ICES WGSCALLOP REPORT 2013

ICES ACOM COMMITTEE

ICES CM 2013/ACOM:42

Report of the Scallop Assessment Working Group (WGScallop)

2–5 September 2013

Galway, Ireland

ICES International Council for the Exploration of the Sea

CIEM Conseil International pour l'Exploration de la Mer

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

H. C. Andersens Boulevard 44–46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

Recommended format for purposes of citation:

ICES. 2013. Report of the Scallop Assessment Working Group (WGScallop), 2–5 September 2013, Galway, Ireland. ICES CM 2013/ACOM:42. 81pp.

Contents

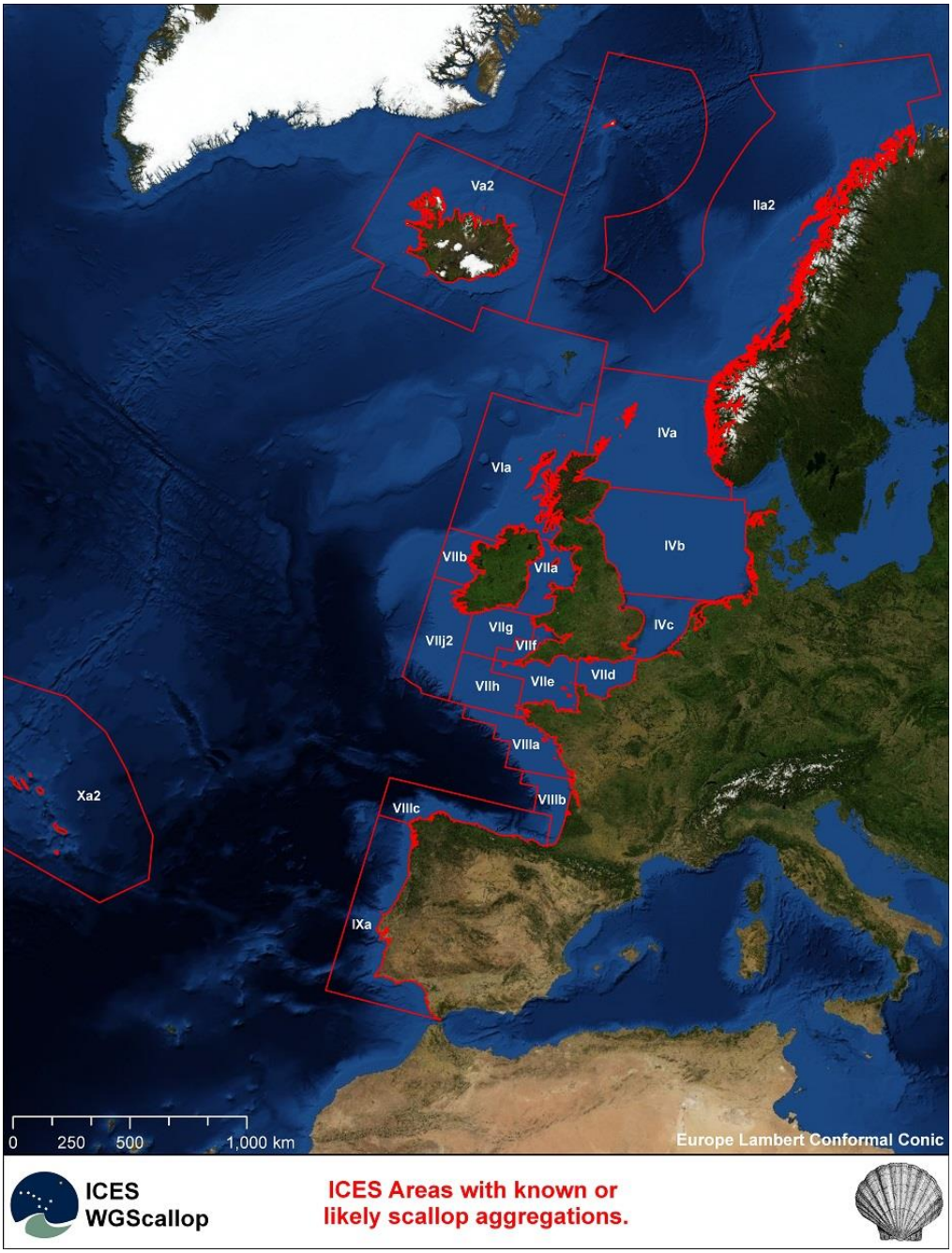
Executive summary

The Scallop Assessment Working Group met at the Marine Institute Rinville Oranmore Galway from the 2nd to the 5th September 2013, with the intent of providing scientific advice on scallops, with a focus on defining a common approach to the assessment of stocks. The proposal to initiate a WG on scallops was justified on the basis of the national and international importance of this fishery in a number of countries in north west Europe and North America. The 2010 FAO estimated combined landings for the King scallop (*Pecten maximus*) and the Queen scallop (*Aequipecten opercularis*) were 64,411 and 24,608 metric tons, worth approximately 126 and 11 million Euros, respectively. However, there is currently no common scientific or assessment forum for discussion and development of common assessment methods for scallops. The last ICES working group to report on scallops met in Brest France from 30 May to 1 June 1991 (C.M. 1991/K:43).

Experts on scallop stock assessment and life history were present. The meeting was chaired by Kevin Stokesbury. The meeting opened with a review of the ToR and overview presentations on the available fisheries data, a review of stock boundaries and identification of stock assessment units.

The workshop focussed ICES areas: IIa, IVa, IVb, V, VIa, VIa and IVb, VIIa, VIId, VIIe/h, VIIg, and VIII. Scallop species and biological stocks were identified in each of the ICES areas. The group developed a working Matrix with points for each of the ToR (Table 1).

A task put to Scallop WG was "Progress towards provision of scientific advice on scallops will be greater where a common approach to assessment of stocks can be developed." We compiled the existing information on surveys, available data and stock assessment approaches; several key factors emerged. All research groups rely heavily on aging methods and proportion by year class is a fundamental dataset. Many of the other factors varied between research groups. A summary focusing on Terms of Reference is presented in Table 1.


Va2
IIa2
IVa
VIa
IVb
VIIb
VIIa
VIIg
IVc
VIIj2
VIIf
VIIh
VIIe
VIId
VIIIa
Xa2
VIIIc
VIIIb
IXa
0 250 500 1,000 km
Europe Lambert Conformal Conic
ICES
WGScallop
ICES Areas with known or
likely scallop aggregations.

1 Introduction

1.1 Opening of the meeting

Experts on scallop stock assessment and life history were present. The meeting opened with a review of the ToR and overview presentations on the available fisheries data, a review of stock boundaries and identification of stock assessment units.

Terms of Reference:

Scallop Assessment Working Group (WGScallop), chaired by Kevin Stokesbury, USA, will meet in Galway 2–5 September 2013, to:

a) Compile and review available fisheries data for scallops

b) Review data on stock boundaries and to identify stock assessment units

c) Compile and review available data on biological parameters for scallop including

  i) Size at age and ageing methods

  ii) Size at maturity including seasonality

d) Discuss development of a common stock assessment methodology(ies) for scallops:

  i) The use of RV surveys

  ii) Catch and effort indices (including VMS data)

  iii) Age based methods

  iv) Depletion methods

e) Data provision for stock assessment

f) Assessing the efficacy of scallop fisheries management measures

g) Quantifying ecosystem effects

Supporting Information

Priority:	Essential
Scientific justification:	The proposal to initiate a WG on scallops is justified on the basis of the national and international importance of this fishery in a number of countries in north west Europe and North America. There is currently no common scientific or assessment forum for discussion and development of common assessment methods for scallops. ToR 1 will provide the data on the distribution of fishing effort and landings for scallop in inshore and offshore waters in ICES Areas VI and VII. These data have not been compiled for the region to date. The meeting in 2013 will review information, including simulations of larval dispersal and seabed habitat, to identify stock assessment and management units (ToR 2). This work will identify priority source areas for larval production and generally increase understanding of the source-sink dynamics of scallops. The biological characteristics of scallop are known to vary geographically. ToR 3 will review the available information and

	cross-reference to the proposed assessment units (ToR 2). Progress towards provision of scientific advice on scallops will be greater where a common approach to assessment of stocks can be developed. Various approaches are currently used, in many cases without a sound biologically basis. ToR 4 will review the application of various methods with a view to developing a standard approach. Data provision and the feasibility of obtaining data relevant to appropriate assessment methods is an important consideration in developing an advisory system for scallops and will be discussed in ToR 5. Scallop fisheries are managed under legislation at the national level and more locally (e.g. in Special Areas of Conservation in the UK). The scientific rationale behind present scallop fisheries management measures and their effectiveness, both in terms of maximising productivity and minimising ecosystem impacts, will be investigated to allow advice to be provided where data deficiency prevents formal stock assessments (ToR 6). Understanding the direct and indirect impacts of scallop dredging and trawling on ecosystems, especially on benthic habitats, is fundamental to achieving successful management of scallop fisheries. Under ToR 7 the impact of scallop dredging will be examined in relation to habitat type (cross-referencing with ToR 2) using fishery-dependent and fishery-independent data (ToR 4). Quantifying recovery rates of benthic flora and fauna will facilitate the provision of advice in an ecosystem context.
Resource requirements:	None.
Participants:	Oliver Tully, Ireland (Marine Institute), Lee Murray, Isle of Man (Bangor University), Ewen Bell, England (CEFAS), Helen Dobby, Scotland (Marine Scotland Science), Eric Foucher, France (IFREMER), Gwladys Lambert, Wales (Bangor University), Kevin Stokesbury, United States (University of Massachusetts), Heather Moore, Northern Ireland (AFBI).
Secretariat facilities:	None.
Financial:	No financial implications.
Linkages to advisory committees:	ACOM
Linkages to other committees or groups:	There are no obvious direct linkages.
Linkages to other organizations:	There are no obvious direct linkages.

1.2 Adoption of the agenda

The agenda was based on the ToR; copies of all the presentations are stored on the Working Group webpage.

2nd September 2013

Morning -9:30 am

- Introductions
- Review of ToR

Expanded areas (4a, 4b, 5, 6a, 7a, 7g, 7d, 7e, 7h)

What species

Where are the boundaries?

- "Progress towards provision of scientific advice on scallops will be greater where a common approach to assessment of stocks can be developed." Is this possible?

Afternoon –

a) Compile and review available fisheries data for scallops

b) Review data on stock boundaries and to identify stock assessment units

- (ToR 1) will provide the data on the distribution of fishing effort and landings for scallop in inshore and offshore waters in **ICES Areas VI and VII**. These data have not been compiled for the region to date.)

  Eric – presentation on the French fisheries; king scallops 25-30,000 mt each year. Presentation from Pectinid workshop.

  Gwladys – fishery around Wales.

  Oliver Tully - we have data on distribution of fishing, effort and landings for ICES Area VII

  Helen Dobby - data & presentation, Scottish stock

  Carrie McMinn - AFBI (Northern Ireland) have been running an annual scallop survey aboard our RV since the 1980's. Prior to 2011 the sites surveyed were around the Co. Down coast of Northern Ireland (Area VIIa). From 2011 the survey has been extended to cover the North coast (Area VIa) where there is a commercial scallop fishery. We will be bringing data from 1992 to present. We hold some commercial landings data showing the value of the scallop industry to NI, landings by port etc. I will also try and get a copy of the VMS data from a colleague which shows the distribution of effort around the Northern Ireland coast.

  Ewen and Dave – UK fishery, using age base surveys. Lots of questions.

- (ToR 2) review information, including simulations of larval dispersal and seabed habitat, to identify stock assessment and management units

Eric, presented his work on Connectivity in English Channel

Oliver Tully - in relation to stock boundaries we can present larval simulations for ICES Area VIIa and VIIg;

Carrie McMinn - We have a seabed map covering the Irish Sea and North coast of Northern Ireland.

3 September 2013

Morning -9:30 am

c) Compile and review available data on biological parameters for scallop including

iii) Size at age and ageing methods

iv) Size at maturity including seasonality

- (ToR 3) will review the available information and cross-reference to the proposed assessment units (ToR 2)

Oliver Tully - Size composition data , Size at age (old data), growth parameters ICES area VII

Helen Dobby - mainly a summary of data we've collected & previous analysis (Lynda)

Carrie McMinn - The data we collect on the annual survey includes scallop length, breadth, total wt, muscle wt, gonad wt, age (from shell for all and from hinge for some), shell bandwidth for some. At the minute we do not have any maturity information as this is something that we have only started this year and the slides are still awaiting staging (we are currently working on a proposal to collect monthly samples of scallops and queenies to determine the reproductive cycle around the coast of NI).

d) Discuss development of a common stock assessment methodology(ies) for scallops:

v) The use of RV surveys

vi) Catch and effort indices (including VMS data)

vii) Age based methods

viii)Depletion methods

- (ToR 4) will review the application of various methods with a view to developing a standard approach.

Oliver Tully - we can present something on depletion methods, PSA, survey data and present up to date LPUE indices based on VMS data

Helen Dobby - assessment of scallop 'stocks' around Scotland (Helen)

Afternoon –

e) Data provision for stock assessment

- (ToR 5) Data provision and the feasibility of obtaining data relevant to appropriate assessment methods is an important consideration in developing an advisory system for scallops and will be discussed in.

  Helen Dobby - we have a presentation about Marine Scotland's scallop data collection

Assessing the efficacy of scallop fisheries management measures

- (ToR 6) Scallop fisheries are managed under legislation at the national level and more locally (e.g. in Special Areas of Conservation in the UK). The scientific rationale behind present scallop fisheries management measures and their effectiveness, both in terms of maximising productivity and minimising ecosystem impacts, will be investigated to allow advice to be provided where data deficiency prevents formal stock assessments.

4th September 2013

Morning -9:30 am

Quantifying ecosystem effects

- (ToR 7) the impact of scallop dredging will be examined in relation to habitat type (cross-referencing with ToR 2) using fishery-dependent and fishery-independent data
  (ToR 4). Quantifying recovery rates of benthic flora and fauna will facilitate the provision of advice in an ecosystem context.

  Carrie McMinn - We collect data on bycatch during each survey. However, there has been no analysis of this to date.

Afternoon

- Discussion - Summarize information and compile 1st draft of the report

5th September 2013

Ageing Workshop

Lead by David Palmer, Ewen Bell and Oliver Tully

1.3 Background to the meeting

The Scallop Assessment Working Group met at the Marine Institute Rinville Oranmore Galway from the 2nd to the 5th September 2013, progress towards provision of scientific advice on scallops, with a focus on defining a common approach to assessment of stocks. The proposal to initiate a WG on scallops is justified on the basis of the national and international importance of this fishery in a number of countries in north west Europe and North America. There is currently no common scientific or assessment forum for discussion and development of common assessment methods for scallops. The last ICES working group to report on scallops met in Brest France from 30 May to 1 June 1991 (C.M. 1991/K:43).

1.4 Common approach to stock – development plan

The task put to Scallop WG was "Progress towards provision of scientific advice on scallops will be greater where a common approach to assessment of stocks can be developed." We compiled the existing information on surveys, available data and stock assessment approaches; several key factors emerged. All research groups rely heavily on aging methods and proportion by year class is a fundamental dataset. Many of the other factors varied between research groups. A summary focusing on ToR is presented in Table 1.

First addressing the "common approach to stock assessment," all groups represented at the meeting had:

- VPA – the ability to calculate a virtual population analysis using at the least psuedochort age information and a representative shell height frequency of the stock. In some cases this shell height frequency relies on samples collected from the commercial fishery and there were some concerns about spatial coverage, representative sampling and cooperation.
- CPUE – the ability to calculate a catch per unit effort analysis, these were divided into two groups, ones from commercial catch data which is perceived to be of poor quality in some cases; on ones from independent survey data which have high quality data, these include the North Irish surveys, the Scottish surveys and the French surveys.
- Landing data – are there issues with illegal fishing/reporting in areas?
- Effort data – all had this but in some cases the quality was of concern.
- ICES Rectangles - this is the finest spatial scallop all groups had; individual datasets from some areas were of much higher resolution.
- Access to visual underwater equipment – discussion on the feasibility of developing an underwater visual survey as a common sampling tool was discussed. Presentations of effort in the North East United States, Alaska US, Iceland, Cardigan Bay Wales, Iceland, and several Bay along the French coast were considered. Every research group has access to visual underwater equipment but the spatial distribution, cryptic nature of the species and funding are challenges that require further research.
- YPR – for the stock unit yield per recruit equations either exists or can be developed based on growth rate data (von Bertalanffy), and shell height/meat weight equations.
- Stock-Recruitment Relationship – All groups DID NOT have this.
- By-catch issues – all research groups felt that by-catch either was or will be an critical issue but the intensity differs between inshore and offshore, the present information on by-catch is patchy.
- Statistical Catch at Age analysis – some groups could calculate this but most did not have the level of information to calculate a model similar to the Scottish TSA. Some have adequate data that has not been assessed and assessment capacity varies by area.
- Productions Models – some groups can calculate production models based on landings and effort data, however in many cases the high quality data extends back only a few years. These will improve in the near future. Some have adequate data that has not been assessed and assessment capacity varies by area.
- Natural Mortality – all groups had an estimate of natural mortality but further research is need as the estimates are presently based on historic litera-

ture or clapper ratios. Research with closed areas shows strong potential for this.

There were a number of differences as well:

- Selectivity and Efficiency –the French researchers had experimental estimates of dredge selectivity and efficiency, allowing them to convert their survey data into absolute values. However, all felt this research in each stock area of important.
- Different fishing and scientific sampling dredges – the French dredge differs from the New Haven dredge and their efficiencies differ with substrate type. Information from mutlibeam sonar reviewed far greater on gravel than on sand in the Irish Sea.
- Information on discard mortality, and incidental mortality, these are poorly understood.
- Early recruitment information (age 2) is available from independent surveys; age 1 in French surveys.

Merits of independent surveys (dredge and image), port-sampling, observers, commercial fisheries sampling:

Reference points

Repeat sampling within ICES rectangles

Live whole weight should be the standard reporting unit

Red bag program (extend outreach)

Table 1.1 Summary table identifying the stocks within each of the ICES areas and addressing the ToR; distribution of fishing effort and landings for scallop inshore and offshore waters (ToR 1), identification of stock assessment and management units (ToR 2) and data provision and feasibility of obtaining data (ToR 5).

			ToR 1, 2, and 5	
ICES	**Stocks**	**Species**	**Data support**	**Assesments**
IVa	Shetland	King	Landings (sq), VIMS, 2 surveys, C at Age,	C at Age TSA, VPA, LPUE
	Moray Firth	King	Landings (sq), VIMS, 1 surveys, C at Age,	C at Age
IVb	East coast Scotland/England	King	Landings (sq), VIMS, 1 surveys, C at Age (limited)	Survey based
VIId	Bay of Seine	King	Survey; logbooks; effort; landings; VMS	TAC
	Greenwich Buoy	King	logbooks;effort; landings;VMS	Effort
	Sussex	King	logbooks;effort; landings;VMS	None
	Bassurelles	King	logbooks;effort; landings;VMS	Effort
VIIe/h	Cornwall	King	VMS, historical survey	None
	Greater Baie de St Brieuc	King	Survey;logbooks; effort; landings	TAC
	West Brittany	King	Survey; logbooks; effort; landings	Effort
	Lyme Bay	King	logbooks; effort; landings	Effort
	Baie de Brest	King	logbooks; effort; landings	Effort
	Casquets	Queen	logbooks; landings	None
VIII	Glenan	King	logbooks; effort; landings	Effort
	Pertuis/Charentais	King	logbooks;effort; landings; historical surveys	Effort
	Belle ile en Mer	King	logbooks; effort; landings	Effort
VIIg	Celtic Sea	King	logbooks, VMS; historic survey, size data	Trend
VIIa	Tuskar	King	logbooks, VMS; historic survey, size data	Trend
VIIa	Cardigan Bay/Liverpool Bay	King	landings; logbooks; VMS; 2 years survey	landing size, engine power, # of dredges, gear specs, closed areas
(Isle of Man)	Liverpool Bay/Isle of Man/Scot coast inshore	Queen	21 yrs surveys(I of M); logbooks; VMS; landings	landing size, # of dredges, gear specs, closed areas
(Isle of Man)	Liverpool Bay/Isle of Man/Scot coast inshore	King	21 yrs surveys(I of M); logbooks; VMS; landings	landing size, # of dredges, gear specs, closed areas
	Liverpool Bay/Isle of Man/Scot coast inshore	King/Queen	15 yrs surveys(I of M); logbooks; VMS; landings	CSA -queen, none for King
(Ireland)	Liverpool Bay/Isle of Man/Scot coast inshore	King/Queen	15 yrs surveys(I of M); logbooks; VMS; landings	CSA -queen, none for King
	Liverpool Bay (separate survey from IOM until 2013)	King/Queens	landings; logbooks; VMS; 2 years survey	landing size, engine power, # of dredges, gear specs, closed areas
	Northern Irish Coast	King	20 yrs of survey, VMS, logbooks	Survey based
VIa	Clyde	King	landings, VMS, C at Age	None
	West of Kintyre (including NI)	King/Queen	survey 3 yr (K), 1 yr (Q); VMS; landing; logbooks; Scottish survey, C at Age	C at Age
	North west	King	survey; landings, VMS; C at Age	C at Age
VIa and IVa	Orkney	King	landings; VMS; C at Age (limited)	None
V	Iceland	Icelandic	survey; landings; logbooks;	TAC
IIa	Frøya, Trøndelag	King	logbooks; effort	landing size

Table 1.2. Summary of Biological parameters (ToR 3)

ICES	Stocks	life span	growth rate	Size at age	aging method	maturity
IVa	Shetland	Age to 10+, live up to 20 years	data available	data available	Count growth rings on shell	Scotland aged 2 onwards
	Moray Firth	Age to 10+, live up to 20 years	data available	data available	Count growth rings on shell	Scotland aged 2 onwards
IVb	East coast Scotland/England	Age to 10+, live up to 20 years	data available	data available	Count growth rings on shell	Scotland aged 2 onwards
VIId	Bay of Seine					
	Greenwich Buoy					
	Sussex		Height_inf=119.2, k=0.516, T0=0.692			
	Bassurelles					
VIIe/h	Cornwall	Age to 8+	Height_inf=110.2, k=0.44, T0=0.68			
	Greater Baie de St Brieuc	12-15	Linf=99; K=0.86 on 2000's (historical Linf=110; K=.7)	Y (years 1974-2012 ; with survey: years 1991-2012)	winter rings+validation daily rings (Univ of Brest)	2 years (H=64 mm)
	West Brittany	12-15	not well estimated (Linf higher than SB; K lower than SB)	Y (only exploitable fraction; data of fishery industry since 1990)	winter rings	2 years H=? close to SB)
	Lyme Bay		Height_inf=113, K=0.56, T0=0.69	data available		
	Baie de Brest	12-15	Linf=105; K=.7	Y (not yearly but sparse information)	winter rings+validation daily rings (Univ of Brest)	2 years H=? close to SB)
	Casquets					
VIII	Glenan					
	Pertuis/Charentais					
	Belle ile en Mer					
VIIg	Celtic Sea		Have data from 2001-2005 surveys & 2012-2013 landings data	Have data from 2001-2004 surveys & 2012-2013 landings data	Limited data, based on rings on shell (Allison *et al*., 1994)	None
VIIa	Tuskar		Have data from 2001-2005 surveys & 2012-2013 landings data	Have data from 2001-2004 surveys & 2012-2013 landings data	Limited data, based on rings on shell (Allison *et al*., 1994)	None
VIIa	Cardigan Bay/Liverpool Bay	None		12+ (2013 survey)	Linf =128; K=0.34 (2013 survey)	Yes
(Isle of Man)	Liverpool Bay/Isle of Man/Scot coast inshore	CSA		Up to 8 (Allison. 1993)	Linf=75.91, k=0.59 (Murray, 2013), Linf=83; K=0.564 (Allison, 1993)	No
(Isle of Man)	Liverpool Bay/Isle of Man/Scot coast inshore	None		Age to 10+, live up to 20 years	Linf=137; K=0.43 (Allison, 1993)	Yes
	Liverpool Bay/Isle of Man/Scot coast inshore	see Lee Murray for data	see Lee Murray for data	see Lee Murray for data	counting rings for kings - none for queens	age 3 for kings
(Ireland)	Liverpool Bay/Isle of Man/Scot coast inshore		Have data from 2001-2005 surveys & 2012-2013 landings data	Have data from 2001-2004 surveys & 2012-2013 landings data	Limited data, based on rings on shell (Allison *et al*., 1994)	None
	Liverpool Bay (separate survey from IOM until 2013)	*None*		12+ (2013 survey)	*Linf=140; K=0.26 (2013 survey)*	*Yes*
	Northern Irish Coast	evidence of 15+	data available	data available	shell/hinge	samples collected from 2013
VIa	Clyde	Age to 10+, live up to 20 years	data available	data available	Count growth rings on shell	Scotland aged 2 onwards
	West of Kintyre (including NI)	NI survey evidence of 15+; Scottish age to 10+ (live up to 20 years)	data available	data available	Scottish count growth rings on shell; NI shell and hinge	Scotland aged 2 onwards; NI samples collected from 2013
	North west	Age to 10+, live up to 20 years	data available	data available	Count growth rings on shell	Scotland aged 2 onwards
VIa and IVa	Orkney	Age to 10+, live up to 20 years	data available	data available	Count growth rings on shell	Scotland aged 2 onwards
V	Iceland	20	8-10 mm a year	-	Shell growth ring counts	40-50mm
IIa	Frøya, Trøndelag	None		Age to 10+, live up to 20 years	data available	data available

Table 1.2 continued.

