann RBD, the Lough Neagh yellow eel fishery is sampled weekly over 20 weeks (from May to September). A sample of 20 eels is chosen to reflect all size ranges caught, and analysed for age and length. In addition the entire ungraded landing of two fishing crew on one day each month is sampled, usually comprising 400–600 eels captured by longline and a similar number by draftnet, to enable comparison between methods. Every eel is measured for length and the total catch recorded.

The silver eel fishery in the River Bann is sampled every week over a twelve week period and ten eels chosen to reflect all size ranges in the catch are analysed for age and length. At weekly intervals the previous night's haul is measured for length. The number analysed can vary widely but on average covers at least 400 fish within a night's catch of >1 t.

Scotland

There are no eel fisheries in Scotland.

11 Other biological sampling

11.1 Length and weight and growth (DCF)

England & Wales

As of 2007, measurements of length are now collected from all eel captured by the Environment Agency during eel-specific and multispecies surveys. The 2012 sampling programme is ongoing at the time this report was produced. In 2010 and 2011, length and weight data were obtained for a sample of silver eel (n = 247; 87 respectively) from the River Stour (Southwest RBD). However, weight is not routinely measured nor age determined so no growth data are available.

Northern Ireland

In addition to the glass eel sampling at the River Bann, other sampling is undertaken at several coastal sites: the Foyle Estuary, the River Lagan (Belfast), River Quoile (Strangford Lough) and Carlingford Lough Estuary.

In Lough Neagh, the glass eel/elvers are monitored for the presence of *Anguillicoloides crassus*, and the weekly samples of yellow eels are also examined for weight, sex, age, stomach contents, the prevalence and intensity of *A. crassus*, and gastrointestinal endohelminths. The undersized yellow eels (<40 cm long) captured via longline are returned to the Lough at the point of capture with hooks in place. Every month 100 undersized eels are sampled at the fishery, their hook location recorded and in conjunction with analysis of the catch composition, attempts are made to quantify possible losses to the fishery through hook mortality.

The weekly silver eel samples are also analysed for weight, sex, age, stomach contents, the prevalence and intensity of *A. crassus*, and gastrointestinal endohelminths. Sex ratio of the silver eel population is also estimated by counting the numbers of individuals contained in the graded 15 kg boxes which the fishery then sell. Eels are graded as small (males) and large (females), based on a length–sex key derived from previous sampling. Sex ratios in the silver eels in 2004 to 2005 were numerically close to 1:1, but changed in 2006 and 2007 to 63% and 62% females (Table 20). However, in 2008, 2009 and 2010, this trend has reverted to close to 1:1 (48, 52 and 47% females). Taking account of differing sizes and weights of males and females, 74% of the recorded silver eel biomass is now female. An eel ageing expert has been employed by AFBI to facilitate the processing of samples gathered for ageing and it is hoped that by end 2012 all eels sampled will have been aged and matched with the other metrics recorded for each fish.

Table 20. Biological characteristics of silver eels emigrating from Lough Neagh. Note – mean ages of males and females for 2005 and 2006 have been revised in light of additional data.

	Males				Females			
year	%	mean L (cm)	mean Wt (g)	Age	%	mean L (cm)	mean Wt (g)	Age
1927	0				100		567	
1943	27				73			
1946	40				60			
1956	61				39			
1957	62				38			
1965	10		180		90		330	
2004	51	40.6	122	11	49	58.6	386	18
2005	52	41.4	126	11.4	48	58.1	393	18.2
2006	37	40.1	117	11.3	63	59.5	368	18.7
2007	38	40.2	121	11	62	62.3	370	n/a
2008	52	40.3	122	n/a	48	59.5	367	n/a
2009	54	40.9	128	n/a	46	61.7	378	n/a
2010	54	40.1	117	n/a	46	56.7	365	n/a
2011	57	40.2	126	n/a	43	61.4	375	n/a

Scotland

Individual growth rates of PIT tagged eels are measured by Marine Scotland Science in two nearby tributaries of the River Dee. To date, growth rates for eels with more than a season between capture and recapture have ranged from 0.8 to 35.2 $mm.yr^{-1}$, with mean ± s.e growth of 10.71 ± 0.70 $mm.yr^{-1}$ (n = 66). On the Baddoch, the range of growth rates was 0.0–14.5 $mm.yr^{-1}$, with mean ± s.e growth rates of 5.62 ± 0.74 $mm.yr^{-1}$ (n = 21). These may be the lowest growth rates ever reported for the European eel.

Since 2008, yellow eel recruitment into the Girnock Burn has been assessed by Marine Scotland, using an eel pass. Eels are measured, weighed, and most are individually marked, either using PIT tags or VIE elastomer. In 2008, a total of 574 elvers ascended into the burn: size range 96–254 mm, mean 155 mm. In 2009, a minimum of 370 elvers ascended (the trap was non-functional for a short period), with a size range of 99–237 mm.

Eel otoliths (ca. 100 pairs) have been collected (by SEPA) and read (by Marine Scotland Science) from a number of sites around Scotland, but these data are not available. Historical data are available for age (estimated from otoliths) and length composition at a variety of sites in Scotland from a survey conducted in the early 1970s (Williamson 1975).

Some Fisheries Trusts collect data on the length of eels captured during routine electrofishing surveys targeted at salmonids (1136 eels were measured between 1996 and 2008). Lochaber Fisheries Trust conducted an eel specific survey in 2010, and data are available at http://www.lochaberfish.org.uk/cust_images/Lochaber_eel_report_2010[1].pdf

11.2 Parasites and pathogens

The following reports new information available in the last twelve months. The historic information, albeit limited, on parasite levels in UK eels has been reviewed in recent UK reports.

England & Wales

Anguillicoloides crassus

Anguillicoloides crassus is widely distributed throughout England and Wales. Since 2009, yellow eels from 30 rivers have been examined for this parasite. Of these, 24 rivers were found to be infected, with up to 83% of eels harbouring nematodes. A small number of catchments and isolated rivers in North Wales and northern England remain either sparsely infected or tentatively free of the parasite. Studies are underway in collaboration with Salford University to confirm and progress these findings.

Efforts have also been made to establish whether *A. crassus* infections occur in other life stages of eels. During 2011, a sample of 200 silver eels obtained from the River Avon, Hampshire for research purposes was examined for parasites. *A. crassus* was found in 85% of these fish, with infections ranging from 1 to 58 parasites (mean = 8.2). Five samples of elvers were also examined for parasites during routine health checks prior to stocking. Only one sample from the River Severn revealed *A. crassus*, with 16 out of 30 elvers (53%) infected. These included a number of heavy infections resulting in total occlusion of the swimbladder. Other notable infections included *Dermocystidium anguillae* in 20% of these fish, with cysts engulfing large areas of the gills.

Mortality investigations

Two eel-specific disease outbreaks investigated during 2009 and 2010 revealed infections of Herpes virus *Anguillae* (HVA). These represent the first records of this virus in wild UK eels. Histopathological changes in the gills, skin and liver, combined with observations from transmission electron microscopy, indicated that HVA was the cause for these losses. Although no further mortalities have been attributed to this virus, efforts have been made to establish the distribution of HVA in England and Wales.

During 2011, yellow eels from a total of 16 rivers were tested for HVA, with at least one river sampled from each RBD. A further six samples of elvers and two samples of silver eels were also tested for antibodies to this virus. Preliminary results suggest that HVA is present in a small number of rivers but at a low prevalence (1.2–6.7%). Further monitoring is currently underway, with development of additional diagnostic tests for other eel viruses (e.g. EVE and EVEX). This work, in collaboration with Cefas, will inform existing disease risk assessments and eel management measures.

Since 2010, no large-scale mortalities of eels have been reported in England and Wales. A single case of vibriosis was investigated in summer 2011 in the River Thames, but this was limited to just a single fish exhibiting gross bacterial lesions.

Collaborative studies

Continued efforts have been made to evaluate the importance of other parasites and pathogens in wild UK eels. This has been conducted in collaboration with various institutes across the UK using archived material, information from disease investigations and samples obtained from elvers, yellow and silver eels, from a range of habitats.

A collaborative study involving the Environment Agency, Southampton and Cardiff Universities was set up in 2011 to investigate the influence of parasites and other health factors on eel behaviour and passage. The behaviour of silver eels in response to a range of flow regimes was observed within flume facilities. Comprehensive health examinations were then completed. Initial results suggest that *A. crassus* infection alters the behaviour of eels during downstream migration. This could have important implications for eel passage, escapement and spawning success.

These studies have led to the development of a comprehensive fish health protocol to assist practitioners with the collection, examination, handling, storage and archiving of eel tissues. This includes a framework for the detection and identification of parasites from both fresh and fixed tissues with methods for tissue sampling to support virology, bacteriology, histopathology, immunology, microchemistry and contaminant analysis. This approach has already helped coordinate resources, enhanced collaborative research opportunities and progressed our understanding of eel health and spawner quality.

Northern Ireland

Anguillicoloides crassus is now considered to be ubiquitous throughout Northern Ireland.

Northeast RBD

It was first recorded from the Northeast RBD in 2010 where it was found in eels sampled from the Quoile system (N = 52, prevalence 30% mean intensity <one worm per

infected eel). In 2011, *A. crassus* was found in other lakes connected to this initial location, but was not detected in three other areas.

Northwestern International RBD

The first records of *A. crassus* in Ireland were from this RBD in July 1998. No new data are available since the last report.

Neagh/Bann RBD

Anguillicoloides crassus was first found in Lough Neagh yellow and silver eels in 2003, and its spread has been monitored via the analysis of over 2200 yellow and over 800 silver eels from 2003 to 2011. Prevalence has always been higher in silver than yellow eels, but has reduced in both stages since 2005 (Table 21).

Table 21. Prevalence (% eels sampled) of *Anguillicoloides crassus* in Lough Neagh yellow and silver eels.

year	% yellow eels	% silver eels
2005	93	100
2008	67.3	86
2009	53.6	73
2010	48.8	80.7
2011	56.7	74

Scotland

Prior to 2008, the only reported instance of *A. crassus* in Scottish RBD was from a site near a fish farm on the Tay catchment (Lyndon and Pieters, 2005), and, while recognising the absence of any coordinated survey, it was tentatively thought that *A. crassus* was not widespread in Scotland. A survey in 2008 and 2009 revealed the presence of adult *A. crassus* in eels from the following catchments: Forth, Leven, and Monikie Burn, at prevalences from 25–40%. The low numbers of eels sampled at each site do not allow confident demonstration of the absence of *A. crassus* where none were found at a site. However, it is noteworthy that all four of the catchments now known to be infected are concentrated in a relatively small part of the east coast of Scotland.

11.3 Contaminants

No new data on contaminant levels in UK have become available in the last twelve months. The historic information, albeit limited, on contaminant levels in UK eels has been reviewed in recent UK reports but is summarised below.

