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Interim Report of the Working Group on Cephalopod Fisheries and Life History (WGCEPH)

8–11 June 2015

Tenerife, Spain

ICES

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Executive summary

Cephalopod resources in the ICES area have apparently fluctuated with no clear trend in the last 4 years (2010–2013). Reported landings have varied from a minimum of 38 600 t in 2009 to a maximum of 55 500 t in 2004. In general each nation maintains a consistent proportion of the total share of annual landings.

In 2015, a new data requirement was launched to specific countries exploiting cephalopods in ICES areas. Information on data availability is presented in Annex 3.

In 2015, the CPUEs series for individual metiers and surveys were updated. The CPUE from the ARSA survey in Div. IXa as s appears to closely follow trends in LPUE from the commercial fleet.

Analytical assessments were attempted for *Loligo* spp. in the Bay of Biscay and *Sepia officinalis* in the English Channel. Other analytical assessment possibilities have been identified and work on this will continue during 2015/2016.

Recent European Policies and Directives which mention cephalopods (or indirectly, affect them) have been reviewed for possible implications for fisheries, ecosystem effects and research.

The need to monitor cephalopods by means of assessment, even if this assessment is not analytical is highlighted. There is a need for assessment models suitable for estimating cephalopod population levels and exploitation rate to be integrated into the forthcoming ecosystem-based fisheries assessment and management.

An update is provided on the possible use of cephalopods as indicators and descriptors of GES under the MSFD, largely based on the work in the UK.

This expert group is producing a literature database for recent publications on cephalopod biology, fisheries, and ecology.

WGCEPH has progressed in its 3 year plan. ToRs and products have been redefined based on a clear direction of the group: science and advice based on two basic pillars: i) fisheries: statistics and stock status and ii) ecosystem: knowledge revision and integrated assessment.

1 Administrative details

Working Group name

Working Group on Cephalopod Fisheries and Life History

Year of Appointment within the current cycle

2014

Reporting year within the current cycle (1, 2 or 3):

Year 2

Chair(s)

Marina Santurtún, Spain

Jean-Paul Robin, France

Meeting venue

Tenerife, Spain

Meeting dates

8–11 June 2015

2 Terms of Reference (summarised) and Work plan

ToR	Description	Background	Duration	Expected Deliverables
a	Report on status and trends in cephalopod stocks: fishery statistics (landings, directed effort, discards and survey catches). Produce and update CPUEs and survey data series for main cephalopod métiers and species. Start exploring economic data collected under Data Call.	Baseline work of the ToR is the result of the data call.	Year 1 (2014), 2 (2015) and 3 (2016)	Peer-review paper in relation to status and trends (Year 3).
b	Preliminary assessments of the main cephalopod species in the ICES area. Assess production methods (Y1). Explore other methods (Y2). Carry out assessment (Y3).	Data is collected with the purpose of assessing cephalopod status for Integrated Ecosystem Assessment (IEA).	Year 1, 2 and 3	Report on the cephalopods assessed.
c	Implications of the application of some Policies and Directives on cephalopods: e.g. CFP (no discards); New regulation of Manipulation of Animals for research; Natura 2000, Blue growth (wind farms)	There are no policies or management measures directed to cephalopods but pressures and activities would affect them.	Year 1, 2 and 3	Report on effects of directives and policies on cephalopod assessment .

d	Review main population parameter: length distribution, sex ratio, first maturity at age, first maturity at length, growth, spawning season (Year 2).	Update main population parameters to assess stock status.	Year 2	Peer review paper in relation to population dynamics, biology. (Year 2) Report of a methodological paper about sampling resolution for best data collection for each stock/species. (Year 2)
e	Review and report on cephalopod research results including all relevant aspects of: biology, ecology, physiology and behavior, in field and laboratory studies (Year 1, Year 2 and Year 3)	Need of updating knowledge.	Year 1, 2 and 3	Database of scientific articles. Data base on already existing tools (e.g. Mendelei,). Report.
f	MSFD and Integrated Ecosystem Assessment: Relevant MSFD indicators (biodiversity, community role, exploitation and contaminants) applied to cephalopods.	Need to describe the state and pressure of cephalopods under MSFD descriptors and indicators.	Year 1, 2	Report on MSFD descriptors applicable to cephalopods.
g	Collect and explore social and economic data (Y2), final analysis (Y3). Data on: landings in value; effort; number of licenses; number of fishers and vessels and governance measures.	Cephalopods are increasingly important for small-scale fisheries across Europe.	Year 2, 3	Peer-review paper in relation to socioeconomic importance, management and governance of cephalopods in Europe (Year 3)
h	Produce short section for the ICES Ecosystem Overviews on the state of cephalopod diversity/populations, for each of the following ICES ecoregions: North Sea, Celtic Seas, Bay of Biscay & the Iberian coast and Baltic Sea.	Section address the overall state and pressures accounting for changes in state.	Year 2, 3	Contribution to report on ICES Ecosystem Overviews Year 2 and update in Year 2.

Full version of the ToRs is included in Annex 4.

Summary of Work plan

YEAR 2: 2015	Report on the cephalopods assessed
	Report on effects of directives and policies on cephalopod assessment
	Peer review paper in relation to population dynamics, biology (No delivered see justification in 5).
	Report about sampling resolution for best data collection for each stock/species. This product has been rephrased see section 5.
	Database on scientific articles in relation to the topic worked out every year.
	Report on MSFD descriptors applicable to cephalopods**.** An update is included.
	Contribution to report on ICES Ecosystem Overviews.

3 List of Outcomes and Achievements of the WG in this delivery period

During 2015 (Year 2), the expert group has been able to deliver the following products:

- Report on the update of the CPUEs of commercial fleets and surveys and the trial in assessment for the 4 species groups in significant ICES areas.
- An update on effects of directives and policies on cephalopods
- Report about the need of cephalopod monitoring.
- Database on scientific articles in relation to the topic worked out every year.
- An update on MSFD descriptors applicable to cephalopods.
- Contribution to report on ICES Ecosystem Overviews.

4 Progress report on ToRs and workplan

Taking into consideration year 2015 multiannual work plan and in relation to species section, this section will focus on "**Report on the cephalopods assessed (b)",** which means that it will highlight any assessment of cephalopod species or species groups by area.

4.1 Sepiidae in Subarea VIIde, VIIIabd, VIIIc & IXa

In this section, the species *Sepia officinalis* and *Sepia elegans* are included. Taking into consideration the year 2015 multiannual work plan, this section will focus on assessment of Sepiidae. Other material is included in the Annex. "*Sepia* spp. in Subarea VIIde, VIIIabd, VIIIc & IXa".

4.1.1 Fisheries in ICES Division VIIde

4.1.1.1 Commercial catch-effort data

Standardized French bottom trawl LPUE data are plotted in Figure 4.1.1.1 for the period 1992–2014. The Delta-glm method was used to estimate LPUE. As explained in the annexed working document WD 4 (Alemany *et al.* 2015), LPUE variability is explained by 4 variables: year, month, ICES rectangle and engine power of the vessel.

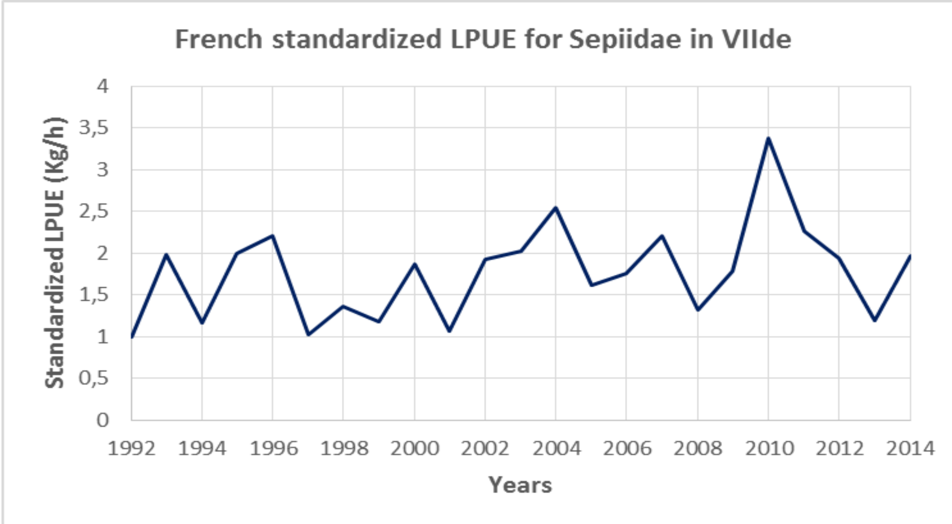


Figure 4.1.1.1. French standardized landings per unit effort using a Delta-GLM method. All values are divided by the first value of the time-series.

4.1.1.2 Fishery independent information and recruitment

The United Kingdom provided abundance indices in kg per hour from the BTS Survey carried out in division VIId in July. France provided abundance indices for the CGFS survey carried out in October each year in division VIId.

Both survey indices are displayed in Figure 4.1.2.1. They have followed similar trends since 2002, although the abundance indices from the BTS survey have shown a more consistent decline.

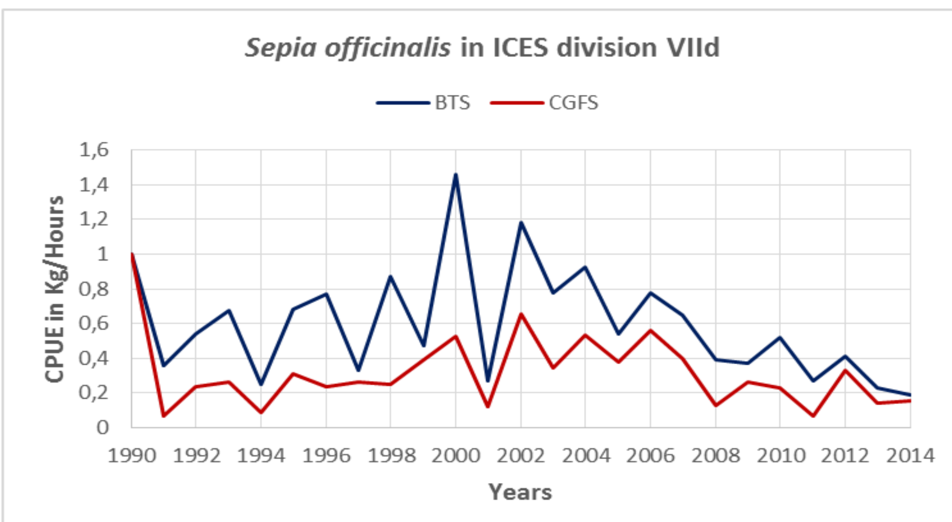


Figure 4.1.2.1. ***Sepia offcinalis*** **abundance indices in division VIId. CPUEs (kg/h) for BTS survey carried out by Cefas in July and CGFS survey carried out by Ifremer in October. All values are divided by the first value of the time-series.**

4.1.1.3 Stock assessment with a two-stage biomass model

In The English Channel (Divisions VIIe and VIId), an exploratory assessment of the cuttlefish stock was available, using a two-stage biomass model (Gras *et al.*, 2014). The last update of the English Channel cuttlefish stock is provided for this report and is presented with more details in the annexed working document (WD 4).

Further work has been done on the two-stage biomass model with a Bayesian implementation of the initial model (WD 4). This allows a more accurate estimation of uncertainty using the resampling method of Monte Carlo simulation instead of bootstrapping, and less time is needed to run the model. Further work is currently underway to achieve a Bayesian model with an estimated growth parameter and better priors, using length frequency data. This model will be available for next year.

4.1.1.4 Management Considerations

Sepia officinalis is managed only in inshore areas in Divisions VIIe and VIId. Along the coast of Normandy a license system is supposed to limit fishing effort and access to the fishery. In France inshore trawling is banned within the 3 miles limit but exemptions are given in some French coastal zones in spring and in late summer. As highlighted by Revill *et al.* (2015), measures that potentially reduce the initial capture of small cuttlefish or increase the survivability could benefit the fisheries in the long term.

It is worth to keep in mind that inshore catches depend on the proportion of cohorts that escape offshore exploitation in the wintering grounds (Royer *et al.*, 2006). There is no specific regulation of offshore trawling related to the cuttlefish stock but regulations defined for ground fish apply.

4.1.2 Fisheries in ICES Division VIIIabd

4.1.2.1 Commercial catch-effort data

The time-series of French LPUE is short (2009–2014) because of changes in effort records after 2008. LPUE for French bottom otter trawlers in the Bay of Biscay was calculated using the Delta-GLM method with R software in order to standardize outputs. Factors used were statistical rectangle, vessel power, effort in hours of fishing and year. Results displayed in Figure 4.2.1.1 show an increase between 2009 and 2012, and a subsequent decrease.

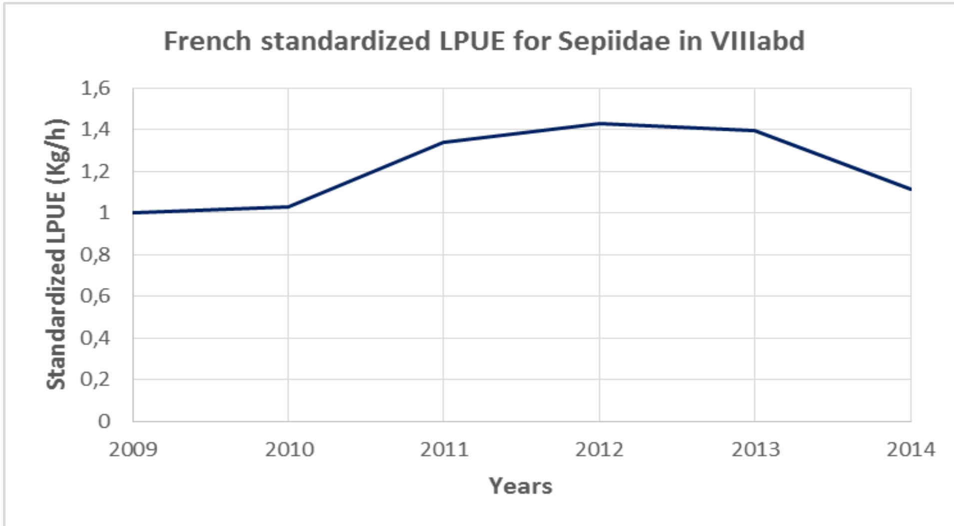


Figure 4.2.1.1. Annual standardized French LPUE for *Sepia officinalis* in Divisions VIIIa,b,d. All values are divided by the first value of the time-series.

4.1.2.2 Fishery independent information and recruitment

In the Bay of Biscay, the annual survey EVHOE carried out by IFREMER in November provides CPUE for Sepiidae. The last update was collected for this report (Figure 4.2.2.1). A decrease is observed in the last year (2014), following the French LPUE trend (Figure 4.2.1.1); CPUE for *Sepia officinalis* remains well below the peak values seen in 1998 and 2008.

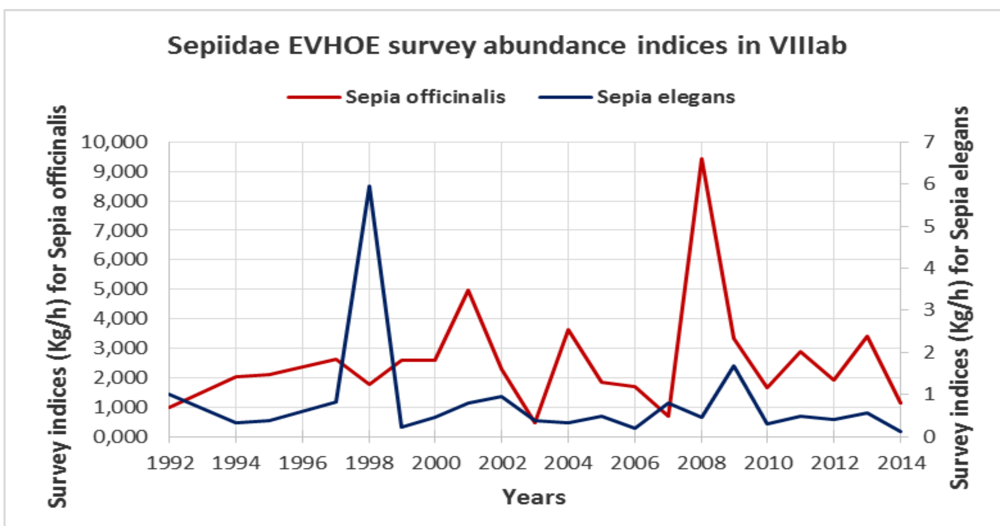


Figure 4.2.2.1. Sepiidae CPUEs (kg/h) according to the Ifremer "EVHOE" survey carried out in Subarea VIIIa,b from 1992 to 2014. All values are divided by the first value of the time-series.