		ToR 3 parameters			
ICES	**Stocks**	**Recruit est**	**M**	**F**	**Carrying Cap**
IVa	Shetland	Recruit at age 3 (from assessment)	0.15	Calculated from stock assessment	NA
	Moray Firth	Recruit at age 3 (from assessment)	0.15	Calculated from stock assessment	NA
IVb	East coast Scotland/England	Estimate from survey	0.15	Proxy calculated as ratio of catch to survey SSB index	NA
VIId	Bay of Seine				
	Greenwich Buoy				
	Sussex				
	Bassurelles				
VIIe/h	Cornwall				
	Greater Baie de St Brieuc	VPA (classes 1964-2005); survey(classes 1984-2011)	0.15	.40 (historical higher values up to 0.7-0.8)	limit:beds already occupied by high densities of American slipper limpet
	West Brittany	not yet (but possible for 2 coastal beds for period 1990-2010)	0.15	NA	NA (anyway lower observed densities than for SB)
	Lyme Bay				
	Baie de Brest	NA (although historical information for years 1949-1963)	0.15	NA	unknown upper limit:beds already occupied by high densities of American
	Casquets				
VIII	Glenan				
	Pertuis/Charentais				
	Belle ile en Mer				
VIIg	Celtic Sea	None	None	Based on data from 2001-2005	Based on data from 2001-2005
VIIa	Tuskar	None	None	Based on data from 2001-2005	Based on data from 2001-2005
VIIa	Cardigan Bay/Liverpool Bay	counting rings	A50 = Age 2; L50=75mm (height)	Yes - from undersize scallops in queen dredges	maximum 0.4
(Isle of Man)	Liverpool Bay/Isle of Man/Scot coast inshore	None	None	Yes- from undersize scallops in queen dredges	0.2-0.5 (Allison, 1993)
(Isle of Man)	Liverpool Bay/Isle of Man/Scot coast inshore	counting rings	age 3 for kings	Yes- from undersize scallops in queen dredges	0.22 (Beukers-Stewart et al. 2005)
	Liverpool Bay/Isle of Man/Scot coast inshore	Yes- from undersize scallops in queen dredges	estimated in stock assessment for queens?	estimated in stock assessment for queens?	No estimate?
(Ireland)	Liverpool Bay/Isle of Man/Scot coast inshore	None	None	None	None
	Liverpool Bay (separate survey from IOM until 2013)	*counting rings*	A50 = Age 2; L50=75mm (height)	Yes - from undersize scallops in queen dredges	*maximum 0.25*
	Northern Irish Coast	data available	not currently available	not currently available	none
VIa	Clyde	NA	0.15	NA	NA
	West of Kintyre (including NI)	Scotland at age 3 from assessment, NI data available	Scotland 0.15; NI not available	Scotland calculated from stock assessment	NA
	North west	Recruit at age 3 (from assessment)	0.15	Calculated from stock assessment	NA
VIa and IVa	Orkney	NA	0.15	NA	NA
V	Iceland	NA	0,05 – 0,40	NA	NA
IIa	Frøya, Trøndelag	winter rings	aged 2 onwards	NA	NA

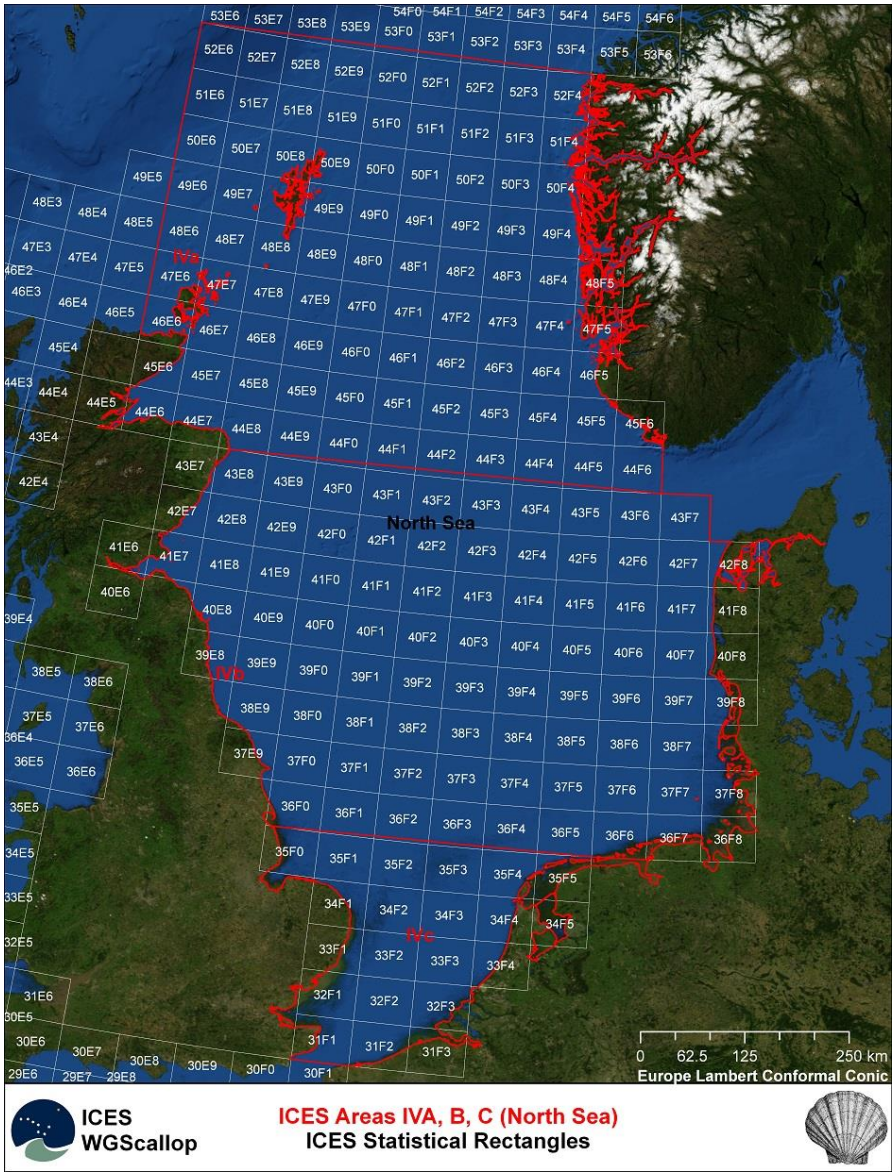
Table 1.3 Summary of stock assessment methods (ToR 4)

				ToR 4 stock assessment					
ICES	**Stocks**	**Gear**	**sampling design**	**Rel/abs**	**efficency**	**selectivity**	**uncertainties**	**CPUE**	**LPUE**
IVa	Shetland	6 dredges per side; one side of commercial dredges (9 teeth and 80mm standard belly rings) second side of scientific dredges (11 teeth and 60mm belly rings)	Fixed stations	Relative index of abundance	Unknown	Juvenile scallops (<3 years) not retained by dredge	Fixed stations are based on historical information on the fishery. May not cover complete stock area.	Data available	Effort data not available
	Moray Firth	6 dredges per side; one side of commercial dredges (9 teeth and 80mm standard belly rings), second side of scientific dredges (11 teeth and 60mm belly rings)	Fixed stations	Relative index of abundance	Unknown	Juvenile scallops (<3 years) not retained by dredge	Fixed stations are based on historical information on the fishery. May not cover complete stock area.	Data available	Effort data not available
IVb	East coast Scotland/England	6 dredges per side; one side of commercial dredges (9 teeth and 80mm standard belly rings), second side of scientific dredges (11 teeth and 60mm belly rings)	Fixed stations	Relative index of abundance	Unknown	Juvenile scallops (<3 years) not retained by dredge	Fixed stations are based on historical information on the fishery. May not cover complete stock area.	Data available	Effort data not available
VIId	Bay of Seine								
	Greenwich Buoy								
	Sussex								
	Bassurelles								
VIIe/h	Cornwall								
	Greater Baie de St Brieuc	dredges (2 types: diving plate+spring loaded)+diving (Jersey)	survey: stratified sampling plan; sampling of landings (auction): subsampling plan; C at age and size)	abs (restrictive SB)	asymptotical value for diving plate up to 0.75-0.8;spring loaded:???)	L50=86 mm	illicit catches (notably summer)+unknown contribution of Channel Islands	Y (restrictive SB)	Y (Jersey: NA)
	West Brittany	dredges (2 types: inshore diving plate offshorespring loaded)	yearly observation of fishery industry on fixed points	rel	NA	L50=86 mm	inaccurate limits of the offshore fisheries	N	Y
	Lyme Bay								
	Baie de Brest	dredge (1 type with no diving plate<170 kg)	only on grounds involved by farming activities	NA	asymptotical upper limit of 0.65	L50=84 mm	not annually conducted assessment	N	Y
	Casquets								
VIII	Glenan								
	Pertuis/Charentais								
	Belle ile en Mer								
VIIg	Celtic Sea		Toothed dredge (Ring size 55, 75 & 89mm; tooth length 80-100mm)	Dredge selectivity & efficiency at 3 different ring sizes on sand or gravel substrates		DE commerical sized scallop ranged from 5-17%; DE for undersized scallop ranged from 4-25%	Have data for 3 ring sizes; 55, 75 & 89mm		Limited CPUE from discard sampling
VIIa	Tuskar		Commercial gear	Trends		None	75mm ring size; tooth spacing of 65mm		Limited CPUE from discard sampling
VIIa	Cardigan Bay/Liverpool Bay	No estimate		2 king scallop dredges - 2 queen scallop dredges + video estimates	Random stratified	Relative	King dredges catch 20 to 50% (based on comparison between videos and dredging)	unknown	Only 2 years of survey
(Isle of Man)	Liverpool Bay/Isle of Man/Scot coast inshore	Unknown upper limit (>30000t)		2 king scallop dredges - 2 queen scallop dredges	fixed stations	Abundance Indices (1993 to 2013)	No	0.35 (scallops<50mm)	Difficulty in sampling juveniles
(Isle of Man)	Liverpool Bay/Isle of Man/Scot coast inshore	No estimate		2 king scallop dredges - 2 queen scallop dredges	fixed stations	Data available	33.3 % for scallops of 110 mm or larger (Beuker-Stewart et al., 2001)	unknown	Possible inconsistencies in aging
	Liverpool Bay/Isle of Man/Scot coast inshore	2 king scallop dredges - 2 queen scallop dredges + video estimates	fixed stations	Relative	5-20% (based on comparison between videos and dredging)	?	?	Yes - see Lee Murray	Yes - see Lee Murray
(Ireland)	Liverpool Bay/Isle of Man/Scot coast inshore		Commercial gear	Trends		None	75mm ring size; tooth spacing of 65mm		Limited CPUE from discard sampling
	Liverpool Bay (separate survey from IOM until 2013)	*No estimate*		2 king scallop dredges - 2 queen scallop dredges + video estimates	*Random stratified*	*Relative*	King dredges catch 20 to 50% (based on comparison between videos and dredging)	*unknown*	Only 2 years of survey
	Northern Irish Coast	4 dredges pre-2013 2 foot, 2013 2 foot 6 inches	historical survey areas and new areas established through VMS and engagement with fishermen. Random sampling within fixed areas	relative	no gear trials carried out	juvenile scallops not retained by gear	boundaries of scallop beds	data available	do not have effort data (will contact DARD to check if available)
VIa	Clyde	NA	NA	NA	NA	NA	NA	NA	Effort data not available
	West of Kintyre (including NI)	Scotland 6 dredges per side using commercial dredge with 9 teeth on one side and standard belly rings and scientific dredges on other side with 11 teeth at smaller belly rings; NI 4 dredges width 2 foot pre 2013 and 2 foot 6 inches from 13 onwards	Scotland fixed stations; Northern Ireland random sampling within fixed areas	relative	no gear trials in NI; Scotland ?	juvenile scallops not retained by dredge	Scotland based on historical so boundaries may differ. NI boundaries of stock unclear	data available	Scotland effort data not available; NI landings data does not contain effort data (will contact DARD to see if this is available)
	North west	6 dredges per side; one side of commercial dredges (9 teeth and 80mm standard belly rings), second side of scientific dredges (11 teeth and 60mm belly rings)	Fixed stations	Relative index of abundance	Unknown	Juvenile scallops (<3 years) not retained by dredge	Fixed stations are based on historical information on the fishery. May not cover complete stock area.	Data available	Effort data not available
VIa and IVa	Orkney	NA	NA	NA	NA	NA	NA	NA	Effort data not available
V	Iceland	Roller dredge	Fixed stratified	Abs	0.285	NA	Not taken into account	100 – 210 kg per hour per fishing feet	
IIa	Frøya, Trøndelag	NA		scuba handpicked	NA				

Table 1.4 Summary of efficacy of scallop fisheries management measures (ToR 6) and impact of scallop harvesting on habitat and recovery rates (ToR 7).

		ToR 6			ToR 7
ICES	**Stocks**	**Management**	**Fleets**		
IVa	Shetland	Has a regulating order	Shetland		
	Moray Firth	Landing size, # of dredges	Scottish		
IVb	East coast Scotland/England	Landing size, # of dredges	Scottish/UK		
VIId	Bay of Seine	landing size, # of dredges, vessel length, season, input/output			Studies underway
	Greenwich Buoy	landing size, # of dredges, input/output, ring size	French, UK, Irish, Dutch		Studies underway
	Sussex	landing size, # of dredges, input/output, ring size	French, UK, Irish, Dutch		Studies underway
	Bassurelles	landing size, # of dredges, input/output, ring size	French, UK, Irish, Dutch		Studies underway
VIIe/h	Cornwall		French, UK, Irish, Dutch		
	Greater Baie de St Brieuc	landing size, # of dredges, input/output, ring size	French, Jersey		
	West Brittany	landing size, # of dredges, input/output, ring size	French,		
	Lyme Bay	landing size, # of dredges, input/output, ring size	French,		
	Baie de Brest	landing size, # of dredges, input/output, ring size	French,		
	Casquets	landing size	French, UK		
VIII	Glenan	landing size, # of dredges, input/output, ring size	French,		
	Pertuis/Charentais	landing size, # of dredges, input/output, ring size	French,		
	Belle ile en Mer	landing size, # of dredges, input/output, ring size	French,		
VIIg	Celtic Sea	landing size	Irish/Scottish		
VIIa	Tuskar	landing size	Irish/Scottish		
VIIa	Cardigan Bay/Liverpool Bay				
(Isle of Man)	Liverpool Bay/Isle of Man/Scot coast inshore				
(Isle of Man)	Liverpool Bay/Isle of Man/Scot coast inshore				
	Liverpool Bay/Isle of Man/Scot coast inshore	landing size, # of dredges, gear specs, closed areas	Irish/Scottish, English, Welsh, N Irish		
(Ireland)	Liverpool Bay/Isle of Man/Scot coast inshore	landing size, # of dredges, gear specs, closed areas	Irish/Scottish, English, Welsh, N Irish		
	survey from IOM until 2013)				
	Northern Irish Coast	gear specs, closures, curfews, effort	N Ireland		
VIa	Clyde	landign size, # of dredges, weekend closures	Scottish		
	West of Kintyre (including NI)		N Irish, Scottish, Dutch		
	North west	landing size, # of dredges	Scottish		
VIa and IVa	Orkney	landing size, # of dredges	Scottish		
V	Iceland	closed	Icelandic		Studies underway
IIa	Frøya, Trøndelag				

2 IIa



2.1 Distribution of fishing effort and landings for scallop inshore and offshore waters (ToR 1)

2.2 Identification of stock assessment and management units (ToR 2)

2.3 Biological parameters (ToR 3)

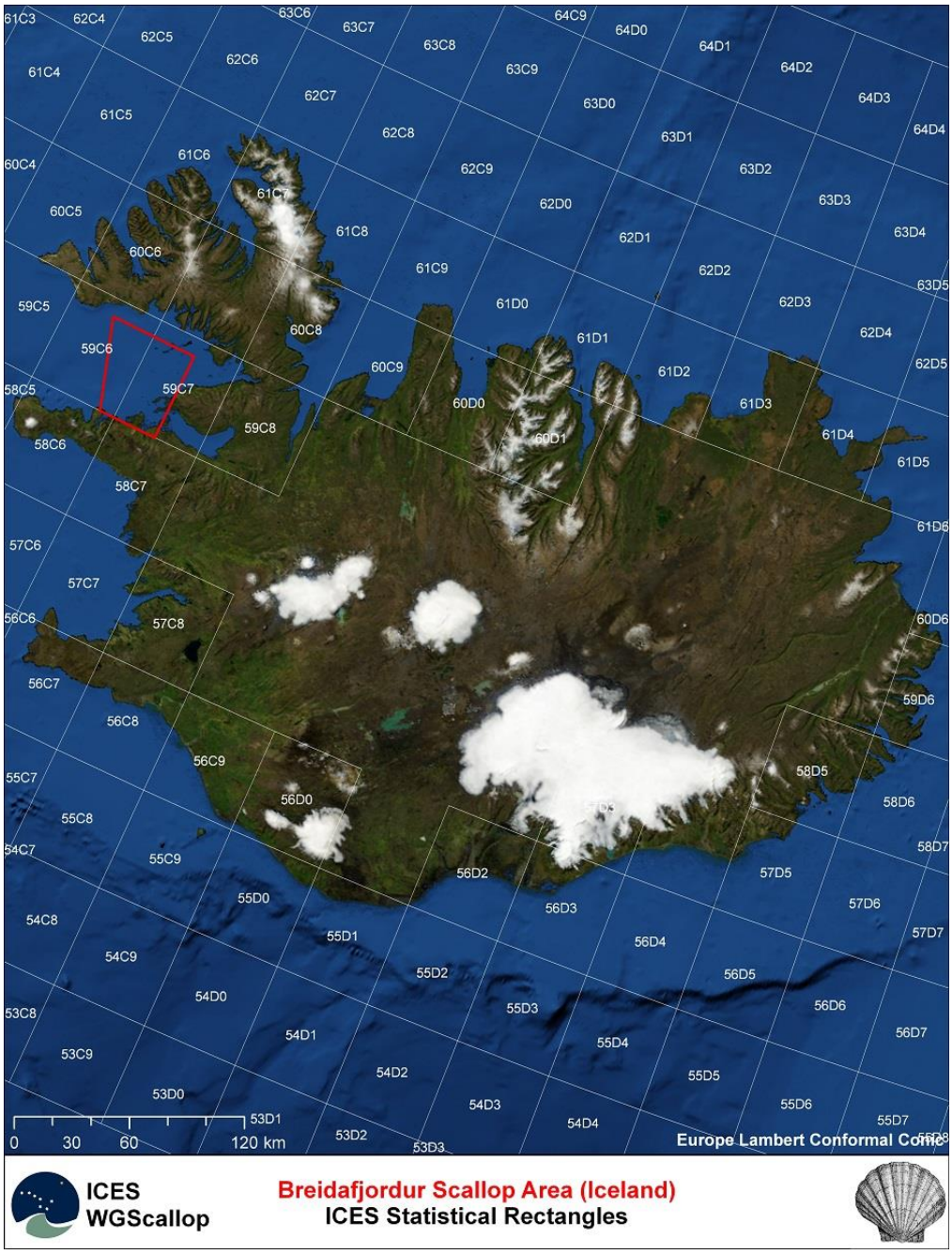
2.4 Stock assessment methods (ToR 4)

2.5 Data provision and feasibility of obtaining data (ToR 5)

2.6 Efficacy of scallop fisheries management measures (ToR 6)

2.7 Impact of scallop harvesting on habitat and recovery rates (ToR 7)

3 V



3.1 Iceland

3.1.1 Distribution of fishing effort and landings for scallop inshore and offshore waters (ToR 1)

Data support

There have been fisheries on nine distinct inshore fishing grounds (fjords and bays) but the majority (84 %) of landings is from the fjord Breiðafjörður and the following information apply to those grounds. Cumulative catch from the start in 1970 to the

closure of the fishery in 2003 in Breiðafjörður was 254 thousand metric tonnes. An annual survey has been carried out in Breiðafjörður since 1972, but only sporadically in other areas. All landings are recorded and loogbooks are mandatory in the fisheries. VMS has not been implemented in Iceland. The following information only applies to Breiðafjörður.

3.1.2 Identification of stock assessment and management units (ToR 2)

Management

The ground have been closed since 2003 due to low biomass estimates. Minimum landings size is 60 mm shell height.

Fleets

The fleet has been Icelandic and usually of local origin. The vessels were roughly between 15 – 40 meters long with tendency towards the end of the fisheries of larger sizes.

Assesments

TAC has been used in this fisheries. Recommendations for TAC were based on 10% of estimated biomass. The total catch was usually slightly above recommendation (not higher than 15%) and between 1994-2002 it followed recommendation.

3.1.3 Biological parameters (ToR 3)

Life span

Maximum observed age at least 23. Maximum age set at 20.

Growth rate

The growth rate is estimated to be 8-10 mm per year for yonger scallops and 0-0.3 for larger scallops (10-15 cm).

Size at age

Missing at the moment

Aging methodology

Shell growth ring counts, but it's not done on regular basis. The age has also been estimated from length based cohort distribution.

Maturity

Matures between 40-50 mm at roughly the age of 5.

Recruitment estimate

Is not available for this fisheries.

M

Natural mortality is based on the occurrence of cluckers in survey tows:

$$a = 1 - e^{-(C/t)(1/L)365}$$

where a is the yearly ratio of natural death, C the number of cluckers, t the average time in days required for the shells of the cluckers to separate (211 d) (Jonasson, 2005), and L is the number of live scallops in the sample. The exponent is equal to the

instantaneous mortality rate. The number of cluckers was adjusted for the numbers of scallop that disarticulate during the tow, by multiplying the number of cluckers in the sample by 1.211 (Naidu, 1988).

F

Conventional F have not been estimated. However, Beverton & Holt length-based fishing mortality has been estimated to be around 0.5 during the last decade of fishing (1993 – 2003), but that estimate also includes indirect mortality and is biased when recruitment is not uniform.

Carrying capacity

Is not available for this fisheries.

3.1.4 Stock assessment methods (ToR 4)

Sampling design

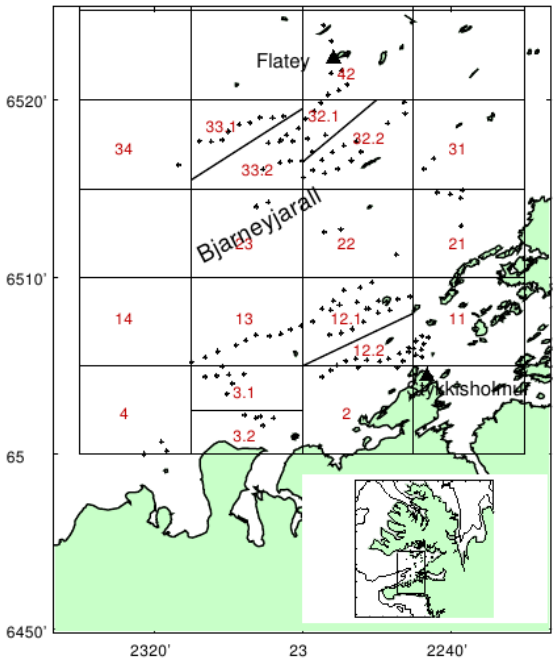


Figure 1. Overview of Breiðafjörður survey stations are marked by points, and grid boxes are numbered to show subareas.

The design of the annual survey is fixed stratified (Fig. 1). On each survey 120 standardized tows were taken and the total area is split up into 19 subareas.

Rel/abs

Biomass is estimated in absolute terms of retained scallops (no dredge selectivity is taken into account). On each annual survey 120 standardized tows were taken and the total area is subdivided into 19 subareas. Each survey tow is approximately 0.4 nautical miles and the tow speed 4 knots. For each tow the total catch is weighed and a random subsample of approximately 25 kg taken to estimate the proportions of scallops. The size of the scallop beds in each subarea was based on an estimate conducted in the early 1970s with the total area estimate of 77 km^2.

Efficiency

The dredge efficiency was estimated to be 0.285.

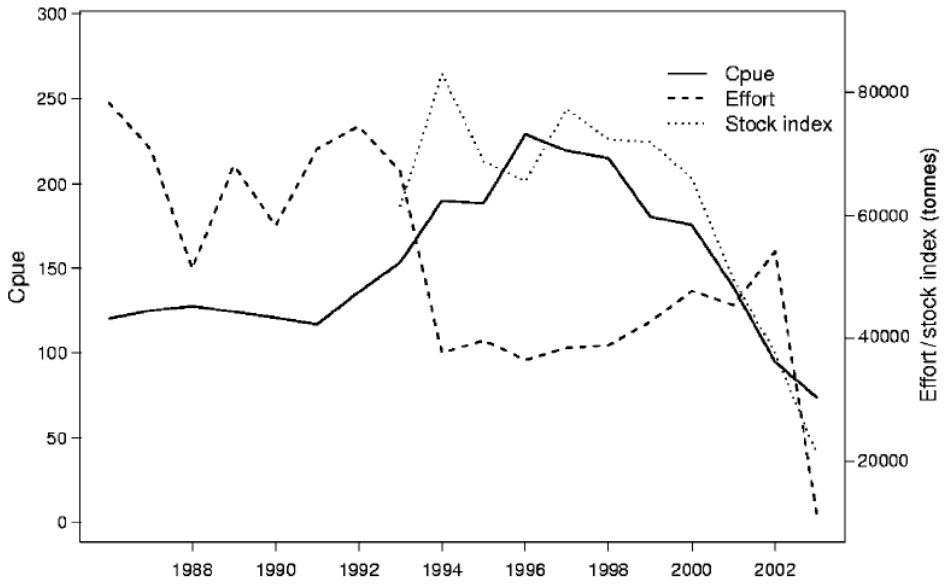
Selectivity

Selectivity of the dredge is currently not available.