England & Wales

A sample of 35 eels from the lower and estuary of the River Thames in 2007 contained organochlorine pesticides and by-products and 41 PCB congeners. However, based on the measured chemicals, all the analysed eels would be considered safe to eat.

Northern Ireland

No routine sampling undertaken but available by request.

Scotland

Eels sampled from sites where high concentrations of pollutants were anticipated, have been analysed for PCBs, DDTs, HCHs, HCBs and BDEs, and initial results have been published (Macgregor *et al*., 2010). DDT was present in nearly all samples despite having been banned for 30 years. However, comparison of data with previous contaminant analyses from 1986 and 1995 showed considerable decreases in DDE and HCH concentrations. When compared to reported European and North American levels, PCBs levels (138–494 µg/kg) were generally low, whilst BDEs were broadly similar, while DDE levels (1–227 µg/kg) were rather high.

11.4 Predators

No new information is available on eel predation this year. The historic information, albeit limited, on predation levels in UK eels has been reviewed in recent UK reports but is summarised below.

England & Wales

Limited studies of the diet of piscivorous birds shot during winter suggest that eels are rare in the diet at this time of the year, but other published information for England and Wales indicates a fairly high proportion of eel at other times.

Northern Ireland

None undertaken and studies into the impacts of predators on the eel stocks of N. Ireland are not likely to form part of Management Plan contents.

Scotland

The consumption of eels by cormorants in Scotland RBD is estimated to be in the region of ten tonnes per year, but this figure should be regarded with great caution as it contains many assumptions and uncertainties.

Data on eel in the diet of otters inhabiting a pair of freshwater lakes in NE Scotland show a decline of the proportion of eels in the diet after 1990, from being present in ca. 90% of faecal samples to being present in only ca. 25% in recent years (H. Kruuk, pers. comm.).

12 Other sampling

No information available.

13 Stock assessment

13.1 Local stock assessment

The Environment Agency, Marine Scotland (Science) and Agri-Food & Biosciences Institute have applied different methods to assess eel production in England & Wales, Scotland and Northern Ireland, respectively. These methods are outlined below.

England & Wales

Prior to the 2009 EMP submission there was a paucity of data on eel populations available to inform the EMPs. A network of over 250 eel monitoring sites has since been established, across all eleven RBDs, to gather more specific data on eel populations to better inform the estimates of silver eel escapement. This monitoring is primarily of yellow eel populations: since 2009, electric fishing surveys targeting yellow eel populations have been carried out biennially on two index rivers per RBD. Some glass eel and silver eel monitoring sites were also established. This is in addition to the network of over 6300 routine multispecies monitoring sites at which the quality of eel data collection has improved since the production of the EMPs. Alongside this data collection was the development and testing of the Scenario-based Management of Eel Populations (SMEP) II model (Walker *et al.*, 2011) to produce best available predictions of silver eel escapement from the spatially-described river networks.

In order to assess compliance with the silver eel escapement target, eel index data and good quality data on yellow eel densities, length–frequencies and sex ratios from multispecies surveys were modelled, using SMEP II, to produce best estimates of current silver eel escapement (B_{best}). Data collected on silver eel populations were used to validate the outputs and further tune the modelling. In addition, mark–recapture and resistivity and acoustic counters (Bilotta *et al.*, 2011) have been used to estimate silver eel escapement from RBDs of England and Wales, including the transboundary Solway Tweed RBD shared with Scotland. Estimates from one to four rivers per RBD were extrapolated to eel-producing habitat of each RBD. Further rivers will be assessed as data and resources allow, and the RBD estimates may be revised accordingly.

$B_{current}$ has been estimated separately for each RBD as B_{best}; estimated losses due to anthropogenic impacts. All impacts have been estimated as a biomass of silver eel or silver eel equivalents, where impacts affect earlier life stages (see below).

B_0 has been estimated using SMEP II modelling of yellow eel data from one RBD in 1984. In the absence of other local data, this estimate has been applied to all RBDs in England and Wales. However, the pristine production from other RBDs is likely to differ because of local and regional variations, and therefore, these values are likely to change as local data and new analyses become available.

Northern Ireland

The estimate of pristine escapement from the Northeast RBD was calculated with reference to the ecology and hydrology of similar systems (option c Article 5 of the Regulation) as described in Section 2.4.1 of the EMP. Current escapement is unknown and not monitored as there are no fisheries in this RBD, and escapement assessments were not an original feature of the terms of this EMP, but all rivers and upland lakes which are suitable for eel have been assessed as having no barriers to migration. As such underadequate recruitment levels and an adherence to the criteria laid down in the Northeast RBD EMP, this RBD should reach or better the 40% target naturally.

An annual mark–recapture programme of silver eel emigrating from Lough Neagh was initiated in October 2003, to estimate silver eel escapement ($B_{current}$) past the weir fishery, which is subject to a trap-free gap in the river channel, a three-month fishing season (some silver eel movement occurs outside this season), and inefficient fishing when river flows are very high. Recaptures occur both during the year of upstream release and at least one or even two years afterwards. To date, 4920 silver eels have been tagged and maximum estimates of escapement, based on "1- the proportion of recaptured Floy™ tagged eels", range from 61% to 84% during 2003 to 2011 (Table 22). No tagging was undertaken in 2007 due to the sporadic nature of the silver eel run. The Neagh/Bann estimate of B_{best} is derived from a known history of natural recruitment plus enhancement stocking, time lagged for known growth rates of silver eel; the current fishery management arrangements significantly contribute to outputs of this system.

The assessment methods for the North Western International RBD are detailed in the original EMP (Section 8; Action 2a). Stock assessment was carried out on the Erne as part of the Erne Eel Enhancement Programme which ended in 2001 (Matthews *et al.*, 2001).

Scotland

Stock assessment methods have been developed for the Scotland RBD, based on quantification of upstream and downstream counts of eel at traps on three rivers. The estimates of B_0, $B_{current}$ and B_{best} rely heavily on the extrapolation of data from small study areas to the RBD as a whole, with the inherent possibility of bias. To derive an estimate of current production and anthropogenic mortality for the RBD from the available data has required a number of assumptions; these have tended to be precautionary in nature (i.e. likely to underestimate current production and overestimate current anthropogenic mortality (see Scotland RBD EMP 2010 for details). Some of these precautionary assumptions could be tested, and the production/mortality estimates adjusted accordingly, if resources become available.

Table 22. Results of mark–recapture estimate of silver eel escapement from the Lough Neagh fishery. * The study was not conducted in 2007 because of the sporadic nature of the silver eel run.

Year	Eels tagged	Toome recaps	Kilrea recaps	Carry over to catch (T+1, T+2y)	Total recaps	recap Rate (%)	Total annual silver catch (t)	Max. possible escapement estimate (t)
2003	189	33	7	7	47	24.9	114	343
2004	838	302	15	4	321	38.3	99	159.4
2005	792	118	0	7	125	15.8	117	623
2006	700	197	1	2	199	28.4	104	262
2007*	0						76	n/a
2008	950	193	18		211	22.2	76	266.2
2009	486	187	0	1	188	38.8	85	134.1
2010	491	167	14	0	181	36.9	97	165.9
2011	474	82	64	3	149	31.4	73	159.5

13.2 International stock assessment

13.2.1 Habitat

The wetted area of rivers, lakes, transitional and coastal waters for each RBD/EMU are presented in Table 23.

The wetted areas for RBDs in England and Wales were calculated from GIS datasets including the 1:50 000 scale river network, a channel width function derived from EA survey data and upstream catchment area profiles, and other datasets created for the Water Framework Directive. The total eel producing habitat area is the sum of all freshwater habitat (lakes and rivers) and transitional waters, but does not include coastal waters.

The wetted area of rivers and lakes in the Scotland RBD were calculated from UK Ordnance Survey MasterMaps, scales 1:10 000 and 1:1250. Below a certain channel width (defined as normal winter flow width) the digital network represents channels as a single dimensional line, which thus provides no data on the width of river channels. On 1:10 000 scale maps this occurs nominally on channels below 5 m in width; at the 1:1250 scale, it is for channels below 1 m. To provide a reasonable measure of the true extent of water area represented by all non-determined widths of channels, these were attributed 1 m width. In some cases this will overestimate and in others underestimate the true width and hence wetted areas.

The wetted areas for each of the Northern Ireland EMUs were calculated from 1:25 000 GIS datasets held within AFBI, the Loughs Agency and the Northern Regional Fisheries Board.

Table 23. Wetted area (ha) of lakes, rivers, transitional waters (estuaries & lagoons) and coastal waters, and total wetted area of habitat potentially available to produce eels within UK RBDs. Data for England and Wales are derived from 1:50 000 scale GIS; for the Scotland RBD from 1:10 000 and 1:1250 scale GIS; and for Northern Ireland from 1: 25 000 scale GIS. Note also that assessments for some EMPs have not included all wetted areas of the RBDs.

Country	RBD	lakes (ha)	rivers (ha)	transitional (ha)	coastal (ha)	total eel producing habitat (ha)
England &	Northumbria[1]	3599	5760	2457	70 461	11 815
Wales	Humber[1]	9743	15 305	32 805	32 885	57 853
	Anglian[1]	9539	12 048	32 786	225 599	54 373
	Thames[1]	9162	8238	33 615	4268	55 283
	Southeast[1]	2061	3954	5428	171 207	11 442
	Southwest[1]	2621	9798	23 431	349 787	35 850
	Severn[1]	6157	14 372	54 542	0	75 071
	West Wales[1]	4271	8824	13 475	433 095	26 569
	Dee[1]	1623	1579	10 928	0	14 129
	Northwest[1]	9780	9076	27 927	151 109	46 783
shared	Solway-Tweed[1]	1575	3142	30 803	0	35 519
Scotland	Scotland	138557	48 104	-	-	186 661
Northern	Northeastern	640	160			800
Ireland	Neagh Bann	38600	1400	0	40 000	80 000
International	Northwestern	28600	4350	1153	34 103	68 206

[1]Total amount of eel producing habitat is the sum of all freshwater (lakes and rivers) and transitional waters, it does not include coastal water habitat.

13.2.2 Silver eel production

13.2.2.1 Historic production

The historic production of silver eels from the 'pristine' environment is the estimate from which the 40% escapement target is derived. This value is called the B_0, because it is the baseline biomass against which present production is compared.

RBD-specific assessments will be made available when the UK EMP Review 2012 is published.

England & Wales

In the absence of data on historic production of silver eel in England and Wales, a standard production rate has been applied by the Environment Agency with reference to a SMEP II estimate of historic production for historic yellow eel data from one RBD. Pristine production is likely to differ between RBDs because of local and regional variations. Therefore, B_0 and the 40% target are likely to be revised as and when local data become available.

The wetted area consists of all freshwater (lakes and river) and estuarine (transitional waters) habitat (Table 23), the latter habitat has been included as a number of fisheries operate in estuarine waters. The estimate of wetted area does not included coastal waters.