4.1.3 Fisheries in ICES Division VIIIc & IXa

4.1.3.1 Commercial catch-effort data

Spanish OTB LPUE in kg per fishing trip shows a high interannual variability in cuttlefish abundance (Figure 4.3.1.1). Over the whole period a weak increasing trend can be observed in commercial LPUE in Division IXa South (solid blue line) which is not evident in Divisions IXa North and VIIIc (solid red line). In 2014, a decrease is observed.

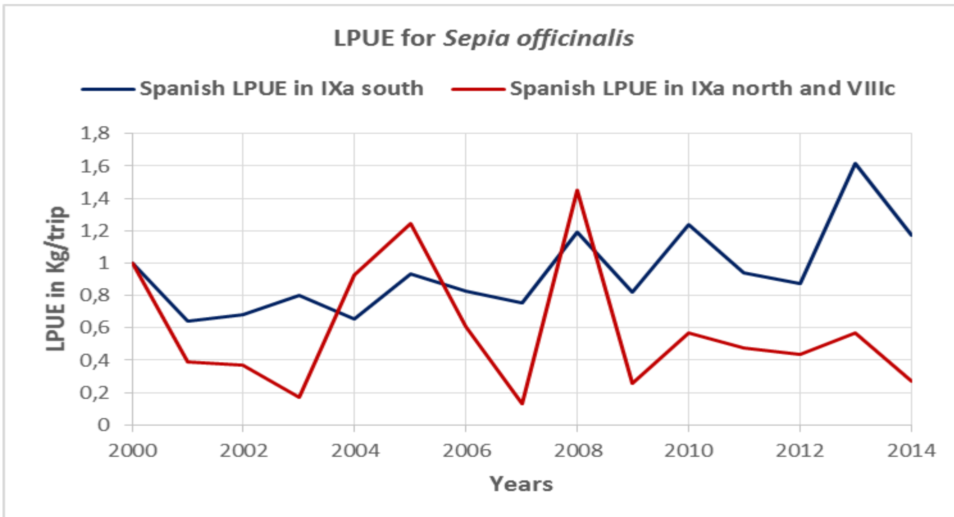


Figure 4.3.1.1. ***Sepia officinalis*** **LPUE in Divisions IXa South and IXa North/VIIIc. All values are divided by the first value of the time-series.**

4.1.3.2 Fishery independent information and recruitment

Time-series of abundance indices were updated for areas IXa and VIIIc (Figure 4.3.2.1). Both commercial LPUE (Figure 4.3.1.1) and survey abundance indices (Figure 4.3.2.1) seem to follow the same trend in Division IXa south.

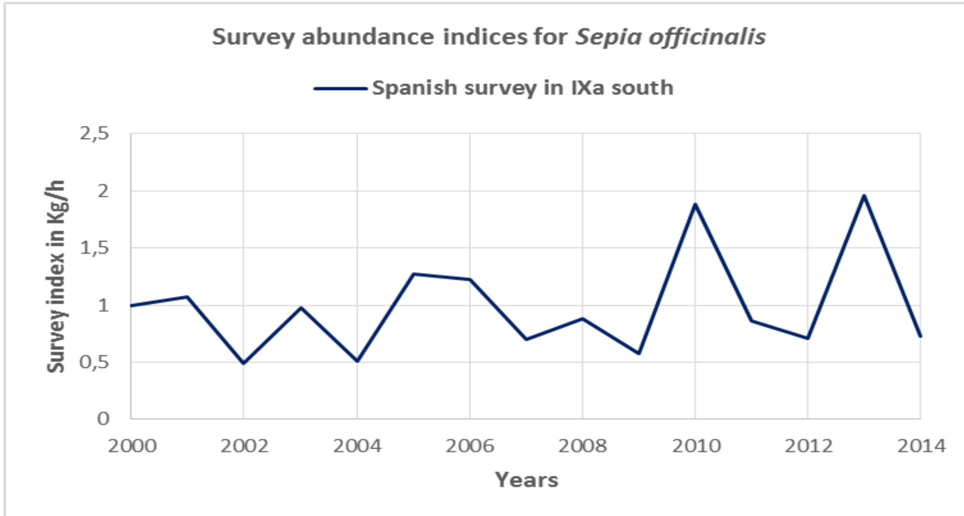


Figure 4.3.2.1. ***Sepia officinalis*** **abundance indices in Division IXa South. All values are divided by the first value of the time-series.**

At the present time Portuguese commercial fleet indices are only ones available for the last 4 years. Landings per unit effort (in Kg/day) was 10.1 in 2013 and increased to 11.9 in 2014, following the opposite trend of Spanish LPUE.

4.2 *Loliginidae*

Currently *Loliginidae* are not assessed and there is not a TAC constraint for the stocks. The available information, species identification in landings and the population biology restrict the variety of methods that can be applied to assess the state of squid in the Eastern Atlantic (Pierce and Boyle, 2003). Taking into consideration the multiannual work plan this section will focus on "**Report on the cephalopods assessed (b)",** and will highlight any assessment of *Loliginidae* by area.

4.2.1 *Loligo* spp. Assessment in ICES Division IV

Landings from IVa into Scotland

Data show the expected seasonal cycle as well as a general upward trend between 1985 and 2013. Maxima show marked variation between years and there is a suggestion of a cycle with a periodicity of around 7 years (Figure 4.2.1.1a). GAMS were fitted to determine environmental relationships, with significant effects of SST, photosynthetically active radiation and rainfall being apparent.

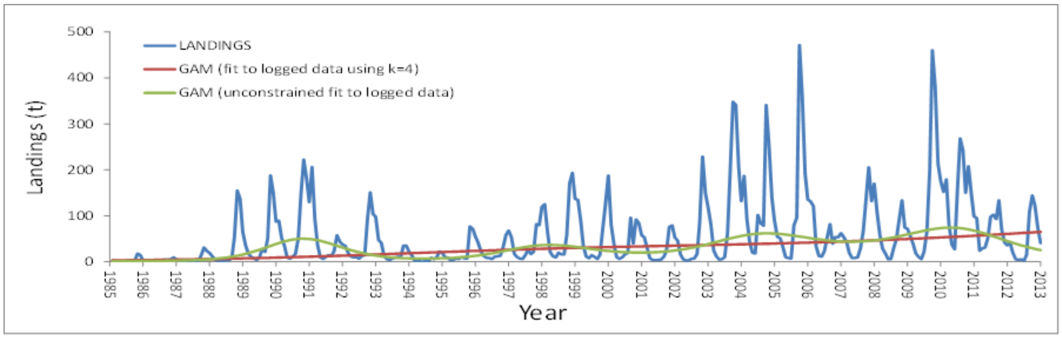


Figure 4.2.1.1a. Monthly landings of squid (*L. forbesii*) from ICES IVa (1985–2013) in Scotland. Two trends lines are also shown. A constrained GAM fit to logged (normalised) data confirms a general upward trend although the unconstrained fit highlights the occurrence of peaks and troughs.

Survey data from MSS

Of around 10 000 survey hauls around Scotland during 1980–2012, approximately 3500 contained *Loligo*. Based on seasons with the best data series in each case, trends in presence over time in the three areas were dissimilar although all three areas showed high presence since 2007 (Figure 4.2.1.2a).

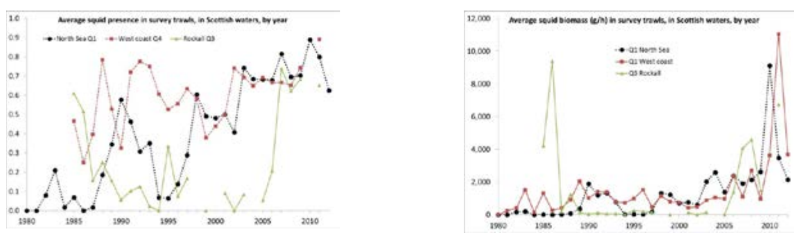


Figure 4.2.1.2. Catches of loliginid squid in MSS surveys: (a) proportion of hauls with loliginids present and (b) average total loliginid biomass per haul, by season and area.

Trends in biomass were more similar for areas IV and VIa and all three areas showed high values in the second half of the decade beginning in 2000 (Figure 4.2.1.2b). Results from modelling revealed a negative effect of haul duration on catch rate (numbers per hour), a negative effect of depth, significant spatial variation and a weak seasonal cycle (with lowest numbers in late summer, as expected). The remaining year-to-year pattern shows a clear peak around 1990 and a general upward trend since the mid-1990s. This yearly pattern is partly explained previous abundance (a positive effect of the previous year's landings) and also shows significant but weak relationships with annual and winter NAO indices.

Survey data from Cefas

Six Cefas survey series yielded abundance indices for loliginid squid, with a wide range of absolute values as well as differences in year-to-year trends. Both *Loligo forbesii* and *L. vulgaris* are likely to be caught in much of the area surveyed, as indeed are *Alloteuthis* spp. The IBTS in southwestern waters (Div. VIIa,e,f,g,h) during November and December, using the GOV trawl, would be expected to coincide with peak abundance of *L. forbesii* and is thus potentially comparable with Scottish data. Catch rates were high but variable, resulting in wide confidence limits. A model standardising for all effects except year shows a similar pattern to the raw annual average catch rates, with peaks in 2004, 2007 and 2011 (Figure 4.2.1.3a).

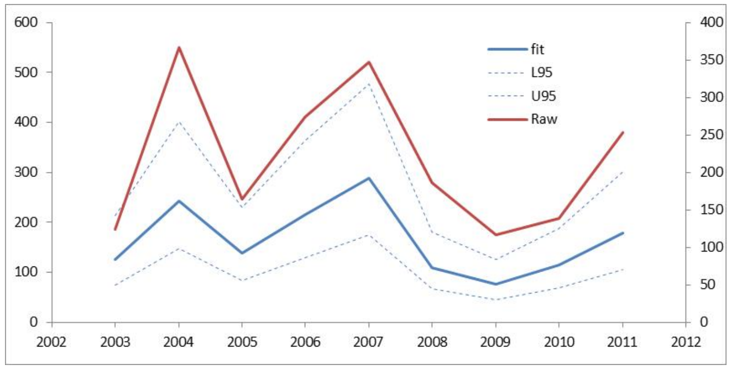
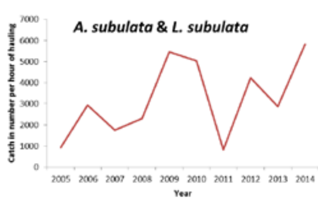


Figure 4.2.1.3a. Survey catch rate (count per hour) of loliginid squid in the Q4SWIBTS surveys (2003–2011): annual average values and modelled values (based on standardising for all other effects included in the model).

Assessment of *Loligo* stock trends based on ICES DATRAS IBTS dataset

Data from this data source included data from Denmark, France, Germany, Netherlands, Norway, Scotland and Sweden. The CPUE values per length and area were summed rto give an overall CPUE for Area IV. A trend analysis was performed for *Loligo* abundance in quarter 1 (Figure 4.2.1.4).



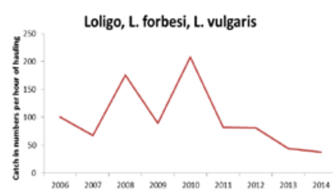


Figure 4.2.1.4. left: CPUE of *A. subulata* (*L. subulata*) in Area IV based on the ICES IBTS Q1 (source: Datras). Right: CPUE of *Loligo, L. forbesi* & *L. vulgaris* in Area IV based on the ICES IBTS Q1 (source: Datras).

Quality of the data

Although high variability in abundance is not unexpected, there are several possible causes for concern about the suitability of the data for trend analysis. The data include different levels of species identification. Furthermore, it is not clear that *A. subulata* and juveniles of other *Loliginidae* have always been accurately distinguished. It would also be useful to check that all cephalopod catch data from each country have been uploaded alongside data for quota species as this has not always been the case in the past.

4.2.2 *L. forbesii* & *L. vulgaris* in ICES Subarea VIId,e

Surplus production models fitted to English Channel (*Loligo forbesii* and *Loligo vulgaris*)

In 2014 an empirical model of English Channel squid abundance was fitted using French Fishery Statistics (Delta-GLM analysis FR-OTB LPUE) and Climatic Variables (SST, wind, NAO); (WGCEPH 2014, Duhem *et al.*, 2014). The present exercise combines the abundance indices and total yields (FR + UK) in a biomass dynamic model. A Schaefer surplus production model is fitted using the ASPIC software (Prager, 1994 version 7.01 Last revised 6 August 2014). The abundance indices show large inter-annual variability. Some graphical outputs of the model are shown in figure 4.2.2.1a. Series or both *Loligo* species show a peak in 2005 but trends are otherwise almost opposite. Note that the proportion of both species in catches is based on regular market sampling.

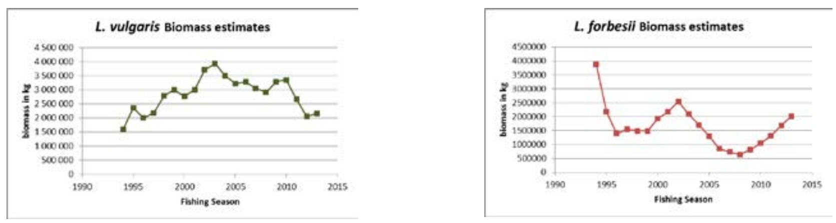


Figure 4.2.2.1a. Biomass estimations from the surplus production models fitted to English Channel squid (*Loligo forbesii* and *Loligo vulgaris*).

Quality of the assessment

The long term target (MSY) may not be very useful in species that undergo wide environmental variation. However, models could be improved by incorporating environmental data (Sobrino and Silva in WGCEPH2014). In the case of squid in the English Channel, environmental variables could be those of the empirical model predicting abundance. Biomass estimates are needed in Food Web models (and this exercise provides a target BMSY but also B variations).

4.2.3 *Loligo* sp. assessment in ICES Divisions VIIIa,b,d

Surplus production models

The Bayesian state-space version of the Schaeffer model that incorporated both observation and process error was applied to squid in the Bay of Biscay. The time-series of relative biomass with respect to Bmsy and relative fishing mortality with respect to Fmsy are shown in Figure 4.2.3.2. In general the relative biomasses are always above 1, indicating that the estimated biomasses are above Bmsy. The time-series shows some fluctuations but is rather stable around 1.7. Similarly the relative fishing mortalities are also slightly above 1, suggesting that fishing mortality is slightly larger than Fmsy. The uncertainty in both relative biomass and relative fishing mortality time-series is large. Finally, the Pearson residuals are within the range of expected values, but the model is not able to capture large fluctuations like the large index values from 2010 to 2013. In conclusion, the stock seems to be in a rather stable situation. Having additional biological information incorporated through the prior distribution could help to improve the results. Additional information on the stock, e.g. a recruitment index, would allow consideration of alternative models more suitable for short-lived stocks.