Uncertainties

Apart from the CV of the survey no other uncertainties are included in the assessment.

3.1.5 Data provision and feasibility of obtaining data (ToR 5)



CPUE / LPUE

Figure 2. CPUE of Iceland scallop in Bredafjordur, 1986–2003 (kg of scallops per hour fishing/feet), effort (hours of fishing Â dredge feet), and a stock index based on data from annual surveys conducted from 1993 to 2003.

The CPUE or Between 100 – 210 kg per hour per fishing feet of whole scallops (Figure 5.1.5.1). CPUE, pooled for all areas in Breidafjordur, was relatively stable during the period 1986– 1990, but it increased considerably from1991 to 1996 (Figure 5.1.5.1). During the years 1996 – 1998, it was relatively high, but it then declined sharply from 1998 to 2003. The increase in CPUE in the early 1990s coincided with changes in the scallop fishing gear, when the fleet changed from sledge dredges to the more efficient roller dredges. Fishing effort was significantly higher during the period 1986–1993 than from 1994 to 1998, but it also increased again from 1999 to 2002, i.e. following an opposite trend to that in CPUE.

3.1.6 Efficacy of scallop fisheries management measures (ToR 6)

Total Allowable Catch (TAC) has been used in this fisheries. Recommendation for TAC is based on 10% of estimated biomass. The total catch was usually slightly above recommendation (not higher than 15%) but between 1994-2002 it followed recommendation.

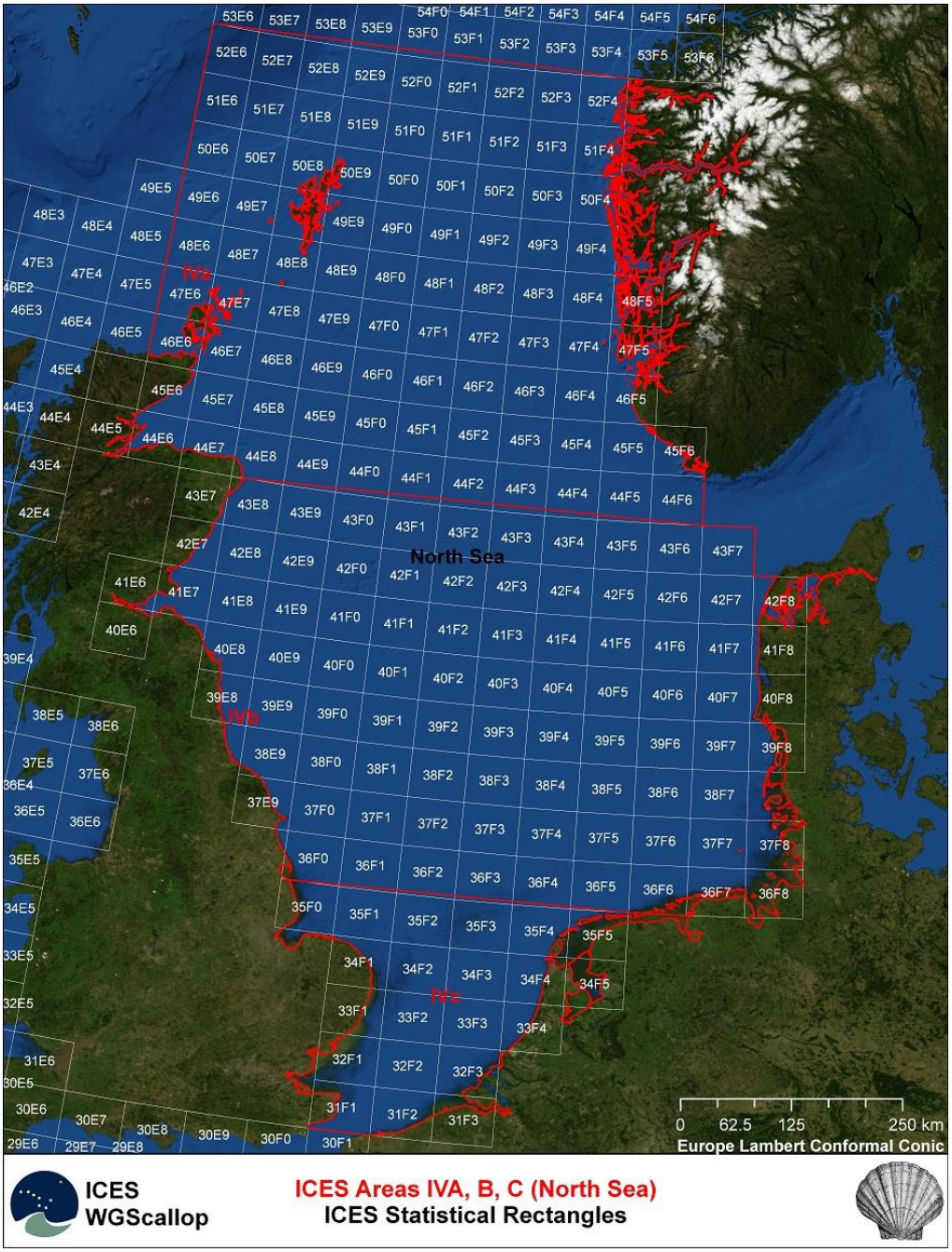
Figure 3. Roller dredge used in the *Chlamys islandica* fisheries in Breiðafjörður.

Since 1990 a roller dredge, typically around 2m wide has been used (Fig 5.1.7.1); vessels often two simultaneously.

3.1.7 Impact of scallop harvesting on habitat recovery rates (ToR 7)

Studies underway

4 IVa



4.1 Shetland

4.1.1 Distribution of fishing effort and landings for scallop inshore and offshore waters (ToR 1)

The stock of King Scallop at Shetland is defined by ICES statistical rectangles 48-51 E7-E9. The fishery in this area developed in the late 1960s and landings (data available from 1974 onwards) have steadily increased and averaged over 1,000 tonnes in recent years with a first sale value of around £2 million. Large scallops vessels (>15 m) based in Shetland generally target the grounds around the Islands of Whalsay and Fetlar in the north east of Shetland and to a lesser extent grounds in the North of Yell

Sound (which can be seen in the VMS data). All vessels exploiting this area (around 30 dredge vessels) are licensed under the Regulating Order (RO) by the Shetland Shellfish Management Organisation (SSMO) to fish at Shetland. The fishery has MSC accreditation. As a condition of the licences issued by the SSMO, fishermen are required to provide detailed records of landings and fishing effort although these data are not available to Marine Scotland (MS).

4.1.2 Identification of stock assessment and management units (ToR 2)

Marine Scotland Science (MSS) has conducted stock assessments of the scallop stock at Shetland (ICES statistical rectangles 48-51 E7-E9) for a number of years. The population structure of Scottish scallop stocks is not well understood and the assessment areas were defined to reflect the characteristics of the fisheries in the past rather than on the basis of evidence to support discrete populations. VMS and landings data suggest that the scallop grounds around Shetland are distinct from those to the northeast of mainland Scotland although this does not preclude larval stage population linkage.

4.1.3 Biological parameters (ToR 3)

Natural mortality is not precisely known but in common with other fish and shellfish stocks of similar longevity (up to 20 years) it is assumed to be 0.15 yr^{-1} for the all ages for the purposes of stock assessment (Cook et al., 1990).

Length weight parameters (total and muscle) derived from historical MSS sampling (Cook et al., 1990) are available for this stock. Additional biological data (length-weight, growth) have been collected more recently but have not yet been fully analysed.

Maturity data (gonad staging) have also been collected by MSS but have not been fully analysed. Currently 100 % maturity is assumed at age 2.

4.1.4 Stock assessment methods (ToR 4)

MSS conducts stock assessments of the scallop stocks on a biannual basis. Historically, these were carried out using a quarterly Virtual Population Analysis (VPA) (Howell et al., 2006) tuned by assuming that the temporal trend in fishing mortality was driven by changes in fishing effort ('effort tuning') or by making the assumption that the final year exploitation pattern was equal to the average (with tri-cubic weighting) over the available time series. Due to continuing effort data quality issues and potential inadequacies in the average exploitation pattern assumption, in the assessments presented more recently (Dobby et al., 2012) the scallop survey data were used as a tuning index within the stock assessment model. In previous assessments, the survey data were used only qualitatively. Results were presented spatially, in terms of total catch rates at each station, and were also used for comparison with the fishery data-based stock assessment results (for example comparing recruitment estimates to survey catch rates of individuals < 100 mm).

A number of potential alternative assessment methods were considered, including the Lowestoft VPA suite of programs (Darby and Flatman, 1994). The Time Series Analysis (TSA) approach was chosen as it is was deemed to have a number of specific advantages over typical VPA type approaches including:

- Allows fishing mortality estimates to evolve over time in a constrained manner.

- Provides precision estimates of estimated parameters (numbers at age and fishing mortality at age).
- Can cope with the omission of catch or survey data if data are of poor quality or missing.
- Allows survey catchability to evolve over time.

TSA is not a conventional time series model in that it does not include autoregressive or moving average terms. It is a state space model with the state of the stock in a particular year described by a vector of stock numbers at age and fishing mortality numbers at age (the 'state vector'). The 'state equations' define how this vector changes over time i.e. how the numbers at age in a particular year relate to the numbers at age and fishing mortality at age in the previous year. This vector is related to the data or observations (typically catch at-age data and survey data) through 'observation equations'. The Kalman filter is used to estimate the state variables. The method was derived by Gudmundsson (1994) and further developed by Fryer (2002) for use in the assessment of North Sea and West of Scotland demersal fish stocks (ICES, 2011).

The model is initialised and run through a series of R scripts although actual parameter estimation is carried out by a Fortran programme which is automatically called from within R.

No biomass or fishing mortality reference points have been defined for Scottish scallop stocks. The advice provided by MSS is on the basis of estimates of recent fishing mortality, recruitment and biomass in relation to historical values. The lack of any clear stock recruitment relationship precludes the calculation of reference points based on maximum sustainable yield. However, per recruit reference points will be investigated as part of the next round of MSS stock assessments.

NAFC Marine Centre also conduct stock assessments of the scallops around Shetland based on catch-at-age data obtained from their own commercial catch sampling. Leslie *et al*. (2009) use a quarterly VPA tuned using fishing effort data and including commercial data from 2000 to 2008. NAFC also conduct statistical analysis of the SSMO landings and effort data.

4.1.5 Data provision and feasibility of obtaining data (ToR 5)

Scallop landings are sampled as part of an integrated MS Science market sampling programme[1]. Sampling began in the early 1970s, however, it is only since 1982 that sufficient samples have been available to construct reliable catch-at-age data.

Most scallops in Scotland are sold privately, rather than by auction, and are sampled at the processing factories. For each trip sampled, one bag of scallops is selected at random and the lengths of all scallops are recorded to the 0.5 cm below. A subsample of the scallops are aged (by counting the growth rings on the flat shell) with all individuals age 10 and above recorded in a '10+' age category. Processors handle both dive and dredge caught scallops although dive caught samples are often obtained directly from the dive vessel at the time of landing.

Length at age data and sampled weights for dredge and dive caught scallops are combined and raised to total dredge landings on a quarterly basis. Quarterly data are summed to provide annual catch-at-age (composition) data for Scottish landings. These data are then raised to total annual landings (all nations) to provide input for

1 Samples in recent years have been collected and provided by staff from NAFC Marine Centre under the Memorandum of Understanding between NAFC Marine Centre and MSS.

the stock assessment. Raising factors are determined using a length-total weight relationship applied to the sampled data. Parameters are fixed across stocks and quarters (see Section 2.3).

The landings from the Shetland area have been consistently well sampled since the late 1980s with 6,800 scallops sampled from 68 trips in 2012.

Marine Scotland have been conducting dredge surveys of the major scallop grounds around Scotland since the mid 1990s (partial surveys of the west coast began in the late 1980s). The surveys have fixed stations. The station locations were determined with reference to sediment type, using British Geological Survey charts to locate sediments suitable for scallops and knowledge of the scallop fishing grounds contributed by skippers fishing at the time when the surveys first took place. The gear set up consists of one array of standard commercial spring-loaded Newhaven type dredges (2.5′ wide, 9 tooth bar, with 80 mm internal diameter belly rings), and another array of smaller configuration sampling dredges with 11 teeth and smaller diameter belly rings similar to commercial gear for queen scallops Aequipecten opercularis (2.5′ wide, 11 tooth bar, with 60 mm internal diameter belly rings).

At each station the dredges are towed at a speed of about 2.5 knots for approximately 30 minutes and all scallops caught are aged and measured (length to the 0.5 cm below). Over the years, different survey dredge widths have been used. Catch rates are, therefore, standardised for both fishing time and dredge width and are presented as numbers caught per hour per metre dredge width (N hr-1 m-1). Indices for each assessment area are calculated by aggregating total catch at age numbers from both dredge types over all hauls and dividing by total duration (and dredge width).

Survey data (catch-at-age indices) from Shetland are available from 1995 with typically around 80 stations completed each year. These data are used in the age based stock assessment described above to provide estimates of recruitment, fishing mortality and SSB. Further details of the stock assessment data, results and diagnostics can be found in Dobby et al. (2012).

4.1.6 Efficacy of scallop fisheries management measures (ToR 6)

Shellfish fisheries (including the dredge fishery for scallops) around Shetland are managed under a Regulating Order (The Shetland Islands Regulated Fishery (Scotland) Order 1999) by the Shetland Shellfish Management Organisation (SSMO). Scallop vessels at Shetland are limited to a maximum of five dredges per side and to fishing within the hours of 0600 to 2100. The fishery is managed on the basis of a harvest control rule (untested in a Management Strategy Evaluation) and LPUE based reference points (See MSC accreditation report for further details).

4.1.7 Impact of scallop harvesting on habitat and recovery rates (ToR 7)

Areas with marine priority feature areas (as defined by the EC Habitats Directive) have been closed on a voluntary basis since 2010. An acoustic survey was carried out in 2012 by NAFC Marine Centre and since then the spatial boundaries of closed areas have been further refined.

Bycatch data are collected during the MSS annual scallop survey. These are currently being analysed.

4.2 Northeast Scotland/Moray Firth

4.2.1 Distribution of fishing effort and landings for scallop inshore and offshore waters (ToR 1)

The scallop fishery in the Moray Firth developed in the 1980s and landings have fluctuated throughout the time series with a peak of 3,491 t in 1996 but falling to around 1,000 t in recent years. In 2012, the first sale value of scallops from the North East was nearly £3 million. Large nomadic Scottish vessels (over 15 m) fish the scallop grounds in the inner and outer Moray Firth with approximately six vessels also fishing grounds to the east coast of the northern Orkney Isles. Landings and VMS data show the fishery to be widely distributed across the Moray Firth (excluding areas of muddy substrate).

4.2.2 Identification of stock assessment and management units (ToR 2)

Marine Scotland has conducted stock assessments of the scallop stock in the Moray Firth (ICES statistical rectangles 44E5-E8; 45E6-E9; 46E7-E9; 47E8-E9) for a number of years. The population structure of Scottish scallop stocks is not well understood and the assessment areas were defined to reflect the characteristics of the fisheries in the past rather than on the basis of evidence to support discrete populations. The VMS data indicate that there are scallop grounds widely across the Moray Firth (excluding *Nephrops* grounds) in both inshore and more offshore waters.

4.2.3 Biological parameters (ToR 3)

Natural mortality is not precisely known but in common with other fish and shellfish stocks of similar longevity (up to 20 years) it is assumed to be 0.15 yr^{-1} for the all ages for the purposes of stock assessment (Cook et al., 1990).

Length weight parameters (total and muscle) derived from historical MSS sampling (Cook et al., 1990) are available for this stock. Additional biological data (length-weight, growth) have been collected more recently but have not yet been fully analysed.

Maturity data (gonad staging) have also been collected by MSS but have not been fully analysed. Currently 100 % maturity is assumed at age 2.

4.2.4 Stock assessment methods (ToR 4)

See section 2.5.

4.2.5 Data provision and feasibility of obtaining data (ToR 5)

Scallop landings are sampled as part of an integrated MS Science market sampling programme. Historically, landings have been sampled relatively consistently with good seasonal coverage in this area. Occasionally some quarters are not sampled, although in some years this may reflect seasonality in fishing patterns (a lack of trips to sample), but the total number of samples obtained has also fallen (ten trips in 2012 measured 2,100 scallops). A partial North Sea scallop survey was conducted in 1993 by MSS, with full coverage (typically around 70 stations) of the North East assessment area beginning in 1994. See section 5.1.5 for further details of MSS commercial sampling methods and RV survey.

These data are used in the age based stock assessment described above to provide estimates of recruitment, fishing mortality and SSB. Further details of the stock assessment data, results and diagnostics can be found in Dobby et al. (2012).

4.2.6 Management measures (ToR 6)

A minimum landing size (MLS) of 100 mm in this area is specified through EU legislation (Council Regulation (EC) No. 850/98). All vessels fishing commercially for scallops in Scotland are required to have a license and no new licenses are granted. The Prohibition of Fishing for Scallops (Scotland) Order 2003 introduced gear restrictions which vary according to where fishing takes place: a maximum of eight dredges per side is allowed in Scottish inshore waters (out to six nautical miles); a maximum of 10 per side in any other part of the UK territorial sea adjacent to Scotland (out to 12 nautical miles); and 14 per side in any other part of the Scottish zone (out to 200 nautical miles). The Order also prohibits the use of "French" dredges (a design incorporating water deflecting plates and rigid fixed teeth) in Scottish inshore waters.

5 IVb

5.1 East Coast of Scotland

5.1.1 Distribution of fishing effort and landings for scallop inshore and offshore waters (ToR 1)

The main fishery in this area, which developed in the 1990s is located off the East coast of Scotland. There has been marked variability in the landings by the Scottish fleet throughout the time period. The Scottish fleet which take the majority of the landings consists of approximately twenty large vessels (15 to 22 m) which are mostly nomadic and fish from Peterhead down to Eyemouth (VMS data available). The fishery continues year round, but has a typical seasonal pattern with peak landings occurring in the second quarter. Vessels may work an area for a period of time before moving on, often returning to the same area the following year. Intense fishing occurred off Bell Rock in the Firth of Forth and also on the scallop grounds further south off the coast of Burnmouth. Vessels land into Peterhead, Aberdeen, Gourdon, Montrose or Eyemouth, depending on which grounds they have been targeting. The Scottish fishery in this area was worth almost £3 million at first sale in 2012.

5.1.2 Identification of stock assessment and management units (ToR 2)

Marine Scotland has conducted stock assessments of the scallop stock to the east of Scotland for a number of years. The area known as 'East Coast' and defined by statistical rectangles 39-43 E8-F0; 40-41 E6; 40-43 E7; 44 E9-F0. The population structure of scallop stocks around Scotland is not well understood and the assessment areas were defined to reflect the characteristics of the fisheries in the past rather than on the basis of evidence to support discrete populations. As part of initial attempts by this WG to define scallop stock units across the NE Atlantic, this stock definition has been expanded to encompass the whole of Sub-area IVb. VMS data indicate scallop fishing occurs much further south, off the Yorkshire coastline in addition to the waters east of Scotland.

5.1.3 Biological parameters (ToR 3)

Natural mortality is not precisely known but in common with other fish and shellfish stocks of similar longevity (up to 20 years) it is assumed to be 0.15 yr^{-1} for the all ages for the purposes of stock assessment (Cook et al., 1990).

Length weight parameters (total and muscle) derived from historical MSS sampling (Cook et al., 1990) are available for this stock. Additional biological data (length-weight, growth) have been collected more recently but have not yet been fully analysed.

Maturity data (gonad staging) have also been collected by MSS but have not been fully analysed. Currently 100 % maturity is assumed at age 2.

5.1.4 Stock assessment methods (ToR 4)

The available commercial catch-at-age composition data are insufficient for an analytical assessment. A preliminary assessment of stock status has been conducted by MSS on the basis of survey data. An SSB index is calculated as the sum of products of the catch rates at age and muscle weight at age for each year. Recruitment is given by

the catch rate at age three. An index of relative fishing mortality (proxy) is calculated as the ratio of catch to survey SSB index.

5.1.5 Data provision and feasibility of obtaining data (ToR 5)

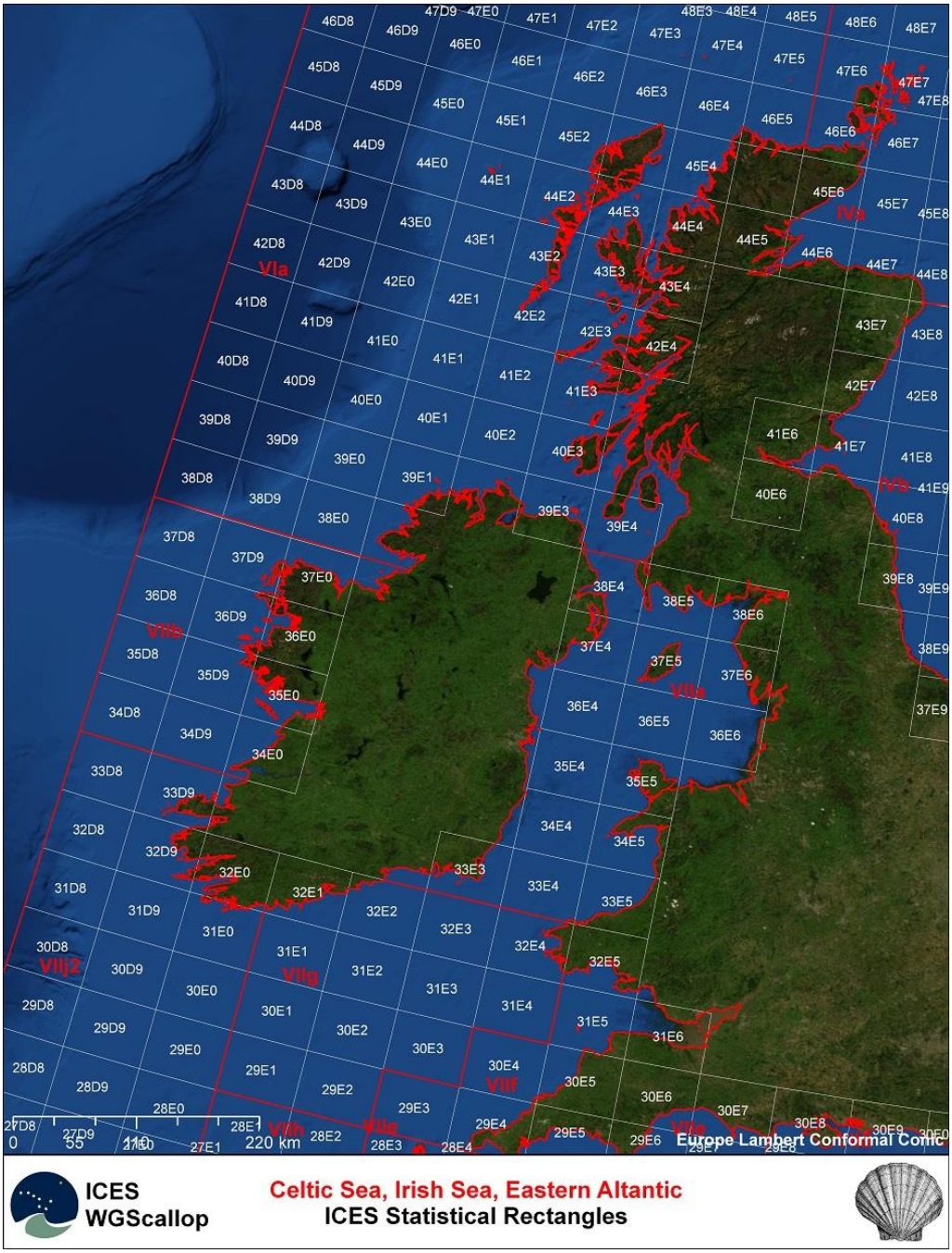
Scottish scallop landings are sampled as part of an integrated MSS market sampling programme. Sampling of the landings has been carried out since the beginning of the fishery and good coverage was achieved in the early years of the fishery (mid 1990s). Periods of low landings have made it difficult to obtain landings samples. In 2012, 2200 scallops were measured from 11 trips. MSS conducts a dredge survey which has partial coverage of IVb (only covers the area to the east of Scotland). The survey typically has around 45 stations per year. It is unlikely that the survey could be extended to cover other grounds within IVb.