Northern Ireland

The area of lakes and rivers available and productive to eel in the Northeast RBD is about 800 ha, of which 640 ha is from the lakes of the Lagan and Quoile catchments, and the remaining 160 ha is productive river area. In the absence of any historic or recent data on eel production from this RBD, a standard pristine production rate of 5 kg per hectare has been chosen, (after Moriarty and Dekker, 1997).

The method used to estimate the historic production of silver eels from this transboundary RBD are reported in the Country Report of the Republic of Ireland.

The current production of silver eels within the Neagh/Bann RBD suggests potential natural outputs in the range of 400 to perhaps 600 tonnes per annum, given historical high natural glass eel supplies.

Scotland

A number of historical/pristine production estimates using different methods were generated in the development of the 2009 EMP for the Scotland RBD. The first two relied on reference to data from Irish catchments (ICES, 2008), whereas the third was based on historical eel data from a single catchment in Scotland (the Girnock Burn). Two further methods, based on the Irish model of silver eel production (ICES, 2008), but adapting the equations to survival and growth rates measured in Scotland RBD led to very low estimates of pristine production, and were rejected. The three methods yielded similar estimates of pristine silver eel production, with none having any obvious advantage over the other:

1) Pristine Escapement Estimate 1 (Burrishoole alone): 138 365 kg;
2) Pristine Escapement Estimate 2 (five Irish catchments and underlying geology): 228 302 kg;
3) Pristine escapement estimate 3a (mean historical Girnock): 184 487 kg.

Accordingly, the mean of the three values was adopted in the 2009 EMP, allowing some rudimentary estimate of uncertainty, and yielding an estimate of total historical/pristine production of silver eels for Scotland RBD of 183 718 ± 25 965 kg.

Subsequent estimates of trap efficiency on the Girnock Burn have led to an increase in the third estimate of pristine escapement, in turn leading to a new mean value of pristine escapement.

13.2.2.2 Current production

The current potential production is the estimated biomass of silver eels produced in the assessment year (or period, where several years have been combined to produce an average value per annum), based on the recent levels of recruitment, calculated prior to the impacts of anthropogenic mortality factors. Note that it is not possible at this time to exclude the contribution of stocked eels, but methods are being developed to achieve this. In essence, this is the present potential escapement of silver eels from the available environment, if anthropogenic mortality was immediately reduced to zero. This value is called B_{best}, as it is the best biomass that would be possible today.

RBD-specific assessments will be made available when the UK EMP Review 2012 is published.

England & Wales

For England and Wales, present potential production is estimated using SMEP II modelling of eel index data and good quality data on yellow eel densities, length–frequencies and sex ratios from multispecies surveys, along with mark–recapture and resistivity and acoustic counters (Bilotta *et al.*, 2011). Estimates from one to four rivers per RBD were extrapolated to eel-producing habitat of each RBD. Further rivers will be assessed as data and resources allow, and the RBD estimates may be revised accordingly.

Northern Ireland

The current silver eel production from the Northeast RBD is not known, but is free and unimpeded, as is natural recruitment. The method used to estimate the current production of silver eels from the transboundary Northwestern International RBD are reported in the Country Report of the Republic of Ireland. The production rate for the Neagh/Bann RBD is based on production estimates from Lough Neagh, including the contribution of stocking. No estimate is available excluding the contribution of stock, but this analysis is being developed.

Scotland

Current estimates of the mean production of silver eels are based on the measured production at three small catchments which occupy different altitude ranges. This production is extrapolated to the RBD as a whole based on GIS estimates of wetted areas, stratified by altitude bands corresponding to the altitudes occupied by the three study catchments: wetted areas between 0 and 239 m above sea level, 240 to 415 m, and areas above 415 m. The total is adjusted for the potential impact of man-made barriers on migration by assuming that barriers defined as impassable for salmonids are also total barriers to eels, and that no additional production occurs downstream as a result of the presence of the barrier.

As it is assumed that no silver eel production occurs upstream of turbines, and there are no fisheries for eel in the Scotland RBD, this is in fact an estimate of escapement, which in itself is possibly an underestimate because it ignores potential production upstream of turbines.

13.2.2.3 Current escapement

The current escapement of silver eels ($B_{current}$ or B_{post}) is the estimated biomass in the assessment year (or period), based on the recent levels of recruitment, calculated after accounting for the impacts of anthropogenic mortality factors, and including the contribution of stocked eels.

RBD-specific assessments will be made available when the UK EMP Review 2012 is published.

England & Wales

For England and Wales, present escapement is estimated as B_{best} minus estimated losses due to anthropogenic impacts expressed as silver eel equivalent biomass.

Northern Ireland

In Northern Ireland, the actual current escapement from the Northeast RBD is not known, but as there are no fisheries, hydropower installations or other significant anthropogenic mortality factors, escapement is presumed to equal production (not known). The current escapement of the Northwestern International RBD is estimated according to the method reported in the Country Report of the Republic of Ireland. The annual average escapement of silver eel from the Neagh/Bann RBD is based on production estimates from the Neagh fisheries, after subtracting the silver eel equivalent biomasses lost from anthropogenic impacts.

Scotland

Current escapement is assumed to be the same as current production (13.2.2.2) since these measures are based on actual numbers of migrating eels at three catchments at different altitudes.

13.2.2.4 Production values e.g. kg/ha

RBD-specific assessments will be made available when the UK EMP Review 2012 is published.

13.2.2.5 Impacts

The main anthropogenic impacts to eel production in the UK are (listed in no particular order) fisheries, tidal flaps or gates, pumping stations, surface water abstraction points and hydropower facilities, although the distribution and therefore potential impact of these factors varies considerably across the UK depending on local circumstances.

RBD-specific assessments will be made available when the UK EMP Review 2012 is published.

Fisheries

There are no eel fisheries in the Scotland, Northeastern or Northwestern International RBDs.

The impact of fisheries to UK eel production was estimated as the annual loss of silver eel equivalent biomass and lifetime mortality (*F*).

To standardise between the losses due to fisheries for glass, yellow and silver eels, the yellow and glass eel catches were first converted to silver eel equivalents. For the glass eel catch, 1 kg of glass eel was considered equivalent to about 93.8 kg[1] of silver eel, based on the instantaneous mortality of 0.14 yr^{-1} (Dekker, 2000), and a 50:50 sex ratio with males maturing at 12 years and 90 g weight, and females maturing at 18 years and 570 g weight (Aprahamian, 1988). It must be stressed that there is very great uncertainty in this estimate converting glass eel to silver eel, it is a theoretical estimate and is not based on empirical data. It also does not take into account any influence of density-dependence on natural mortality or other eel life-history processes. The biomass of yellow eel caught was considered to be the equivalent of the potential silver eel escapement because the instantaneous mortality rate of 0.14 yr^{-1} (Dekker, 2000) approximated to the instantaneous growth rate of 0.2 yr^{-1} (Aprahamian, 1986), i.e. the growth in weight between the yellow eel catch and their potential weight as silver eels was compensated for by the fact that some of them would have died of natural causes.

RBD-specific assessments will be made available when the UK EMP Review 2012 is published.

Other anthropogenic impacts

RBD-specific assessments will be made available when the UK EMP Review 2012 is published.

13.2.3 Stocking requirement eels <20 cm

England & Wales

Though stocking plans have not been produced for each EMP as required by the Regulation, England and Wales is not relying on stocking to meet the escapement target if the RBD is failing for the following reasons:

- There is insufficient stocking material.
- Restocking is not seen as the most sustainable action when compared with improving access. The cost of an eel pass is in the region of £800 equivalent to stocking 4 kg (12 000) glass eel. Where we have installed passes we have recorded thousands of eel moving past these structures in the first year. We consider this to be the most sustainable management option to implement.
- England and Wales is not keen to use material caught other than by dipnets as this achieves the best quality product for restocking. Elvers acquired from fisheries that use trawls or large boat assisted seinenets suffer very high mortalities. UK elvers are hand caught and of premium quality.

Northern Ireland

There are no stocking plans for the Northeast or Northwestern International RBDs.

The LNFCS stocking target for Lough Neagh in the Neagh/Bann RBD is 6 to 8 million individuals (approximately 2 t) or 150 to 200 elvers per hectare (which produces a density of eel that ultimately provides a size of eel that reaches a prime market price). This target is consistent with gaining maximum benefit per elver and on the basis of the input–output analysis will supply a managed fishery and allow adequate escapement.

Of interest also is the effect of stocking level on the proportion of males and females in the emigrating silver eel catch. The gear is not thought to be selective for sex, implying a true record of sex ratio, dependent at least partly on input stock density (Rosell *et al.*, 2005). As male eels leave earlier and are much smaller, this suggests that at high stocking levels the number of silver eels increases but without increase in weight of eel produced, perhaps suggesting habitat saturation at levels above 400 elver per hectare or 12 million individuals for the Lough. In 2010, 996 kg of glass eel (approximately 3 million individuals) were stocked into Lough Neagh, in 2011 it was approximately 1035 kg (about 3.1 million individuals), and in 2012 about 1300 kg (about 3.9 million).

Scotland

None.

13.2.4 Summary data on glass eel

The only commercial glass eel fisheries in the UK are operated in England and Wales. Table 24 presents the fate of commercial glass eel catch in 2009 to 2012. There is a small loss in the catch accounting for mortality and weight loss between capture and trade. Glass eel were either sold for restocking in the UK (mainly Lough Neagh, Northern Ireland) or Europe, or for aquaculture (Table 25). No glass eel went for direct consumption in the UK, and neither was any UK glass eel exported outside of the European Union.

Table 24. Fate of glass eel weight (kg) caught by commercial fisheries in the UK between 2009 and 2012. n/a = data not available.

	2009	2010	2011	2012
Commercial catch	445.1	1889.6	3642.1	3819.9
Exported to Asia	0	0	0	0
Restocked	n/a	1019.16	1322.31	3233.8
Aquaculture	n/a	704.44	1960.79	400.0
Consumed direct	0	0	0	0
Mortalities & weight loss	n/a	166	359	186.1

Table 25. Destination of glass eel (by weight, kg) from UK commercial fisheries, caught between 2009 and 2012.

Country	2009	2010	2011	2012
Czech Rep			30	76
Denmark		200	515	400
Estonia			306.5	90
Germany		97	882	384
Greece			411	
Latvia			100	343.3
Netherlands		1288	593	100
Poland				120
Slovakia		85	79.5	
Sweden	205			1200
UK	240.1	53.6	366.1	920.5
Total	445.1	1723.6	3283.1	3633.8

Prior to 2010, the glass eel stocked in Lough Neagh (Northern Ireland) and small quantities stocked in England and Wales were all sourced from the UK commercial glass eel fishery. Since 2010, however, quantities of glass eel from France and Spain have been stocked in Lough Neagh (Table 26).

Table 26. Source and quantity (kg) of glass eel imported into the UK for restocking between 2009 and 2012.

Country	2009	2010	2011	2012
France	0	1150	714	400
Spain	0	198	0	0

There are no glass eel fisheries in Northern Ireland or Scotland.