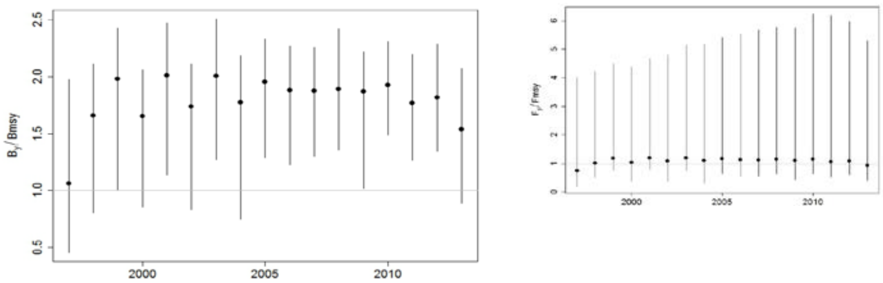


Figure 4.2.3.2. Median and posterior 95% probability intervals for the ratio of biomass and Bmsy (top panel) and for the ratio of fishing mortality and Fmsy (bottom panel) when the second set of prior distributions is used.

4.2.4 *Loligo* sp. *Loligo* sp. stock trends and assessment in ICES Divisions VIIIc & IXa

Stock trends

Abundance of *L. vulgaris* in divisions VIIIc and IXa was estimated from four survey cruises: SP Q4 GFS in VIIIc and IXa north, PT Q4 GFS IXa and SP Q1 & Q4 GFS in IXa south. Abundance decreased in 2014 and was highest in the Gulf of Cadiz.

The commercial CPUE and survey indices obtained by Spain in divisions VIIIc and northern IXa often present conflicting trends. They both nonetheless agree in showing a lower abundance in 2014 than in previous years (Figure 4.2.4.1.).

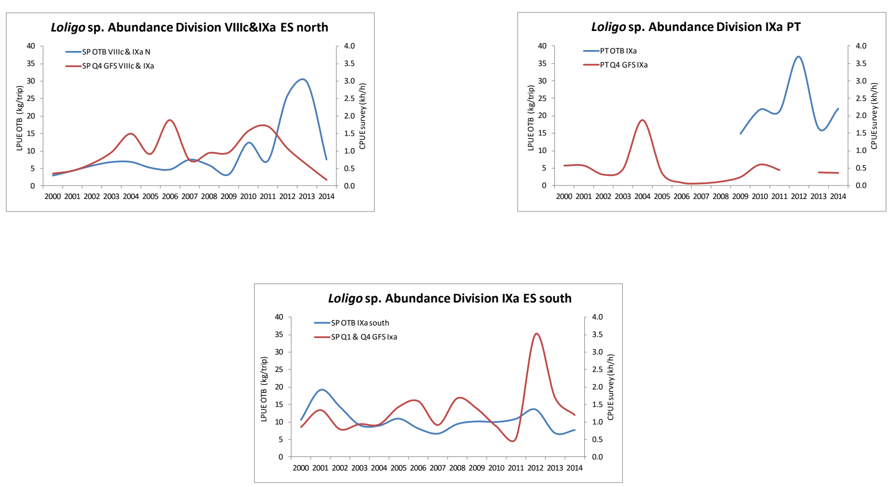


Figure 4.2.4.1. Spanish commercial CPUEs and survey indices in Div. VIIIc and northern IXa.

However, whilst the commercial CPUE index returns to 2011 levels following two years of greater than average abundances, the research survey index now indicates abundances at the minimal levels for this 15-year series. Going further south, the Portuguese commercial index is more variable and does not reflect the same extreme low abundance that is seen further North. It shows a peak in 2012. The research survey index is also without a trend and is presently around average. Further south and east, in the Gulf of Cadiz, both the commercial and research indices show oscillations and no marked trend for the period 2000–2014, both presently around the mean, having decreased from 2012. Data therefore appear to indicate that loliginid squid abundance in the area is presently low in the north and average in the south, but overall relatively low, particularly when compared to 2012.

Assessment of *L. vulgaris* stock status in sub-area IXa

Forecasts obtained from seasonal autoregressive integrated moving average (SARIMA) models were used to monitor the behaviour of *L. vulgaris* time-series of monthly landings (Prista *et al.,* 2011). All models adequately fitted the landings data from the trawling fleet, but an improvement in fit was obtained after considering a trend in the modelling of 4 out of 7 *L. vulgaris* time-series (1995–2013), as strong seasonality is generally detected in the landings. Strong correlations were found between present landings and landings registered in previous months and previous years. Model parameterization closely reflected presently known facts, namely the short life-span, recruitment seasons and typical fisheries practices, thus sustaining the application of the models. SARIMA model forecasts outperformed an array of simpler alternatives indicating an overall usefulness of SARIMA modelling and forecasting in these data-limited scenarios. Most importantly, the prediction intervals of SARIMA models allowed the detection of a recruitment failure in the 2nd semester of 2006 that came to affect the production of European squid by trawl fishery in the following years. In 2013 all time-series were found to be "in-control" from a statistical quality control perspective indicating no evidence for significant changes in the underlying data generating process (for details read Prista *et al*., 2011 and WD 3). However, European squid landings were somewhat lower than expected in the 2nd semester of 2013 (WD 3) signalling a reduction in fisheries production that deserves attention and further investigation.

4.3 *Ommastrephidae* in Subarea II, III, IV, V, VI, VII and Divisions VIIIabd, VIIIc & IXa

4.3.1 Introduction

Short-finned Squid (*Illex coindetii* and *Todaropsis eblanae*), European Flying Squid (*Todarodes sagittatus*), Neon Flying Squid (*Ommastrephes bartrami*) and other less frequent families and species of decapod cephalopods are included in this section. All these species are distributed from ICES Subarea III to Div. IXa, Mediterranean waters and North African coast.

4.3.2 Fisheries in ICES Division IV

Data from the IBTS DATRAS dataset were provided by ICES (downloaded 9 June 2015) and included data from Denmark, France, Germany, Netherlands, Norway Scotland and Sweden. The quality of the data seemed to be insufficient because in 2011 and 2012 species were listed as 'teuthida' showing that problems with species identification occurs. Therefore all *Ommastrephids* were accumulated for analysis and species were not distinguished. This is a general issue for most relevant surveys including CEFAS surveys (England; data not in DATRAS but analysed separately).

Based on the ICES DATRAS IBTS dataset, a trend analysis was performed for quarter 1. CPUE values per length and area (RFA 1-7) were summed for each RFA. After a decrease in 2011 the data show an increase in RFA 1 & 2 and stable and low CPUE values in the other RFA's.

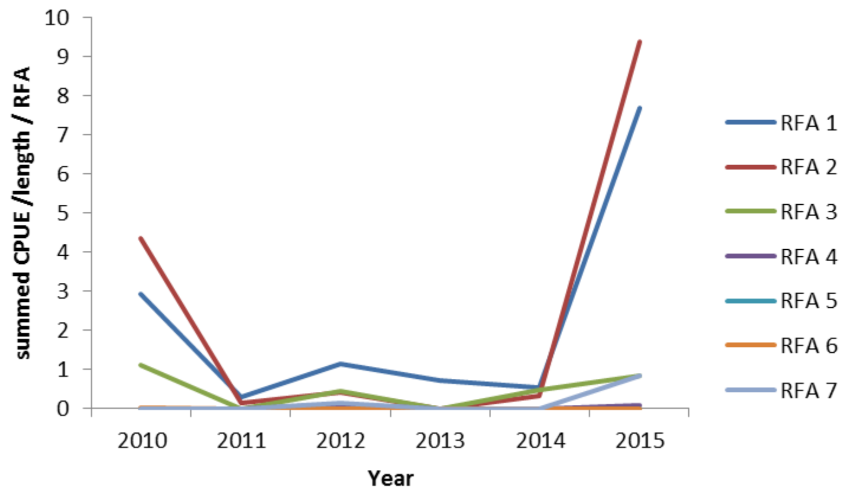


Figure 4.3.2.1a. Summed CPUE per length per area (1-7) based on the ICES IBTS DATRAS (download 9th of June 2015).

Based on the Cefas IBTS data (quarter 3 North Sea survey), average annual catch rates were extracted as well as standardized rates (based on a GAM that also accounted for spatial and day-of-year variation (Figure 4.3.3.2a)).

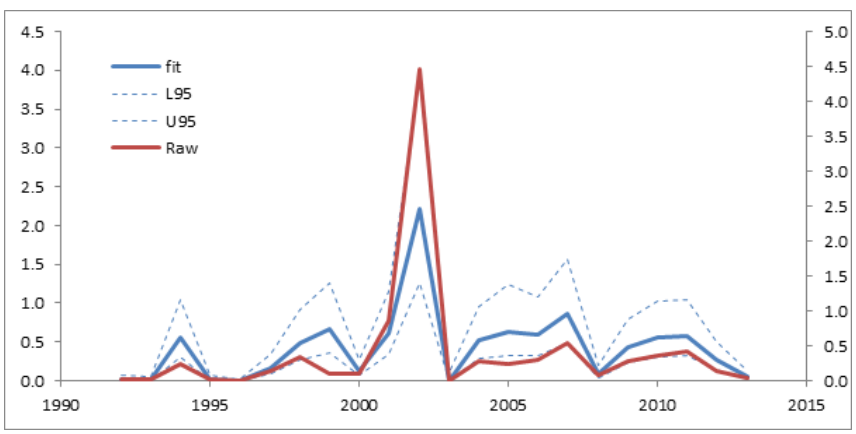


Figure 4.3.2.2a. Ommastrephid squid caught per 30 minute haul in the Cefas IBTS3E survey): raw data (red, left axis) and standardized for effects of spatial and seasonal patterns (blue, right axis).

4.3.3 Fisheries in ICES Division VIIabcdegk

Available commercial landing data show a value between 300 and 1200 tonnes per year in area VII. Most landings were reported by Spain in VII b+c and VIIg+k and by France in VIId+e and VIIg+k respectively. However, data from England, Scotland, Northern Ireland, Ireland, Wales, Netherland and Germany report undifferentiated landings of *Loliginids* and *Ommastrephids*. Therefore, it is questionable how useful these available landings data are.

Cefas survey data permit some analysis of trends in area VII. The VIId beam trawl survey (BTS7D) and the northwest ground fish survey NWGFS caught too few *ommastrephids* to examine trends. Trends extracted from the remaining three survey programmes look rather different but in all cases confidence limits are wide. Catch rates were low in Q1SWBEAM (quarter 1) but a general upward trend in ommastrephid catch rate was seen from 2006 to 2015. Catch rates in Q4IBTS (quarter 4) were also low, rising from 2003 to a peak in 2008 and then falling again to 2011. Catch rates in WCGFS were higher than in the other two survey series and suggested a general increase from 1982 to 1993 followed by a decline to 2004. These trends are illustrated below.

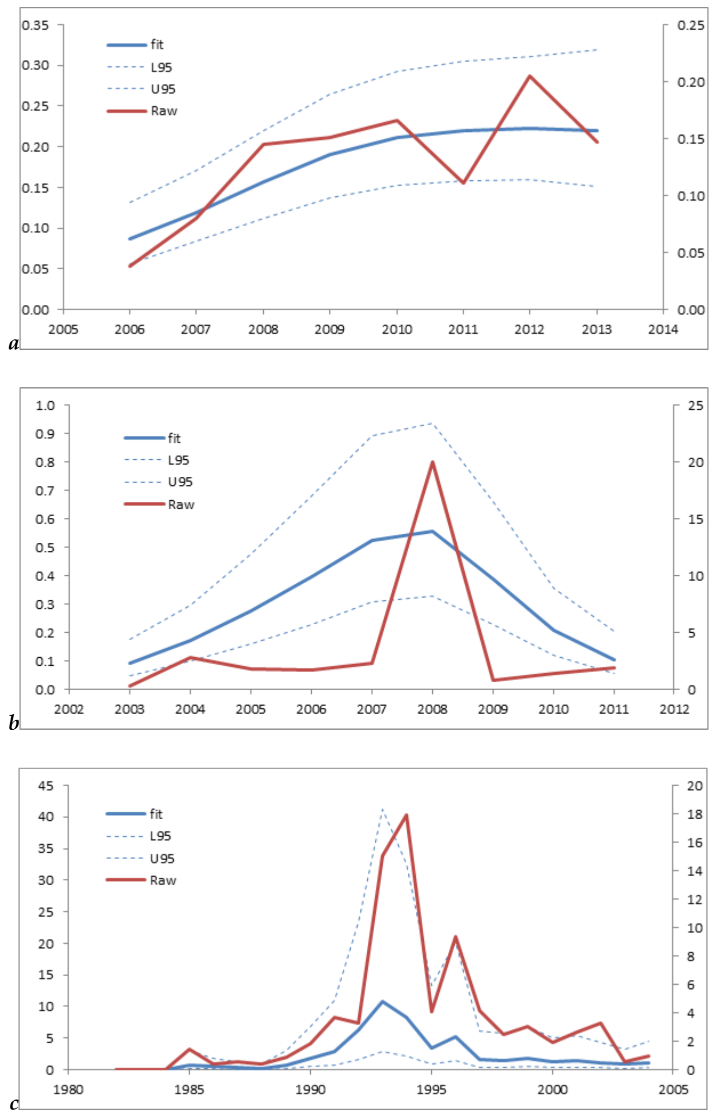


Figure 4.3.3.1 Trends in ommastrephid catch rates (numbers per 30 minute haul) in area VII from Cefas surveys: (a) Q1SWBEAM, (b) Q4SWIBTS, (c) WCGFS. Each graph shows raw data (red, left axis) and standardized for effects of spatial and seasonal patterns (blue, right axis).

As for area IV, there are concerns about the lack of taxonomic resolution in the data. There are also concerns about the suitability of some of the trawl gears used and indeed doubts about the consistency of reporting.

4.3.4 Fisheries in ICES Division VIIIabd

Countries contributing to *Ommastrephids* catches in Division VIIIabd are France and Spain. In 2014, France landed 230 t of *Ommastrephids* (83% of catches) from Div. VIIIabd, while Spnish landings amounted for 48 t (17% catches).

No assessment is presented. Spanish Commercial LPUE and French EVHOE Survey abundance indices present conflicting trends. As Ommastrephidae are not among target species for those fleets, and catches may not always be landed, the LPUE obtained could not be considered as abundance indices for this group of species.

4.3.5 Fisheries in ICES Division VIIIc & IXa. Assessment

Overall, landings of *Ommastrephids* amounted to 2998 t caught by Spain and Portugal. The 62% of landings from ICES Div. VIIIc and around 38% in Div. IXa. Spain comprise 99 % of the catches of these species in Div. VIIIc and 90% for Div. IXa.

Variation in abundance indices from Spanish Commercial and Survey series showed some correspondence. Thus, high abundances were seen at the beginning of the data series in 2000, low abundance for most intermediate years and increasing abundance from around 2011 although with high fluctuations.

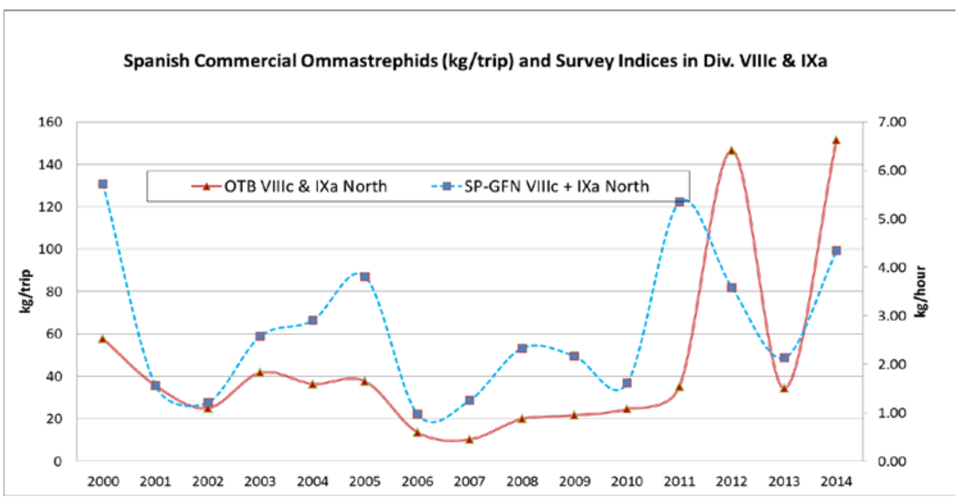


Figure 4.3.5.1. Comparison between LPUEs (kg/trip) and Abundance Indices (kg/h) trips of the Spanish commercial fleet and Scientific Surveys in Divisions VIIIc & IXa North.