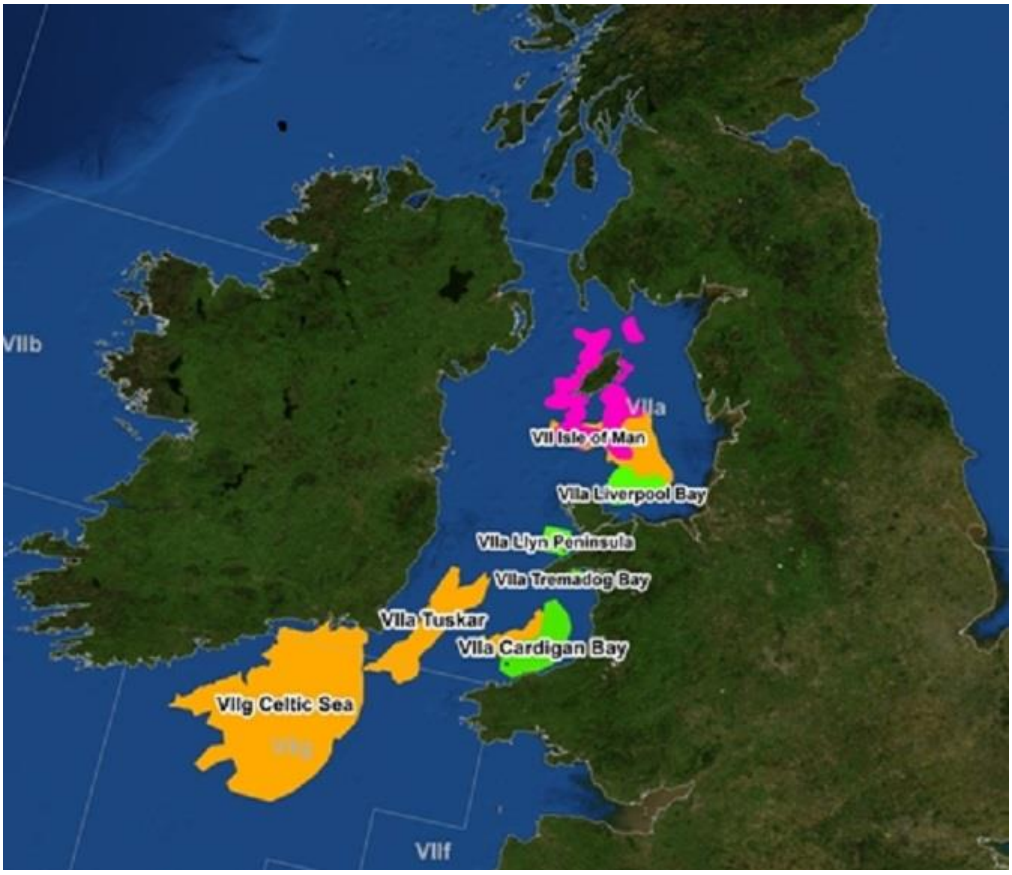
5.1.6 Management measures (ToR 6)

A minimum landing size (MLS) of 100 mm in this area is specified through EU legislation (Council Regulation (EC) No. 850/98). All vessels fishing commercially for scallops in Scotland are required to have a license and no new licenses are granted. The Prohibition of Fishing for Scallops (Scotland) Order 2003 introduced gear restrictions which vary according to where fishing takes place: a maximum of eight dredges per side is allowed in Scottish inshore waters (out to six nautical miles); a maximum of 10 per side in any other part of the UK territorial sea adjacent to Scotland (out to 12 nautical miles); and 14 per side in any other part of the Scottish zone (out to 200 nautical miles). The Order also prohibits the use of "French" dredges (a design incorporating water deflecting plates and rigid fixed teeth) in Scottish inshore waters.

5.1.7 Impact of scallop harvesting on habitat and recovery rates (ToR 7)

6 VIa


VIa
VIb
VIIa
VIIb
VIIg
VIIj2
VIIh
VIIe
VIIf
IVa
0
55
110
220 km
Europe Lambert Conformal Conic
ICES
WGScallop
Celtic Sea, Irish Sea, Eastern Altantic
ICES Statistical Rectangles



This map demonstrates the global assessment problem; VIIA is a complex mix of 'stocks' with Irish, Northern Irish, Scottish, Isle of Man and English vessels. This issue will be addressed at the next working group meeting.

6.1 Clyde

6.1.1 Distribution of fishing effort and landings for scallop inshore and off-shore waters (ToR 1)

The Scottish commercial King scallop (*Pectin maximus*) fishery began in the Clyde (ICES area VIa, statistical rectangles 39-40 E5; 40 E4 split square, eastern half) in the 1960s. Official landings (1974-present day for UK vessels landing into Scotland) have fluctuated markedly over the time period, declining to under 20 tonnes in 1990 and increasing since then to over 700 tonnes in 2012. The value of the Clyde scallop fishery has increased steadily over the last 19 years from approximately £240,000 in 1995 to a peak of over £1.5 million in 2012. The fishery is prosecuted by vessels from the Scottish fleet (dredge and diver) and a small number of vessels from the Isle of Man. The scallop vessels vary in size from 9.9 m to approximately 20 m and regularly land into Campbeltown or occasionally into Ayr and Troon. VMS data for larger vessels >15m (2007-2012) and ScotMAP GIS layers (for vessels <15m) are available and showscallop fishing activity around most of the coastal regions of the Clyde and around the Isle of Arran. There appears to be an area of intensive fishing activity to the South east of the Kintyre peninsula in the area off Campbeltown.

6.1.2 Identification of stock assessment and management units (ToR 2)

The population structure of Scottish scallop stocks is not well understood, and the assessment areas were defined to reflect the characteristics of the fisheries in the past

rather than on the basis of evidence to support discrete populations. The Clyde assessment unit as defined by Marine Scotland Science includes ICES rectangles 39-40 E5; 40E4 (split square, eastern half) but VMS data reveals a intensive patch of fishing activity to the south east of the Kintyre peninsula (ICES stat square 39E4) that should possible be included in the Clyde assessment area and not in the West of Kintyre assessment area.

6.1.3 Biological parameters (ToR 3)

Natural mortality is not precisely known but in common with other fish and shellfish stocks of similar longevity (up to 20 years) it is assumed to be 0.15 yr^{-1} for the all ages for the purposes of stock assessment (Cook *et al*., 1990).

Length weight parameters (total and muscle) derived from historical MSS sampling (Cook *et al*., 1990) are available for this stock. Additional biological data (length-weight, growth) have been collected more recently but have not yet been fully analysed.

Maturity data (gonad staging) have also been collected by MSS but have not been fully analysed. Currently 100 % maturity is assumed at age two.

6.1.4 Stock assessment methods (ToR 4)

Due to limited port sampling, the age composition data are insufficient for carrying out a reliable stock assessment. No survey data are available for the Clyde assessment area.

6.1.5 Data provision and feasibility of obtaining data (ToR 5)

Scallop landings are sampled as part of an integrated MSS market sampling programme (see Section 5.1.5). Sampling began in the early 1970s, however, it is only since 1982 that sufficient samples have been available to construct reliable catch-at-age data.

Catch-at-age data for the Clyde are available for 1982-present day, however sampling has been limited in terms of seasonal coverage and number of trips and samples and are currently not deemed of sufficient quality for further analysis.

6.1.6 Efficacy of scallop fisheries management measures (ToR 6)

Scottish scallop fisheries are not subject to EU or national TAC regulations. EU measures to restrict effort include the Western Waters effort regime (which applies to all UK waters except the North Sea), and is applicable to all vessels over 15 m in length. The limits for UK vessels are 1,974,425 KW days for Sub-area VI a (Council Regulation (EC) No. 1415/2004). Minimum landing size (MLS) is also specified through EU legislation and is 100 mm for this area (Council Regulation (EC) No. 850/98). All vessels fishing commercially for scallops in Scotland are required to have a license and no new licenses are granted. The Prohibition of Fishing for Scallops (Scotland) Order 2003 introduced gear restrictions which vary according to where fishing takes place: a maximum of eight dredges per side is allowed in Scottish inshore waters (out to six nautical miles). The Order also prohibits the use of "French" dredges (a design incorporating water deflecting plates and rigid fixed teeth) in Scottish inshore waters. There is a weekend closure of mobile fishing gear in the Clyde area and also a No Take Zone (NTZ) in Lamlash Bay, which is located on the south eastern shore of the island of Arran. All fishing for sea fish, including scallops, is

prohibited within the confines of the 2.65 km2 NTZ under by means of an Order, The Inshore Fishing (Prohibition on Fishing) (Lamlash Bay) (Scotland) Order 2008 made under section 1(1) of the Inshore Fishing (Scotland) Act 1984.

6.1.7 Impact of scallop harvesting on habitat and recovery rates (ToR 7)

The NTZ in Lamlash Bay was established in 2008 in response to concerns relating to the effects of fishing on local fish and shellfish populations in general, and *P. maximus* in particular, and to the damage to both seabed and epifauna resulting from the prosecution of the scallop fishery (COAST, 2005). Since then a number of studies have been conducted to determine how the cessation of fishing has affected the scallop population in this area. Boulcott et al. (2012) used a drop camera to survey the grounds, but concluded that there was insufficient evidence that the NTZ contained higher densities of adult *P. maximus* or *A. opercularis* than reference areas sited in adjacent waters, or that abundances within the NTZ had increased more rapidly than elsewhere. Similar results were found for adult scallops by Howarth *et al.* (2011) during dive surveys. They also concluded that the greater abundance of juvenile scallops within the NTZ was related to the greater presence of macroalgae and maerl within the reserve boundaries.

6.2 North West

6.2.1 Distribution of fishing effort and landings for scallop inshore and offshore waters (ToR 1)

The North West assessment area covers much of the west coast of Scotland and the waters around the Hebrides (ICES stat squares 35-37 E3-E7; 38 E4-E6). There is a long history of scallop (*Pectin maximus*) fishing in this area with the main fishing grounds around the Inner Hebrides and South Uist. Landings have fluctuated over time and reached a peak of 4500 t in 2002. Dredge landings in 2012 were 1,553 t, with an approximate first sale value of £2.9 million. The fishery is prosecuted by the Scottish dredge and dive fleet, with vessels ranging in size from 9.9 m to approximately 18 m. The dive fishery operates largely in the sheltered inshore waters around Ullapool, Uig, Kyle, Uist and Barra and in 2012 accounted for just over 10% of total scallop landings in the North West area.

Information on the spatial distribution of landings and value from < 15 m vessels has been obtained through the MSS ScotMap project and is available at: www.scotland.gov.uk/Topics/marine/science/MSInteractive/Themes/ScotMap.

6.2.2 Identification of stock assessment and management units (ToR 2)

The population structure of Scottish scallop stocks is not well understood, and the Marine Scotland Science (MSS) assessment areas were defined to reflect the characteristics of the fisheries in the past rather than on the basis of evidence to support discrete populations. The North West assessment unit as defined by Marine Scotland Science is covered by ICES rectangles 35-37 E3-E7; 38 E4-E6. MSS has conducted stock assessments of the scallop stock in the North West for a number of years (Dobby *et al*., 2012).

6.2.3 Biological parameters (ToR 3)

Natural mortality is not precisely known but in common with other fish and shellfish stocks of similar longevity (up to 20 years) it is assumed to be 0.15 yr^{-1} for the all ages for the purposes of stock assessment (Cook et al., 1990).

Length weight parameters (total and muscle) derived from historical MSS sampling (Cook et al., 1990) are available for this stock. Additional biological data (length-weight, growth) have been collected more recently but have not yet been fully analysed.

Maturity data (gonad staging) have also been collected by MSS but have not been fully analysed. Currently 100 % maturity is assumed at age two.

6.2.4 Stock assessment methods (ToR 4)

See section 2.5.

6.2.5 Data provision and feasibility of obtaining data (ToR 5)

Scallop landings are sampled as part of an integrated MS Science market sampling programme. Historically, landings have been sampled relatively consistently with good seasonal coverage in this area. Occasionally some quarters are not sampled, although in some years this may reflect seasonality in fishing patterns (a lack of trips to sample). There has been an improvement in sampling levels in recent years although seasonal coverage varies, with typically more samples from the second half of the year

Scallop surveys have been conducted on an annual basis since 1993 by MSS. See section 5.1.5 for further details of MSS commercial sampling methods and RV surveys.

These data are used in the age based stock assessment described above to provide estimates of recruitment, fishing mortality and SSB. Further details of the stock assessment data, results and diagnostics can be found in Dobby *et al*. (2012).

6.2.6 Management measures (ToR 6)

A minimum landing size (MLS) of 100 mm in this area is specified through EU legislation (Council Regulation (EC) No. 850/98). All vessels fishing commercially for scallops in Scotland are required to have a license and no new licenses are granted. The Prohibition of Fishing for Scallops (Scotland) Order 2003 introduced gear restrictions which vary according to where fishing takes place: a maximum of eight dredges per side is allowed in Scottish inshore waters (out to six nautical miles); a maximum of 10 per side in any other part of the UK territorial sea adjacent to Scotland (out to 12 nautical miles); and 14 per side in any other part of the Scottish zone (out to 200 nautical miles). The Order also prohibits the use of "French" dredges (a design incorporating water deflecting plates and rigid fixed teeth) in Scottish inshore waters.

6.2.7 Impact of scallop harvesting on habitat and recovery rates (ToR 7)

7 VIa

7.1 West of Kintyre including Northern Ireland north coast

7.1.1 Distribution of fishing effort and landings for scallop inshore and offshore waters (ToR 1)

King Scallops

The Department of Agriculture and Rural Development (DARD) hold official landings data for scallops landed by Northern Ireland vessels into Northern Ireland ports. In 2012 40 vessels landed in excess of 1,000 tonnes of King scallops into Northern Ireland, with a first sale value of £1.8 million (this encompasses landings into both ices Area VIa and VIIa). This represents a peak in scallop landings into Northern Ireland (figure 10.1.1.1). Vessel size ranged from 9m to 18m, with 19 of the vessels being under 12m in length. Scallop landings into Northern Ireland ICES Area VIa are to the ports of Ballycastle or Portrush with four Northern Ireland vessels landing scallops into these ports.

There is information available on the indicative location of the scallop fishery based on VMS data. As VMS is only available on vessels over 12m in length (over 15m vessels pre 2012) the information does not reflect the entire Northern Ireland fishery which has a high proportion of smaller vessels. A study of fishing effort carried out by the University of Ulster, which involved asking fishermen to mark the areas where they fish, produced GIS layers which indicate the spatial extent of scallop fishing.

The main Scottish fishing grounds in the West of Kintyre area are around the islands of Islay and Jura and the southern end of the Kintyre peninsula as indicated by recent VMS data (2007-2012). Landings have fluctuated between around 500 and 2,000 tonnes over the last 30 years. The fishery is prosecuted by a fleet of around 14 vessels which range from 9.9 m to approximately 20 m in length and typically land their catch into Tarbert, Tayinloan and Campbeltown. There is also a small dive fishery which operates in the sheltered inshore waters. In 2012, total landings were just over 2,000 t (< 5 % dive caught) with an approximate first sale value of £4.2 million.

Information on the spatial distribution of landings and value from < 15 m vessels has been obtained through the MSS ScotMap project and is available at: www.scotland.gov.uk/Topics/marine/science/MSInteractive/Themes/ScotMap.

Queen Scallops

DARD hold official landings data for queen scallops fished by Northern Ireland vessels and into Northern Ireland ports. In 2012 18 vessels landed over 3,600 tonnes of queen scallops into Northern Ireland, with a first sale value of £1.5 million (this encompasses landings into both ICES Area VIa and VIIa). As with King scallops, this represents a peak in landings of queen scallops into Northern Ireland (figure 4). Vessels landing queen scallops into Northern Ireland range in size from 9m to 24m in length. Queen scallop landings into Northern Ireland ICES Area VIa are to the ports of Ballycastle or Portrush with eight Northern Ireland vessels landing queen scallops into these ports.

There is information available on the indicative location of the queen scallop fishery based on VMS and observer data. As VMS is only available on vessels over 12m in length (over 15m vessels pre 2012) it does not include effort placed on the fishery by under 12m vessels.

7.1.2 Identification of stock assessment and management units (ToR 2)

King Scallops

Northern Ireland: Annual surveys are carried out by AFBI on behalf of DARD. In 2011 the survey was extended to Area VIa, with the location of new survey areas identified based on VMS and stakeholder engagement. The Northern Ireland fleet are regulated by DARD who manages scallop stocks within Northern Ireland territorial waters including Area VIa (see 8.1.6 for details on the regulation of the NI scallop fishery). This stock is targeted by Northern Ireland and Scottish fleets.

The population structure of Scottish scallop stocks is not well understood, and the Marine Scotland Science (MSS) assessment areas were defined to reflect the characteristics of the fisheries in the past rather than on the basis of evidence to support discrete populations. The West of Kintyre assessment unit as defined by MSS is covered by ICES rectangles 39-40E2-E3, 39E4, 40E4 (western half) and 41E4. MSS has conducted stock assessments of the scallop stock in the West of Kintyre for a number of years (Dobby *et al.*, 2012).

Queen scallops

Northern Ireland: There has only been a significant commercial queen scallop fishery on the north coast of Northern Ireland since 2009. In 2013 AFBI carried out a survey of the queen scallop grounds in Area VIa. The location of survey areas were identified based on VMS and stakeholder engagement. DARD manages the Northern Ireland fishing fleet targeting queen scallops within Northern Ireland territorial waters. This stock is targeted by Northern Ireland, Scotland and the Dutch fleet.

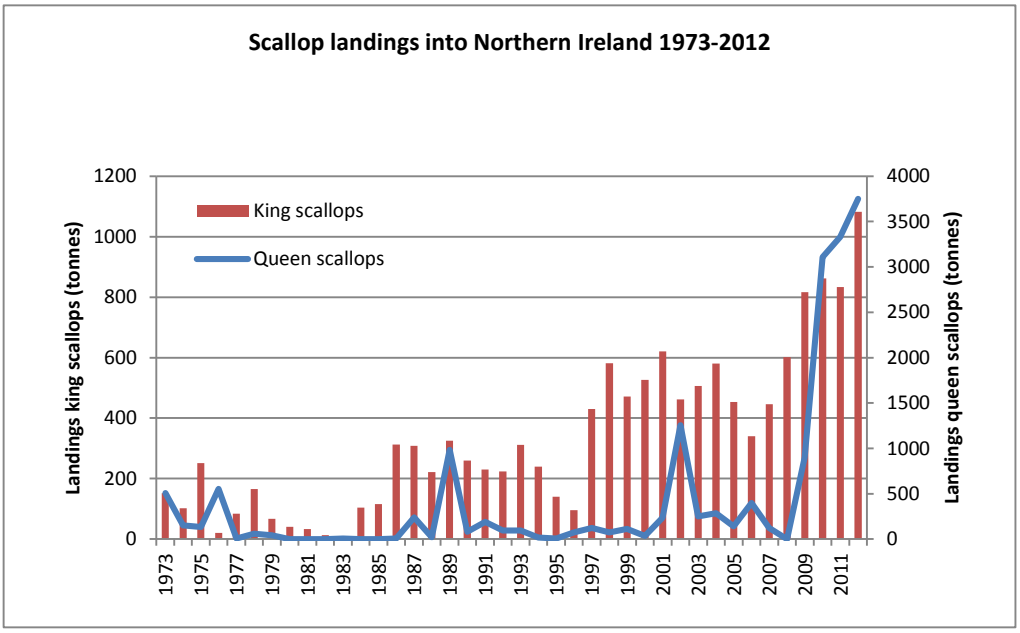


Figure 4. Landings of scallops into Northern Ireland 1973 – 2012 (ICES Areas VIa and VIIa combined)

7.1.3 Biological parameters (ToR 3)

King Scallops

Northern Ireland: AFBI extended the annual King scallop survey in 2011 to cover ICES Area VIa. Data collected includes catch nm-1, length, breadth, muscle weight, gonad weight and age (all aged by shell, some also aged by hinge). In 2013 gonad samples were collected from this area for histological examination to determine spawning season. Using the data collected we can calculate growth rates and Catch at Age etc.

Natural mortality is not precisely known, but in common with other fish and shellfish stocks of similar longevity (up to 20 years) it is assumed to be 0.15 yr^{-1} for all ages for the purposes of the Scottish stock assessment (Cook et al., 1990).

Length weight parameters (total and muscle) derived from historical MSS sampling (Cook et al., 1990) are available for this stock. Additional biological data (length-weight, growth) have been collected more recently but have not yet been fully analysed.

Maturity data (gonad staging) have also been collected by MSS but have not been fully analysed. Currently 100 % maturity is assumed at age two.

Queen scallops

In July 2013 a survey was carried out by AFBI which covered the queen scallop stock in ICES Area VIa. Data collected includes; length, breadth, total weight and gonad weight. Gonad samples have been collected from this area in February and July 2013 for histological examination.

7.1.4 Stock assessment methods (ToR 4)

Northern Ireland: Following an extension to the historical AFBI scallop survey in 2011, there are now dedicated survey areas within ICES Area VIa off the north coast of Northern Ireland. The survey areas were determined from VMS information and communication with fishermen. For more details on the AFBI survey see section 8.1.4.

Stock assessments conducted by MSS are described in detail in Section 2.5.

Queen scallops

A pilot queen scallop survey was carried out in July 2013. Throughout this survey different gear types were deployed – camera, queenie net, otter trawl and dredge. Stations were based on observer trips, VMS data and fishers input. The areas around these stations were also surveyed in an attempt to determine stock boundaries. There was little correlation between captured video footage and fishing gear. The efficiency of the fishing gear is not known. The video footage will be analysed to estimate relative abundance.

7.1.5 Data provision and feasibility of obtaining data (ToR 5)

Northern Ireland: King Scallops

Lifespan: When aging by the shell the categories finish at age 10+ as it is commonly accepted that older shells are more difficult to age accurately from shell rings. Based on aging from the hinge there is evidence of scallops 15+ years of age within this area.

Growth rate: Data available

Size at age: Data available.

Aging Method: During the survey all of the scallops are aged using the rings on the flat shell. On return to the lab they are aged via the hinge and the shell bandwidths are measured.

Maturity: In 2013 gonad samples were collected from this area for histological examination to determine spawning season. A proposal is currently being prepared to carry out monthly sampling (over a period of 12-18 months) to determine the reproductive cycle of scallops.

Recruitment estimate: During the survey only a few scallops under 3 years of age are captured (even with the use of a mesh liner in one of the dredges used). We have no way of estimating recruitment but can assume that recruitment occurs annually due to the presence of all year classes present.

Carrying capacity: None.

Northern Ireland: Queen scallops

Lifespan: Queen scallops were not aged in the survey. Length frequency data were collected.

Growth rate: Data not available.

Size at age: Data not available.

Aging Method: Not aged

Maturity: In 2013 gonad samples were collected from this area for histological examination to determine spawning season. A proposal is currently being prepared to carry out monthly sampling (over a period of 12-18 months) to determine the reproductive cycle of scallops.

Recruitment estimate: Data not available

Carrying capacity: None

Around Scotland, scallop landings are sampled as part of an integrated MS Science market sampling programme. Historically, landings have been sampled relatively consistently with good seasonal coverage in this area. Occasionally some quarters are not sampled, although in some years this may reflect seasonality in fishing patterns (a lack of trips to sample). There has been an improvement in sampling levels in recent years although seasonal coverage varies, with typically more samples from the second half of the year

Scallop surveys have been conducted on an annual basis since 1993 by MSS. See section 5.1.5 for further details of MSS commercial sampling methods and RV surveys.

These data are used in the age based stock assessment described above to provide estimates of recruitment, fishing mortality and SSB. Further details of the stock assessment data, results and diagnostics can be found in Dobby *et al*. (2012).

7.1.6 Efficacy of scallop fisheries management measures (ToR 6)

Northern Ireland or Scottish scallop fisheries are not subject to EU or national TAC regulations. EU measures to restrict effort include the Western Waters effort regime (which applies to all UK waters except the North Sea), and is applicable to all vessels over 15 m in length. The limits for UK vessels are 1,974,425 KW days for Sub-area VI a (Council Regulation (EC) No. 1415/2004). Minimum landing size (MLS) is also

specified through EU legislation and is 100 mm for this area (Council Regulation (EC) No. 850/98).

Northern Ireland: All vessels fishing commercially for scallops in Northern Ireland are required to have a license. The Northern Ireland fleet is managed by the Conservation of Scallops Regulations (Northern Ireland) which sets out regulations including gear restrictions (maximum of 6 dredges per side; a maximum of 9 teeth per dredge; minimum tooth spacing of 75mm; a scallop dredge or system of scallop dredges with a width, or in the case of a system of scallop dredges, an aggregate width, not exceeding 915cm; a minimum diameter of belly ring of 75mm; a minimum mesh size of 100mm in the netting cover; the prohibition of French dredges), a curfew with fishing only permitted Monday to Friday 0600 to 2000 and the MLS of scallops landed by the Northern Ireland fleet is above the EU MLS at 110mm. Presently, whilst not legislated, an agreement has been made that scallop dredging should not be carried out within the Rathlin Island Special Area of Conservation.

Scotland: All vessels fishing commercially for scallops in Scotland are required to have a license and no new licenses are granted. The Prohibition of Fishing for Scallops (Scotland) Order 2003 introduced gear restrictions which vary according to where fishing takes place: a maximum of eight dredges per side is allowed in Scottish inshore waters (out to six nautical miles). The Order also prohibits the use of "French" dredges (a design incorporating water deflecting plates and rigid fixed teeth) in Scottish inshore waters. Scallop dredging is prohibited in the Firth of Lorn marine Special Area of conservation which has been designated to protect rocky reef habitats.