13.2.5 Data quality issues

No information.

14 Sampling intensity and precision

No new information available. Refer to previous UK Country Reports.

15 Standardisation and harmonisation of methodology

15.1 Survey techniques

England & Wales

Knights *et al.* (2001) provided recommendations for design of monitoring programmes to detect spatial and temporal changes in population status, including those on electrofishing method. The Environment Agency has two standard work instructions in relation to eel, for eel-specific electrofishing surveys in rivers and for fykenetting.

Baldwin and Aprahamian (2012) undertook an evaluation of electric fishing for assessment of resident eel in rivers. Electric fishing is the sampling method of choice in smaller rivers and can be very efficient in optimal conditions. There are, however, widely held assumptions about the efficiency of electric fishing for eel which suggest that it is difficult, if not impossible, to get accurate population estimates from electric fishing surveys. Relationships between efficiency of eel capture by electric fishing and survey method were examined. Data from over 2000 routine electric fishing surveys carried out by the UK Environment Agency were used. Catch efficiencies (CE) were compared for surveys targeted at salmonid, coarse fish (multispecies) or eel (mean CE 0.575, 0.569, 0.605 respectively), and different size ranges of eel. Eel catch efficiency was compared with that for other species. The assumption that surveys targeted at multiple species or salmonids invariably under-represent eel is not supported by this study. The results from eel-specific surveys examined in this study did not demonstrate any significant advantage over multispecies or salmonid surveys in terms of catch efficiency.

Northern Ireland

No information.

Scotland

No information.

15.2 Sampling commercial catches

England & Wales

There is no routine sampling of commercial catches, although some sampling has occurred to characterise migrating silver eel populations sampled by commercial eel-rack fisheries (Knights *et al.*, 2001; Bark *et al.*, 2007; see also Section 10.1).

Northern Ireland

Methods described above. No Quality Assurance is undertaken within the sampling of the commercial catches.

Scotland

No commercial catches are reported.

15.3 Sampling

England & Wales

Details can be found in:

http://publications.environment-agency.gov.uk/PDF/GEHO0411BTQF-E-E.pdf

Northern Ireland

No information.

Scotland

No information.

15.4 Age analysis

England & Wales

Ages reported in Knights *et al.* (2001) were quality assured by the Environment Agency's National Fisheries Laboratory at Brampton. A similar QA method was employed by Bark *et al.* (2007). Age analyses currently being conducted on otoliths using the cutting and burning method (as per ICES Eel Ageing Workshops held in Bordeaux in 2009 and 2011), or sectioning and staining where the otoliths are used for microchemistry analyses.

Northern Ireland

Age analysis is performed on yellow and silver eels sampled from the Lough Neagh fisheries using the grinding and polishing technique. The results have been quality assured against burning and cracking of sister otoliths performed at the Marine Institute labs in Newport. Results to date indicate mean yellow eel age of 14 years, male silvers eleven years and female silvers 18 years. These findings and the methodologies by which they were calculated were corroborated during the ICES Eel Ageing Workshop held in Bordeaux in 2009.

Scotland

Age analyses currently being conducted on otoliths deploy the cracking and burning method (as per ICES Eel Ageing Workshops held in Bordeaux in 2009 and 2011).

15.5 Life stages

England & Wales

No information.

Northern Ireland

All life stages on Lough Neagh are studied. Glass eels and yellow eels are periodically examined from those systems listed previously and as part of NS Share work.

For Northern Ireland in general, no analysis of glass eel developmental stage is undertaken. The difference between yellow eel and silver eel is determined by gross morphology, aided by length and time of year and was originally under the guidance of senior fisheries scientists and in the company of experienced fishermen.

Scotland

No information available.

15.6 Sex determinations

England & Wales

No information.

Northern Ireland

The correct gender assignment was originally under the guidance of senior fisheries scientists and is based on *in situ* macroscopic examination.

Scotland

No information.

16 Overview, conclusions and recommendations

Recruitment of glass eel to UK waters appears to continue at very low level compared to the highs of the 1970s and early 1980s. Although the reported catch to the Environment Agency in 2012 (2.35 t) by the England and Wales fishery was the highest since 1998, it is still less than 10% of typical levels two to three decades ago. Catch alone is not necessarily a good index of glass eel abundance because changes in effort can affect catch independent of abundance. A comparison of the cpue glass eel data between 2007–2009 with that between 2010–2012 indicates an increase of ~100%, suggesting an increase in recruitment between these two periods. The glass eel catch in the fishery-independent trap in the River Bann, Northern Ireland in 2011 (16 kg) was the lowest in the current dataseries (from 1960), but the 2012 catch was 189.3 kg by August.

Approximately 84% of the UK glass eel catch in 2012 was used in stocking, whereas about 10% was used in aquaculture for consumption. The remainder was lost due to the normal processes of mortality and weight loss between capture and sale.

The cpue for the England and Wales yellow and silver eel fishery in 2011 was 0.22 kg per trap per day, which is similar to the values from 2007 onwards, but only 68% of the cpue from 2005 and 2006. This reduction suggests that the stock is currently lower when compared with the estimates in 2005 and 2006, but has remained steady over the last five years. The silver eel catch from Lough Neagh (River Bann) was similar to recent years; no meaningful cpue index of abundance is available at this time.

Eel stocks have been assessed throughout the UK as part of the 2012 Eel Management Plan Review process. These assessments will be made available for each RBD as soon as the EMP Review 2012 is published (anticipated later in 2012). These assessments take account of the losses due to fishing and other anthropogenic impacts (e.g. tidal flaps/gates, pumping stations, surface water abstractions, and hydropower).

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Annex 11: Technical minutes from the Review Group on Eel

- RGEEL
- By correspondence 13–15 November 2012.
- Participants: Gérald Chaput, Canada (Chair), David Cairns, Canada, Didier Gascuel, France and Henrik Sparholt (ICES Secretariat).
- Working Group: WGEEL

Introduction

The Review Group conducted its work by correspondence. The report of the 2012 Session of the Joint EIFAAC/ICES Working Group on Eels of 3–9 September, 2012, was made available to the Review Group on 6 November 2012. The Review Group was asked to examine and review Sections 4, 8 and 9 of the Working Group report. Draft reviews were exchanged within the Review Group during 13 to 15 November 2012 and the draft technical minutes were prepared, reviewed and finalized on 19 November 2012.

The Introduction (page 13) states that the 2012 meeting of WGEEL is the first step in the post-evaluation process, including an international assessment of the status of the stock and the levels of anthropogenic mortalities, of progress of Member States of the EU relative to EU Regulation (EC 1100/2007) that established measures for the recovery of the eel stock. As such, no ICES advice is expected from this assessment at this time.

The report was prepared by the Working Group in response to terms of reference. In this report the Terms of Reference are at the end of the section entitled "Adoption of the Agenda". It would be clearer for readers to have the Terms of Reference in a stand alone section at the start of the report. It would also be important to indicate which management body(ies) developed the terms of reference. The client for this advice is not clearly identified, is it the European Inland Fisheries and Aquaculture Advisory Commission and the Food and Agriculture Organization of the United Nations?

Report structure

Overall, the report is very well written and well organized with minimal errors in references to figures and tables. Some minor spelling and grammar errors are present, these could be rectified quickly by the secretariat.

There are many inconsistencies in how figures are generated. For example in some cases line charts are used, whereas in others scatterplot chart formats are used, axes are labelled or not, chart titles are used or not, as well as figures being generated using different software. As many of these figures are or will become standard summaries presented for assessments, the Working Group could begin standardizing the formats of these figures and agreeing on labelling standards.

Some of the tables require editing, in some cases the columns are too narrow and the value wraps over multiple rows which makes reading and interpretation awkward. Footnote marks in table text are diverse and sometimes inconsistent. Specifics are provided in the annex notes to this review.

The reference list in the report is incomplete, not all references in the report are identified in the literature cited list (details are provided in the section on specific editorial comments as annex to this report) nor are references cited in a consistent format.

There is a very large amount of data summarized, analysed and discussed in this report and the Review Group acknowledges the effort of all contributing members to collate, check and update these important time-series. Section 13 describes the status of the existing databases and indicates that the transfer of these datasets to the ICES DataCentre is envisioned, although it may take several years to complete. The Review Group recommends that the Working Group continue to make progress on that task. Some of the raw time-series data (landings, and stocking of glass eels) summarized in the report are provided in table format in Annex 6. Until such time as the database is secured and available for reviewers and readers at the ICES DataCentre, it would be important to include in tables in an annex the time-series of glass eel, glass and yellow, yellow, and silver eel indices which are the basis of Section 4.

Review of assessment and interpretations

The issues raised by the Review Group do not put into question the concerns arising from the assessment of the Working Group nor the value of the actions undertaken by Member States to reduce mortality, arrest declines, and recover European eel abundance in its geographic range.

For an assessment approach based on stock–recruitment (SR) considerations to be useful, we need to have confidence that the assumed SR relations reflect real-world patterns with reasonable accuracy. If the assumed SR patterns deviate substantially from real-world patterns, then the modelling approach will not provide reliable outputs. The use of SR relations in population modelling assumes that SR patterns (including such features as depensation) flow from inherent characteristics of the species' biology and ecology. As such, SR patterns seen in the past should continue to be exhibited by populations currently and in the future (stationarity). However, if the SR relation of European eels in past decades is controlled or at least substantially influenced by shifts in ocean regimes, then past SR relations have limited value to predict present and future SR dynamics (non-stationarity).

Depensation is being proposed to explain the pattern of low recruitment index values at low SSB. Such patterns might also be explained by non-stationarity in ocean survival of the oceanic stages of eel, between the egg and the glass eel stage, particularly as the declines in both SSB and Recruitment have happened over the same time period. Shifts in the ocean dynamics of the Sargasso Sea and the Gulf Stream have been hypothesized to be causes of changes in American and European glass eel recruitment (Castonguay *et al*., 1994a, 1994b; Friedland *et al*., 2007; Bonhommeau *et al*., 2008). Oceanic regime shifts have been described for the Northeast Atlantic during the mid-1980s and effects have been seen in Atlantic salmon recruitment, as well as zooplankton indices (see various papers in ICES Volume 69(9) 2012, Chaput *et al*., 2005). For eel, and in particular given the long period spent at sea prior to glass eel recruitment, a decline in density-independent ocean survival between the silver eel stage and the recruiting glass eel stage that would result in a non-stationary SR series is a possibility that should be considered by the Working Group.

The report concludes that spawning–stock biomass (SSB) trends derived from landings reflect the actual SSB trend. It would be useful for readers to have documented in the report an assessment of the extent of the potential bias of using landings as a proxy for SSB. Bias could result from incompleteness of the landings within Member

States and back in time, the possible effects of management measures on landings (and independent of abundance), and the mixed nature of the life stages in the landings (yellow eel vs. silver eel). All of these factors are noted in the report but there is no discussion of how important any of these might be in the translation of landings as a proxy for SSB. If these points have previously been considered by the Working Group, it would warrant summarizing them again.