The coincidence in trends of the indices obtained in the Spanish surveys has to be treated with caution. The survey will represent the abundances, either by covering the whole area of distribution of the species and because the gear used and timing of survey were adequate considering the characteristics and dynamics of the species. However, it has to be noted that at least 2 to 3 species are represented in these indices.

For Div. IXa south, commercial and survey data series provided by Spain appear to coincide also in trends and in peaks of abundance detected. However, the survey index did not show the marked high abundance seen in the commercial LPUEs series in 2011. As commented above, for Div. VIIIc and IXa, high abundancess were seen the first years of the data (2000–2003) series and in 2010–2012. These promising results enhance the possibility of using these data series as abundance indices for *Ommastrephids*.

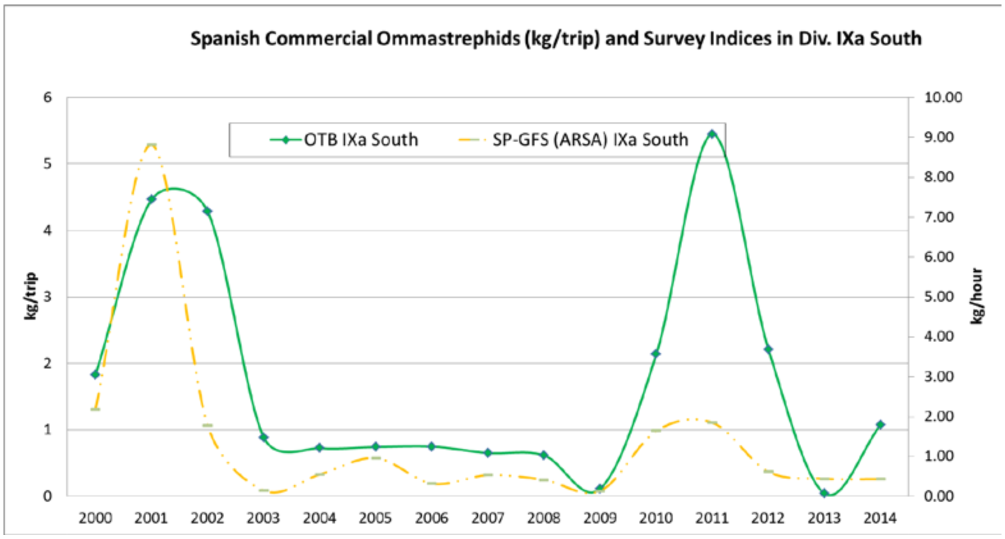


Figure 4.3.5.2. Comparison between LPUEs (kg/trip) and Abundance Indices (kg/h) trips of the Spanish commercial fleet and Scientific Surveys in Divisions IXa south.

A trial of two stage biomass model assessment was proposed for some *Ommastrephids* for the next year if species could be identified from survey information. In some survey series (e.g. Cefas data), *ommastrephids* are occasionally identified to species and it is possible that ratios of the species could be estimated. More promisingly, landings of *ommastrephids* in Galicia (Spain) have been identified to species during market sampling (see Working Document 1 in the WGCEPH report from 2009). However, the lack of identification to species in both survey and commercial data is an ongoing problem.

4.4 *Octopodidae* in Subarea, VIIIabd, VIIIc and IXa

In this section, the species ***Octopus vulgaris***, ***Eledone cirrhosa*** and ***Eledone moschata*** are included. Taking into consideration year 2015 multiannual work plan, this section will focus on "**Report on the cephalopods assessed (b)",** which means that it will highlight any assessment of *Octopodidae* by area. The other sections will be included in the Annex.

In northern European waters, octopus are of low interest to fisheries. *Octopus vulgaris* is largely absent and there has generally been little interest in exploiting *Eledone cirrhosa.* However, survey abundance indices are available for Scotland (see MacLeod *et al.*, 2014) and there is some local consumption of the species in Scotland (G. Pierce, pers. Obs.).

4.4.1 Fisheries in ICES Division VIIIabd. Assessment

Catches of *Octopodidae* species are scarce in this area. *E. cirrhosa* account for more than 95% of the total catches, and it appear in the logbooks grouped by family level: *Octopodi-*

dae. Basque LPUEs were calculated for *O. vulgaris* and *E. cirrhosa* separately, aggregated by gear. Overall, fluctuating trends are observed for both *Octopodidae* species with a notable increasing trend for the most recent years. No survey data is presented in this section.

4.4.2 Fisheries in ICES Division VIIIc and IXa. Assessment

In 2014 and for the whole area here considered (Div. VIIIc and IXa), Portugal contributed around 66 % of the landings. Landings are mostly concentrated in Division IXa from which Portugal takes 75 % and Spain 25 %. Total catches of *O. vulgaris* in Division VIIIc and IXa were 14 280 t, less 0.5% being discarded. Subdivision IXa-centre (Portuguese waters) and IXa north provide the highest values for landings in 2014, with 10 626 and 1641 t, respectively, followed by landing in the south of Subdiv.IXa, with 990 and 961 tonnes. For the whole area, the majority of landings were provide by the artisanal fleet.

Total catches of *Eledone* spp in Div. VIIIc and IXa were 944 tonnes, with 106 tonnes of estimated discards from the OTB metier in VIIIc and IXa north and 10 t in IXa south. The highest discards were in Subdiv. IXa south (465 t), followed by IXa north and VIIIc (378 t). Discards in Subdiv. IXa-center were estimated as 101 t.

Fishery independent information is supplied by different surveys carried out annually in the four quarters of the year in Iberian waters by Portugal and Spain: SP-NGFS "DEMERSALES survey" carried out in VIIIc and IXa north, P-GFS survey in IXa-center by Portugal and SP-GCGFS "ARSA survey" in IXa south.

Effort data is available for Spanish single trawls (OTB), by fishing trip for all Iberian waters. Trawl LPUE series (Octopus catches/nº fishing trips) in Div. VIIIc and IXa and Div.IXa-south show conflicting signals although with a similar trend in 2013/2014 (Figure 4.4.2.1). Thus, in Div.IXa-south the trend is generally opposite to that from the north of Spain, with a decreasing trend from 2005 to 2011 when the minimum values of the time-series were reached.

Portuguese LPUEs compared to those of Spanish otter trawlers in Div. VIIIc show same pattern of a peak of yield in 2010 (75 kg/d) with a decrease in 2011 and increasing again in 2012 and 2013. This maximum in 2010 is at the same level as the historical yield in 2000 reached by the Spanish trawlers. There is no data available for the Polyvalent fleet in 2014.

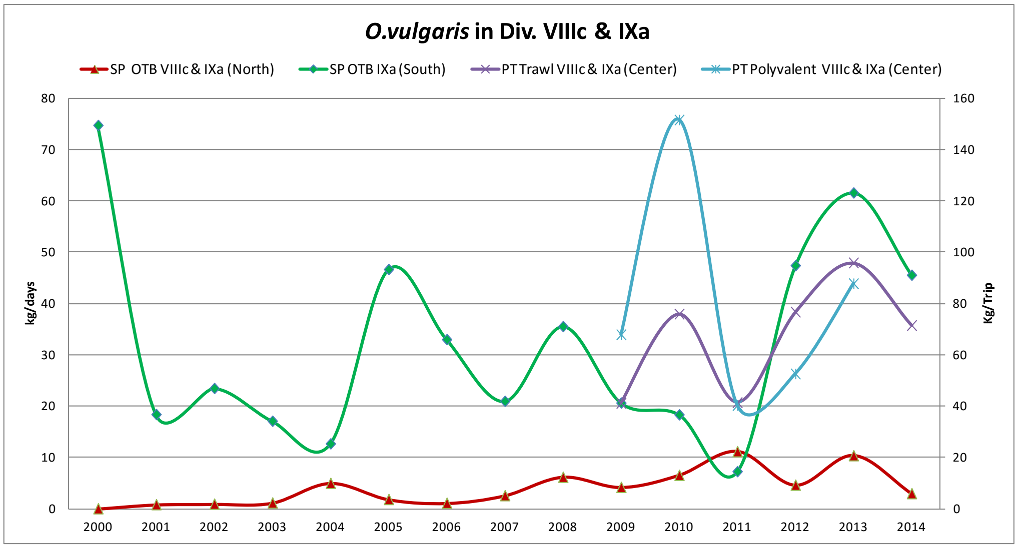


Figure 4.4.2.1. Commercial LPUE for *O. vulgaris* in the Spanish (kg/trip) and Portuguese (kg/d) fleets in Div. VIIIc and IXa.

The biomass indices obtained in the different survey appears to provide a robust abundance index of this species in each area, except for Portuguese waters. In order to test their quality as abundance index, these have been plotted with the corresponding fishing LPUE series for the same area. For the commercial LPUE indices just data from "Baca" Otter trawlers are used in the analysis. In all series, it should be taken into account that the fishing effort used in the different LPUE series was not directed effort to *O. vulgaris*. Furthermore, the LPUE series in the north of Spain has been obtained for the total area, VIIIc and IXa together, due to the "Demersal" survey covering these two Divisions. In division IXa south, Gulf of Cádiz, the survey index used is the average value of the two surveys carried out during the year in this area (Spring-Autumn).

Figure 4.4.2.2 shows the Spanish Demersal survey biomass index for *Octopus vulgaris* plotted jointly with annual data series coming from Spanish commercial bottom trawl fleet "Baca" (OTB) in VIIIc and IXa north. Both series show a general upward trend and a drop in the last year (2013/2014) but correspondence of peaks and troughs is generally poor.

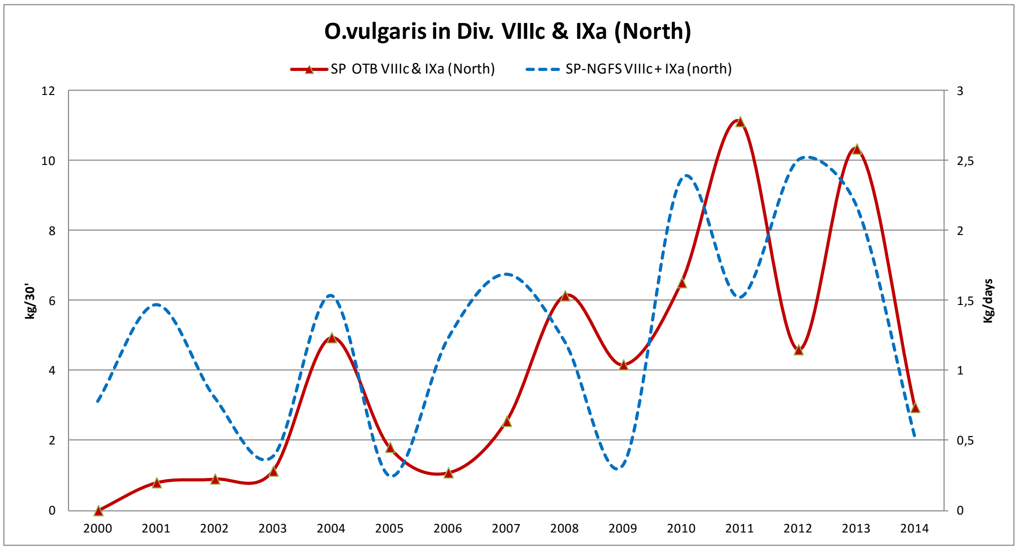


Figure 4.4.2.2. Comparison of Commercial LPUE trends for *O. vulgaris* of the Spanish (kg/trip) fleets and Spanish Scientific Survey (kg/h) in Div. VIIIc and IXa.

The series of commercial fleet (OTB) and ARSA survey biomass indices in Div. IXa south are shown in Figure 4.4.2.3. In this case, the trend of both sets of data show high similarities throughout the time-series.

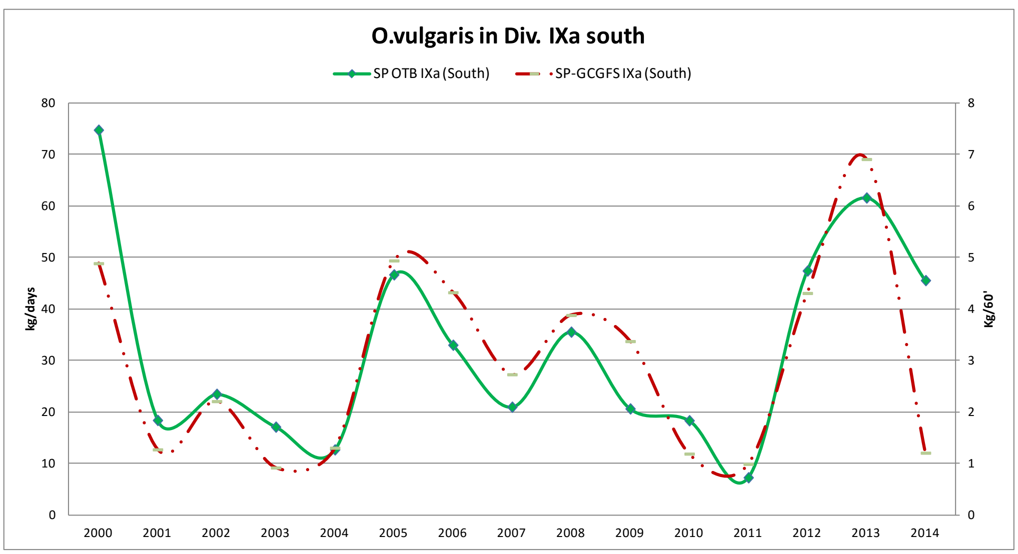


Figure 4.4.2.3. Comparison of Commercial LPUE trends for *O. vulgaris* of the Spanish (kg/trip) fleets and Spanish Scientific Survey (kg/h) in Div. IXa south.

The demersal survey biomass index for *E. cirrhosa* is plotted jointly with annual LPUE series from the commercial bottom trawl fleet "Baca" (OTB) in VIIIc and IXa north (Figure 4.4.2.4.). In this species some similarities can be observed in the trends, although from 2010 to 2012 and 2000 to 2004 the trends are opposite.

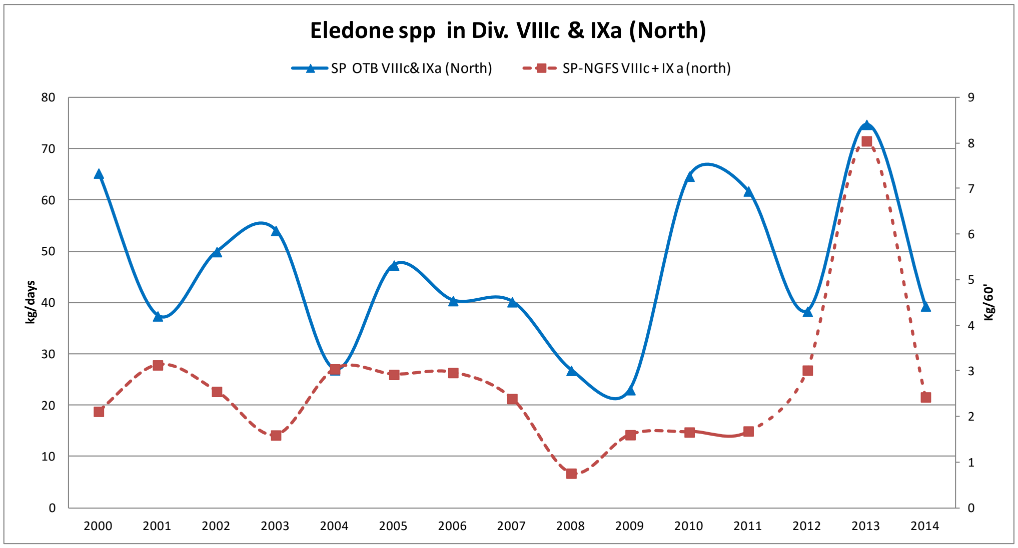


Figure 4.4.2.4 Comparison of Commercial LPUE for *Eledone spp*. of the Spanish (kg/trip) fleets and Spanish Scientific Survey (kg/h) in Div. VIIIc and IXa north.