7.1.7 Impact of scallop harvesting on habitat and recovery rates (ToR 7)

Northern Ireland: Bycatch data are collected during the annual scallop survey. This will be analysed using benthic analysis software to determine the scale of impact of this fishery on the benthos. Habitat mapping covers Northern Ireland territorial waters in Area VIa.

MSS has conducted experimental scallop dredging in this area to assess the vulnerability of emergent epifauna on hard substrates. Using camera surveys, Boulcott et al. (2014) found no clear evidence that experimental dredging reduced the coverage of faunal turfs on hard substrates. However, the coverage of faunal turfs on hard substrates in the SAC was typically greater than in areas that were still being fished commercially, consistent with a dredging effect. They suggest that emergent epifauna living on hard substrates that are morphologically suited to dredging, such as pebble and cobble substrates, could be particularly vulnerable to dredging.

8 VIIa

8.1 Northern Ireland – East Coast

8.1.1 Distribution of fishing effort and landings for scallop inshore and offshore waters (ToR 1)

DARD hold official landings data for scallops landed by Northern Ireland vessels and into Northern Ireland ports. In 2012 40 vessels landed in excess of 1,000 tonnes of King scallops into Northern Ireland, with a first sale value of £1.8 million (this encompasses landings into both ices Area VIa and VIIa). This represents a peak in scallop landings into Northern Ireland. Vessel size ranged from 9m to 18m, with 19 of the vessels being under 12m in length. Scallop landings into Northern Ireland ICES Area VIIa are to one of eight with all 40 of the vessels landing into Northern Ireland having some landings into the Area VIIa ports. In recent years there has been a shift in the size of vessel landing scallops into Northern Ireland ICES area VIIa ports, with a decline in vessels greater than 15m in length and an increase in vessels less than 10m in length (Figure 5).

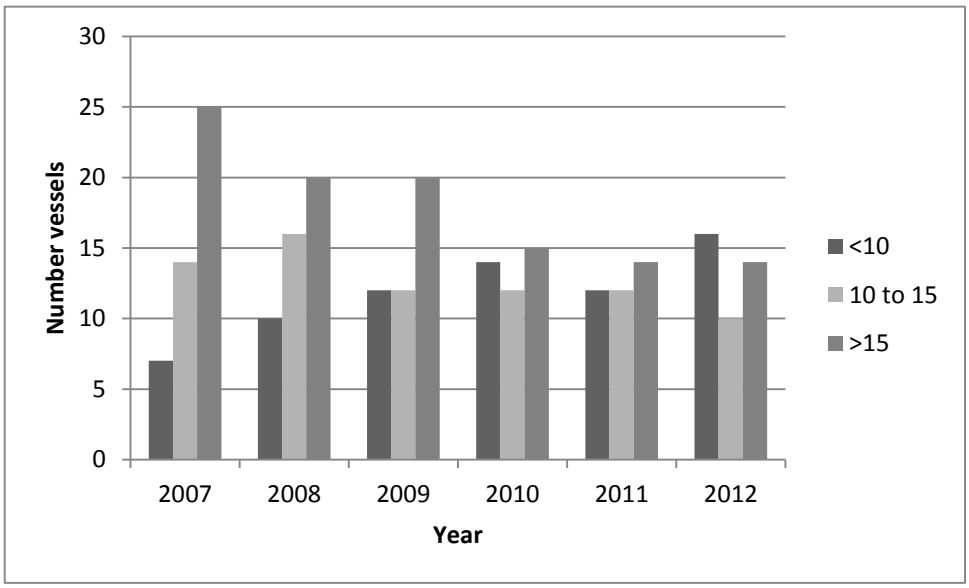


Figure 5 Vessels landing scallops into Northern Ireland ICES Area VIIa ports, by length

There is information available on the indicative location of the scallop fishery based on VMS data. As VMS is only available on vessels over 12m in length (over 15m vessels pre 2012) the information does not reflect the entire Northern Ireland fishery which has a high proportion of smaller vessels. A study of fishing effort carried out by the University of Ulster, which involved asking fishermen to mark the areas where they fish, produced GIS layers which indicate the spatial extent of scallop fishing.

8.1.2 Identification of stock assessment and management units (ToR 2)

Northern Ireland: AFBI carry out an annual scallop survey on behalf of DARD and hold more than 20 years of data on scallops from ICES Area VIIa . The Northern Ireland fleet are regulated by DARD who manages scallop stocks within Northern Ireland territorial waters including Area VIa see 10.1.6.

8.1.3 Biological parameters (ToR 3)

During the annual AFBI scallop survey data which is collected includes catch nm-1, length, breadth, muscle weight, gonad weight and age (all aged by shell whilst some are also aged using the hinge). In 2013 gonad samples were collected from this area for histological examination to determine spawning season. Using the data collected we can calculate growth rates, catch at age etc.

8.1.4 Stock assessment methods (ToR 4)

The historic scallop survey involves randomly deploying dredges within defined areas. In 2013 a site was added close to Dundrum bay based on VMS data which showed commercial scallop fishing.

Prior to 2013 a minimum of four 2 foot dredges were deployed. In 2013 new dredges based on industry specification (2 foot 6 inches) were used. The old dredges were used at some stations for comparison purposes this is still to be completed. A fine mesh liner is placed in one dredge to retain juvenile and small bycatch. Gear is deployed a towed for 30 minutes. The survey provides an estimate of relative abundance. The gear is inefficient at collecting juvenile scallops, which are rarely caught. The type of ground may affect the efficiency of the gear.

8.1.5 Data provision and feasibility of obtaining data (ToR 5)

Lifespan: When aging by the shell the categories finish at age 10+ as it is commonly accepted that older shells are more difficult to age accurately from shell rings. Based on aging from the hinge there is evidence of scallops 15+ years of age within this area.

Growth rate: Data available

Size at age: Data available

Aging Method: During the survey all scallops are aged using the rings on the flat shell. These are then returned to the lab where they are aged via the hinge and the shell bandwidths are measured

Maturity: In 2013 gonad samples were collected from this area for histological examination to determine spawning season. A proposal is currently being prepared to carry out monthly sampling (over a period of 12-18 months) to determine the reproductive cycle of scallops.

Recruitment estimate: During survey only a very few under 3 years of age are captured (even with the use of a liner in one of the dredges used). We have no way of estimating recruitment but can assume that recruitment occurs annually due the presence of all year classes present.

Carrying capacity: None

8.1.6 Efficacy of scallop fisheries management measures (ToR 6)

All vessels fishing commercially for scallops in Northern Ireland are required to have a license. The Northern Ireland fleet is managed by DARD through the Conservation of Scallops Regulations (Northern Ireland) which sets out regulations including gear restrictions (maximum of 6 dredges per side; a maximum of 9 teeth per dredge; minimum tooth spacing of 75mm; a scallop dredge or system of scallop dredges with a width, or in the case of a system of scallop dredges, an aggregate width, not exceeding 915cm; a minimum diameter of belly ring of 75mm; a minimum mesh size of 100mm in the netting cover; the prohibition of French dredges), a curfew with fishing

only permitted Monday to Friday 0600 to 2000 and a minimum landing size for scallops around Northern Ireland of 110mm. This legislation also prohibits diving for scallops within Strangford Lough between June and October (inclusive). Through the Inshore Fishing (Prohibition of Fishing and Fishing Methods) (Amendment) Regulations (Northern Ireland) 2003 scallop dredging is prohibited in Strangford Lough. Under The Scallops (Irish Sea) (Prohibition of Fishing) Order 1984 the Irish Sea is closed to scallop dredging between the 1st of June and the 31st of October.

8.1.7 Impact of scallop harvesting on habitat and recovery rates (ToR 7)

Bycatch data are collected during the annual scallop survey. This will be analysed using benthic analysis software to determine the scale of impact of this fishery on the benthos.. Habitat mapping covers Northern Ireland territorial waters in Area VIa.

9 VIIa

9.1 Isle of Man

9.1.1 Distribution of fishing effort and landings for scallop inshore and offshore waters (ToR 1)

Within the Isle of Man's territorial sea two species of scallop, king (*Pecten maximus*) and queen (*Aequipecten opercularis*), are commercially fished. Within this area the stocks of these two species are defined by ICES statistical rectangles 36E5 and 37E5.

A fishery for queen scallops has been prosecuted in and around the Isle of Man's territorial sea since the 1950s, becoming increasingly important during the late 1960s. Until recently queen scallops were targeted almost entirely with either toothed dredges or skid dredges. However, most Manx vessels now fish for queen scallops with otter trawls, while UK vessels usually use toothless dredges. The queen scallop trawl fishery is MSC certified and has European Protected Designation of Origin status (Murray & Kaiser, 2012). In 2011, 4529 t (£1,389,904) of queen scallops were landed to the Isle of Man (DEFA, 2012).

An important commercial fishery for king scallops has been prosecuted in and around the Isle of Man's territorial seas since 1937. A fishery for king scallops is prosecuted within the Isle of Man's territorial sea from 1st November to 31st May by vessels using toothed, Newhaven, dredges (Murray et al., 2010). In 2011, 1534 t (£2,586,024) of king scallops were landed to the Isle of Man (DEFA, 2012).

In addition to landings data, information is also available on the indicative location of both the king and queen scallop fishery based on satellite Vessel Monitoring System (VMS) data. Within the Isle of Man's territorial sea it is compulsory for all vessels that are fishing for king or queen scallops to carry and use VMS, regardless of vessel size.

9.1.2 Identification of stock assessment and management units (ToR 2)

Within the ICES VIIa area the geographical bounds and structure of populations and larval dispersion, for both king and queen scallops, remain unclear. Nevertheless, detailed knowledge of the spatial distribution of fishing effort and stocks can elucidate the impact of fishing on the target population. VMS data combined with fishing effort from E-logbooks have been used to monitor and map fishing effort around the Isle of Man. This information on current and historical fishing effort has been used to define the assessment areas, rather than on the basis of any evidence that supports the existence of discrete populations within the area.

9.1.3 Biological parameters (ToR 3)

Natural mortality is not known precisely for king or queen scallops. Estimates of natural mortality for king scallops range from 0.31 to 0.61 (Brand et al., 1991) while estimates of total mortality range from 0.22 in Port Erin closed area to 0.76 in fished areas (Beukers-Stewart et al., 2005). Allison (1993) used six different methods to estimate natural mortality of queen scallops all yielding different results, ranging from 0.037 to 1.88, but values of between 0.2 and 0.5 were identified as the most appropriate. The effects of using values of M between 0.2 and 0.4 were examined and based on the results from this the current queen scallop stock assessment for the Isle of Man uses $M = 0.2$ (Murray & Kaiser, 2012). It is important to note that in the queen scallop catch survey analysis mortality estimates relate only to recruits (25 to 54 mm length) and

fully-recruited (≥ 55 mm) queen scallops not to scallops < 25 mm (Murray & Kaiser, 2012). Average individual weights of recruits were derived from the relationship between length and weight measurements of 600 queen scallops from stations across the Isle of Man's territorial sea (Murray & Kaiser, 2012).

9.1.4 Stock assessment methods (ToR 4)

The first formal stock assessment of the Isle of Man queen scallop stock was undertaken in 2012 using the Catch-Survey Analysis (CSA) method (Murray & Kaiser, 2012). The CSA method estimates stock size using abundance indices and is reasonably well-suited to the data available for the Isle of Man's queen scallop fishery.

In ICES statistical rectangles 36E5 and 37E5 landings increased between 2010 (Jan. to Dec.) and 2011 (Jan. to Dec.). Queen scallop landings from 36E5 and 37E5 totalled 11398t in 2012, with an additional 572t caught in 38E5. Of the total taken across these three rectangles, 8005t was caught by dredgers, 3884t by otter trawlers, and 80t by *Nephrops* trawls. Landings of queen scallops from within the territorial sea increased from around 5000t in 2010 to around 8000t in 2011 (Figure 6). This represents 46% of total landings from 36E5 and 37E5 in 2010 and 49% in 2011. Landings by both dredgers and trawlers increased in the territorial sea between 2010 and 2011, from 3375t to 4673t for dredgers, and from 1559t to 3361t for otter trawlers. The origin of landings in 2012 changed substantially compared to previous years. Within the territorial sea in 2012 otter trawlers caught around 63% of total landings; outside of the territorial sea dredgers took 95% of landings. Overall, in 2012, 52% of landings were taken from within the territorial sea, amounting to around 6000t. Fishing effort increased sharply in 2010 and 2011 but declined in 2012. However, the number of days spent fishing for queen scallops was still high relative to 2009.

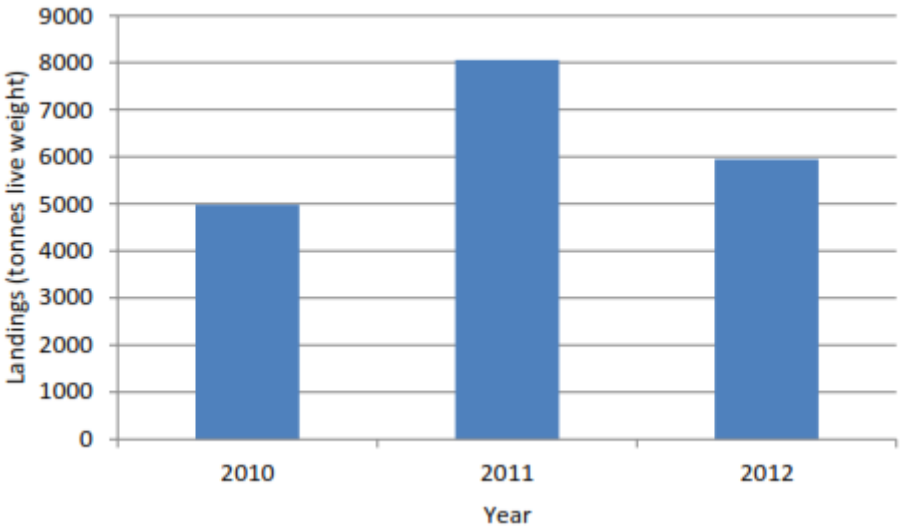


Figure 6. Estimated landings from the Isle of Man's territorial sea. These estimates are derived from VMS data combined with logbook data and include only data where matches were found between logbooks and VMS records. Data are for calendar years (Jan. to Dec.) rather than fishing years (from Murray (2013)).

The results of the Catch Survey Analysis showed consistent trends over time in fishing mortality and biomass estimates over a range of input data (Murray & Kaiser, 2012). However, the magnitude of the parameters did vary with changes in the allo-

cation of recruits and post-recruits, natural mortality estimates and recruit selectivity. The greatest effect on the recruit and post-recruit indices resulted from changing the threshold size from 50 to 55mm (Murray & Kaiser, 2012). The stock assessment revealed sharp increases in fishing mortality in 2010 and 2011, with lower fishing mortality in 2012. Total biomass generally increased between 2006 and 2010 (Fig. 7) but has declined thereafter. Biomass of both recruits and post-recruits decreased in 2010 and 2011. Biomass of recruits and post-recruits decreased slightly in 2012/2013. Surplus production fluctuates widely between years and shows no relationship with biomass. Surplus production was around 5000t in 2011/2012 and 5700t in 2012/2013, following high values in 2006, 2007, 2009 and 2010. Following three years of increasing biomass (2005-2007), biomass has decreased during each of the past three years with the largest decrease occurring in 2011/2012 (Fig. 8) when landings were at their highest.

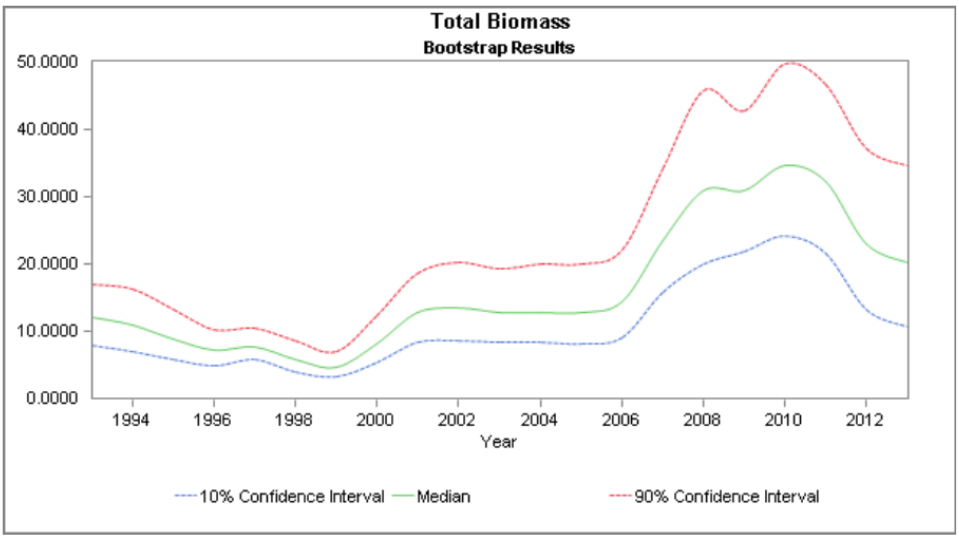


Figure 7: Total queen scallop biomass (1000s tonnes) (from Murray (2013))

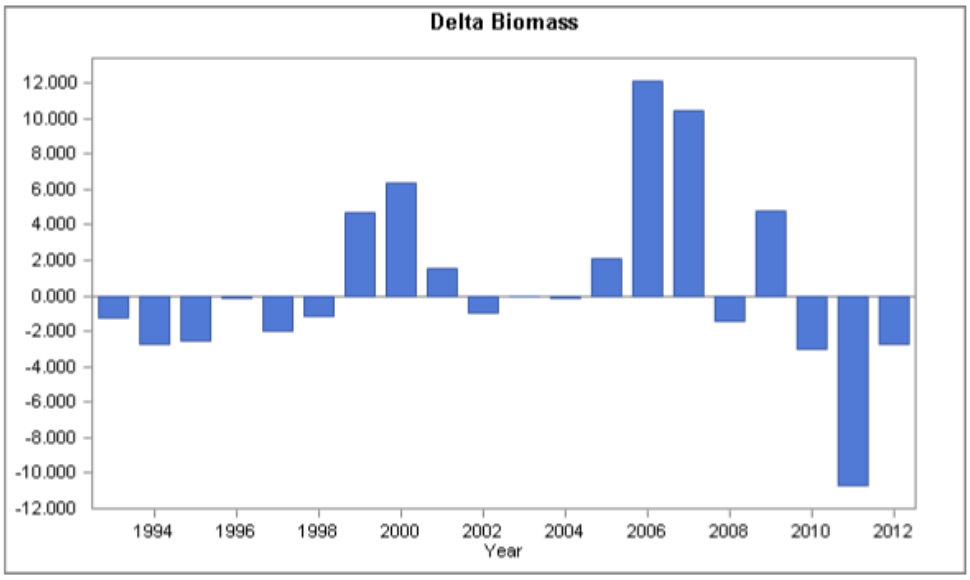


Figure 8: Annual change in total queen scallop biomass (from Murray (2013))

At present there is no formal stock assessment in place for the Isle of Man king scallop stock. However, an assessment of available methodologies is currently underway in order to prepare for a stock assessment to be undertaken in 2014.

9.1.5 Data provision and feasibility of obtaining data (ToR 5)

Survey data for king (catch-at-age indices) and queen scallops has been collected from the major fishing grounds within the Isle of Man's territorial seas since 1992. The surveys have fixed stations based on historical fishing grounds and are conducted twice a year in spring (April/May) and then in autumn (Sept/Oct). The surveys are now conducted from the R.V. Prince Madog and sampling is done by towing a single bar with 4 Newhaven dredges: 2 king dredges (with 9 teeth of 110 mm and 80 mm internal diameter belly rings) and 2 queen dredges (with 10 teeth of 60 mm and 60 mm internal diameter belly rings). At each station the dredges are towed at a speed of about 2.5 – 3.0 knots for approximately 20 minutes. King and queen scallops caught are measured and king scallops are also aged.

9.1.6 Efficacy of scallop fisheries management measures (ToR 6)

The queen scallop fishery is managed on the basis of a precautionary management strategy. A minimum landing size (MLS) of 50 mm and a minimum trawl mesh size of 85 mm is currently in place for queen scallops within the Isle of Man's territorial sea. There is restricted entry into the fishery for vessels over 221kW. These vessels must meet the specified track record requirements to qualify for entry into the fishery. A curfew is also in operation between 18:00 to 06:00 Monday to Friday and there is no weekend fishing (curfew: 00:01 Saturday to 00:00 Sunday). A closed season operates from 1st April to 31st May and a Total Allowable Catch (TAC) is set by the Queenie Management Board (QMB) on an annual basis, so that once the annual TAC is reached the fishery is closed. In addition, the Queenie Conservation Zone (where queen scallop dredging is prohibited) has been extended to restrict the impact of dredging on queen scallops. This extension introduces a single small dredging zone located to the south of the Island, known as 'The Chickens', where queen scallop dredging is permitted. A separate annual TAC allocation is set for this dredging zone.

In 2013 the queen scallop trawl fishery opened on 17th June and by early July it was apparent that the fishery was at risk of exceeding the precautionary TAC (4,000 t) early. In order to protect and sustain the fishery a set of emergency measures was introduced (The Sea Fisheries (Queen Scallop Fishing)(Emergency Measures) Byelaws 2013) these included a daily bag limit and a 1 day closure (Friday). These measures enabled the fishing season to be extended until the beginning of October when the TAC was met. Regulatory measures to manage the 2014 queen scallop fishing season are currently under review and will include a statutory consultation with stakeholders.

Management of the king scallop fishery differs between an inner 0 to 3 nautical mile zone and an outer 3 to 12 nautical mile zone, with more stringent regulations in place within the inner zone. A range of regulations exist including: a minimum landing size (MLS) of 110 mm; a closed season (1st June to 31st October); closed areas (e.g. Douglas Bay and Port Erin closed area); fisheries management zones (e.g. Ramsey Bay); limits on dredge numbers (e.g. 5 dredges per side in the 0 to 3 nm zone) and curfews (e.g. 18:00 to 06:00 within the 0 to 3 nm zone).

9.1.7 Impact of scallop harvesting on habitat and recovery rates (ToR 7)

In addition to the direct impact on the target species there are secondary effects that could lead to reduced larval settlement in the future. Trawling is generally considered to be less damaging to benthic habitats than dredging (Kaiser et al., 2006). Consequently, while the queen scallop trawl fishery was MSC certified the dredge fishery failed to meet the standard due to its impact on benthic habitats (Andrews et al., 2011). Of particular relevance to the fishery is the fact that the habitats that support queen scallops may be damaged by excessive fishing activity. For example, there is a positive relationship between the presence of macroalgae and maerl and the abundance of juvenile scallops (Howarth et al., 2011) and queen scallops have been found to settle on bryozoans and hydrozoans (Lambert et al., 2011). At fishing intensities before 2010 benthic conditions were clearly suitable to allow large settlement of queen scallop larvae, as evidenced by the increase in biomass (Fig. 2). Therefore, this level of fishing activity may provide an indicator of an appropriate, sustainable, level of fishing in relation to benthic habitats (Murray & Kaiser, 2012).

9.2 References

ALLISON, E.H., 1993. The Dynamics of Exploited Populations of Scallops (Pecten maximus L.) and Queens (Chlamys opercularis L.) in the North Irish Sea., University of Liverpool, PhD Thesis, pp. 1- 457.

ANDREWS, J.W., BRAND, A.R. and HOLT, T.J., 2011. MSC Assessment Report for Isle of Man Queen Scallop Trawl and Dredge Fishery.

BEUKERS-STEWART, B.D., VAUSE, B.J., MOSLEY, M.W.J., ROSSETTI, H.L., and BRAND, A.R. (2005). Benefits of closed area protection for a population of scallops. Marine Ecology Progress Series, **298**, pp.189-204.

BEUKERS-STEWART, B.D., JENKINS, S.R., BRAND, A.R. (2001). The efficiency and selectivity of spring-toothed scallop dredges: a comparison of direct and indirect methods of assessment. Journal of Shellfish Research, **20**, pp. 121-126.

BRAND, A.R., ALLISON, E.H., and MURPHY, E.J.,1991. North Irish Sea scallop fisheries: a review of changes. In SHUMWAY, S.E. and SANDIFER, P.A. (Eds). An International Compendium of Scallop Biology and Culture. World Aquaculture Workshops, Number 1. World Aquaculture Society, Baton Rouge, LA. pp.204-218.

DEPARTMENT OF ENVIRONMENT, FOOD AND AGRICULTURE (DEFA), 2012. Fisheries Digest 2012: Weight and value of fish landed into Isle of Man ports by species, 2001 - 2012. Department of Environment, Food and Agriculture.

HOWARTH, L.M., WOOD, H.L., TURNER, A.P. and BEUKERS-STEWART, B.D., 2011. Complex habitat boosts scallop recruitment in a fully protected marine reserve. Marine Biology, **158**, pp. 1767-1780.

KAISER, M.J., CLARKE, K.R., HINZ, H., AUSTEN, M.C.V., SOMERFIELD, P.J. and KARAKASSIS, I., 2006. Global analysis of response and recovery of benthic biota to fishing. Marine Ecology Progress Series, **311**, pp. 1 - 14.

LAMBERT, G.I., JENNINGS, S., KAISER, M.J., HINZ, H. and HIDDINK, J.G., 2011. Quantification and prediction of the impact of fishing on epifaunal communities. Marine Ecology Progress Series, **430**, pp. 71-86.

MURRAY, L.G. and KAISER, M.J., 2012. The Isle of Man Aequipecten opercularis fishery stock assessment 2012. Bangor University Fisheries and Conservation Report No. 17. pp. 1 - 20.