The effect of recruitment on subsequent stock is a key part of life cycle. Over the past several decades, the recruitment indices have decreased very substantially. During this time, available yellow and silver eel indices have not exhibited as steep a decline. The Working Group should examine possible explanations for this. One explanation may be that the indices of yellow eel and silver eel are derived from sampling in areas of favoured habitat and do not adequately represent the contraction of habitat use of eels as abundance has declined, i.e. the indices are hyperstable. Another possible explanation is density-dependent effects in the continental areas. Glass eels/elvers arrive in growth areas in large numbers, especially on the western face of Europe. Under a density-dependent mechanism, as recruitment falls, a larger proportion of recruits survive, leading to less change in stock size over a range of recruitment levels. The analyses presented in the report assume no density-dependence in the continental stage. However, Section 4 provides observations that are consistent with density-dependent mechanisms, such as increased size of silver eels and in the proportion female as abundance declines.

The following questions might be considered by the Working Group in the subsequent assessments and in future work.

1) A comparative evaluation of competing hypotheses of mechanisms that control the SR relations for eel and the implications on the assessment approach and resulting management should be discussed. Two possible hypotheses to be considered include:

    1.1) Non-stationarity: ocean regime shifts influence egg to glass eel survival, and therefore time-series patterns of stock and recruitment, with the result that past SR patterns do not characterize present or future SR dynamics.

    1.2) Depensation: inherent and ongoing features of eel biology control SR patterns particularly at low stock abundance and as a result past dynamics characterize present and future dynamics.

2) Trends of recruitment from the ocean should be inferred primarily from indices with the least likelihood of bias (i.e. scientific series, conducted on glass eel runs that have not been subject to fishing). The composition of indices that are used to derive a recruitment trend indicator should be more clearly documented.

3) The current method of estimating SSB, and its alternatives, should be evaluated. This would include, but not be limited to, the following points:

    3.1) Use of landings to estimate SSB: what are the effects of uncertainties in landings data, and shifts in regulatory environment, fishing gear, life stage of captures, and fishing effort?

    3.2) Potential use of yellow/silver eel series to estimate SSB: what are the effects of the limited sample size and the limited geographic coverage of available series? Can the lack of consistent steep declines in yellow eel indices be attributed to recruitment-dependent within-river settlement patterns (i.e. when recruitment is high, eels colonize the whole river, but when recruitment is low, they only colonize the lower part of the river)? What is the evidence of (and against) density-dependent population responses acting in the continental phase of the life cycle, especially at low abundance?

3.3) The report points out a lack of assessment coverage in "coastal marine waters" (p. 105). Eels in brackish and salt water likely have different demographic characteristics and different conservation vulnerabilities than eels in freshwater. An evaluation of the impact of the paucity of data on marine eels on SSB trend estimates and assessment results would be useful.

3.4) Does the best method, chosen after a full evaluation, provide an index that reliably reflects the true SSB trend? To be useful in assessment and SR modelling, an SSB index must meet this standard. It is not sufficient that the chosen method be merely the best among available options.

The Review Group recognized that assessing the status of a panmictic species with such a broad geographic distribution as the European eel is very challenging. The rates of a large number of life-history parameters (growth rate, mortality rate, size or age-at-maturity, and sex ratio) would be expected to vary geographically across the range. What appears to constraining advancements in the continent-wide assessment of European eel is the lack of comprehensive (geographically, serially) data with which to populate appropriate assessment models. The Working Group recommends (Annex 5) that additional data on life-stage composition of the catches be collected, but there is no recommendation to collect basic life-history data including age, growth rates, sex ratio, proportion silvering, etc. data which are essential to making progress on a continent wide assessment. The Working Group should continue developing, improving, and applying assessments at the MS or EMU scale which collectively can result in a continent-wide assessment.

General comments on Section 4

Section 4 of the report addresses the following terms of reference:

- assess the trends in recruitment, stock and fisheries indicative of the status of the European stock, and of the impact of exploitation and other anthropogenic factors; analyse the impact of the implementation of the eel recovery plan on time-series data (i.e. data discontinuities). Establish an international database for data on eel stock and fisheries, as well as habitat and eel quality (update EEQD) related data – seek advice from ICES Data-Centre for this task; review and make recommendations on data quality issues;

The modelling approach laid out in this report is based on considerations of recruitment and spawning stock. Due to the peculiar nature of eel ecology, it cannot be assumed that stock–recruitment relations and recruitment–stock relations will follow the patterns exhibited by typical fish. It is therefore necessary to determine the nature of these relations empirically, with real data on the European eel. It follows that trendlines for recruitment and for stock must be generated with care, and that potential biases and imprecisions must be evaluated and documented.

The model used to develop a standardized recruitment index series is not fully described. There are concerns regarding the mix of series, the standardization to a common time period, and the absence of characterization of uncertainty of the individual and standardized indices.

- Annex 6 Table 4-1 lists 48 series of eel recruitment indices, not 49 as given in text (Section 4.1.1). Also, Figure 4-2 shows eleven yellow eel series (and also mentioned in text on page 14) but twelve are listed in Annex 6 Table 4-1. Five glass/yellow indices are shown in Figure 4-2 but only four are listed in Annex 6 Table 4-1.
- Series are not complete over the time period of analysis. Some series do not have data every year, and new series have been added. Therefore the mean of each series can potentially have been calculated over different years, within the 1979–1994 standardization period. This may not be that important an issue if only a few years are missing for the 1979–1994 period but for some series there may be only a few points used to calculate the mean – at least based on information in Figure 4.2 and Annex Table 4.1. It would be helpful to the reader to include in Annex 6 –Table 4.1 two other columns: one that describes the start and end years of data used in the analyses, the second column that gives the number of years that include data.
- There are a large number of series, which show broadly similar trends of steep decline. However, the analysis in the report mixes recruitment indices which can be expected to be reliable indicators of recruitment from the ocean (fisheries-independent catch rates of glass eels) with indices which are less reliable indicators (glass eel landings, cpue of young yellow eels). The use of commercial catches and commercial cpues as indices raises questions. How are catches and cpue affected by management plans, quotas, seasons, etc? As stated on page 22, Section 4.1.5, some of the commercial series were stopped (Vidaa and Ems) and the decline in the series index may have been a consequence of changes in fishing effort. Are some of the lost series the ones where the decline was the most severe? The same is stated for the glass eel fisheries in France which have come under quota management. Interpretation of these issues might be aided by sensitivity analyses, such as jackknifing where a series is left out and its effect on the mean index is assessed, and then for all series in sequence.
- With so many of the indices for glass eels being fishery-dependent, it does raise the issue of representativeness of these indices. One check on this is to include index type (commercial vs. scientific) as an explanatory variable in the recruitment index series.
- Potential uncertainty in these series should be properly described. For example, if a scientific series of glass eel abundance is collected upstream from commercial glass eel fisheries, the scientific series may be affected by fisheries removals. Glass eel landings and yellow eel series should be presented only for comparative purposes.
- All the recruitment indices time-series are shown on the log scale so the GLM model used is likely a multiplicative model with the indices scaling proportionally to each other. If there are null values in any of the annual data, how are these treated? Standard errors are available from such analyses and the mean plus or minus two standard errors (log scale) should be shown in the figures. For example, Figure 4-4 should show the mean and standard errors from the GLM analysis for glass eel and the yellow eel GLM index.

- All the individual series contribute to the annual index of abundance. However, there may be pseudo-replication in some of the series. In Appendix 6 Table 4-1, the Gironde (France) has three series for glass eels, one based on commercial catch, one based on commercial cpue and a third based on scientific index. These three must represent the index of glass eel abundance in the Gironde which is one river within Europe. Similarly, Adour estuary has a commercial catch index and a commercial cpue index. Unless the model corrects for this, the Gironde index actually gets more weight in the WGEEL recruitment calculation compared to other indices. The same applies to Adour and perhaps the IYFS and IYFS2 scientific indices. One way to address this is to nest the Gironde indices into the Gironde index and Adour indices within Adour and then estimate the recruitment index based on the higher level of area or river so that Gironde contributes one degree of freedom and not three.
- The glass eel recruitment series is presented as “North Sea” vs. “Elsewhere Europe”, suggesting that there were different trends in recruitment being noted for those two areas. A closer look at Appendix 6 Table 4-1, using the glass eel only indices, and interpreting “trapping all” as equivalent to “scientific”, provides the following breakdown of dataseries source: for the North Sea area, there are ten “scientific” indices and two “fishery-dependent” indices whereas for “Elsewhere Europe” there are five “scientific” and 15 “fishery-dependent” indices. Are the different trends since the 1990s between North Sea and Elsewhere Europe due to differences in monitoring type?
- By eye, it is concluded that there was a change in trend in the two areas (North Sea, Elsewhere Europe) between 1980 and 1985. The existence of a break year that results in a change in trend can be tested using a segmented regression, running the model over a sequence of shifting break years that defines two time periods (by default) of possibly differing trends and using model selection indices (Akaike information criterion for example) to determine in which year the change in trend has the most explanatory power. This could be done for the series combined, and then separately for “North Sea” and “Elsewhere Europe”. It may be that the early 1980s are the point where such a break provides a good fit and if so it would strengthen the interpretation of that pattern and lead to examination of possible explanatory hypotheses.
- For the yellow eel index, area might be considered as a covariate. There are few indices for this life stage, Figure 4-6 indicates ten in total. But based on Annex 6 Table 4-1, there are 12 yellow eel series shown, about equal numbers from the Baltic Sea (five indices), and non-Baltic area (seven indices). The Baltic Sea vs. North Atlantic separation seems natural given the differences in the ecosystem in the Baltic relative to the Atlantic, for example Baltic Atlantic salmon are isolated from the North Atlantic salmon.

As spawning–stock biomass (SSB) cannot be measured directly, SSB must be inferred from abundance of a mixture of earlier stages in the continental zone. The Working Group used landings to infer abundance of the continental stock, based on a "raising factor" which is a function of exploitation rate. Inferring abundance from fishery landings is an uncertain business, especially in fisheries which are subject to market and regulatory conditions that vary widely geographically and over time. In addition, there are substantial uncertainties in the reliability of the European eel landings time-series. Landings reports are absent from some jurisdictions and incomplete in some other jurisdictions over the time-series.

- The use of a General Linear Model to reconstruct, not correct, the landings back to the 1960s is not fully described. Presumably, the landings by country and year are reconstructed using a model with multiplicative errors such that the mean proportion per jurisdiction is estimated and applied over the entire time-series using reported landings by country where available. However, management likely differed over time in individual countries and is such an assumption realistic? A run-reconstruction model that could be relevant to reconstructing eel abundance is described by Potter *et al*. (2004) and applications of this approach for developing catch advice are provided in the recent North Atlantic salmon reports (ICES, 2012). We would encourage efforts to develop such a run-reconstruction approach for eel.
- Scientific series of yellow and silver (especially the latter) eels are alternate indicators of SSB. However, all but one of these series are based in northern Europe; the exception is a series from the Garonne which is not plotted in the report. There is therefore a possible bias in that the data poorly reflect the eel's full continental range. Abundance of eels measured in these series is potentially affected by local fisheries and by stocking. These and any other potential influencing factors should be described.