In Figure 4.4.2.5. the ARSA survey index for *E.cirrhosa* in Div. IXa-south and the LPUE series of the otter bottom trawl fleet "Baca" (OTB metier) are plotted together. The trends of both sets of data show similarities along the whole-time-series, especially during the last 10 years.

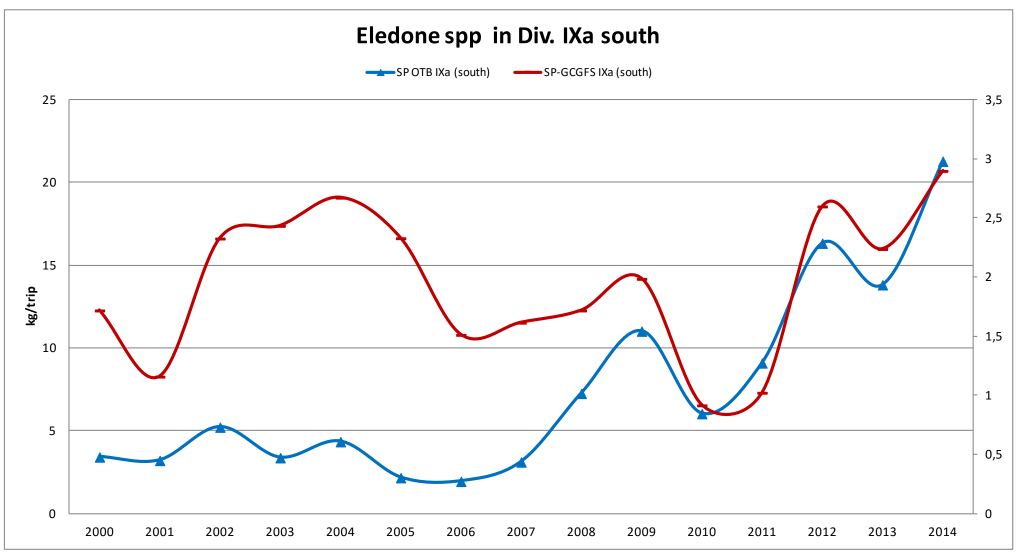


Figure 4.4.2.5. Comparison of Commercial LPUEfor *Eledone spp*. of the Spanish (kg/trip) fleets and Spanish Scientific Survey (kg/h) in Div. IXa-south.

When looking at the figures and based on the behaviour of both data series, the similarities suggest that commercial LPUEs can reflect changes in abundances detected by the surveys series. This is more evident in IXa south that in other areas. Thus, it could be concluded (at least in some cases) that changes in LPUEs appear to be real reflection of changes in the abundances. The idea would be to use these LPUEs or the survey index as a proxy of abundance.

In Portuguese waters, trend analyses were conducted for the octopus fishery of the Algarve (IXa south) using SARIMA (seasonal autoregressive integrated moving average). Trends were only identified in 1 out of 7 octopus data sets in the period between 2003 and 2013. Seasonality is also not detected in the landings of octopus. Strong correlations were found between present landings and landings registered in previous months and previous years.

Model parameterization appears to reflect present knowledge on the life cycle and fisheries of the common octopus, namely their short life-span, recruitment seasons and typical fisheries practices, thus sustaining the application of the models. SARIMA model forecasts outperformed an array of simpler alternatives indicating an overall apparent usefulness of SARIMA modelling and forecasting. In 2013 all time-series were found to be "in-control" from a statistical quality control perspective, indicating no evidence for significant changes in the underlying data generating process, i.e., in the presently unknown combination of biological, oceanographic and anthropogenic factors that drives the landings. These results highlight that SARIMA forecasts and prediction intervals could useful tools for the regular monitoring of cephalopod landings when more sophisticated alternatives would not available (or could not be routinely implemented), thus contributing to the identification and setting of research priorities and advice to fishers and managers.

4.5 Progress report on ToR c: Implications of the application of some Policies and Directives on cephalopods

Natura 2000, network of Marine Protected Areas, Blue growth (wind farms)

Cephalopods are largely ignored by the Habitats Directive. They rate a single mention in the Natura 2000 Interpretation Manual (2013 [1]), in relation to features of reefs which should be protected in Macaronesia. They are also mentioned in the Financing Natura 2000 Guidance Handbook (2007 [2]), in relation to activities that might be required for harbour porpoise conservation, specifically: "Trials in protection and management of food sources for harbour porpoises, e.g. fish and cephalopods".

In relation to marine renewable energy installations, Wilson *et al.* (2006) commented that "…if such devices kill or injure fish or squid then seals and delphinids are likely to scavenge around these installations", thus increasing the risks to protected marine mammal species. Another somewhat tangential link between cephalopods and renewable energy exploitation is the proposed use of a squid-derived protein (reflectin) in renewable energy technology (Ordinario *et al.*, 2014). The EU Blue Growth Policy also focuses on aquaculture, and so several European cephalopod species have aquaculture potential, most plausibly *Octopus vulgaris* (see Jereb *et al.*, 2015 for a recent review of this species).

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[1] http://ec.europa.eu/environment/nature/legislation/habitatsdirective/docs/Int_Manual_EU28.pdf

[2] http://ec.europa.eu/environment/nature/natura2000/financing/docs/financing_natura2000_en.pdf

The landing obligation (LO)

The main objective of landing obligation (LO) rules is to generate incentives for fishermen to reduce the level of current discards. There will be an obligation to land catches of all commercial species with catch and quota limits. Application of the regulation will result in changes in fishing metier behaviour and amounts of species landed. Also, innovative fishing tactics and gears designed to comply with the new rules could result in changes in the composition of the catches. Since cephalopod catches are not subject to catch or quota limits, there is no general requirement to land all cephalopod catches.

The LO will however affect those cephalopod species for which minimum landing length or weight regulations apply (e.g. *Loligo vulgaris* and *Octopus vulgaris* in Spain and Portugal). Length or weight limits will be adapted to the new regulation and renamed as Minimum Conservation Reference Size (MCRS). All specimens under MCRS will have to be landed but not marketed for direct human consumption (as for the other species under the landing obligation). For some cephalopod species, such as octopus, survival rates are known to be high and this fact could be used to justify releasing (at sea) of specimens below marketable size.

Indirect effects of new CFP rules could result in changes in landings of several species caught incidentally by fisheries and currently discarded. For example, based on recent surveys of the trawling fleet operating in the Celtic Sea and ICES area VIIIc and information from fisher associations, it appears that fishers will tend to retain and land more other species, including cephalopods. This would be a consequence of reduced income from high value quota species (due to the combination of quota restrictions and the landing obligation), resulting in incentives for the better utilization of other resource species.

Directive 2010/63/EU of the European Parliament and of the Council of 22 September 2010 on the protection of animals used for scientific purposes

Directive 2010/63/EU includes cephalopods as the sole invertebrate taxon to be regulated for scientific and educational purposes. It has been transposed into national legislation in all EU Member States, and this will have a series of consequences that may impact on scientific research in many fields, including those not directly linked to biomedical experimentation. The CephsInAction FA1301-COST Action (2013–2017) operates to facilitate this important phase of transition and to foster the changes due to compliance with Directive 2010/63/EU and other EU policies (see WGCEPH 2014 Report).

In relation to non-EU members of ICES, it should be noted that squid and octopus are covered by Norway's 2009 Animal Welfare Act[3] and the Canadian Council on Animal Care's system of self-regulation[4] (see Smith *et al.*, 2013), while in the USA "legislation is in place for some research institutes in some states" (Moltschaniwskyj *et al.*, 2007); see also Fiorito *et al.* (2014). Finally, "Guidelines for the Care and Welfare of Cephalopods in Research" (Fiorito *et al.*, 2015) is expected to be published as Special Issue of Laboratory Animals within October 2015.

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[3] https://www.regjeringen.no/en/dokumenter/animal-welfare-act/id571188/

[4] http://www.ccac.ca/en_/standards/policies/policy-categories_of_invasiveness

4.6 Progress report on ToR d: Review data availability for the main commercial exploited cephalopod species in relation to the main population parameters: length distribution, sex ratio, first maturity at age, first maturity at length, growth, spawning season

4.6.1 Peer review paper in relation to population dynamics, biology

The expert group discussed the practicality of this deliverable in the light of recent publications on the biology and population dynamics in cephalopods. In the last few years, there have been a number of peer reviewed papers and books published in which these topics have been reviewed. Based on this, WGCEPH decided not to work on a peer reviewed paper as it will be redundant.

Some examples of these recent publications are:

ICES Cooperative Research Report on European cephalopods (325, the species accounts) (2015).

http://www.ices.dk/sites/pub/Publication%20Reports/Cooperative%20Research%20Report%20(CRR)/crr325/CRR%20325.pdf

The previous cephalopod CRRs, 324 (2015, paralarvae) and 303 (2010, biology and fisheries) are also available.

http://www.ices.dk/sites/pub/Publication%20Reports/Cooperative%20Research%20Report%20(CRR)/crr324/CRR%20324.pdf

http://www.ices.dk/sites/pub/Publication%20Reports/Cooperative%20Research%20Report%20(CRR)/crr303/CRR-303%20final.pdf

4.6.2 First draft report of a methodological paper about assessment methods for each stock/species

There is evidence that cephalopod assessment and, for those commercially exploited species, management is needed. In the few cases where there is assessment, populations are considered to be fully exploited or overexploited (e.g. *Sepia officinalis* in the English Channel). Also, some evidence of growth overfishing could be detected in Octopus in Portugal (WKCMM, 2013). In other cases, an increase in fishing efficiency and/or effort could be expected as a response to the new Landing Obligation Regulation. Thus, there is a significant risk that if no assessment is implemented (i.e. if no knowledge about abundance is obtained) and, for some species, management is not implemented, there could be negative consequences for both cephalopod populations and marine ecosystems. The precautionary approach and the ecosystem aspects contemplated under Nature 2000 and UNESCO lead us to identify this management need.

There is also a need to monitor cephalopods by means of assessment (even if not analytical). Monitoring would allow formulating measures and having them readily available in the event that populations reach unexpected low levels jeopardizing sustainability. The relatively high importance of cephalopod fisheries in some areas leads us to the need to maintain sustainable fisheries based on adequate assessment and management of the target species and regions.

The need for assessment is also supported by the important role of cephalopods in marine food webs. Cephalopods occur regularly in the diets of various well-known predator species, e.g. cetaceans, seabirds and large epipelagic fish — e.g. sharks, tuna and swordfish , as well as smaller demersal fish. Cephalopods´ carnivorous diet situates them at a relatively high trophic level compared with other molluscs (Boyle, 1987). Cephalopods' ecological importance and impact on fishing could be high.

Review of the ongoing assessment

Some suitable assessment models are available to be explored for the data already available (ICES data calls), both for the small-scale and large-scale fisheries:

> **CPUE trends and survey trends:** As a first approach, CPUE trends and surveys trends are offered for a number of species in areas (See sections from 4.1 to 4.4).
>
> **Production models:** seem to work very well for cephalopods and could be tried with the existing data. (e.g. Sahara bank Octopus (Balguerias *et al.* 2000)). In these models, survey data can be used together with data series of LPUEs and/or CPUEs.
>
> A two-step biomass model, stochastic or deterministic: In case of quarterly data, assessment models to be used are the same ones as those presented for *Sepia officinalis* in the English Channel or the currently assessment model used for anchovy in VIIIabdc.

The expert group decided that the two-step biomass model would be tried in a number of species and areas as the expertise is already present in the group, data to be used in the models is also readily available and model itself behaves quite well for the cephalopod species already tried. Stocks to be tried for the model would be:

- Loliginids in Subarea IV and VI, Loliginids in Division VIIIabd and Loliginids in VIIIc and IXa.
- *Ommastrephids* in VIIIc and IXa.
  - **Data needed to apply the initial two-stage biomass model**

Data required for applying the initial two-stage biomass model are summarized as:

- Survey timing and data
- Standardized Landings Per Unit Effort: e.g. in case of Sepia officinalis in VIId,e the standarisation was carried out with delta glm including year, month, rectangle, power, landing with proportion of individuals older than one year old applied and effort). Any other standardised method can be used.
- Total catches and season: is the fishing deployed all along the year?
- Growth and natural mortality, recruitment month
- Information about life cycle, namely spawning season, growth, age at maturity at a regional level

Need for research and monitoring to achieve assessment and forecasting

More complex assessment models should be able to incorporate environmental variables so important for short living species, especially for recruitment. The predictive variables could be the environmental variables. For example, abundances of *Octopus vulgaris* in the Gulf of Cadiz are highly related to the rainfall detected 1 year in advance (Sobrino *et al.*, 2002). Abundance of *Octopus vulgaris* in the Northwest of Spain (Div. VIIIc, Galicia) is related to the wind strength inducing a local upwelling event. (Otero *et al.*, 2008). Also, for *Sepia officinalis* the success of the recruitment can be related to other environmental variables.

If abundances of cephalopods could be forecasted, management could be facilitated. The forecasting capacity of the assessment production models is usually limited. Thus, there is a need of assess the use of pre-seasonal surveys for forecasting cephalopods abundances for the next season. An alternative, although only applicable to directed fisheries and requiring considerable monitoring effort, would be to undertake in-season assessment as carried out in Southwest Atlantic squid fisheries, applying depletion models

In general, it appears to be useful to have the highest temporal resolution on effort and catches as catches are very responsive to effort, so, from this relationship, evidence of abundance could be found. There is a need of monitor variables or parameters accommodating the periodicity and seasonality of the monitoring to these short living species and life histories.

4.7 Progress report on ToR e: Review and report on cephalopod research results in the ICES area: abundances and distributions and their relationships with environmental variables, role of cephalopods in the ecosystem; cephalopods as indicators (MSFD) and assessment methods used in commercial cephalopod fisheries

4.7.1 Database of scientific articles

The database on cephalopods literature is here:

https://www.zotero.org/groups/cephalopod_research/items/

The tool was created in June 2014. It is necessary to register if you wish to add/edit/delete references in the database.

The references are grouped in collections and organised on an annual basis (Ceph_Res_2013 / Ceph_Res_2014 / Ceph_Res_2015). It is not a problem to organise references by year since the whole data base can be searched also directly.

There is also a collection that contains references more distantly related to Cephalopods (Other_distantly_related_papers_2013_2014). There has been identified a list of tags: Behaviour, biochemistry, culture, ecology, ecotoxicology, fisheries, food processing, genetics, physiology, population dynamics, reproduction and taxonomy.

Tags can be used to filter references very quickly. Tags are also in the process to be deployed as some of them sound vague (ecology) or others could be included (evolution). These tags should help us to indicate more clearly within the data base which are the articles in relation to the topic worked out every year as indicated in ToR e. Most references include the abstract.

4.8 Progress report on ToR f: Marine Strategy Framework Directive indicators and Integrated Ecosystem Assessment for Cephalopods

The Integrated European Maritime Policy aims to provide a transparent, legislative framework for governance of the marine environment. This policy is ratified through the Marine Strategy Framework Directive (2008/56/EC), which outlines an ecosystem-based approach to the sustainable management of resources and services. Member States are required to develop a marine strategy for the protection and conservation of the marine environment, taking into account 11 qualitative descriptors to determine good environmental status for each marine region or sub-region. The MFSD process involves development of indicators for these descriptors, introduction of appropriate monitoring programs and management measures, and achievement of good environmental status by 2020.

In the present report, we update information on (a) relevant MSFD descriptors and indicators related to cephalopod stocks and (b) cephalopod species coverage in the initial 2010 MSFD assessment report for each of the member countries. This update is largely based on new information provided by the UK.