MURRAY, L.G., HINZ, H. and KAISER, M.J., 2010. Predicted impacts of proposed management measures in the Isle of Man's Pecten maximus fishery. Bangor University Fisheries and Conservation Report No 13. pp. 1- 27.

MURRAY, L.G. (2013). The Isle of Man Aequipecten opercularis fishery stock assessment 2013. Bangor University Fisheries and Conservation Report No. 25. pp. 1-27.

10 VIa and IVb,

10.1 Orkney

10.1.1 Distribution of fishing effort and landings for scallop inshore and offshore waters (ToR 1)

The Orkney scallop fishery began in the 1970s but has remained relatively small in comparison to other Scottish assessment areas. There are approximately six local dredgers (some of which also fish with nets and creels) and twelve dive boats that fish grounds in Scapa Flow, Bay of Firth and around the northern isles of Orkney and other sites locally. Annual landings have fluctuated over the years and in 2012 dredged scallop landings were approximately 421 tonnes and dive caught approximately 130 tonnes. The dredge fishery in 2012 was worth approximately £900,000 and the dive fishery approximately £450,000.

Information on the spatial distribution of landings and value from < 15 m vessels has been obtained through the MSS ScotMap project and is available at: www.scotland.gov.uk/Topics/marine/science/MSInteractive/Themes/ScotMap.

10.1.2 Identification of stock assessment and management units (ToR 2)

The population structure of Scottish scallop stocks is not well understood, and the assessment areas were defined to reflect the characteristics of the fisheries in the past rather than on the basis of evidence to support discrete populations. The Orkney assessment unit as defined by Marine Scotland Science (MSS) includes ICES rectangles 47 E4; 46-47 E5-E6; 47 E7. VMS data reveals that most dredge (vessels >15m) activity occurs along the coastline of the North of Scotland whilst ScotMAP GIS layers reveal that the inshore areas around the Orkney islands are important for the dive caught scallop fleet. A Scottish Fishing Industry Science Alliance (FISA) project is currently being carried out by Orkney Fisheries Association (OFA) in partnership with Heriot-Watt University (HWU) on the spatial dynamics of scallops with the aim of determining immigration rates at local and more distant spatial scales.

10.1.3 Biological parameters (ToR 3)

Natural mortality is not precisely known but in common with other fish and shellfish stocks of similar longevity (up to 20 years) it is assumed to be 0.15 yr^{-1} for the all ages for the purposes of stock assessment (Cook *et al*., 1990).

Length weight parameters (total and muscle) derived from historical MSS sampling (Cook *et al*., 1990) are available for this stock. Additional biological data (length-weight, growth) have been collected more recently but have not yet been fully analysed.

Maturity data (gonad staging) have also been collected by MSS but have not been fully analysed. Currently 100 % maturity is assumed at age two.

10.1.4 Stock assessment methods (ToR 4)

Due to limited port sampling, the age composition data are insufficient for carrying out a reliable stock assessment. No survey data are available for the Orkney assessment area.

10.1.5 Data provision and feasibility of obtaining data (ToR 5)

Scallop landings are sampled as part of an integrated MSS market sampling programme (see Section 5.1.5). Catch-at-age data for Orkney are available for 1989-present day, however sampling has been sporadic and limited in terms of seasonal coverage and number of trips. Samples are currently not deemed of sufficient quality for further analysis. In 2012, 6 trips were sampled and 740 individuals measured.

The MSS scallop survey does not cover the Orkney assessment area.

10.1.6 Efficacy of scallop fisheries management measures (ToR 6)

Scottish scallop fisheries are not subject to EU or national TAC regulations. EU measures to restrict effort include the Western Waters effort regime (which applies to all UK waters except the North Sea), and is applicable to all vessels over 15 m in length. The limits for UK vessels are 1,974,425 KW days for Sub-area VI a (Council Regulation (EC) No. 1415/2004). Minimum landing size (MLS) is also specified through EU legislation and is 100 mm for this area (Council Regulation (EC) No. 850/98). All vessels fishing commercially for scallops in Scotland are required to have a license and no new licenses are granted. The Prohibition of Fishing for Scallops (Scotland) Order 2003 introduced gear restrictions which vary according to where fishing takes place: a maximum of eight dredges per side is allowed in Scottish inshore waters (out to six nautical miles). The Order also prohibits the use of "French" dredges (a design incorporating water deflecting plates and rigid fixed teeth) in Scottish inshore waters.

10.1.7 Impact of scallop harvesting on habitat and recovery rates (ToR 7)

10.2 Cardigan Bay (and Liverpool Bay)

10.2.1 Distribution of fishing effort and landings for scallop inshore and offshore waters (ToR 1)

The extent of the Cardigan Bay king scallop stock is mapped on Figure 9. Cardigan Bay is the area 4 but there is a possibility that the stock may extend to area 3, Tremadog Bay, and area 2, the Llyn Peninsula. Area 1 is Liverpool Bay. The map shows the distribution of Bangor University stock assessment survey in Welsh waters in 2013.

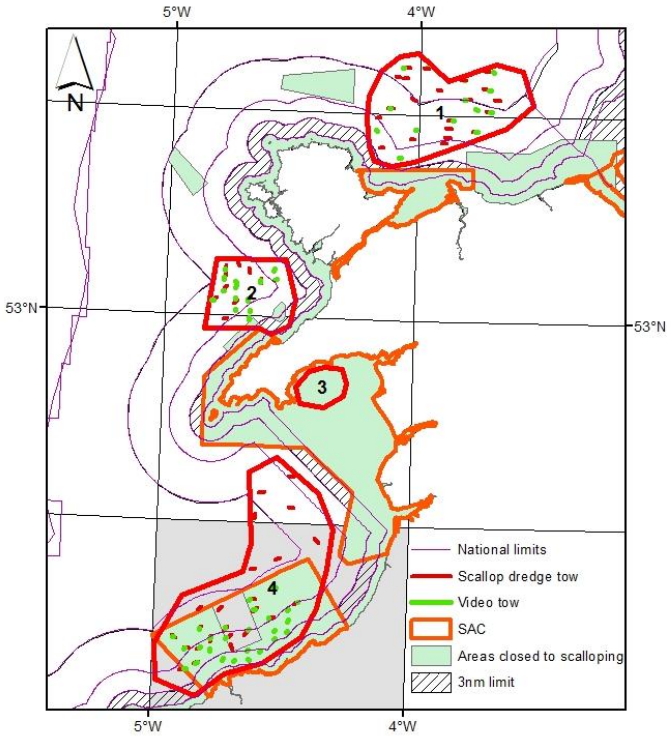


Figure 9. Stock assessment survey Bangor University 2013 (same areas 1 to 4 were sampled in 2012). The grey square is the ICES rectangle 33E5.

In terms of fishing effort in Cardigan Bay and landings of scallops caught in the area, there is no official figure yet, but some data from the ICES rectangle 33E5 (Figure 9) covering most of Cardigan Bay, were shared by the MMO. More accurate estimates should be available in the near future (Figure 10).

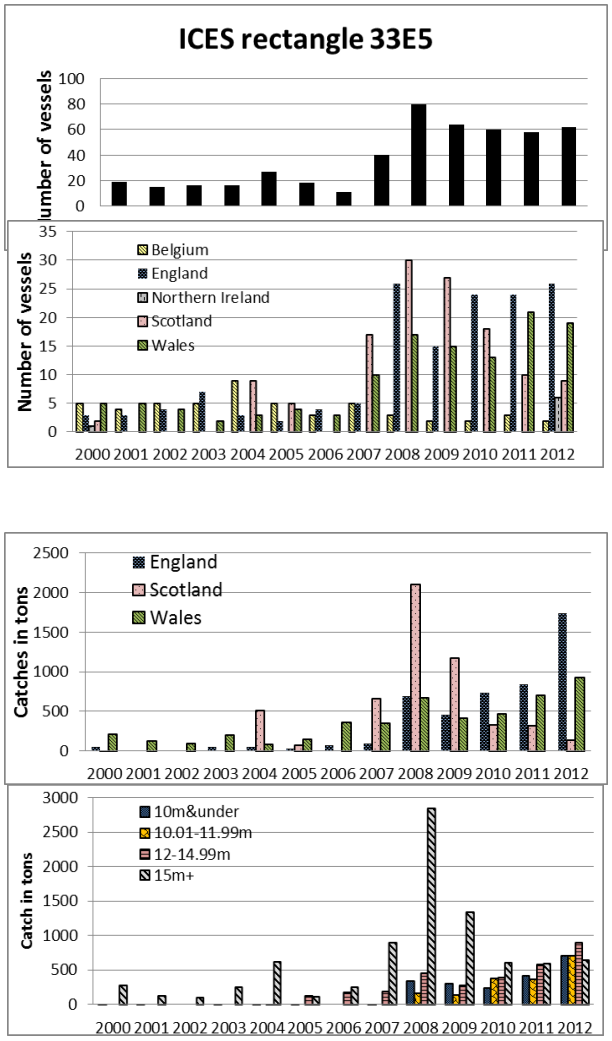


Figure 10. Statistics of scallop fishery in ICES rectangle 33E5. Data source MMO.

10.2.2 Identification of stock assessment and management units (ToR 2)

In Welsh waters, scallop dredging is banned within 1nm all along the coast line. There are also 3 large Special Areas of Conservation (SACs) where scallop dredging is mostly prohibited as well as two restricted areas within 3nm off the north of the Llyn Peninsula, a further two restricted areas between 6 and 12nm west and north of Anglesey and another one north of Conwy. The fishery is seasonally closed in summer from 1st of May to 1st of October. Most of the stock is situated in the south of the Cardigan Bay (south of area 4) and has been protected since 2010 under new regulations in the Special Area of Conservation of Cardigan Bay. Only part of this area is now open to fishing for 6 months of the year, the rest is closed all year round. As well as a seasonal closure in all Welsh waters, there is an engine power limit of 221kW and there are vessel size restrictions and gear specifications, some of which, such as number of dredges aside, being related to distance from shore. The minimum landing size is 110mm. These management measures are not based on biological or ecological information at this stage.

10.2.3 Biological parameters (ToR 3)

All parameters given below are based on 2 scientific surveys conducted in Welsh waters in June 2012 and in July-August 2013. Details of the surveys are given in section 12.1.4 Stock assessment methods. The survey reports can be obtained online (Lambert et al. 2012 and Lambert et al. 2013).

Lifespan

Although some scallops have been be aged up to 12+ years old during the 2012 and 2013 surveys, generally scallops over age 8 are grouped into a plus-group, age 8+, because of the scarcity of individuals above that age.

Growth

During our surveys, scallops have been measured in width, according to the way the fishery is regulated (MLS is 110mm wide in Welsh waters). However, other countries have used the height of scallops to estimate the growth parameters. In June 2012, we have measured a subsample of over 310 scallops in both directions, i.e. width and height. We derived the equation linking width to height for scallops between 75mm and 160mm in width:

*Height = 9.216 + 0.818*Width* (R-squared=0.957)

	K	L_{inf}	t_0
June 2012 survey			
- Cardigan Bay, Llyn Peninsula pooled	0.33	129	-0.38
- Liverpool Bay	0.34	132	0.00
July-August 2013 survey			
- Cardigan Bay, Llyn Peninsula pooled	0.34	128	-0.57
- Liverpool Bay	0.26	140	-0.79

Length-weight relationship

The length-weight relationship was modelled on the equation *Weight = a * Height ^ b*

The parameters were estimated for both the 2012 and 2013 surveys:

	a	*b*	*Allometry*
June 2012 survey			
- Cardigan Bay, Llyn Peninsula pooled	$3.33*10^{-4}$	2.80	Significant
- Liverpool Bay	$6.63*10^{-4}$	2.65	Significant
July-August 2013 survey			
- Cardigan Bay, Llyn Peninsula pooled	$1.56*10^{-5}$	3.22	Significant
- Liverpool Bay	$6.92*10^{-5}$	2.93	Not significant

Maturity at age

Here the samples from Cardigan Bay, Llyn Peninsula and Liverpool Bay were pooled as there were not enough scallops in the smaller size and age classes to get estimates of maturity rates split between the different grounds.

During the June 2012 survey, all the scallops sampled for maturity analyses were from age-groups 3-4 and above and all were mature (over 310 samples).

In July-August 2013, one age 1 scallop was sampled and was found to be immature. More significantly, 47 scallops of age-group 2 were also sampled, of which 70% were

immature. A small percentage of age 3 scallops were also immature, 4% out of a sample of 96 age 3 scallops. One age 4 scallop was immature (<2%) and all age 5+ scallops were mature (see summary table below).

Using a binomial regression, L50, the length at 50% maturity was determined from the 2013 samples. L50 is 75mm in height, corresponding to a width of 80mm, i.e. 3cm below the minimum landing size.

Age (years)	*Maturity (number of samples in brackets)*	*Height / Width class (mm)*	*Maturity (number of samples in brackets)*
1	0% (1)	65 / 68	10% (21)
2	30% (47)	70 / 74	39% (13)
3	96% (96)	75 / 80	67% (12)
4	98% (61)	80 / 87	99.95% (19)
5+	100% (258)	85 / 93	99.95% (39)
		90 / 99	99.94% (35)
		95/ 105	99.97% (38)
		100/ 111	100% (58)
		[…]	100% (228)

Natural mortality

The catch-curve analysis of our survey data, following the cohorts between 2012 and 2013, gave us a first estimate of mortality for the scallop stocks around Wales. The analysis revealed that 4 year old scallops may not be fully recruited to the fishery yet, hence a low to positive mortality estimate. The most reliable estimate of mortality was obtained for age-group 5. Indeed, the scallops appeared fully recruited to the fishery then and the numbers at age 5 and 6 remained high enough to limit the variability in their estimation. Older scallops are scarcer and more difficult to estimate accurately with a limited number of survey tows.

Since we sampled in an area which has been closed since June 2009, the mortality at age 5-6 estimated from the survey catch-curve was an estimate of natural mortality. In the Cardigan Bay SAC, instantaneous rate of natural mortality was therefore estimated at $0.41yr^{-1}$, equivalent to a decrease of 34% in number of scallops from age-group 5 to 6. In Liverpool Bay, the total mortality $Z_{5\text{-}6}$ was estimated at 0.25, corresponding to a decline in abundance of 22% between age 5 and 6. This estimate is probably close to the natural mortality rate since fishing effort on scallops is low in the area.

Recruitment estimate

A recruitment estimate can be obtained as we sample with a queen scallop dredge, i.e. capturing a significant amount of undersize scallops. See section 12.1.4 Stock assessment methods and survey reports (Lambert et al. 2012 and Lambert et al. 2013)

Carrying capacity

We do not have estimates of carrying capacity

10.2.4 Stock assessment methods (ToR 4)

There have been only 2 scientific surveys conducted in the Cardigan Bay area, in June 2012 and July-August 2013. The sampling was done by towing a bar with 4 dredges, 2 king dredges and 2 queen dredges. Camera tows were also used in protected areas where there were likely to be some sensitive features. Further cameras tows were conducted alongside the dredge tows in order to compare the estimates from either sampling method (see reports Lambert et al. 2012 and Lambert et al. 2013).

Fisheries dependent data may not be informative enough in the case of the Cardigan Bay as most of the stock is protected. Also, data earlier than 2006 are not believed to be reliable since fisheries data quality has increased since the buyer and seller agreement in 2006. VMS data will only be useful for vessels over 15meters, but a large part of the fleet is composed of <12m vessels. There is no port sampling in place in Wales but the red bag scheme, instigated by Cefas, allows us to start collecting information on the size and age frequency of the catch since 2012.

There are therefore indicators of abundance and stock status available for this stock but no full stock assessment yet.

10.2.5 Data provision and feasibility of obtaining data (ToR 5)

All survey data on biological parameters and indices of abundance are readily available. Fisheries dependent data (logbooks, VMS, landings) are subject to restriction but relevant aggregated data can be obtained from Cefas and the MMO. A new order has been published by the Welsh Government in 2012, stating that from the 1st of November 2012 any vessel fishing for scallops in Welsh waters has to have a tracking device fitted. The ping rate is also much higher than the usual VMS system (at least once every 10min). At the minute, those data are available to scientists if fisher's agreement is obtained.

10.2.6 Efficacy of scallop fisheries management measures (ToR 6)

There is no management measure as such, only technical, temporal and spatial restrictions as described in section 12.1.2. but the stock has not been monitored so far.

10.2.7 Impact of scallop harvesting on habitat and recovery rates (ToR 7)

There is a project of looking at fishing impact and recovery in collaboration with the fishing industry in the Cardigan Bay SAC. The project is due to start in March 2014 (Annex 6).

10.3 References

Lambert, G.I., Hold, N., Hinz, H., Kaiser, M.J. (2012) Welsh waters scallop survey – Cardigan Bay to Liverpool Bay June 2012. Bangor University, Fisheries and Conservation Report No. 21. http://fisheries-conservation.bangor.ac.uk/wales/documents/21v2_002.pdf

Lambert, G.I., Murray L.G., Kaiser M.J., Salomonsen H., Cambie, G. (2013) - Welsh waters scallop survey – Cardigan Bay to Liverpool Bay July-August 2013. Bangor University, Fisheries and Conservation Report No. 30. http://fisheries-conservation.bangor.ac.uk/wales/documents/30_000.pdf

11 VIIa

11.1 Tuskar

11.1.1 Distribution of fishing effort and landings for scallop inshore and offshore waters (ToR 1)

The Tuskar stock extends along the south east coast of Ireland outside of 6nm. The boundaries of the bed are currently defined by VMS data (2000-2011) and remain open to review. VMS data shows an expansion in the distribution of effort in the area during the period. Habitat, as shown by multibeam backscatter data, is a mix of sand, gravel and scoured rock and boulder patches. There is a dynamic current regime.

The stock is fished mainly by Irish vessels and by Scottish vessels to a much less extent. The number of vessels, dredges and annual effort varies. Post 2006 the number of vessels in the Irish fleet was limited by permit. Vessel size and the total number of dredges in the Irish fleet and fishing the Tuskar stock have declined since 2000. Nevertheless landings are increasing probably as a result of higher catch rates. There are no management measures in place other than a minimum landing size of 110mm shell width. All dredges are spring loaded toothed dredges. The ring size used in the dredges is 75mm. Tooth spacing on the dredge is 65mm. The teeth are 8-10cm in length. The annual effort of the Irish fleet is limited through the western waters agreement which restricts the total activity of the fleet to 515000kw.days.year^{-1} in ICES VII.

Logbook data showing landings by ICES rectangle are available from 1995-2013 (Annex; 1995-2011). Data quality is higher in the most recent years of this time series and is incomplete for earlier years. Logbook data coupled to VMS allows daily catch data to be reported spatially. In addition to official logbook data 'vessel diary' information were compiled for the period 1995-2004 from a number of vessels. These data provide finer spatial scale LPUE data for the period and also provide additional information on the landings not available in the logbook data for the early years in the series.

Size composition data for the landings are available for the period 2001-2005 and 2011-2013 with lesser quantity of data for 2008-2010. These data are obtained by port sampling and are traceable to ICES rectangle. Sampling is opportunistic and spatial coverage varies according to the distribution of fishing. Size composition data for the catch is obtained from a limited observer programme; 1 trip of approximately 5 days is covered per quarter. CPUE, LPUE and DPUE information is collected for each commercial tow taken during the trip and size composition of the landings and discards is also taken for each tow.

11.1.2 Identification of stock assessment and management units (ToR 2)

The Tuskar assessment unit is identified from the distribution of fishing activity (VMS) and also from particle tracking simulations. However, the simulations show a one way transport of larvae from the Tuskar bed south into the Celtic Sea. The source of recruitment to the Tuskar stock is therefore uncertain. It may originate from the Cardigan Bay stock to the east or even from the north Cornwall stock to the south.

11.1.3 Biological parameters (ToR 3)

Growth

Growth rate parameters have or can been derived from size at age data for the period 2001-2004 and 2011-2013 using size at age data derived from shell rings. Significant spatial variability, at a scale probably finer than ICES rectangle, is present in this stock although this has not been quantified.

Size and age at maturity

Parameters for size and age at maturity are not available. However, size at maturity is known to be well below the minimum landing size and most likely occurs at age 2-3. Some work on seasonal development of the gonad was undertaken in 2001-2004 and is known to be highly variable spatially.

Natural mortality

No estimates are available

Fishing mortality

Estimates of Z (F+M) have been derived from cohort analysis of numbers of scallop landed by age (Annex).

11.1.4 Stock assessment methods (ToR 4)

Stock assessment

No analytical stocks assessments have been undertaken.

Yield per recruit (2001-2004) have been derived by statistical rectangle using spatial data on growth rates and assuming a constant M. Furthermore F_{max} and $F_{0.1}$ reference points were estimated by stat rectangle.

11.1.5 Data provision and feasibility of obtaining data (ToR 5)

Total annual catch and fishing effort is being obtained from the logbook and VMS data. In addition the number of dredges carried by each vessel is known. The annual effort can be described in terms of total area fished, the annual dredge track or VMS hours. A time series is available and this can be continued.

Size composition of the landings and catch can be obtained by port sampling and observer programme respectively. However, there is limited scope to ensure good spatial coverage using the existing programmes. Spatial sampling is opportunistic and depends on the distribution of fishing by the fleet.

Surveys were completed in 2001-2004. These are no longer feasible due to limited funding and given that there is no specific harvest strategy or management regime in place for the stock.

Scope to improve the estimates for biological parameters is limited due to lack of resources. In particular it may be difficult to construct age length keys with sufficient frequency and at the appropriate spatial scale (probably at ICES rectangle level) in order to obtain the age composition of the landings for age based assessments.

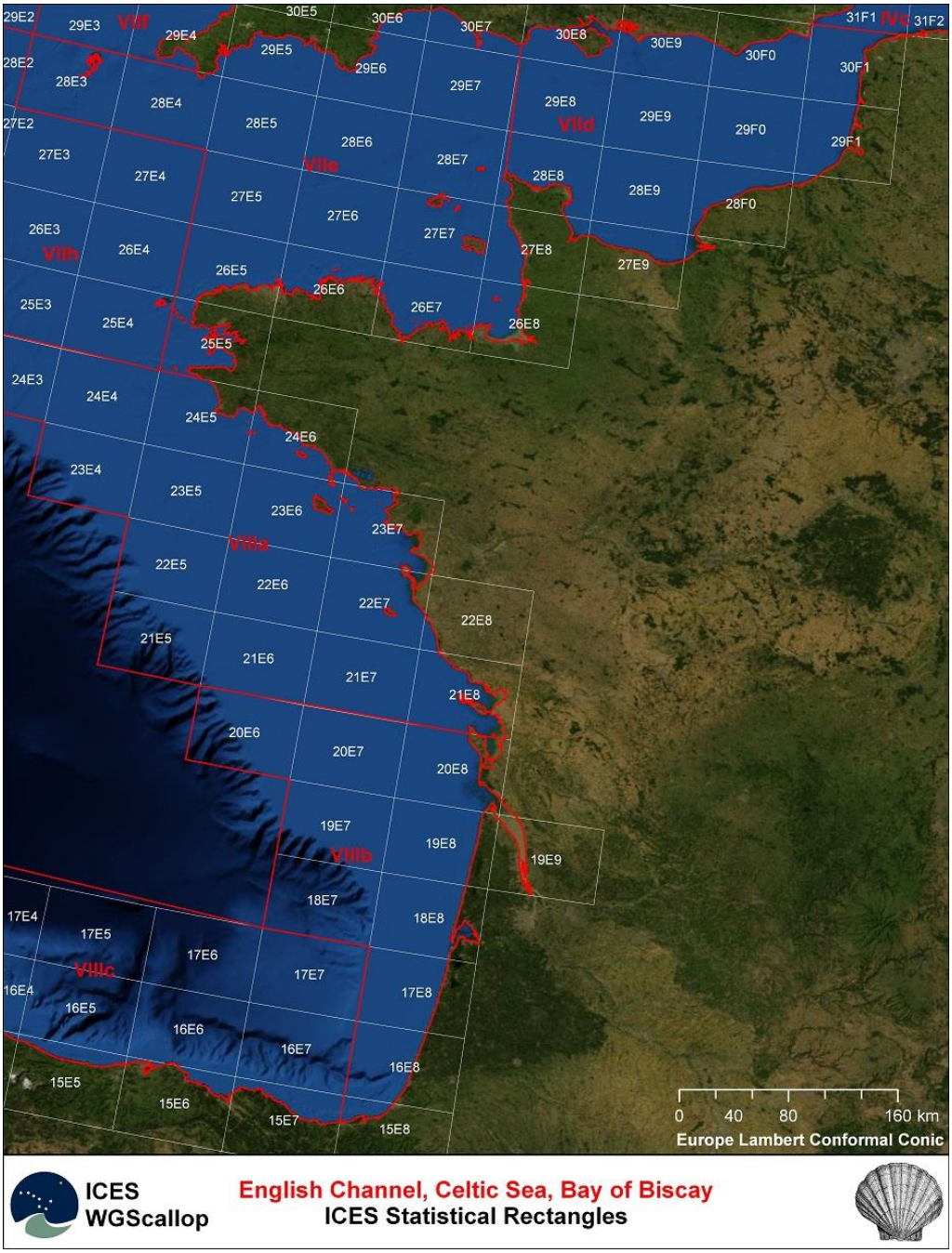
11.1.6 Efficacy of scallop fisheries management measures (ToR 6)

The only existing management measure is the 110mm shell width minimum landing size (MLS). This is probably effective in protecting spawning potential given that size at maturity is well below MLS. However, this is contingent discard mortality being low and that mortality that may occur due to contact with the fishing gears and that is unseen is also limited.