Reference is made to changes in sex ratio or mean size as abundance declines (Irish fykenet survey data, Dutch estuaries data, Burrishoole Ireland series, Sweden cpue). This dynamic (change in sex ratio, increased size) at low abundance has implications for how the spawning stock is quantified in the SR time-series and suggests a life-history response to low abundance, perhaps positive for rebuilding. This is discussed further in Section 9.

General comments to Section 8

Section 8 of the report is intended to address the following terms of reference:

- plan for an evaluation of the EU Regulation for recovery of the eel stock (EC No. 1100/2007), its target (40% SSB escapement compared to historic production) and its consistency with the precautionary approach, including planning for data exchange, quality control, methodology for stock-wide assessment;
- assess state of current and historic data (including outputs from WKBALTEEL and GFCMEEL) and undertake an analysis of the possible stock–recruitment relationships, incorporating spatial differences (e.g. age-at-maturation, sex ratio), that could lead to establishing precautionary reference limits;
- make recommendations on how WGEEL 2013 should undertake the post-evaluation and assessment using the 2012 reported data, taking note of previous WGEEL and SGIPEE reports.

The Review Group noted that the ToRs specified in the report for this section are also included as TORs for Section 9. Is this a copy mistake? The first two ToRs are addressed in Section 9 while only the third ToR relates to Section 8 and more precisely to Section 8.6. Sections 8.2 to 8.5 on data and methods quality control address important issues but do not relate directly to the final ToR.

To a reader not intimately involved with the challenges of assessments of European eel, this section condenses a large amount of history and progress. There is a mixture of general principles, as for example Section 8.3.1 on bias and precision, followed by a long and somewhat unclear discussion of indicators and methods, which have not been previously defined. Reference is made to a number of Member State reports which are not accessible to the reader and as a consequence makes it difficult to follow the discussion. A more prescriptive approach, specifying for instance what should be improved in the MS reporting or in the methods used by MS would be useful.

The definition of the four indicators B_0, B_{best}, $B_{current}$ and $\sum A$ should be included as a small text table at the beginning of the section, rather than in the glossary at the beginning of the report.

The rates of a large number of life-history parameters (growth rate, mortality rate, size or age-at-maturity, and sex ratio) would be expected to vary geographically across the range. The Working Group states in Section 8.2.1 that because of these considerations, a single shared assessment that would estimate a combined anthropogenic mortality-at-age would be meaningless. If indeed such a naïve assessment that ignores spatial structure in these critical life-history features was conducted, the conclusion would be incorrect. The scientific community has however moved far beyond these simplified concepts and very complex assessments accounting for such diversity in life-history features and in anthropogenic mortality are being conducted.

Section 8.3.2 makes reference to Annex 9 (and not 8). Annex 8 is very relevant. Is the table in Annex 8 considered to be in its final state? If not, the work should be finalized and implemented as an assessment tool.

Section 8.4 provides a very good review of the current state of capacity to conduct assessments at local scales and at the continent-wide scale. It provides an excellent summary against which progress can be assessed. The Working Group has identified the numerous gaps in knowledge and data collection, and in particular the unknown contribution of coastal marine waters for European eel, a significant knowledge gap which is paralleled for the American eel in North America.

Section 8.5 begins with some strong conclusions on the stock and recruitment dynamic of eel. The second sentence of the opening paragraph indicates that a stock and recruitment relationship for eel is difficult to demonstrate and therefore, it has yet to be proven that a low spawning–stock biomass is restricting recruitment. Yet, later in the paragraph, the report states that a strongly depensatory relationship has been demonstrated. The Review Group feels that such a conclusion has not been demonstrated. Less strong interpretations and appropriate acknowledgements of uncertainties in the modelling and assumptions would be more appropriate. It is not the complex ecology of eels that makes the characterization of the stock and recruitment process difficult; it is lack of data. The proposed test scenarios and the two case examples provided are difficult to follow for a reader not familiar with the details of the assessment. Further clarification and adjustments may arise as the proposed approach is put into practice.

Section 8.6 proposes how the post-evaluation of 2013 could proceed, considering quality checks for data, indicators and assessment approaches. This is strategically important and the Working Group should strive for the best assessment available at the Member State or EMU scale, and not limit its assessment to the lowest common denominator. It should be clear to Member States that anthropogenic mortality rates on European eel will be accepted by other Member States if it can be demonstrated that the mortality rates imposed within the Member State are within the limits of the species productivity. There is therefore benefit to individual Member States to improve their individual assessments.

The Review Group questions the opening sentence of Section 8.7. Quality control procedures applied in ICES are indeed relevant and applicable for the European eel, although at this time, they may not be implementable. The Working Group has identified and proposed work and deliverables for the next assessment that will redress some of the shortcomings in data collection, processing, and quality control procedures currently used by a very large number of independent assessment activities. More data collection and consideration of the conclusions of the Report of the Workshop on Eel and Salmon DCF Data (WKESDCF) should be considered.

General comments to Section 9

Section 9 addresses the derivation of biological reference points and proposals for new approaches where no protocols are available or do not fit the case of the eel well. It addresses the following ToRs:

- plan for an evaluation of the EU Regulation for recovery of the eel stock (EC No. 1100/2007), its target (40% SSB escapement compared to historic production) and its consistency with the precautionary approach, including planning for data exchange, quality control, methodology for stock-wide assessment;
- assess state of current and historic data (including outputs from WKBALTEEL and GFCMEEL) and undertake an analysis of the possible stock–recruitment relationships, incorporating spatial differences (e.g. age-at-maturation, sex ratio), that could lead to establishing precautionary reference limits;

This section however does not address the third term of reference stated in the report and that reference should be deleted ("make recommendations on how WGEEL 2013 should undertake the post-evaluation and assessment using the 2012 reported data, taking note of previous WGEEL and SGIPEE reports.").

The eel management plan was developed and adopted before the ICES approach formally changed, moving from the precautionary approach to the MSY transition scheme (in order to achieve the F_{MSY} targets by 2015). Thus consistency between the eel management plan (based on a pseudo B_{PA} approach) and the new ICES MSY framework should be discussed in this section. Is the objective to achieve the biomass of silver eel at 40% of the notional pristine biomass consistent with the B_{MSY} target? This issue should be discussed, or at least it should be mentioned that this question would have to be further examined by WGEEL. ICES (SGIPEE, 2010) proposed a modified PA diagram with spawning–stock biomass expressed as ratio of B to B_0 on the x-axis and using sum of anthropogenic mortality (including fishing) (expressed as $\sum A$) rather than fishing mortality on y-axis.

In Section 9.3.3, B_{lim} is estimated to equal 21% of B_0 (and around 23% on Figure 9.4), whereas in the next section reference is made to the 40% objective previously adopted for management and to the value of 50% previously considered as desirable by scientists. Consistency between the various values needs to be addressed. Even if it is preliminary (as clearly explained in the text), could the new 21% estimate mean that the target would have to be re-examined and maybe revised? Or does it mean that the 21% value is a (still preliminary) estimate for B_{lim}, while the adopted 40% (or the recommended 50%) should be considered as a proxy for B_{PA}? Even if not resolved by the Working Group at this stage, what should be the next steps?

It is stated that the context for eel is complex and an alternate proposal is proposed, based on the sum of anthropogenic mortalities over the lifespan of the eel adjusted for the proportion of the age/life stage that would become silver eel. The case of the eel is not so special. It is identical with the situation in most fish stocks where partial recruitment vectors at age are applied to estimate total F on the stock. As life stages or age groups become more vulnerable to fishing, the PR value increases and the sum of the product of PR-at-age and F-at-age is the overall F value which is defined in PA frameworks for these stocks.

There are inconsistencies in how recruitment declines are described in the text. With the default hockey stick SR function for estimating B_{lim}, recruitment declines linearly with SSB below B_{lim}. The terms impaired recruitment and recruitment failure are used in this chapter, when neither is appropriate. A consistent and ICES-compliant terminology is required.

The Working Group indicated that the purpose of this section was to illustrate the concept of developing reference points. But the use of the specific data in the example does raise a number of issues of how the recruitment index or the SSB values are to be calculated.

- The recruitment-series in the example is the relative index of recruitment of glass eels for the "Elsewhere Europe" area (thus excluding "North Sea"). However, the use of a partial recruitment-series modelled against SSB for all of European eel assumes that the recruitment relative to SSB trend for the European eel stock is represented by the partial index. Yet in Section 4, the North Sea glass eel trend is shown to have declined more rapidly than the Elsewhere trend. There is no information with which to weight the individual recruitment-series to the proportion of total eel recruitment. But this is what needs to be done in order to develop an appropriate SSB to recruit series.
- The SSB series proposed is based on landings by country partitioned into the catches that originate from different regions (Baltic Sea, North Sea, Atlantic Ocean, Mediterranean) and then adjusted for an estimate of exploitation rate. Catches are partitioned into regions for those countries with rivers flowing into more than one region. That approach is okay if catch is already provided by regions in the country but any other means of partitioning requires assumptions on quantity of productive habitat and production rates in the habitats. Expert opinion could provide some starting values for these, and that would be important to do if the SSB by regions is to be reconstructed from catches. As discussed earlier in this review, the SSB reconstruction has several issues. Are glass eel landings included in the calculation? It is indicated that the "corrected series" of catches as described in Section 4 was used but there are questions on the appropriateness of this reconstruction (rather than corrected) of catches in the time-series. Landings are subject to numerous influences unrelated to stock size. Yellow, and especially silver, eel cpue indices are an alternate indicator of SSB trends. These indices show conflicting trends, with some suggestion of decline.
- Use of landings to indicate SSB requires the assumption that constant exploitation rates are applicable to a species and populations that exhibit in-

variant growth and mortality schedules. Getting at the silver eel biomass from reconstruction of mixed yellow and silver eel fishery catches requires another correction factor which could be developed from sampling programs (as per EU DCF). Assumptions implicit in the use of landings to indicate SSB should be fully described and assessed.

- The raising factor β is defined as the ratio of catch and current escapement biomass. It would be clearer to the reader if that relationship could be described mathematically; as described it doesn't follow with the equation that follows in the text. What is meant by current escapement biomass? Is it silver eel biomass after all anthropogenic mortality (SSB – (catches + other mortality) = escapement) or is it biomass before fishing? Presumably as used in a stock and recruitment analysis it represents biomass after fishing. So as written in the report, it is specified as $\beta = C / B$; and therefore $B = C / \beta = C * \beta^{-1}$. In the equation on page 120, it is not written that way.