4.8.1 Relevance of MSFD criteria for cephalopod species

The UK situation

This section is based on a report to UK Defra[5]. Current threats to cephalopods include fishing pressure, pollution, habitat degradation, underwater noise and climate change. High catches of small squid are likely indicate fishing in recruitment areas, which could result in both growth and recruitment overfishing and have thus the potential to endanger the fished population. Published and ongoing model-based studies at the University of Caen, using fishery and survey data suggest that squid and cuttlefish in the English Channel are fully exploited.

Annual landings of all cephalopod categories show considerable fluctuation over time and in some species (notably ommastrephid squid) landings are sporadic. This result is consistent with our knowledge of the species biology, and does not reflect the effects of overfishing. Although it cannot be ruled out, it should also be considered that markets for octopus and ommastrephid squid are less well established in the UK and the species may be routinely discarded. Note that the most valuable octopus species, *Octopus vulgaris*, is presently uncommon in UK waters and almost certainly absent north of the English Channel.

Central to the process of indicator development is the concept of a baseline value which can represent Good Environmental Status. As marine ecosystems have been modified by exploitation, determination of unmodified baselines values is unrealistic and historic or

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[5] The report was prepared by a team the University of Aberdeen, Cefas, Marine Scotland Science, Falkland Islands Fishery Department, University of Caen, Hellenic Centre for Marine Research and the Spanish Oceanographic Institute,

recent values maybe used. In the case of cephalopod, their environmental sensitivity will result in considerable year to year abundance variation. Here we suggest that such variable abundance could be considered as a baseline.

European cephalopod stocks have not been formally defined. However, genetic studies suggest that for all the squid species, single populations exist in shelf waters around the UK (although an offshore form of *Loligo forbesii* has been tentatively identified). In the case of cuttlefish and, especially, octopuses, their relatively low mobility means that different stocks may exist within UK shelf waters.

Squid landings in Scotland, have generally increased since 1985, albeit with strong fluctuations (Figure 4.8.1) and this is thought to reflect an increase in abundance. Although a reference/baseline level, indicating GES, is difficult to define due to variability, a sustained decline is a cause for concern. In the analysis it is important to try to account for the effect of past fishing pressure (although this would operate entirely via the stock-recruitment relationship, if any, due to the short-live nature of the species). In fact, the effect, on landings, of the previous year's landings was positive overall and there was no apparent adverse effect of high landings in the previous year. This is of course consistent with landings indicating abundance. Landings were also positively correlated with sea temperature and productivity, signalling the likely importance of environmental influences on abundance.

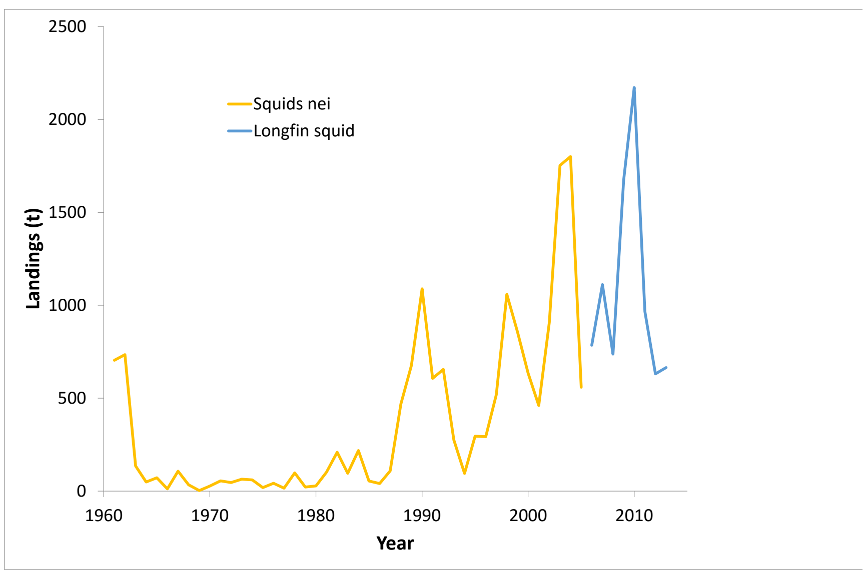

Figure 4.8.1. Landings of squid into Scotland 1960-2013. Note the change in classification of landings around 2006. Almost all squid landed is thought to be *Loligo forbesii.*

Several CEFAS trawl survey series include data on cephalopods, mainly in shelf waters around the English and Welsh coasts. Data from the late 1980s onwards, showed interannual variation in abundance, accounting for spatial, seasonal and depth-related variation. A proportion of the interannual variation was shown to be related to environmental conditions (e.g. NAO index). Again it is difficult to define a baseline value for abundance but (a) we can have more confidence that the survey indices represent abundance than is the case with landings, (b) we are able to control for other components of the spatiotemporal variation in catch rate (e.g. the seasonal cycle, spatial distribution), and (c) we may be able to factor out environmental variation. A standardised survey catch rate over a period of a decade or more, when there were no known issues with overexploitation, might thus represent a reasonable choice of baseline.

Comparable survey data series are available from IFREMER (English Channel) and MSS (Scottish waters). In trawl surveys undertaken by MSS, annual abundance of cephalopod species was also highly variable. As seen for the Scottish fishery data, interannual variation in squid abundance was related to both environmental conditions and the previous year's landings but a high proportion of variation was unexplained. However, this may be overcome by further analysis on individual survey data series as already undertaken for the Cefas data. Analysis of the age-length relationship in *Loligo forbesii* based on counts of growth rings in statoliths revealed the existence of a relatively consistent relationship once the month of hatching was taken into account, although variability is still too high to support use of age-length keys.

Results of the study indicate that good data exist on the abundance patterns shown by some species (e.g. *Loligo forbesii*, *Sepia officinalis*), data which could in principle, at least in standardised form, be used to establish baseline abundance values. The existence of routine monitoring and interpretable abundance data suggest that these species have potential for use as environmental indicators in UK waters.

Aside from MSFD descriptor 1 (biodiversity), cephalopods are also potential indicators for descriptors 3 (fished species), 4 (food webs), 7 (oceanographic conditions), 8 (pollution), 9 (contaminants in seafood) and 11 (underwater noise). However, suitable information is only currently available for descriptors 1 and 3. The possibility of calculating exploitation rates means that cephalopod indicators could be developed for descriptor 3. Bioaccumulation of heavy metals and organic pollutants by cephalopods would justify monitoring under descriptors 8 and 9. Food safety regulations state maximum levels permitted for certain named contaminants in food, such as certain heavy metals and dioxins. However, routine monitoring of fishery products in the UK appears to be infrequent.

In conclusion, several commercial cephalopod categories could be brought into MSFD monitoring for descriptor 1, since trawl survey programmes provide data, and plausible indicators of abundance can be generated, allowing comparison with defined baseline levels and/or detection of sustained negative trends. Monitoring of size distributions could reveal effects of exploitation, through use of a "small squid indicator" (i.e. avoidance of directed fishing on pre-recruits, relevant to descriptors 1 and 3) as well as through more sophisticated assessment approaches which permit calculation of exploitation rate. The main caveat with the existing survey and fishery data is the lack of routine identification of cephalopods to species level, potentially causing difficulties in interpreting observed trends. These results are currently specific to UK waters, but similar analyses could be carried out for other European Seas.

4.8.2 Applicability of MSFD indicators for cephalopods species

The applicability to cephalopod species of the established indicators within the most relevant criteria was updated from the 2014 report by the WG.

In annual species, size-related indices like the large fish index (Descriptor 3) are generally not relevant. Recent development of population models in a series of cephalopod stocks are now providing diagnostics that could be used to determine if these stocks are exploited within safe biological limits. At the present time this concerns English Channel cuttlefish, English Channel loliginid squid, Bay of Biscay loliginid squid, and Gulf of Cadiz Octopus. The sensitivity of cephalopod populations to environmental variations suggests that long term averages may not be sufficient and that recruitment variability should be taken into account.

In addition, the combination of biomass estimates and trophic data in cephalopods allows us to better take into account the role of cephalopods in the ecosystem/food web and potentially to detect "fishing down the food web". Stomach contents analysis and stable isotopes signatures confirm that squid are piscivorous predators with rather high trophic level. Cephalopod species could be taken into account in MSFD descriptor 4 (marine food webs) with indicators like mean trophic level (MTL)."

4.9 Progress report on ToR g: Collect and explore social and economic data (Y2), final analysis (Y3)

A Database was designed for collecting socio-economic data. A survey has been already launched to start collecting these data for 2016.

4.10 Progress report on ToR h: ICES Ecosystem Overviews on the state of cephalopod diversity/populations for each of the following ICES ecoregions: Greater North Sea, Celtic Seas, Bay of Biscay & the Iberian coast and Baltic Sea

No key ecosystem signals were identified to be specifically considered in assessment or management in all areas here described. The anthropogenic pressures relevant to cephalopod stock management are not well known. Since cephalopods are in general short lived and opportunistic species, they are arguably well adapted to coping with fishing pressure. Examples of trends are known from the different areas but no documented overfishing. Natural environment and ecosystem changes are expected to significantly influence the life cycle, recruitment and abundance of most species in these regions.

4.10.1 Baltic

The Baltic shelf is characterized by large shallow areas and a number of deeper basins near 500 m. The waters are characterized by a salinity gradient from southwest to northeast and an oceanographic water circulation due to inflow of saline bottom water and flow out low salinity water. The most abundant cephalopod species in the area is *Alloteuthis subulata*.

4.10.2 North Sea

The shelf in the North Sea can be broadly described as having a shallow (<50 m) southeastern part, which is sharply separated by the Dogger Bank from a much deeper (50–100 m) central part that runs north along the British coast. The salinity and the temperature variations generally reflect the influence of the North Atlantic Oscillation (NAO). The most abundant species are *Alloteuthis subulata* and *Loligo forbesii*, which presents seasonal migration patterns throughout and into the North Sea. The main exploited species is long-finned squid *(Loligo forbesii*).

4.10.3 Celtic Seas and west of Ireland

The Celtic Seas comprise the shelf area west of Scotland (ICES Subarea VIa), the Irish Sea (VIIa), west of Ireland (VIIb), as well as the Celtic Sea (VIIf-k) and western Channel (VIIe). There are a variety of oceanographic features which determine cephalopod abundance and spatio-.temporal distribution in the ecoregion. The main ecosystem characteristics vary somewhat along the ecoregion, influencing cephalopod occurrence. The most abundant cephalopods species in the area are *Loligo forbesii* and *Illex coindetii* which are mainly found close to the self break, while *Alloteuthis subulata* is a common species found close to shore waters. The main exploited species is cuttlefish (*Sepia officinalis*).

4.10.4 Bay of Biscay and Iberian coast

The advisory region extends from west of Brittany to the Strait of Gibraltar. Within this area the topographic diversity and the wide range of substrates result in many different types of coastal habitat. To the northeast, in the southern Bay of Biscay area, the most exploited and commercially valued species are members of the *Loliginidae* (long-finned squid) and Sepiidae (cuttlefish) families, whereas the importance of the Ommastrephid (short-finned squid) family increases westwards towards the western end of Galicia, decreasing sharply immediately to the south. *Octopodidae* assume importance in the north Spain, increasing towards the west and south. The latter is the most important family in the region in terms of abundance, fishery landings and commercial value, attracting a large small-scale fishery effort, with concomitant social relevance and consequently greater management commitment.

The conservation (sustainability) status of the populations varies depending on the particular geographic portion of the population (/stock) with declining CPUE of octopus in Galicia and long-finned squid off western Portugal and increasing CPUE of octopus in western Portugal and squid in the southern Bay of Biscay.

5 Revisions to the work plan and justification

The expert group discussed the practicality of the deliverable *Peer review paper in relation to population dynamics, biology (ToR d, Year 2)* in the light of recent publications on the biology and population dynamics in cephalopods. See discussion in 4.6.1. The expert group decision was not to work on a peer reviewed paper as it will be redundant.

In relation to the *Report (and/or first draft) of a methodological paper about sampling resolution for best data collection for each stock/species*, this part of the report is based on discussions during Workshop on the Necessity for Crangon and Cephalopod Management (WKCCM)) in October 2013, which remain relevant.

In relation to the *Database to be developed under ToR e (Year 2),* during the last year an initiative by the Cephalopod International Advisory Council (CIAC) has already created such a resource (EndNote Data base on cephalopods scientific articles). The idea is that database produced by WGCEPH would include CIAC data base.

A report on MSFD descriptors (ToR f Year 2) applicable to cephalopods has been updated as the United Kingdom has progreed in the work to include cephalopods under the MSFD descriptors.

ToR g Collect and explore social and economic data. The collection of economic data (understood as being focused on the value of the catch and cost: effort and vessels) is been collected regularly. Other economical variables: i.e. number of licenses; fishers and governance measures will be collected during 2014.

ToR h (contribution to report on ICES Ecosystem Overviews) was introduced last year by ICES; a short section was produced. It will be updated next year.

6 Next meeting

The Working Group on Cephalopod Fisheries and Life History (WGCEPH), chaired by Marina Santurtún, Spain and Jean-Paul Robin, France, will meet in Copenhagen, Denmark, from 14th to 17th June 2016, in addition to working by correspondence, to work on ToRs and generate deliverables as listed in the ToRs Table.

Annex 1: List of participants

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Annex 2: Recommendations

Recommendation	Adressed to:
1. WGCEPH will review the current format and design of the Data Call. The, group will get in contact with National correspondants to inform them about WGCEPH working procedure for 2016 in relation to data required.	*ICES Secreatriat and National correspondants.*
2. Routine collection of cephalopod length–frequency data, by species, during research bottom trawl surveys (e.g. IBTS) is suggested, in addition to provision of these data to the WGCEPH prior to the next meeting. Note that much existing survey data on cephalopods does not include identification to species level, limiting its usefulness.	*ICES IBTS Chair, and National correspondant.*
3. In relation to sampling and monitoring for achieving Integrated Ecosystem Assessment, WGCEPH recommends that for major cephalopod stocks in which assessment and management are likely to be necessary in the near future, data collection under the DCMAP should be modified to reflect the additional data requirements imposed by the short life cycles. We recommend: (a) Increases in the level of cephalopod sampling in metiers where these are highly valuable, based on the short life cycle of cephalopods. Thus, sampling of cephalopod species on a quarterly basis is not adequate. (b) Focus of the more intensive sampling (i.e. weekly or monthly) during periods of higher catches in order to ensure adequate characterizations of the length compositions of the multiple microcohorts that are often present, while avoiding unproductive sampling effort at times of low abundance. (c) Collection of maturity data for the most important cephalopod fisheries, to facilitate comparison of trends in maturity and length composition data by cohort, from research surveys versus the fishery, in order to assess trends in recruitment and length at 50% maturity (L50).	National Correspondents

Annex 3: Data provided by countries in relation to Data Call 2014 (just countries with significant participation on the cephalopod fisheries have been contacted)

		GER	UK (just for summary Table, includes Wales and Scotland)	IRL	FRA	ESP	PRT
Landings	Year	X	X	X	X	X	X
	Quarter	X	X	X	X	X	X
	Month	X			X	X	X
	Area	X	X	X		X	X
	Statist. Rectangle	X			X		
	Subpolygon						
	Species[6]	X	X	X	X	X	X
	Landing category	X	X			X	X
	Commercial size	X					X
	Fishing activity category National*					X	X
	Fishing activity category European lvl 5*			X		X	
	Fishing activity category European lvl 6*	X	X		X	X	
	Harbour	X	X		X	X	X
	Vessel length category	X	X	X		X	X
	Unallocated catch weigth	X	X	X			X
	Area misreported catch weigth	X	X	X			X
	Official Landings weigth	X	X	X	X	X	X
	Landing multiplier	X					
	Official landing value	X	X	X			X
	% cephalopods over total catch		X				
Effort	Year	X	X	X	X	X	X
	Quarter	X	X	X	X	X	X
	Month	X			X	X	
	Area	X	X	X		X	X
	Statist. Rectangle	X			X	X	
	Subpolygon						
	Fishing activity category National*					X	X
	Fishing activity category European lvl 5*			X	X	X	
	Fishing activity category European lvl 6*	X	X			X	
	Harbour*	X	X		X	X	X
	Vessel length category*	X	X	X	X	X	X
	Total number of trips (for lv5 or lv6)	X	X	X		X	X
	Number of trips directed or catching cephalopods (for lv5 or lv6)	X		X			
	Number of sets/hauls	X					
	Fishing time/soaking time	X		X	X*		
	kW-days	X		X	X*		X
	GT-days			X			X
	Total Days at sea		X	X		X	X