11.1.7 Impact of scallop harvesting on habitat and recovery rates (ToR 7)

The environmental effects of scallop fishing will need to be assessed as per the requirements of the Habitats Directive (HD), in Special Areas of Conservation (SACs) and under Descriptor 6 (Seafloor integrity) of the Marine Strategy Framework Directive (MSFD)

12 VIId



12.1 Sussex

12.1.1 Definition of stock unit.

This fishery is prosecuted by UK, French, Irish and Dutch vessels. On the English coast, Sussex IFCA has a by-law that bans dredging within 3 nm of the shore. For UK vessels there is a limit of around 75mm ring size and 20 dredges in the 6-12nm belt on the English side. The minimum landing size is 110mm shell length.

The UK has very little data beyond VMS, landings and effort trends for UK vessels and some very limited dredge survey data.

12.1.2 Biological parameters

The shells are aged from annual growth stages which are sometimes clear, but often require microscopic examination. Growth is generally rapid (H_∞ 119.2, k 0.516, t_0 0.692).

Spawning takes place in early summer and there is a single peak after which the animals remain out of condition until the winter.

12.1.3 Identification of stock assessment and management units (ToR 2)

12.1.4 Biological parameters (ToR 3)

12.1.5 Stock assessment methods (ToR 4)

12.1.6 Data provision and feasibility of obtaining data (ToR 5)

12.1.7 Efficacy of scallop fisheries management measures (ToR 6)

12.1.8 Impact of scallop harvesting on habitat and recovery rates (ToR 7)

12.2 Bay of Seine

12.2.1 Distribution of fishing effort and landings for scallop inshore and offshore waters (ToR 1).

It could be considered that there is a single King scallops stock in the bay of Seine, between the French coast in the south and the 49°42N line in the north, even if there is some connectivity with scallop beds situated in northern Channel (Nicolle *and al*., 2013[2]). Nevertheless, this stock is divided by the 12nm limit defining the French territorial waters. In the North of this line, King scallops are exploited by international fleets, coming from France, UK (resident fleet coming from English Channel coast as offshore fleet coming from Scotland), Ireland and Belgium. Within French territorial waters, Belgium has historical rights to fish scallops in the 6-12nm belt, but in fact only French fleet are exploiting this resource.

In both parts of the bay of Seine (inshore and offshore waters), French landings are very fluctuating from one year to another, because landings are very linked to the recruitment. Within French territorial waters, French landings since 2000 from 2969 mt (2000) to 12149 mt (2005). For the moment, available data don't allow to identify catches coming the offshore bay of Seine aera. French landings from all Eastern Channel offshore area vary between 3295 mt (2000) and 7604 mt (2011). Landings data from Irish and UK fleets are not avalaible yet.

[2] Nicolle A., Dumas F., Foveau A., Foucher E. and E. Thiébaut, 2013. Modelling larval dispersal of the king scallop (*Pecten maximus*) in the English Channel: examples from the bay of Saint-Brieuc and the bay of Seine. *Ocean Dynamics*, Volume 63, Issue 6, 661-678. http://link.springer.com/article/10.1007%2Fs10236-013-0617-1

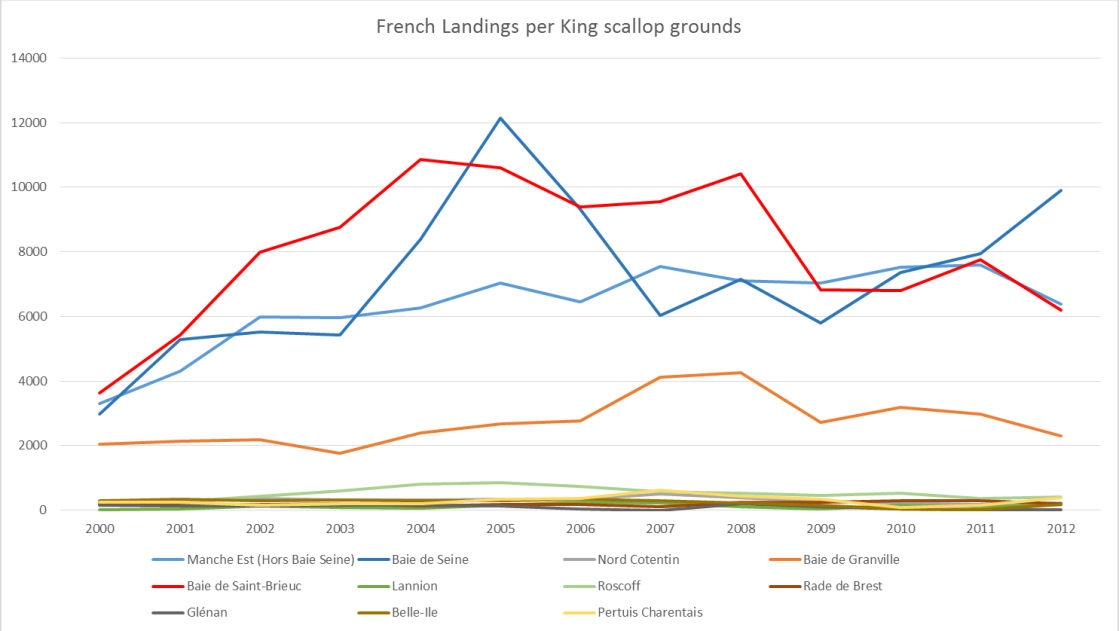


Figure 11: French King scallops landings per fishing grounds.

French fishing effort declined during the 2 last decades in the inshore area, from around 1700 hours/year in 1992 to less than 600 hours in 2011.

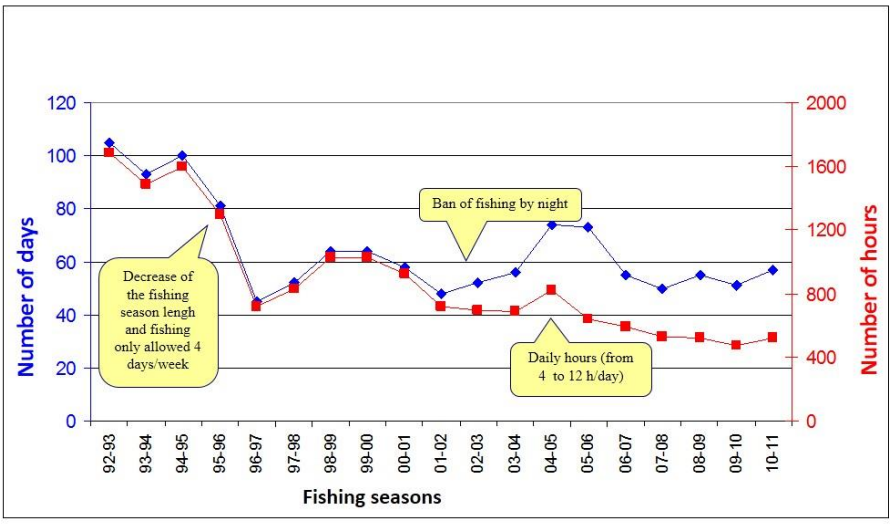


Figure 12: Evolution of French fishing effort within French territorial waters of the inshore bay of Seine.

12.2.2 Identification of stock assessment and management units (ToR 2)

The assessment of the bay of Seine stock is conducted each year by a French scientific survey (see below Chapter 12.2.4), but the two parts of the bay of Seine (inshore and offshore parts) have to be separated in terms of management units. The management regulations are very different in each aera, especially for French vessels subjected to national constraints (see below Chapter 12.2.6).

All the different offshore scallop beds in the Eastern Channel are exploited by resident (F and UK) and opportunistic fleets, and need probably to be considered as a

single global management unit. Local scallop beds within territorial waters, as inshore bay of Seine (France) or Sussex (UK) could probably be considered as separated management units.

12.2.3 Biological parameters (ToR 3)

The shells are aged from annual growth stages which are generally quite clear (but could sometimes require microscopic examination, especially for studies on individual growth). In the bay of Seine, lifespan is usually estimated to 12-15 years, but the terminal age is fixed at 7+ years.

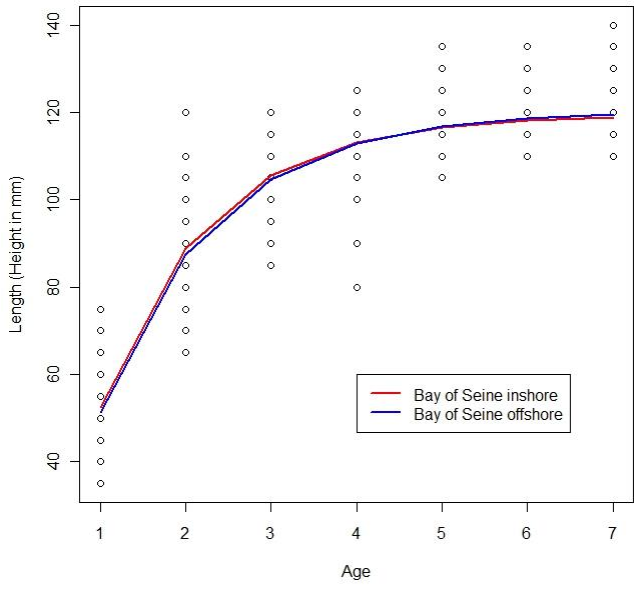


Figure 13. Growth of King scallop in the bay of Seine.

Growth is very rapid in the bay of Seine: H_{inf} = 119.5, k = 0.785 and T_0 = 0.262. Spawning occurs from May to September, with a first peak at the end of spring followed by a succession of replicates durung all summer (Lubet *et al*., 1987)[3]. Considering that the date of birth is the 1st of July, all King scallops are mature at 2 years old, and highly participate to the reproduction. Recruitment also occurs at 2 years old, considering that all scallops in the bay of Seine reach the minimum landing size at this age. Recruitment is linked to environmental effects, more than the level of spawning stock biomass, and could so highly fluctuate year after year.

[3] Lubet P., Besnard J., Faveris R., Robbins I., 1987. Physiologie de la reproduction de la coquille Saint Jacques (*Pecten maximus* L). Oceanis (**13**), 265-290.

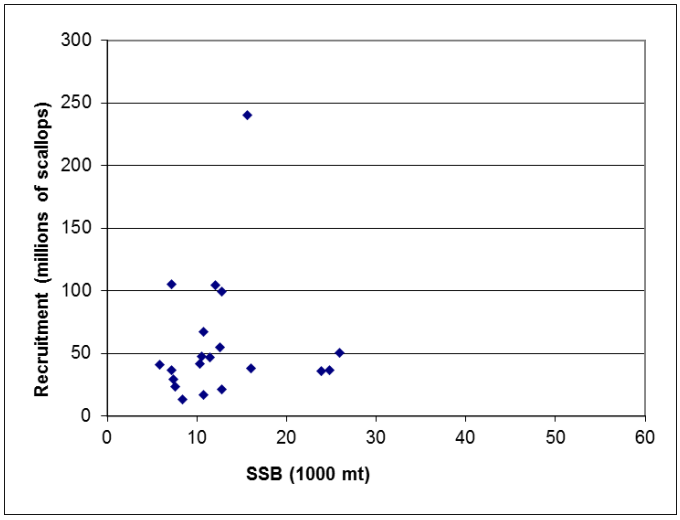


Figure 14: King scallop Recruit-SSB relationship in the bay of Seine.

12.2.4 Stock assessment methods (ToR 4)

The bay of Seine King scallop stock is assess by a scientific survey, which takes place each year in July from the French coast in the South to the 49°48N line in the North.

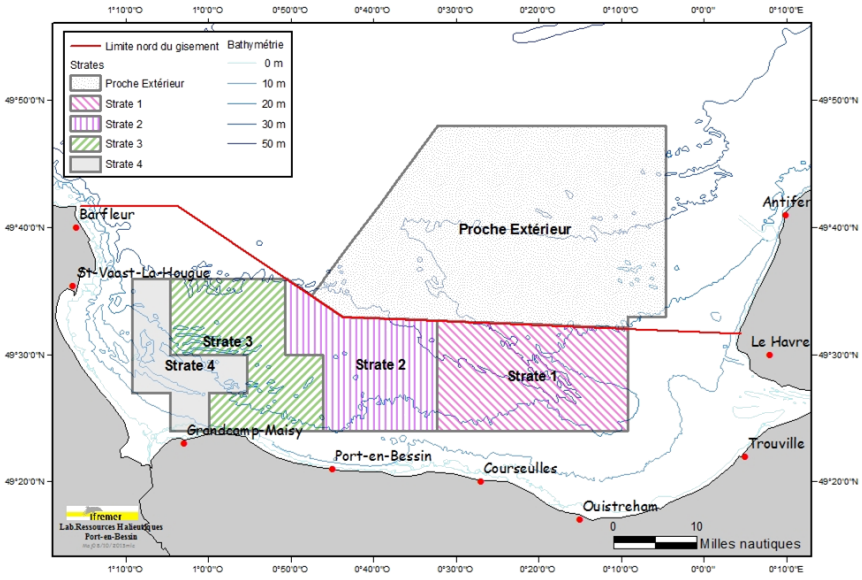


Figure 15.2.4.1: Area prospected by King scallop assessment survey in the bay of Seine.

The methodology applied to scallop survey in the Eastern Channel (COMOR) is described in Vigneau and al. (2001)[4]. The sampling plan is a multi-stage random stratified sampling, where the number of units is computed from the last year young scallop variance. The knowledge of the gear (britanny dredge with a diving plate) selectivity and efficacity parameters is required to estimate age and stratum abun-

[4] Vigneau J., Fifas S. and Foucher E., 2001. Les campagnes d'évaluation du stock de coquilles Saint-Jacques en Manche orientale : méthodologie et estimation des indices d'abondance. http://archimer.ifremer.fr/doc/00000/6550/

dance indices and available biomass. Mathematical development of these estimators are detailed. Non parametric bootstrap is used to calculate confidence bounds.

The expertise resulting from these surveys contributes to the elaboration of the annual management scheme of scallop resources in France: estimation of exploitable biomass, juveniles (1 year old), recruitment and remainder biomass after the fishing season, geographical distribution of the scallops on the seabed. It also allows to make short-term (1-3 years) forecasts. TAC could be compute, but not officially given to French administration and stakeholders because there is no possibility for the moment to follow day after day the landings in real time.

For example, results of the survey and status of the bay of Seine stock in 2013 is given in Foucher (2013)[5].

12.2.5 Data provision and feasibility of obtaining data (ToR 5)

Landings and fishing effort are available for French vessels (logbooks). VMS data are not available for the moment, but fishing boat over 15 meters are now equiped, and there are discussions with French administration to get them.

Assessment surveys are planned for the next few years.

Scallop landings are sampled by Ifremer within the French National Sampling program, incuded into the UE sampling program (DCF – Data Collection Framework) in support to European Fishing Policy.

12.2.6 Management measures (ToR 6)

All the areas have to follow UE regulations (Council Regulation EC N°850/98): minimum landing size (MLS) of 110mm in ICES VIId zone and ban of onboard scallop shocking. For each country, there is also an annual fishing effort limit in terms of KW/day (valid for all VII division). At the European level, the minimum inside diameter of the dredges'rings is 72mm. UK and Belgium vessels are usually using 75-85mm rings. For French fishermen, French national regulation enforce all vessels to use 92mm rings, for all scallop fisheries in France.

UK, Irish and Belgium vessels are only subjected to UE regulations.

For French vessels, scalloping is forbidden during the summer: fishing season is closed from 15th of May of 30th of September in all areas. In the inshore fishery of the bay of Seine (within French territorial waters), all the boats have to get a special licence, subjected to technical limitations of the boat and gears, and limitations of fishing effort. So, only boats under 16 meters and 450 KW are allowed for fishing, with a maximum of 16 dredges (fishing width 12.80 meter maximum). The fishing season duration is limited, from 1st of Décember to middle or end of February. Only 4 days per week are opened, with a mimit of hours per day (from 4 hours/day in Décember to 12 h/d in February). Moreover, there is a catch limit per boat and day set to 1800 Kg maximum (depends of the length of the boat).

12.2.7 Impact of scallop harvesting on habitat and recovery rates (ToR 7)

A study was undertaken in 2011 on evolution of abundance of different species caught on scallops grounds during assessement surveys. It seems that some species

[5] Foucher Eric (2013). Evaluation annuelle du stock de coquilles Saint-Jacques de la baie de Seine : résultats de la campagne COMOR 43 (3 au 24 juillet 2013). http://dx.doi.org/10.13155/26890

show a light increasing during recent years, but the link between that observation and the fishing effort decreasing can not be established yet (Leblanc *et al*., 2011)[6].

[6] Leblanc N., Harmel B. and Foucher E. (2011). Evaluation de l'impact des dragues à coquilles Saint-Jacques sur les communautés benthiques en baie de Seine. http://dx.doi.org/10.13155/26747

13 VIIe/h,

13.1 Cornwall

13.1.1 Definition of stock unit.

The Cornwall stock unit is defined as landings of scallops from statistical rectangles 27E3, 27E4, 28E3, 28E4, 28E5, 29E5

Statistical rectangles 27E3, 27E4, 28E3, 28E4, 28E5, 29E5

The Cornish ground is prosecuted by English, Scots and Irish vessels. The Management measures in place in the Cornish fishery mirror those in Lyme Bay except that there is no closed season. A closed area in Falmouth Bay has been imposed to protect rocky reefs, areas of seagrass and maerl beds. The protection of further areas of reef is proposed, but should not impact on scallop fishing areas.

Historical surveys were quite extensive and there is a set from 1990 to 1995 that provide a picture of recruitment, growth and abundance on a productive area in rectangle 29E5. VMS, landings and effort are available for the UK fleet, but the latter is of poor quality.

13.1.2 Biological parameters

Shells are aged from growth stages, but these are mostly indistinct and can be difficult to distinguish even under a microscope. There are frequently spurious rings and check marks which need to be discounted. Growth is variable across the area, with particularly slow growth evident inshore in the Plymouth area ($H\infty$ 105.5mm, k 0.44, t0 0.68) with growth then rate increasing offshore to the south and west of The Eddystone ($H\infty$ 110.2mm, k 0.44, t0 0.68).

Maturity cycles in this area are very variable both spatially and between years and spawning occurs from late March to September, sometimes with two peaks, sometimes only one. The size at first maturity is approximately 80 mm shell height. Generally fishers are able to find animals with commercially acceptable roes throughout the year.

13.1.3 Stock assessment methods (ToR 4)

There are currently no assessments for this fishery unit as there are insufficient data regarding age structure coupled to a short time series of reliable landings (2006 onwards).

13.1.4 Data provision and feasibility of obtaining data (ToR 5)

Landings by rectangle are available from all countries. Some effort data should also be available but the quality of these for producing meaningful CPUE indicies is not clear.

A National scheme (English) has been developing since 2012 to provide quarterly length and age samples from the commercial fishery.

13.1.5 Efficacy of scallop fisheries management measures (ToR 6)

13.1.6 Impact of scallop harvesting on habitat and recovery rates (ToR 7)

13.2 Lyme Bay

13.2.1 Definition of stock unit.

The Lyme bay stock unit is defined by landings coming from statistical rectangles 30E6, 30E7, 29E6 and 29E7.

This fishery is prosecuted by English, Scots and Irish vessels, although only English vessels from local ports currently work in the 0-6 nm zone, which is managed by Devon and Severn Inshore Fisheries and Conservation Authority (IFCA),

The IFCA inshore zone has a closed season from 1 July to 30 September, a vessel size limit of 15.24m, a ban on night fishing and a dredge limit of 12 spring-loaded dredges In addition there is a large closed area designed to protect a vulnerable area of mudstone reef. In the 6-12nm zone, English national legislation limits dredge numbers to 20, while outside 12nm there are no limits on dredge numbers, which can be as large as 40. In all of ICES division VIIE area there is a minimum legal size of 100mm shell length. The regulations on the dredge that may be used are somewhat complex, but amount to a spring-loaded dredge with a maximum width of 85cm and a belly-ring size of at least 75mm.

13.2.2 Biological parameters

Data exist to define area specific growth rates which are known to vary considerably over short distances within the area. Scallops from this area are aged from shell growth stages but these are not clear to the naked eye and require microscope examination of the shell striae to discern them. Growth is variable but generally rapid relative to other populations on the UK side of the western channel ($H\infty$113, k 0.56, t0 0.69).

Spawning generally occurs in July and the evidence suggests that there is a single spawning after which the scallops remain out of condition until the winter.

13.2.3 Stock assessment methods

There are currently no assessments for this fishery unit as there are insufficient data regarding age structure coupled to a short time series of reliable landings (2006 onwards).

13.2.4 Data provision and feasibility of obtaining data.

Landings by rectangle are available from all countries. Some effort data should also be available but the quality of these for producing meaningful CPUE indicies is not clear.

A National scheme (English) has been developing since 2012 to provide quarterly length and age samples from the commercial fishery.

13.2.5 Efficacy of scallop fisheries management measures (ToR 6)

13.2.6 Impact of scallop harvesting on habitat and recovery rates (ToR 7)

13.3 Casquets

13.3.1 Definition of stock unit.

The Casquets stock unit concern only Queen Scallop caught by bottom trawlers in offshore waters on northern and western part of the Channel Islands (especially Guernesey). Landings are coming from statistical rectangle 28E7, and little from 27E7.

This fishery is prosecuted by French vessels, and probably also by English vessels from local ports of Cornwall and Devon. There is no specific regulation for this fishery.

13.3.2 Biological parameters

Knowledge is very limited on this species. Aging directly the shell is not easy. So lifespan is still uncertain, we don't have any data on lifespan, maturity, recruitment rate.

13.3.3 Stock assessment methods

There are currently no assessments for this fishery unit.

13.3.4 Data provision and feasibility of obtaining data.

Landings by rectangle are available from all countries. Some effort data should also be available but the quality of these for producing meaningful CPUE indicies is not clear.

13.3.5 Efficacy of scallop fisheries management measures (ToR 6)

No management measures.

13.3.6 Impact of scallop harvesting on habitat and recovery rates (ToR 7)

Data not available.

14 VIIg,

14.1 Celtic Sea

14.1.1 Distribution of fishing effort and landings for scallop inshore and offshore waters (ToR 1)

The Celtic Sea stock extends from the south east coast of Ireland south to and south west for approximately 80km into the Celtic Sea. The south and west boundaries of the bed are currently defined by VMS data (2000-2011) and remain open to review. Fishing effort (as shown by VMS point density) is concentrated in an inshore area off the south coast of Ireland and a second patch further offshore 20-50km from the coast. Habitat, as shown by multibeam backscatter data, is a mix of sand waves and gravel patches. Approximately 95% of the stock area is outside of the 12nm limit.

The stock is fished mainly by Irish vessels and by Scottish vessels to a much less extent. The number of vessels, dredges and annual effort varies. Post 2006 the number of vessels in the Irish fleet was limited by permit. Vessel size and the total number of dredges in the Irish fleet and fishing the Celtic Sea stock have declined since 2000. Nevertheless landings are increasing probably as a result of higher catch rates. There are no management measures in place other than a minimum landing size of 100mm shell width. All dredges are spring loaded toothed dredges. The ring size used in the dredges is 75mm. Tooth spacing on the dredge is 65mm. The teeth are 8-10cm in length. The annual effort of the Irish fleet is limited through the western waters agreement which restricts the total activity of the fleet to 515000kw.days.year^{-1} in ICES VII.

Logbook data showing landings by ICES rectangle are available from 1995-2013 (Annex; 1995-2011). Data quality is higher in the most recent years of this time series and is incomplete for earlier years. Logbook data coupled to VMS allows daily catch data to be reported spatially. In addition to official logbook data 'vessel diary' information were compiled for the period 1995-2004 from a number of vessels. These data provide finer spatial scale LPUE data for the period and also provide additional information on the landings not available in the logbook data for the early years in the series.

Annual surveys were completed during the period 2001-2005 using standard commercial dredges and modified small mesh dredges. These surveys covered approximately 60 stations per year. Data include size composition and relative abundance. Absolute abundances were not estimated because of uncertainties regarding dredge efficiency and data interpolation.

Size composition data for the landings are available for the period 2001-2005 and 2011-2013 with lesser quantity of data for 2008-2010. These data are obtained by port sampling and are traceable to ICES rectangle. Sampling is opportunistic and spatial coverage varies according to the distribution of fishing. Size composition data for the catch is obtained from a limited observer programme; 1 trip of approximately 5 days is covered per quarter. CPUE, LPUE and DPUE information is collected for each commercial tow taken during the trip and size composition of the landings and discards is also taken for each tow.

14.1.2 Identification of stock assessment and management units (ToR 2)

The Celtic Sea assessment unit is identified from the distribution of fishing activity (VMS) and also from particle tracking simulations. The simulations show a south and

south west dispersal of larvae from the stock area and downstream transport from the Tuskar scallop bed in the south Irish Sea into the Celtic Sea. The Celtic Sea stock as identified is highly unlikely to be structured at any smaller scale.