- Overall, few to no details are provided of the run-reconstruction analysis but the concept for the reconstruction of spawning stock and abundance has already been developed for Atlantic salmon at ICES. A run-reconstruction model that could be relevant to reconstructing eel abundance is described by Potter *et al*. (2004) and applications of this approach for developing catch advice are provided in the recent North Atlantic salmon reports (ICES, 2012). We would encourage efforts to develop such a run-reconstruction for eel.

The S–R series shown in Figures 9.3 and 9.4 should be the same but the plots differ. In Figure 9.3 the SSB range extends from <20 kt to >80 kt whereas in Figure 9.4, the SSB range is from <20 kt to just over 70 kt. As well, the maximum recruitment values occur at SSB values of 70+ kt in Figure 9.3 but in Figure 9.4, the maximum recruitment values occur at <60 kt.

- The stock and recruit series look unusual; the large range of the recruitment index is surprising as SSB exceeds 50 kt in Figure 9.3. Might SSB be overestimated in the early portion of the time-series (large catches resulting from high true exploitation rates but assumed exploitation rates are lower). Might recruitment indices be underestimated in the latter part of the time-series? The SR time-series represents a common problem of a one way trip.
- The segmented regression differs from the hockey stick fit only in allowing for an intercept (the hockey stick forces the regression through the origin). The two breakpoint regression may statistically be a better fit to the scatter of points but a biological explanation should be given and discussed. The possibility of non-stationarity in the time-series should be discussed by the Working Group.
- As an alternative to a formal stock and recruitment functional analysis, the working group could also consider a simpler approach of calculating the relationship between the median recruitment value for blocks of SSB and characterizing how the median values change with SSB. Eyeballing the points in Figure 9.3 (which is not a good thing to do but is done here for illustrative purposes), the median recruitment drops sharply at SSB <50 kt. So as an illustration of what could be a B_{lim} value, 50 kt could be a reasonable first value (for illustrative purposes).

In Section 9.4.2 (top of page 126), there appears to be some confusion between F_{lim} and F in the advice. F_{lim} is the maximum exploitation rate when the stock/species is in the healthy zone of PA plot. If ICES advised that anthropogenic mortality should be as close to zero as possible to promote stock rebuilding, that means F should be close to zero, not that F_{lim} or A_{lim} should be zero.

Interpreting the objective to have silver eel escapement biomass at 40% of pristine biomass as anthropogenic mortality corresponding to 40% SPR is a consistent general interpretation. The objective of 40% of pristine biomass of silver eel is more appropriate than 40% of pristine abundance by number. Fecundity scales with weight so larger female eels make larger contributions in terms of eggs than smaller females.

There is a simple relationship between %SPR and instantaneous F or A. If %SPR = 40%, then Survival = 40% and mortality is 60%.

> S = exp(-Z); Z = - ln(S); -ln(0.4) = 0.92
> Note that exp(Z) which is mortality = Annual mortality; Exp(0.92) = 0.60.
> So simply, if the total mortality reference point is $X\%_{SPR}$, then the total allowable mortality is (1-X)% which is easier for managers to understand than an instantaneous rate value of 0.92.

There is nothing special about eel that requires unique treatments of age-specific data in assessment models. Silver eel escapement in any given year is comprised of multiple year classes. In other stock assessments, stock status in terms of F on the stock and SSB is estimated for the year in question even when many of these fish stocks are comprised of multiple cohorts in the SSB and multiple cohorts being fished. The estimates of F and SSB are based on partial recruitment factors (usually at age); SSB is expressed as the sum of the product of the abundances at age and the proportion mature at age, overall F is estimated using partial recruitment vector to the fishery.

There is insufficient information to confirm an absence of a compensatory mechanisms at low SSB in the SR relation.

- The example dataset in Figure 9.7 is intended to represent a stock with a depensatory stock–recruitment dynamic but it is not obvious what is depensatory in this function. Recruitment occasionally falling below the replacement line at low and intermediate levels of SSB is indicative of large process uncertainty (i.e. highly variable density-independent mortality).

The discussion regarding the definition of biomass reference points which would advise that anthropogenic mortality should be reduced to zero is useful for applying the MSY approach to eel management. The proposal for two reference values, B_{stop} and B_{stoppa}, is not clearly presented.

- The proposal to use generalized smoothing functions rather than classic stock and recruitment functions requires some justification. Posterior distributions of recruitment at SSB should always be provided in any SR analyses, regardless of the functional relationship being examined. There is nothing special about using GAM functions that allows one to estimate these posterior distributions. In fact, if the simulated data in Figure 9.7 were fitted to a Beverton–Holt function for example, some of the posterior predicted recruitment distributions would likely include values below the replacement line at low SSB.

Any analyses that requires a replacement line for SSB, requires information on mortality and transition rates from recruitment to spawners.

- How is the replacement line in Figure 9.8 calculated? Required for this are values for M, growth rates, maturation probabilities. How is the value of B_0 defined from the data and analyses in Figure 9.4?
- The replacement line is drawn passing through the origin. The plateau of recruitment is indicated to have been estimated using the segmented regression but the segmented regression has R falling to zero at SSB ~18 kt. So to be consistent, the replacement line should be drawn with R = 0 at SSB just under 20 kt (as per Figure 9.4), in which case the 5th percentile of the GAM fit never falls below the replacement line.

In Figure 9.9 and in the text, the precautionary diagram illustrates the sum of anthropogenic mortality plotted against SSB. It is proposed, and shown in Figure 9.9, to have two y-axes scales, one showing instantaneous $\sum A$ (with reference level = 0.92) and the other axis showing %SPR (on the log scale). But as plotted in Figure 9.9, the axis that should correspond to %SPR is labelled as lifetime mortality. For instantaneous $\sum A = 0.92$, annual anthropogenic mortality = 60%, and it is confusing to have the 0.92 instantaneous value referred to as A_{lim} correspond to 40% on the opposite axis. If mortality is to be shown, the % axis needs to be inverted, with 0.92 corresponding to 60% and declining to 0% at the origin.

Comments on Glossary of terms (p. vi)

This table of definitions is labelled "Eel references points/population dynamic"

- It would be much clearer to the reader to simply call it definition of terms because at first reading, it seemed the Working Group had confused status indicators ($B_{current}$, A_{post}, etc.) with reference points (B_{lim}, B_{stop}).
- Reference to Cadima, 2003 (A_{lim}, B_{lim}) is not in the Literature cited (Section 16).

References cited in the review

Bonhommeau, S., E. Chassot, and E. Rivot. 2008. Fluctuations in European eel (*Anguilla anguilla*) recruitment resulting from environmental changes in the Sargasso Sea. Fish. Oceanogr. 17:32-44.

Castonguay *et al*. 1994a. Why is recruitment of the American Eel, *Anguilla rostrata*, declining in the St Lawrence River and Gulf? Canadian Journal of Fisheries and Aquatic Sciences 51:479–488.

Castonguay *et al*. 1994b. Is there a role of ocean environment in American and European eel decline? Fisheries Oceanography 3(3):197–203.

Chaput, G., Legault, C. M., Reddin, D. G., Caron, F., and Amiro, P. G. 2005. Provision of catch advice taking account of non-stationarity in productivity of Atlantic salmon (*Salmo salar* L.) in the Northwest Atlantic. ICES Journal of Marine Science, 62: 131–143.

Friedland *et al*. 2007. Oceanic changes in the Sargasso Sea and declines in recruitment of the European eel. ICES J. Mar. Sci, 64: 519–530.

ICES. 2012. Report of the Working Group on North Atlantic Salmon (WGNAS), 26 March–4 April 2012, Copenhagen, Denmark. ICES CM 2012/ACOM:09. 322 pp.

ICES Journal of Marine Science. 2012. Special Volume 69(9). Salmon at Sea: Scientific Advances and their Implications for Management.

Potter *et al*. 2004. Estimating and forecasting pre-fishery abundance of Atlantic salmon (*Salmo salar* L.) in the Northeast Atlantic for the management of mixed mixed-stock fisheries. ICES Journal of Marine Science, 61: 1359–1369.

Appendix: Specific editing notes and questions

Some of the tables require editing, in some cases the columns are too narrow and the value wraps over multiple rows which makes reading and interpretation awkward. Footnote marks in table text are diverse and inconsistent.

- Table 4–10 on page 41 “ongrown cultured” “Wild bootlace”, p. 44 year values wrap over two lines.
- Use of “n/a” for “not applicable” in Table 4-7 or not specified in Table 5.2; “na” but no description in Table 4-11; “NA” and referenced as “na = not applicable” in Table 4-13; “n.d.” referenced as “n.d. = no data” in Table 4-14; “no data” in Table 5-1 and 5-6; “-“ in Table 6.2 and 6.3 without explanation.
- As well, various symbols are used as footnote markers in tables, a simple standard of using a, b, c, etc. would make table preparations much easier and table appearance much cleaner.

Specific comments to Section 4

Figure 4-1:

- Legend. What is a seaoutlet? The grey-green areas on the map appear to resemble watershed areas.

Section 4.1.1:

- Last paragraph. What is the minimum number of years to qualify for inclusion in the analysis?

Section 4.1.3

- End of first paragraph. What does GFCM stand for? Spell out first time used.
- "There should be a programme next year . . ." This is stated as a recommendation. However, the remainder of the paragraph reads as if it has been decided that the series will resume. Text should be revised to clarify whether the resumption of the Tiber and Marta series is a recommendation or if there are firm plans in place to resume the series.

Section 4.1.4:

- Sentence beginning "This raw analysis . . .": need to specify what year is referred to.
- Sentence beginning "According to SGIPEE . . . ": Does this mean that the decline in the trends is not statistically significant? If this is so, one wonders why so much effort is directed towards eel assessments and conservation.
- Caution should be made in interpreting Figure 4-3 as the geometric line is calculated using only the available series. The red line in Figure 4-3 is the geometric mean line of the observed values for glass/glass-yellow indices and yellow indices combined. The 2012 update includes <20 (as per figure 4-3) of 45 historical series.
- The explanatory value of the bootstrap mean and 95% confidence intervals calculation is not indicated. It is not referred to in the trend analysis, that being confined to the GLM calculation. As it is, it appears to have been calculated using the arithmetic values for each series, and then plotted on the

log scale (the arithmetic mean transformed to the log scale is different from the geometric mean, the latter is the median on the arithmetic scale). As the time-series for each of the indices are of different lengths, bootstrap values based on raw indices are of no value. Nothing would be lost by removing the calculation. This applies to Figures 4-3 and 4-4.