6 Note that most identifications are in fact to genus or family level; identification to species would be more useful

	(for lv5 or lv6) Days at sea catching cephalopods (for lv5 or lv6)						
Discards	Year	X	X		X	X	X
	Quarter*	X	X		X	X	
	Month*	X	X				
	Area*	X	X		X	X	
	Statistical rectangle*	X	X				
	Subpolygon*	X	X				
	Species*	X	X		X*	X	
	Vessel length category*		X			X	
	Fishing activity category National*		X				
	Fishing activity category European lvl 5*		X				X
	Fishing activity category European lvl 6*	X	X			X	
	Harbour*	X	X				
	Total discard weigth	X	X		X	X	
	Total number of trips by metier (lv5)	X	X			X	X
	Number of simple trips by metier (lv5)					X	
	Total number of sets/hauls	X	X				
	Number of sample sets/hauls					X	
	Total Fishing time/soaking time	X	X				
	Sampled Fishing time/soaking time						
	kW-days		X				
	GT-days		X				
	Total Days at sea		X				
	Total Days at sea (for the lv5)						
Surveys	Year	X		X	X	X	X
	Quarter*	X		X		X	X
	Month*	X			X	X	X
	Area*	X		X	X	X	X
	Statistical rectangle*	X		X	X		
	Subpolygon*						
	Latitude (degrees)	X		X			
	Latitude (minutes)	X		X			
	Longitude (degrees)	X		X			
	Longitude (minutes)	X		X			
	Species*	X		X	X*	X	X
	Abundance indice*	X		X	X	X	X
	Units for abundance (please specify: e.g. numbers per tow/per hour/ per swept km²)	X		X		X	
	S.E.			X		X	X
	Year	X		X	X	X	X
	Quarter*	X		X		X	X
	Month*	X			X	X	X
	Area*	X		X	X	X	X
	Statistical rectangle*	X		X	X		
	Subpolygon*						

	Latitude (degrees)	X		X			
	Latitude (minutes)	X		X			
	Longitude (degrees)	X		X			
	Longitude (minu-tes)	X		X			
	Species*	X		X	X*	X	X
	CPUE	X		X	X	X	X
	S.E.			X		X	X

***United Kingdom additional information:**

The following data are not available:

- Discard data for UK.

***Scotland additional information:**

For Annex_1 data;

(i) The IFISH data do not specify everything at the species level so we have had to use the same taxonomic mishmash as in previous years;

(ii) The discard page is blank following advice on the lack of discarding;

(iii) The data are now presented by month (last year it was by quarter);

(iv) Landings weight is in Kg and value in Euro (at £1.00 = €1.24051- the ECB annualised rate);

(v) The reason the landings, effort and biological sampling data for the UK are presented separately for each of its administrations is because this is as agreed by the Regional Coordination Meetings for data uploads into the DCF regional databases. The country codes used are the ISO 3166-2 alpha-3 country sub-division codes;

For Annex_2 data:

(i) SE is undefined (and given as 'NA') where only one haul was carried out in a stat rectangle.

(ii) Note that there was a vessel breakdown in 2013 Q4 and the survey was not completed (hence fewer stat rectangles compare to the equivalent 2014 survey)

(iii) Zero cpue and abundances are included for each species encountered.

***France:**

Landing data:

- Data were delivered on a quarterly bases.
- Data were delivered by species groups and/or families.
- There are problems eith octopus species as all of them are identified under Octopus vulgaris and caught by trawlers.
- Percentage of cephalopods over the total catch is estimated to be 100%

Discard data:

- Discard data was provided from 2009 to 2013:
- Data was provided for 2 families and 1 species groups: Sepiidae, *Loliginidae* and llex spp.
- Data was provided quarterly
- There is no indication about how to use the 0 discarded weigth, in the colum discard_weigth.

Survey data:

No survey data have been provided for 2014.

Annex 4: WGCEPH Terms of Reference

ToR	Description	Background	Science Plan topics addressed	Duration	Expected Deliverables
a	Report on status and trends in cephalopod stocks: Update, quality check and report relevant data on: European fishery statistics (landings, directed effort, discards and survey catches) across the ICES area and if feasible in waters other than Europe . Produce and update CPUEs and survey data series for the main cephalopod métiers and species and assess the possibility of their use as abundance indices. Examine the above trends in relative exploitation rates (i.e., catch/survey biomass) to evaluate stock status. Start exploring economic data collected under Data Call.	Data call is part of the justification of this ToR. Discussion of the data collected is important to be hold in a framework of experts. The results of the ToR are an output of this discussion. Some of the outputs consist on the identification of cephalopod stocks to be assessed or even managed, the need of more data (spatial, temporal) and the level of species information required. Thus, the baseline work of the ToR is the result of the data call.		Year 1, 2 and 3	Peer-review paper in relation to status and trends (Year 3: 2016).
b	Conduct preliminary assessments of the main cephalopod species in the ICES area. Assess production and/or depletion methods utility, if feasible (YEAR 1). Explore other possible assessment methods if needed (e.g. early season assessment) (YEAR 2). Carry out assessment of species with the methods chosen (YEAR 3).	Data is being collected with the purpose of assessing the status of cephalopods stocks for Integrated Ecosystem Assessment (IEA).		Year 1, 2 and 3s	Report on the cephalopods assessed (Year 1: 2014, Year 2: 2015 and Year 3: 2016).
c	Implications of the application of some Policies and Directives on cephalopods: e.g. Implication of the CFP (no discards) on cephalopods exploitation, how this regulation has been applied in other places and how it has affected them; New regulation of Manipulation of Animals for research; Natura 2000, Blue growth (wind farms)	There are no policies or management measures directed to cephalopods but many other pressures and activities would affect them. These directives and policies are essential to assess the ecosystem in its whole (IEA)		Year 1, 2 and 3	Report on effects of directives and policies on cephalopod assessment (Year 1: 20145, year 2: 2015 and year 3: 2016)
d	Review data availability for the main	There is a need to		Year 2	Peer review

	cephalopod species in relation to the main population parameters: length distribution, sex ratio, first maturity at age, first maturity at length, growth, spawning season (YEAR 2);	update main population parameters to be able to relate them to the most recent fisheries data collected through Data calls and to assess stock status.		paper in relation to population dynamics, biology. . (Year 2: 2015) . Report (and/or first draft) of a methodological paper about sampling resolution for best data collection for each stock/species. (Year 2: 2015)
e	Review and report on cephalopod research results in the ICES area, and if feasible in waters other than Europe, including all relevant aspects of: biology, ecology, physiology and behavior, in field and laboratory studies (YEAR 1, YEAR 2 and YEAR 3)	Experts should be able to assess population status, and give management advice, if needed, for stocks/populations. Also there is a need for understanding response to stress, factors causing changes in cephalopod abundances and distribution. In this way the expert group will have to be able to inform ICES about population status; dynamics and their relationship with environmental variables; the role of cephalopods in the ecosystem; possible indicators for cephalopods under the MSFD and assessment methods used in commercial cephalopod fisheries.	Year 1, 2 and 3	. Database of scientific articles in relation to the topic worked out every year. This data base will make use of the already existing tools (e.g. Mendelei, Research Gate…). (Year 1: 20145, year 2: 2015 and year 3: 2016) Report. (Year 1: 20145, year 2: 2015 and year 3: 2016)
f	MSFD and Integrated Ecosystem Assessment: Relevant MSFD indicators (biodiversity, community role, exploitation and contaminants) applied to cephalopods.	There is a need of describing the state and pressure of cephalopods under MSFD descriptors and indi-	Year 1, 2	Report on MSFD descriptors applicable to cephalopods Year 2014 and Year 2015.

		cators. ToR a address topics in relation to fisheries (exploitation) and ToR e addresses MSFD from the literature review (knowledge base). In this case, ToR f will cover MSFD focused on the applicability of descriptors on cephalopod populations (status) and level of exploitation (pressures). Thus, ToR a, e and f are complementary in this respect.		
g	Collect and explore social and economic data (YEAR 2), final analysis (YEAR3). Data on: - Landings in value (total national and cephalopods, species by species), - number of days at sea/days fishing and number of days targeting cephalopods (already collected under ToR a) - number of licenses (total for SSF and cephalopods)* - estimate the number of fishers and vessels involved in cephalopods fisheries** - identify governance measures in place for cephalopods***	Cephalopods are increasingly important for small-scale fisheries across Europe. Data is being collected with the purpose to assess the socioeconomic importance, and dependence on, cephalopods fisheries in Europe, mainly for small-scale artisanal fisheries	Year 2: 2015 & Year 3: 2016	Peer-review paper in relation to socioeconomic importance, management and governance of cephalopods in Europe (Year3: 2016)
	h) Produce four short paragraphs for the ICES Ecosystem Overviews on the state of cephalopod diversity/populations, one paragraph for each of the following ICES ecoregions: Greater North Sea, Celtic Seas, Bay of Biscay & the Iberian coast and Baltic Sea.	Each paragraph should be maximum 150 words in length and can be support by one figure. Paragraphs for each ecoregion should be similar in style and address the overall state and comment on the pressures accounting for changes in state. These will go in section four of the ecosystem overviews and not supposed to be	Year 2: 2015 & Year 3: 2016	Contribution to report on ICES Ecosystem Overviews Year 2015 and update in Year 2016.

	long descriptions, but a short synopsis of important points for managers and policy developers.	

Annex 5: Working Documents

Working Document 1. presented to the ICES WGCEPH Working Group on Cephalopod Fisheries and Life History.
Tenerife, Spain, 8-11 June 2015

AN UPDATE OF CEPHALOPOD LANDINGS DATA OF THE SPANISH FISHING FLEET OPERATING IN ICES AREA FOR 2000-2013 PERIOD.

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Data of Spanish landings of cephalopods on an annual basis were collected both by the *Instituto Español de Oceanografía's* (IEO) Sampling and Information Network, for catches from the ICES sub-areas VII, VIIIabd, VIIIc and IXa, and by the *AZTI* Fundation, for catches from sub-areas VIab, VIIb-k and those ones from the VIIIc-East landed in the Euzkadi ports.

Table 1 shows the Spanish annual landings (in tons) by species group (*Octopodidae*, *Loliginidae*, Ommastrephidae and Sepiidae) and for the total annual for the 2000-2013 period. The 2011 landings have been updated in relation to the information reported last year. Landings data in 2014 hould be considered as provisional because of gaps of information still present in some subdivisions. However, the 2013 landings will be considered in further analysis of trends henceforth presented.

Table 1. Spanish cephalopod annual landings (in tons) caught in the ICES Area by species group and total annual during the 2000-2013 period.

Year	Loliginidae	Octopodidae	Ommastrephidae	Sepioidea	*Total*
2000	676	7032	2017	1637	**11361**
2001	1052	3896	1305	1129	**7383**
2002	958	5150	1718	1133	**8959**
2003	917	4888	1164	1286	**8256**
2004	980	4882	1471	1394	**8726**
2005	880	6040	1950	1635	**10505**
2006	441	5238	1018	1456	**8152**
2007	598	4643	834	1563	**7637**
2008	765	4920	1636	1412	**8734**
2009	546	3935	1314	1224	**7019**
2010	1109	5776	3023	1535	**11444**
2011	1196	5122	3397	1423	**11138**
2012	1683	6391	4718	1714	**14505**
2013	814	7798	1580	1985	**12177**
2014	496	4689	3508	1257	**9950**

Figure 1 shows the trend of total annual landings through the analyzed time period (2000-2014). Average annual landings along the time-series were around 9730 tons, with a minimum of 7019 t in 2009 and a maximum of 14504 tons in 2012. The highest landings correspond to the *Octopodidae* group which accounted for 55 % of the averaged landings for the analyzed period, followed by Ommastrephidae (21 %), Sepioidea (15 %) and *Loliginidae* (9 %). The trend present a drop of landings from 2000 to 2001, followed by a slight increase until to reach a peak in 2005 of 10500 t. Afterwards, a new decrease appear until 2009, with a great increase in 2010 of about 63% with regard to 2009. In 2011, the landings showed similar values to previous year, with a new increase in 2012 reaching the highest value of the time-series. In 2013, the landings decrease a 16% with regard to previous year due to the reduction of Ommastrephidae, This decrease continued in 2014, with a 18% regard to 2013, due to the reduction of *Octopodidae*.

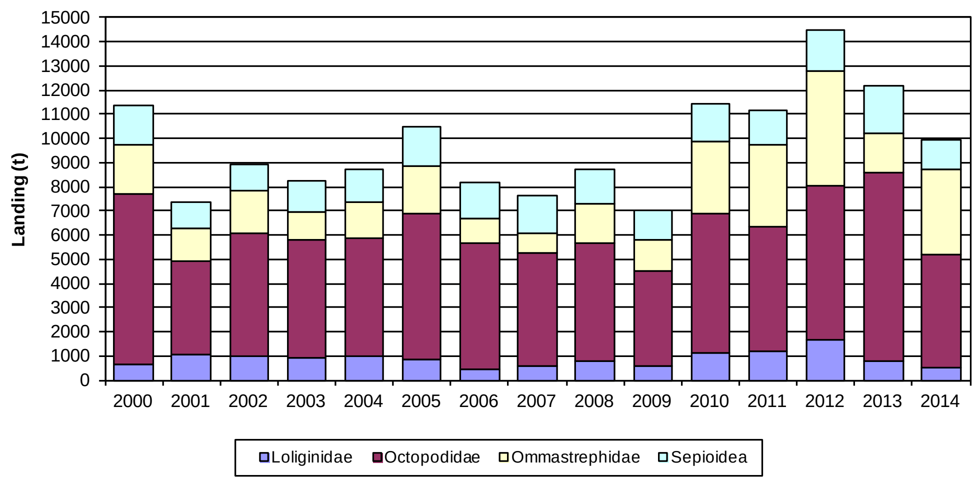
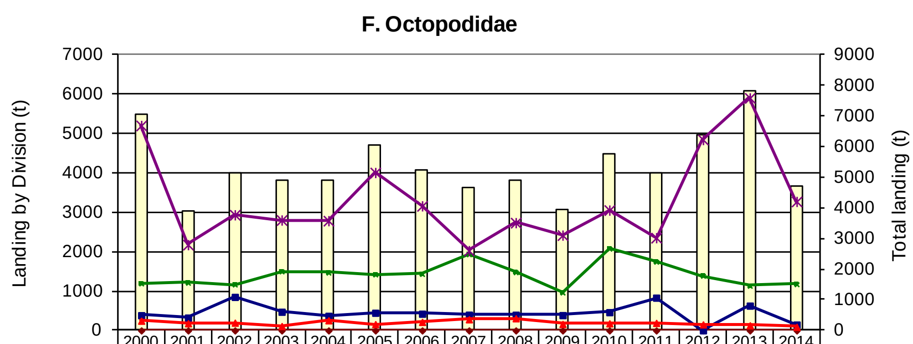


Figure 1. Spanish cephalopod annual landings (in tons) caught in the ICES area by species group during the 2000-2013 period. (2013: provisional data)

Octopodidae

Commercial landings of octopods (Fam. *Octopodidae*) comprise common octopus *Octopus vulgaris* and horned octopus *Eledone cirrhosa*, plus musky octopus *Eledone moschata* in Sub-Division IXa-South. Figure 2 shows the trend of total octopods landings and by Subarea/Division in the last fourteen years. Total annual catch ranged between and 3895 t in 2001 and 7798 t in 2013, which represents a very important increase along the time-series. A slight increase until reaching a peak in 2005 of 6039 t can be observed. Afterwards, a new decreasing trend appear until 2009 with 3935 t, followed by a great increase in 2010 of about 46% with regard to 2009, remaining with similar value in 2011. In the last two years, a sharp increase can be observed until to reach the highest values of the times series in 2013 with 7798 t. More than 87% of *Octopodidae* were caught along the Spanish coast (Divisions IXa and VIIIc), where common octopus *O. vulgaris* is the main species caught. In Division VIIIc and Subdivision IXa-north most of the *O. vulgaris* were caught by the artisanal fleet using traps, comprising more than 98% of octopus landings (Figure 3). The rest of landings is reported by the trawl fleet. However, this species is caught by the bottom-trawl fleet in the Subdivision IXa-South (Gulf of Cadiz), accounting for around 60% of total catch on average, and the remaining 40% by the artisanal fleet using mainly clay pots and hand-jigs (Figure 3). In the last three years, the artisanal landings have exceeded significantly the trawl landings, providing 70% of total catch. Subdivision IXa-South contributes to the total landings from the Division IXa with variable percentages that ranged between 16 % (285 t) in 2011 and 80% (2871 t) in 2005, with a 48% on average through the time-series. In figure 3, it can be observed these strong fluctuations in the octopus landing along the time-series in Subdivision IXa -South, with the minimum values in 2011 (285 t) and maximum values in 2013 (3785 t). However, this interannual fluctuations are less pronounced in Subdivision IXa-North. In this last tow year, the artisanal fleet accounted for the 70% of total octopus landings. Possibly, such oscillations may be related with environmental changes such as rainfall and discharges of rivers (Sobrino *et al.*, 2002).