14.1.3 Biological parameters (ToR 3)

Growth

Growth rate parameters have or can been derived from size at age data for the period 2001-2004 and 2011-2013 using size at age data derived from shell rings. Significant spatial variability, at a scale probably finer than ICES rectangle, is present in this stock; growth rate is slower towards the west of the area than in the east. This is probably driven by spatial variability in seabed temperatures and current speeds; the water column in the east of the area is less likely to stratify in summer and bottom temperatures are therefore higher than in stratified waters to the west. Similarly currents are stronger towards the east.

Size and age at maturity

Parameters for size and age at maturity are not available. However, size at maturity is known to be well below the minimum landing size and most likely occurs at age 2-3. Some work on seasonal development of the gonad was undertaken in 2001-2004 and is known to be highly variable spatially.

Natural mortality

No estimates are available

Fishing mortality

Estimates of Z (F+M) have been derived from cohort analysis of numbers of scallop landed by age (Annex).

14.1.4 Stock assessment methods (ToR 4)

Dredge selectivity and efficiency

100% selectivity occurs for 89mm shell height (which approximates to the MLS of 100mm shell width). Efficiency of the commercial dredge for commercial size scallop is 5-17%. This was estimated from depletion experiments in sand/gravel substrates. Efficiency for undersized scallop was 4-25%.

Stock assessment

No analytical stocks assessments have been undertaken.

Exploration of deLury depletion methods using fine scale spatial LPUE data derived from vessel diary data generally failed to show depletion effects at local level due to fishing for a consecutive number of days or weeks. Where depletion was detected estimated exploitation rates, due to fishing effort in the period analysed, was 2-7%. This is not an estimate of annual exploitation rate as repeat fishing events may occur in a given area during a single year.

Yield per recruit (2001-2004) have been derived by statistical rectangle using spatial data on growth rates and assuming a constant M. Furthermore F_{max} and $F_{0.1}$ reference points were estimated by stat rectangle.

Survey data (2001-2005) and commercial LPUE nominal indices provide indicators of trends in stock abundance.

14.1.5 Data provision and feasibility of obtaining data (ToR 5)

Total annual catch and fishing effort is being obtained from the logbook and VMS data. In addition the number of dredges carried by each vessel is known. The annual effort can be described in terms of total area fished, the annual dredge track or VMS hours. A time series is available and this can be continued.

Size composition of the landings and catch can be obtained by port sampling and observer programme respectively. However, there is limited scope to ensure good spatial coverage using the existing programmes. Spatial sampling is opportunistic and depends on the distribution of fishing by the fleet.

Surveys were completed in 2001-2004. These are no longer feasible due to limited funding and given that there is no specific harvest strategy or management regime in place for the stock.

Scope to improve the estimates for biological parameters is limited due to lack of resources. In particular it may be difficult to construct age length keys with sufficient frequency and at the appropriate spatial scale (probably at ICES rectangle level) in order to obtain the age composition of the landings for age based assessments.

14.1.6 Efficacy of scallop fisheries management measures (ToR 6)

The only existing management measure is the 100mm shell width minimum landing size (MLS). This is probably effective in protecting spawning potential given that size at maturity is well below MLS. However, this is contingent discard mortality being low and that mortality that may occur due to contact with the fishing gears and that is unseen is also limited.

14.1.7 Impact of scallop harvesting on habitat and recovery rates (ToR 7)

The environmental effects of scallop fishing will need to be assessed as per the requirements of the Habitats Directive (HD), in Special Areas of Conservation (SACs) and under Descriptor 6 (Seafloor integrity) of the Marine Strategy Framework Directive (MSFD)

15 VIII.

15.1 South of Brittany

15.1.1 Distribution of fishing effort and landings for scallop inshore and offshore waters (ToR 1)

There are some little King scallop seabeds exploited in the south of Brittany (Glénan, Quiberon, Belle-Ile en mer). They constitute very inshore waters, concerning only few French boats, more often under 12 meters long. Landings vary between few tons to 300 tons per year.

15.1.2 Identification of stock assessment and management units (ToR 2)

No stock assessment.

15.1.3 Biological parameters (ToR 3)

15.1.4 Stock assessment methods (ToR 4)

None.

15.1.5 Data provision and feasibility of obtaining data (ToR 5)

15.1.6 Efficacy of scallop fisheries management measures (ToR 6)

15.1.7 Impact of scallop harvesting on habitat and recovery rates (ToR 7)

15.2 Pertuis charentais.

15.2.1 Distribution of fishing effort and landings for scallop inshore and offshore waters (ToR 1)

There are a little King scallop stock exploited within the French territorial waters in both northern and southern waters of the Ile de Ré, called Pertuis Charentais. They constitute very inshore waters, concerning only few French boats, more often under 12 meters long. Landings vary between 81 tons (2010) to 624 tons (2007) per year.

15.2.2 Identification of stock assessment and management units (ToR 2)

The fishery is regulated by a licence system.

15.2.3 Biological parameters (ToR 3)

Data are available.

15.2.4 Stock assessment methods (ToR 4)

Direct stock assessment survey using the same methodology as the bay of Seine survey from 2000 to 2011, stopped in 2012.

15.2.5 Data provision and feasibility of obtaining data (ToR 5)

Logbooks data are available.

15.2.6 Efficacy of scallop fisheries management measures (ToR 6)

Knowledge missing.

15.2.7 Impact of scallop harvesting on habitat and recovery rates (ToR 7)

Knowledge missing.

Annex 1: List of participants

Name	Address	Phone/Fax	E-mail
Kevin Stokesbury			kstokesbury@umassd.edu
Brad Harris			bharris@alaskapacific.edu
Gwladys Lambert			g.lambert@bangor.ac.uk
Ollie Tully			Oliver.Tully@Marine.ie
Ewen Bell			ewen.bell@cefas.co.uk
David Palmer			dave.palmer@cefas.co.uk
Helen Dobby			H.Dobby@MARLAB.AC.UK
Lynda Blackadder			Lynda.Blackadder@scotland.gsi.gov.uk
Jonas Jónasson			jonasp@hafro.is
Eric Foucher			Eric.Foucher@ifremer.fr
Spyros Fifas			Spyros.Fifas@ifremer.fr
Carrie McMinn			Carrie.McMinn@afbini.gov.uk
Heather Moore			Heather.Moore@afbini.gov.uk
Sarah Clarke			Sarah.Clarke@Marine.ie
Isobel Bloor			ismbloor@gmail.com

Annex 2: WGScallop terms of reference for the next meeting

2012/ACOM42 The **Scallop Assessment Working Group (WGScallop)**, chaired by Kevin Stokesbury, USA, will meet in October 2014 (week 40 or 41) in Nantes, France, to:

Terms of Reference:

a. Building on the 2013 working group meeting and report we will review and update the information on the 7 ToRs:
    1) Distribution of fishing effort and landings for scallop inshore and offshore waters
    2) Identification of stock assessment and management units
    3) Biological parameters
    4) Stock assessment methods
    5) Data provision and feasibility of obtaining data
    6) Efficacy of scallop fisheries management measures
    7) Impact of scallop harvesting on habitat and habitat recovery rates

b. There is a problem of global assessment; for example in ICES division VIId there is a problem of regulation of the stock (between UK, Ireland and France), and VIIA is a complex mix of 'stocks' with Irish, Northern Irish, Scottish, Isle of Man and English vessels. The North Western Water Regional Advisory Council (NWWRAC) has just schedule a WS next April in UK on that subject, and we will discuss and build upon the resulting advice.
c. All research groups rely heavily on aging methods and proportion by year class is a fundamental dataset. Continuing the discussion on standardizing between surveys, age methods, and life-history/reference points is critical to sustainable management.
d. Scallop stocks are not well understood and the assessment areas were defined to reflect the characteristics of the fisheries in the past rather than on the basis of evidence to support discrete populations. Implementing the need to understand the population relationships within and across stock areas.
e. Different management alternatives including spatial management and the increasing use of closed areas and their effect on scallop stock and habitats will be examined.

WGScallop will report by February 2015 for the attention of ACOM.

Supporting Information

Priority:	Essential

Scientific justification:	The proposal to initiate a WG on scallops is justified on the basis of the national and international importance of this fishery in a number of countries in north west Europe and North America. There is currently no common scientific or assessment forum for discussion and development of common assessment methods for scallops. These justifications used in 2013 continue to be valide and provide a bases to build upon. ToR 1 will provide the data on the distribution of fishing effort and landings for scallop in inshore and offshore waters in ICES Areas VI and VII. These data have not been compiled for the region to date. The meeting in 2014 will review information, including simulations of larval dispersal and seabed habitat, to identify stock assessment and management units (ToR 2). This work will identify priority source areas for larval production and generally increase understanding of the source-sink dynamics of scallops. The biological characteristics of scallop are known to vary geographically. ToR 3 will review the available information and cross-reference to the proposed assessment units (ToR 2). Progress towards provision of scientific advice on scallops will be greater where a common approach to assessment of stocks can be developed. Various approaches are currently used, in many cases without a sound biologically basis. ToR 4 will review the application of various methods with a view to developing a standard approach. Data provision and the feasibility of obtaining data relevant to appropriate assessment methods is an important consideration in developing an advisory system for scallops and will be discussed in ToR 5. Scallop fisheries are managed under legislation at the national level and more locally (e.g. in Special Areas of Conservation in the UK). The scientific rationale behind present scallop fisheries management measures and their effectiveness, both in terms of maximising productivity and minimising ecosystem impacts, will be investigated to allow advice to be provided where data deficiency prevents formal stock assessments (ToR 6). Understanding the direct and indirect impacts of scallop dredging and trawling on ecosystems, especially on benthic habitats, is fundamental to achieving successful management of scallop fisheries. Under ToR 7 the impact of scallop dredging will be examined in relation to habitat type (cross-referencing with ToR 2) using fishery-dependent and fishery-independent data (ToR 4). Quantifying recovery rates of benthic flora and fauna will facilitate the provision of advice in an ecosystem context.
Resource requirements:	None.
Participants:	Oliver Tully, Ireland (Marine Institute), Lee Murray, Isle of Man (Bangor University), Ewen Bell, England (CEFAS), Helen Dobby, Scotland (Marine Scotland Science), Eric Foucher, France (IFREMER), Spyros Fifas, France (IFREMER), Gwladys Lambert,

	Wales (Bangor University), Kevin Stokesbury, United States (University of Massachusetts), Brad Harris, United States (Alaska Pacific University), Heather Moore, Northern Ireland (AFBI), David Palmer (CEFAS), Lynda Blackadder Scotland (Marine Scotland Science), Jonas Jónasson, Iceland (HAFRO), Carrie McMinn, Northern Ireland (AFBI), Sarah Clarke, Ireland (Marine Institute), Isobel Bloor, Isle of Man (Bangor University), Bryce Beukers-Stewart England (University of York), Strand Øivind, Norway (IMR)
Secretariat facilities:	None.
Financial:	No financial implications.
Linkages to advisory committees:	ACOM
Linkages to other committees or groups:	There are no obvious direct linkages.
Linkages to other organizations:	There are no obvious direct linkages.

Annex 3: VIIa (Tuskar)

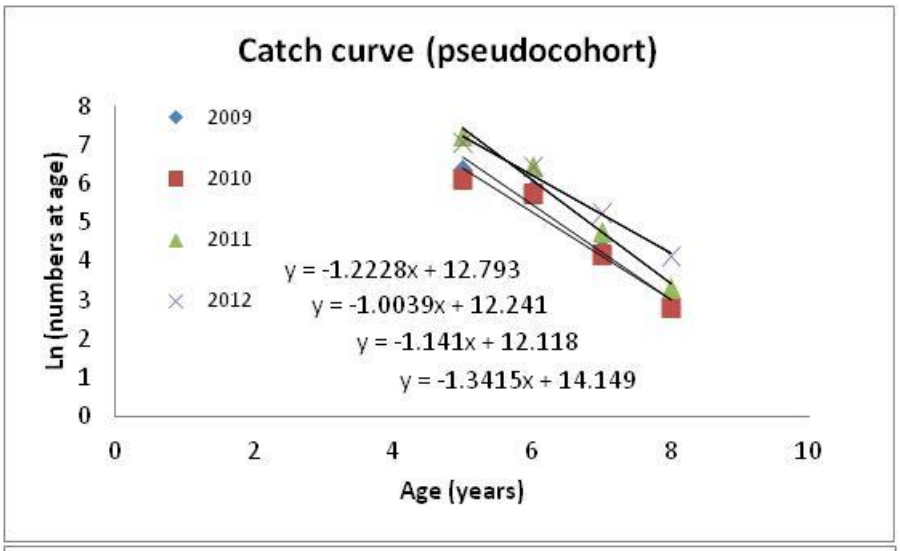
Landings, effort and LPUE

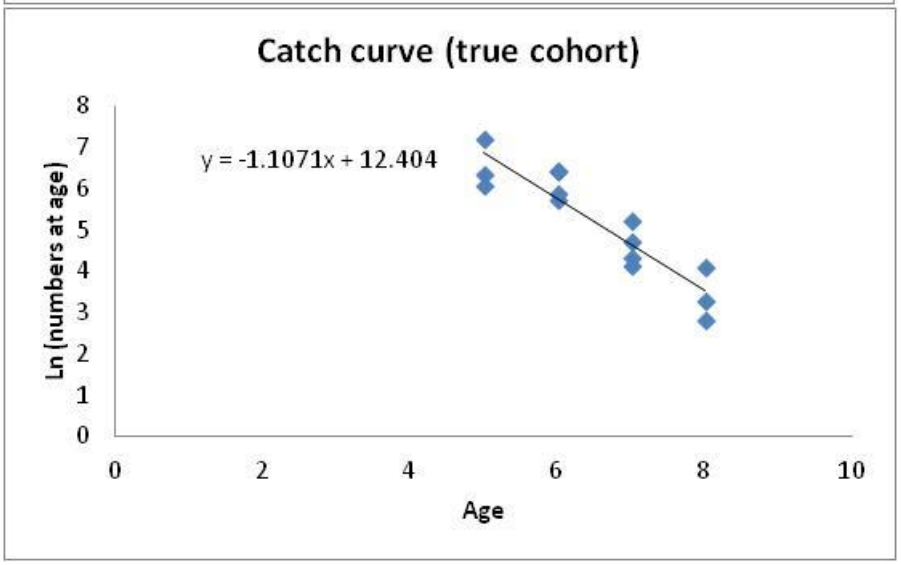
Comments on data quality: Scallop catch and effort data from EU logbooks; 1995-2004 Includes landings by rectangle for Scottish vessels. Number of dredges from logbook records or in most cases obtained independently from the vessel owner. The number of hrs fished per day is poorly recorded in logbooks and is unreliable. Catch rate data can only be resolved to dredge.day and not to dredge.hour. Catch data for years 2001-2004 estimated from catch rate per dredge per day and number of dredges. Some data for landings are missing because of incomplete logbook data. Total landings from the official national landing stats (Source: www.SFPA.ie) are used to raise the log book recorded landings according to the ratio official stats/logged land for each year. This distributes the 'missing data' equally across all vessels and rectangles. This assumes all vessels and ICES rectangles have the same proportion of landings missing. Catch rates associated with catch per day of over 10 tonnes are deleted as implausible

Year	Total	LPUE (kgs.dredge.day)
1995	33.7	69.5
1997	43.9	36
1998	17.5	27
1999	42.8	31.8
2000	583.2	45.4
2001	311.1	35.2
2002	425.8	37.1
2003	127.5	34
2004	200.4	43.4
2005	14.4	48.19
2006	53.2	81.186
2007	161	66.448
2008	279.1	83.358
2009	188	78.972
2010	3.9	110.23
2011	39.2	94.388

Age composition of the landings and estimates of Z

Size composition data are available for the period 2009-2012. Using an age length key derived for the period 2001-2004 these data have been converted to age composition. A crude raising factor of the ratio of the sample weights to total weight of the landings provides the age composition of the landings. A pseudocohort (analysis of numbers at age in a single year data) or true cohort analysis provides estimates of Z of 1.1 between ages 5-8. There are currently too many sources of bias and uncertainty in these data and methods. Age length keys need to be updated annually or quarterly and used to raise the size composition of the landings to age composition. This process also needs to be disaggregated to ICES rectangle within stock to account for spatial variability in growth rate. Improved raising procedures are needed.


Catch curve (pseudocohort)
2009
2010
2011
2012
y = -1.2228x + 12.793
y = -1.0039x + 12.241
y = -1.141x + 12.118
y = -1.3415x + 14.149
Ln (numbers at age)
Age (years)
0
1
2
3
4
5
6
7
8
0
2
4
6
8
10


Catch curve (true cohort)
y = -1.1071x + 12.404
Ln (numbers at age)
Age
0
1
2
3
4
5
6
7
8
0
2
4
6
8
10

Annex 5: VIIg (Celtic Sea)

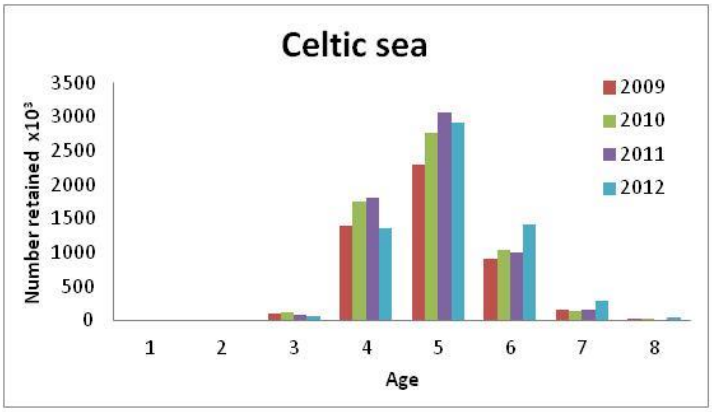
Landings, effort and LPUE

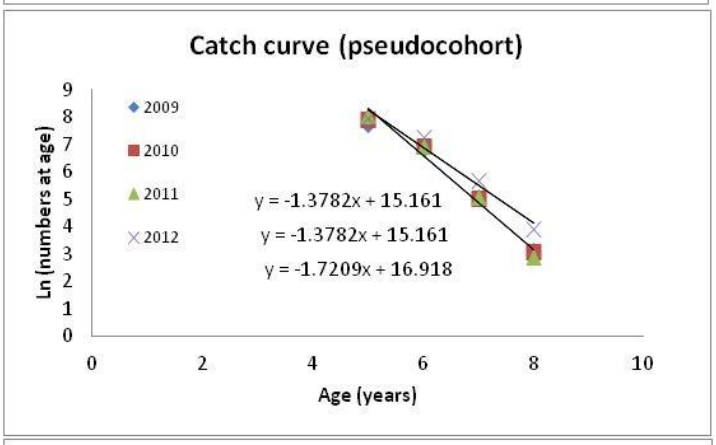
Comments on data quality: Scallop catch and effort data from EU logbooks; 1995-2004 Includes landings by rectangle for Scottish vessels. Number of dredges from logbook records or in most cases obtained independently from the vessel owner. The number of hrs fished per day is poorly recorded in logbooks and is unreliable. Catch rate data can only be resolved to dredge.day and not to dredge.hour. Catch data for years 2001-2004 estimated from catch rate per dredge per day and number of dredges. Some data for landings are missing because of incomplete logbook data. Total landings from the official national landing stats (Source: www.SFPA.ie) are used to raise the log book recorded landings according to the ratio official stats/logged land for each year. This distributes the 'missing data' equally across all vessels and rectangles. This assumes all vessels and ICES rectangles have the same proportion of landings missing. Catch rates associated with catch per day of over 10 tonnes are deleted as implausible

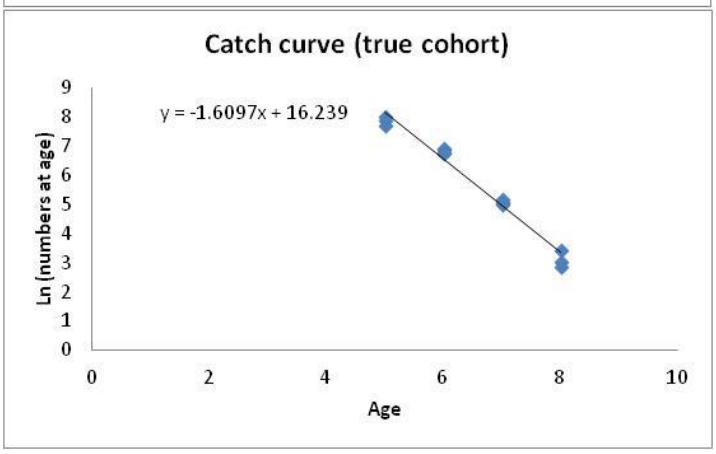
Year	Landings (tonnes)	Cpue (kgs.dredge.day)
1995	380.8	19.0
1996	599.0	31.6
1997	818.3	35.0
1998	591.3	44.4
1999	1245.9	47.5
2000	941.2	34.6
2001	318.6	30.9
2002	304.1	32.1
2003	545.0	32.5
2004	567.0	36.1
2005	497.2	52.5
2006	479.6	50.6
2007	658.7	47.6
2008	844.5	55.1
2009	860.6	72.2
2010	1096.2	83.0
2011	1113.0	80.5

Age composition of the landings and estimates of Z

Size composition data are available for the period 2009-2012. Using an age length key derived for the period 2001-2004 these data have been converted to age composition. A crude raising factor of the ratio of the sample weights to total weight of the landings provides the age composition of the landings. A pseudocohort (analysis of numbers at age in a single year data) or true cohort analysis provides estimates of Z of 1.6 between ages 5-8. There are currently too many sources of bias and uncertainty in these data and methods. Age length keys need to be updated annually or quarterly and used to raise the size composition of the landings to age composition. This process also needs to be disaggregated to ICES rectangle within stock to account for spatial variability in growth rate. Improved raising procedures are needed.


Celtic sea
Number retained x10³
3500
3000
2500
2000
1500
1000
500
0
1
2
3
4
5
6
7
8
Age
2009
2010
2011
2012


Catch curve (pseudocohort)
Ln (numbers at age)
Age (years)
2009
2010
2011
2012
y = -1.3782x + 15.161
y = -1.3782x + 15.161
y = -1.7209x + 16.918

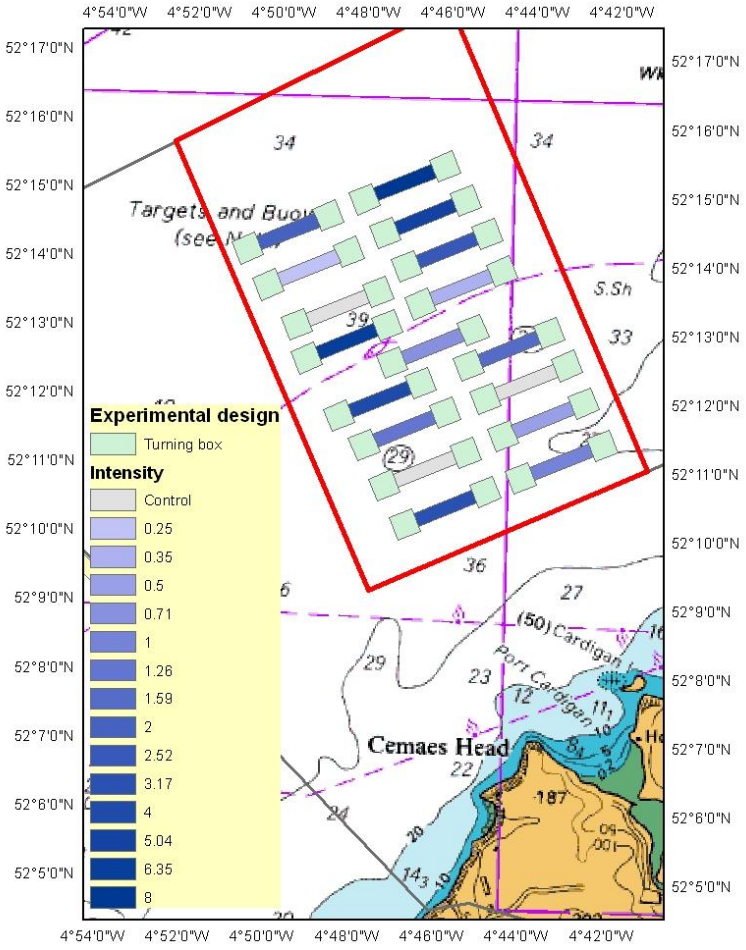

Catch curve (true cohort)
Ln (numbers at age)
Age
y = -1.6097x + 16.239

Annex 6: Proposed Habitat study for Cardigan Bay

Bangor University is proposing to run an experiment in the Cardigan Bay SAC, as part of their European Fisheries Fund project. The work aims at quantifying the effect of scallop fishing on the seabed in order to advise the Welsh Government on possible sustainable options for the scallop fishery in an ecosystem approach framework.

The experiment will consist of 14 corridors fished by scallop dredgers across a gradient of fishing intensities (+ 3 control sites). The effect of dredging on the benthic ecosystem will be assessed by sampling the seabed before and directly after scallop dredging with the RV Prince Madog. At least one more scientific survey will be conducted after a few months to monitor recovery.

Bangor University's request to undertake this Cardigan Bay scallop fishing intensity study has been submitted to the Welsh Government and NRW and the appropriate assessment is underway (as of the 10th of January 2014).



Experimental area and proposed design. The key refers to the number of times the area is to be swept, with 0.25 referring to a quarter of an area being swept, 1 an area being fully swept once and 8 an area being fully swept 8 times.

Full proposal:
http://fisheriesconservation.bangor.ac.uk/wales/documents/Fishingintensitytrial_Experimentaldesign_201213.pdf