- In Figure 4.5, the series are shown relative to the 1960–1979 time period. Why was a different time period used to scale the indices than the one described and used previously? In fact the period 1960–1979 is a period of rapidly expanding indices with the 1979–1994 being a more stable period of seemingly consistent indices. This has consequences later in how the annual coefficients are interpreted.
- Line 3: "high levels in the late 1970s". But, from Figures 4.3 and 4.4, it appeared that the level was even higher in the 1950s.
- In the paragraph on yellow eels (bottom), the 10% is calculated with respect to this period. But compared to the 1950s, the remaining recruitment would be less than 5% (see Figure 4.6).
- Need consistency in text and figures as to how GLM model is referred to. The text on page 18 and 19 refers to GLM as glass eel ~ year:area + site and yellow eel ~ year + site. In Tables 4-2, 4-4, and Annex 6 Table 4-3 in the heading, it refers to GLM N = area:year + site. In Figures 4-5 and 4-6, refer to GLM (recruit = area:year + site) or GLM (recruit = year + site). To standardize, use the structure shown in Figures 4-5 and 4-6 but referring to the multiplicative form of the GLM as: log(recruit) = log(area:year + site).
- Reference is made to "area" as an explanatory variable in the model but "area" in this case does not refer to "area" in Annex 6 Table 4-1 (North Sea, British Isle, Atlantic Ocean, Mediterranean, Baltic) but rather to the larger area (North Sea, Elsewhere Europe). Perhaps a different term than "area" should be used in the GLM analysis so that it is not confused with headers in Annex 6 Table 4-1.
- Delete from Figure 4-4 the bootstrap calculated values, the mean lines based on the available series and the grey shading showing the range for all indices. If the mean lines for yellow eel (brown line) and glass eel (blue line) are in fact the GLM means, then this should be stated. The y-axis on Figure 4-3, should use the same format as Figure 4-3, 4-5 and 4-6 (% of mean).
- Figure 4-6: Show +/- two standard error bars for the GLM mean value. How is the smoothed trend which is shown as a line and 95% band calculated? Is this done in the GLM using year as a continuous explanatory variable? It doesn't appear to be so.

Section 4.1.5:

- First paragraph. Because this report will be read in future years, avoid referring to time since present (e.g. " . . two years ago . . "). Instead, specify the year (e.g. "in 2010").
- First paragraph. Last sentence is confusing. The point to be made is that the series after 1985 decline in parallel.
- "the North Sea series are diminishing more rapidly than Atlantic ones." This seems to contradict the statement two paragraphs earlier: " after that period the trend of the two series was about the same as before."

- Figures 4-7 and 4-8. These figures are referred to in Section 4.1.5. The opening paragraph of that section appears to indicate that the section deals with glass eels. We therefore don't understand why Figures 4-7 and 4-8 give data from Baltic, where there are no glass eels and no glass eel series.
- Analysis of deviation from a common trend. Please describe what is meant by deviation, or give a reference (Mandel’s deviation and bundle). This seems to be a calculation of the difference in slope between the common trend (all indices) and individual series trend. Is a deviation positive when the slope of the index is steeper than the slope of the common trend ($slope_{common} – slope_{index}$)? Is this why the North Sea deviation values for glass eel are positive; the slope (decline for these) is steeper for these indices than the common trend? Not sure the interpretation is correct for all situations. We are not familiar with “Mandel’s bundle of straight line” summary shown in Figures 4-7 and 4-8. These figures appear to simply be the deviation values from Annex 6 Table 4-5 summarized by area with pseudo-box plots overlain on the values. With so few observations in each group, the boxplots over-interpret the information. We would prefer the figures (larger) with simply the symbols and the acronyms by area and life stage as shown, without boxplots.

Section 4.2.1:

- Yellow eel abundance may be altered by fisheries and by stocking. We need to know for each series if the local population is subject to exploitation and stocking.
- Paragraph beginning with "Available information on long ..." replace "reduced opportunities" with "reduced pressure".
- Figure 4-9. It is difficult to reconcile the lower panel of this figure with the text of Section 4.2.1. Are Steendorp and Kastel both in the Scheldt estuary? The graph shows both of these series increasing, but the text says one of them (lower estuary) decreased. The text also refers to a multi-decade decrease, but the graph indicates the Steendorp and Kastel series only started in the early 2000s.
- The text mentions a Swedish fyke series, but doesn't give the location. Is this Barseback? Vendelso? An Irish fyke series is mentioned in the text, but this series does not appear to be shown in the graph. The geographic names in the text should allow the text comments to be matched to the lines in the graph. All the series mentioned in the text should be plotted in Figure 4-9.
- Several papers suggested that upstream migration could be density-dependent, with a decrease in abundance leading to a decrease in the surface occupied by the stock in each river basin, but not necessarily to a decrease in the most occupied places which would likely be the lower part of the river basin or on the coast. Estimating yellow eel abundance should take into account where the samples come from (coastal or inland waters, distance to the sea).

Section 4.2.2:

- First paragraph. What's the difference between a river and a riverine site?
- Text states that numbers declined by 50% in three rivers from an earlier to a recent period. It is unlikely that the decline was exactly 50% in each of

three rivers. Give the exact percent of decline for each river. Are these rivers fished and/or stocked?

- Plot the series mentioned in the text. Indicate the probable origin of these eels; local area in Sweden, Baltic Sea in general?

Section 4.3:

- Figure 4-11. What country has the abbreviation "I"?
- Merging of catches from mixed life stages. Are catches available by life stage (glass eel, vs. yellow/silver eel)? Specification of catches by stages in each country would be useful.

Section 4.4 Recreational and non-commercial fisheries:

- Paragraph above Table 4-7, second to last line. "precise métier because of the varied…". What does "métier" mean in this context? Is it fishing gear?
- Does this paragraph only refer to marine recreational and non-commercial fisheries; rivers and lakes being excluded. Clarification/comment required.
- Table 4-7. It is not clear from the caption or other information in the table what the numbers after Active or before prohibited refer to under yellow and silver columns. It appears to refer to the estimates of the catch volume in each of the yellow and silver eel categories, and the sum of those with the not specified equals total. Perhaps clarify in table by removing the "/" and putting the catch volume in "(t)".

Section 4.5.1:

- Third paragraph. Text says that stocking of young eels (presumably yellow) dropped in the late 1990s. There is little evidence of a decline during this period in Figure 4-14.
- Page 32, last line of the paragraph: may be useful to add ", but still very low compared to the values estimated for the 1952 to 1987 period."

Section 4.5.2:

- Denmark section. Text says 1284 million young eels were stocked in 2012. This number does not match values in Table 4-10 and is ca. 50 times greater than the total number of glass eels stocked in Europe as given by Figure 4-13.
- The caption of Figure 4-13. states that glass eel stocking data for 2011–2012 are not fully available. This could give a mistaken interpretation of recent trends. The lack of recent data should be mentioned in the text when recent trends are discussed.
- Why is Table 4-10 placed in text rather than in Annex 6? The table caption on the first page should refer to the entire table. Each new page of the table should say simply "Table 4-10 (continued). There is no need for captions, with different geographic references, on each new page.

Section 4.6.1:

- Dekker (2000) is referenced. However in Section 16 (References), there are two references from Dekker in 2000. Need to call one 2000a and the other 2000b, and specify which paper is referred to.
- Is M=0.138 on an annual basis, for the first several years after arrival as glass eels? If so, it is implausibly low for such small animals and relative to

what is proposed by Bevacqua *et al*. If M is truly this low, western European rivers would contain an extraordinary number of eels.

- Table 4-12 is referenced before Table 4-11. Tables should be numbered in the order in which they are referenced in the text.

Section 4.6.2:

- Paragraph before Figure 4-18. There are missing words and miss-spellings in this paragraph. E.g. "are limited" rather than "limited", "<u>from</u> 8000" rather than "<u>form</u> 8000".
- Figure 4.17. Values in 1992 are not equal to zero (but unknown) and thus the figure should start in 1993. Use an alternate graph format. Correct the caption (1993–2012).

Section 4.7:

- First paragraph. The text states that production data are compiled by integrating different sources. In fact, there is no process of integrating the various sources. Instead, each dataseries is presented separately.
- Table 4.16. Heading of table, series shown is 2003 to 2010 not 2008.

Section 4.8 conclusions:

- "The WGEEL recruitment index five year average is at the lowest historical level at 1% for North Sea and 5% for Elsewhere Europe." The reasons for the change in time period used for the glass eel index is not described in the previous section. The methods state that the 1979 to 1994 period is used, not 1960–1979 as in text and in the figure.

Table 4-8 in Annex 6:

- Heading refers to stocking of glass eels in Canada but none is shown in the table and no glass eels from Canada were stocked in Europe.

References cited but not in the reference list:

- Dekker, 2002. p. 14 Section 4.1;
- Dekker, 2003. p. 26, Section 4.3.

Specific comments to Section 8

There are a number of inconsistent reference citings in this section. The Working Group should adhere to ICES standards for referencing workshops, study groups and working groups. Rather than using acronyms such as "WKACCU" without further reference in text, these reports should be cited in text using format such as ICES (2008), as used in the literature cited section of the report, with appropriate alpha characters to distinguish multiple reports from the same year.

A number of references in text are missing from Section 16.

- Section 8.2.2 on page 100, the opening sentence begins with "SLIME (Dekker *et al*., 2006)…" Neither SLIME nor Dekker *et al*., 2006 are in references.

There are several references missing or mis-cited.

- Page 100. Top of page, Dekker *et al*., 2000a is cited in text but there is only one Dekker, 2010 in references. Yet further down the page, Dekker, 2010b is cited in text.
- Page 100. Walker *et al*., 2011 is not in the references.

The last paragraph of Section 8.4.3 is repeated word for word as the first paragraph of Section 8.4.4.2.

p. 110, third paragraph.

- "between 2 and 20 kg/ha*year". What does the "*" mean? Is that "per" year? Please spell out.

p. 112, bottom of page. "5. Statistical uncertainty."

- Delete exclamatory statements. Reword such as "Uncertainties are not considered in most assessments." Jackknifing is one way to characterize sensitivity of an input type or value but usually not uncertainty. Use of a range of input values is a way to characterize uncertainty or bootstrapping is another.

Section 8.6. When referring to the units of ∑A, this should be a rate.

Specific comments to Section 9

Section 9.3 S–R relationship:

- What is the lag used for SSB to R?

Figure 9.3:

- What are the two lines (blue and red) shown in the upper left panel? One is the hockey stick line, the other is a smoothed line?

Section 9.3.3:

- Estimate of biomass (B_0) without anthropogenic mortality is stated to be 191 kt. Where does that value come from? If correct, then 40% of this value is just under 80 kt, very close to the hockey stick value of 73 kt or the highest SSB value in the reconstructed series.

Top of page 127, the equation that partitions mortality into natural and anthropogenic sources:

- Mistake in use of Z symbol (should be S symbol) in the following
  - %SPR = exp(-S - ∑A) and not exp(-Z - ∑A)

Figure 9.6:

- lower panel. What does the inset text "the polar form of the lower confidence limit" mean?

Comments to Section 16–References

In addition to the errors noted previously,

- ICES. 2008 WKACCU appears twice but the second entry should be ICES 2009.
- Various editorial inconsistencies.
  - Use of period after initials of authors: see Hemmingsen, see McCoy, etc.
  - Use of comma between surname and initials: see Allee, Astrom, Dekker(s), and many more.