Most of the horned octopus *E. cirrhosa* is caught by the bottom-trawl fleet, with their landings accounting for the bulk of the octopod landings in Subarea VII (457t of average) and Subdivisions VIIIabd (199 t) (Figure 2). Horned octopus landings in Division VIIIc account for 25% (285 t), on average, of total octopods landings along the time-series. In Sub-division VIIIc-east the fishery statistics for the '*Octopodidae*' mixed species group correspond to *E. cirrhosa* landings in the case of the trawl fleet and to *O. vulgaris* for the artisanal fleet. The contribution of *Eledone* spp in the total cephalopod landings from Division IXa is higher in Subdivision IXa north, with 21.4% (352 t) of total landings, than in Subdivision IXa south, with only 10% (167 t) (Figure 4). In this last Subdivision, the main landed species is the musky octopus *Eledone moschata* instead of *E. cirrhosa*, that is caught in the Gulf of Cadiz by the trawl fleet as a by-catch due its scarce commercial value (Silva *et al.*, 2004). This has been changing in the three last years, as it is possible to observe in the increasing of landings.

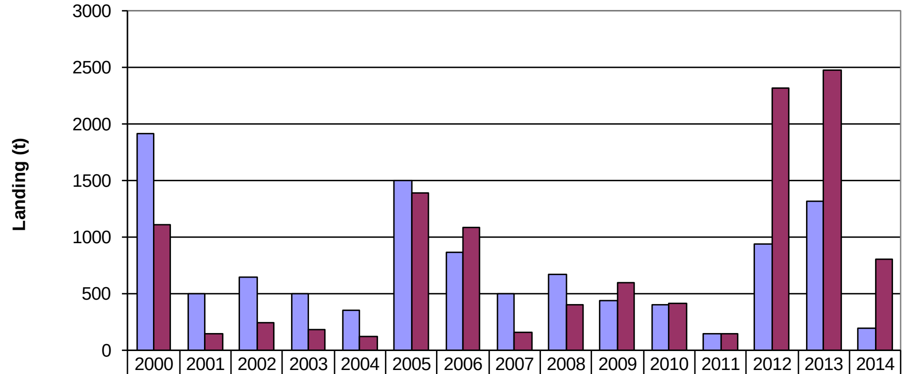


	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Total	7032	3896	5150	4888	4882	6040	5238	4643	4920	3935	5776	5122	6391	7798	4689
VI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VII	387	326	851	475	371	449	425	400	399	389	464	832	4	630	149
VIIIabd	247	182	197	112	257	161	216	282	308	164	181	191	153	130	92
VIIIc	1193	1209	1165	1498	1466	1421	1433	1933	1476	961	2075	1743	1387	1133	1172
IXa	5205	2179	2936	2804	2787	4010	3164	2027	2737	2421	3056	2355	4847	5905	3276

Figure 2. Spanish landings (in tons) of octopus species (Fam. *Octopodidae*) by ICES Subarea/Division during the 2000-2013 period.

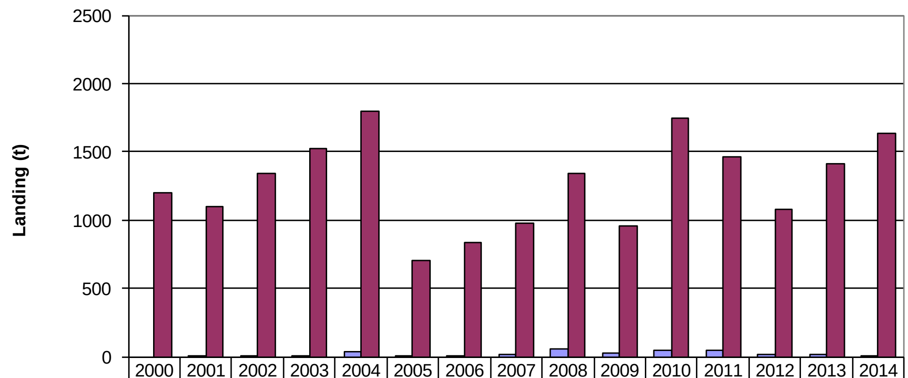
Octopus vulgaris

Subdivision IXa- South



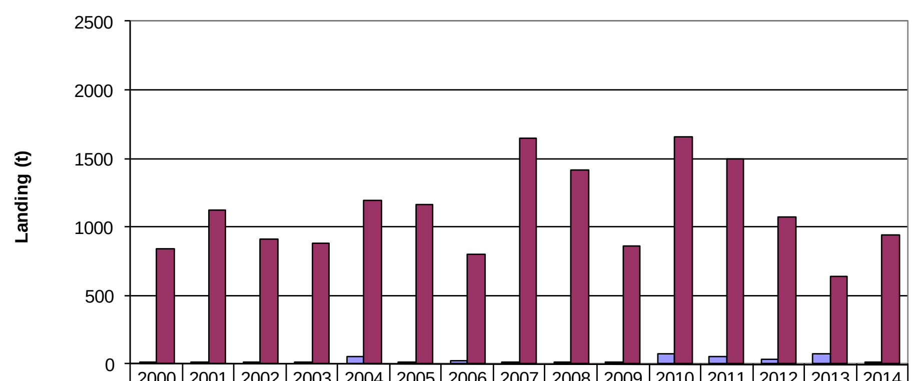
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Trawler fleet	1915	498	645	496	342	1490	855	497	663	434	396	146	927	1317	187
Artisanal fleet	1101	139	234	182	112	1381	1077	149	402	595	403	139	2315	2468	803

Subdivision IXa- North



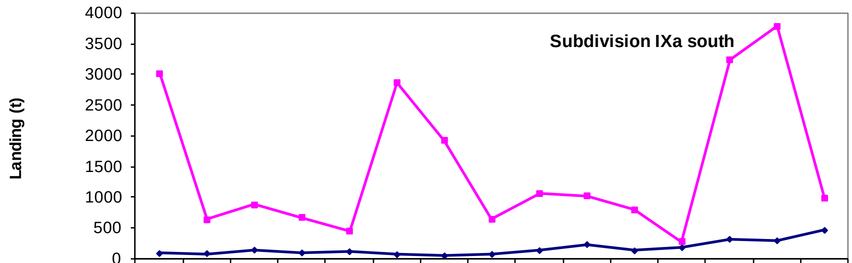
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Trawler fleet	0	7	5	10	37	4	4	18	54	29	50	42	12	18	9
Artisanal fleet	1201	1097	1337	1518	1798	701	837	977	1342	958	1741	1463	1078	1416	1633

Division VIIIc

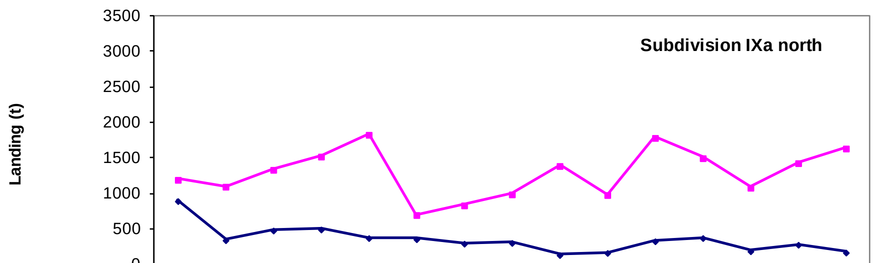


	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Trawler fleet	6	7	4	5	51	4	23	15	16	3	80	55	37	76	20
Artisanal fleet	843	1126	914	881	1195	1168	802	1648	1412	860	1659	1502	1075	639	942

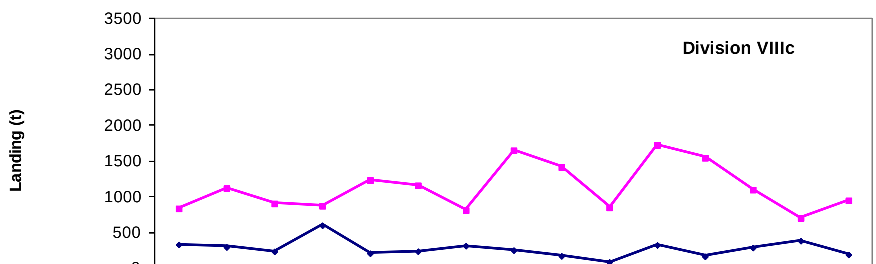
Figure 3. *O. vulgaris* landings (in tons) by fleet in Sub-division IXa south, Sub-division IXa-north and Division VIIIc during the 2000-2013 period.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Eledone spp	88.4	87.7	144.2	98.7	118.1	70.0	51.0	74.5	136.0	234.8	131.7	184.3	320.3	296.2	465.6
O. vulgaris	3015.	637.6	878.9	677.1	454.5	2871.	1932.	646.0	1064.	1028.	798.5	285.2	3242.	3784.	990.4



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Eledone spp	900.6	349.6	486.1	500.5	379.6	363.8	300.9	311.3	140.6	170.3	335.1	380.3	194.3	285.8	175.5
O. vulgaris	1200.	1103.	1341.	1528.	1835.	705.0	840.5	995.6	1395.	986.6	1791.	1505.	1089.	1435.	1641.

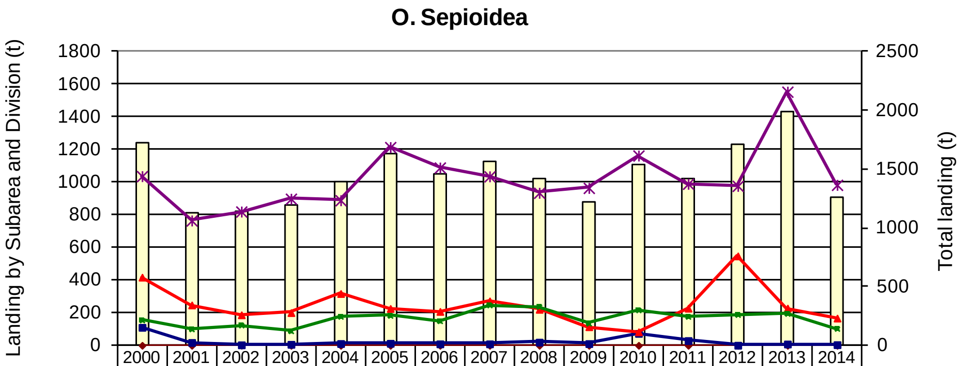


	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Eledone spp	343.9	308.5	246.8	612.4	220.1	248.7	326.2	264.3	183.6	98.6	336.6	176.9	300.0	396.4	202.7
O. vulgaris	848.8	1132.	918.3	886.3	1246.	1172.	825.1	1663.	1428.	862.5	1738.	1558.	1112.	715.5	961.6

Figure 4. *Octopodidae* landings by species in Division VIIIc and IXa (north and south) during 2000-2013 period.

Sepiidae

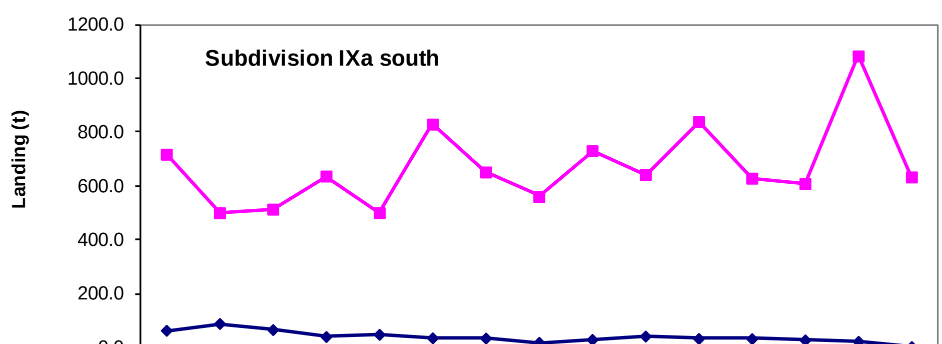
The trend of cuttlefish annual landings by Subarea/Division is shown in Figure 5. Total landings ranged between 1985 t in 2013 and 1129 t in 2001. Since 2001, landings increased to 2005 and 2007, when they reached two new maxima values similar to 2000. Afterwards, landings decreased slightly up to 1224 t in 2010, reaching the highest values of the time-series in 2013, with an important decreasing in 2014 of the 36% in relation to the previous year. Division IXa contributed with 70% of total cuttlefish landed by Spanish fleet (1.021 t), with the 71% of landings in this Division corresponding to the Subdivision IXa-South (Gulf of Cadiz). Landings in Division VIIIc increased at the end of the analysed period, reaching 102 t in 2014, whereas in Division VIIIabd they showed a value of 170 t in average, with a marked drop in the last three years of the time-series, from 548 t in 2012 to 167 t in 2014. Landings in Subarea VII were below 20 t, except in 2000 and 2010 with 110 t and 73 t, respectively, and they were almost absent in the Subarea VI.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Total	1719	1129	1133	1193	1394	1635	1456	1563	1412	1224	1535	1423	1714	1985	1257
VI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VII	110	18	3	6	11	12	9	9	19	11	73	29	1	8	4
VIIIabd	418	247	187	200	318	226	208	272	221	114	83	227	548	228	167
VIIIc	154	99	123	88	176	182	149	246	237	134	216	176	187	194	102
IXa	1037	765	820	899	889	1215	1090	1036	935	965	1164	991	978	1555	984

Figure 5. Spanish landings (in tons) of cuttlefish species (O. Sepioidea) by ICES Subarea/Division during the 2000-2013 period.

Cuttlefish (O. Sepioidea) landings from Subarea VII and Divisions VIIIabd mainly comprise common cuttlefish *Sepia officinalis* and, in a lesser amount, also elegant cuttlefish *Sepia elegans* and pink cuttlefish *Sepia orbignyana*. Bobtail squid *Sepiola* spp. is not identified in the most of landings. Only *Sepia officinalis* and *Sepia elegans* are present in landings from Divisions IXa and VIIIc-West. Data on the proportion of each species are only available for Subdivision, where *Sepia officinalis* makes up about 94% of cuttlefish landed (Figure 5). In this, *Sepia elegans* and *Sepia orbignyana* appear mixed in landings, although the last species is quite scarce. The commercial value of *Sepia elegans* is high, and for this reason is separated in the catch. In 2014, the landing of *Sepia elegans* in Subdivision IXa-South shows an important drop.



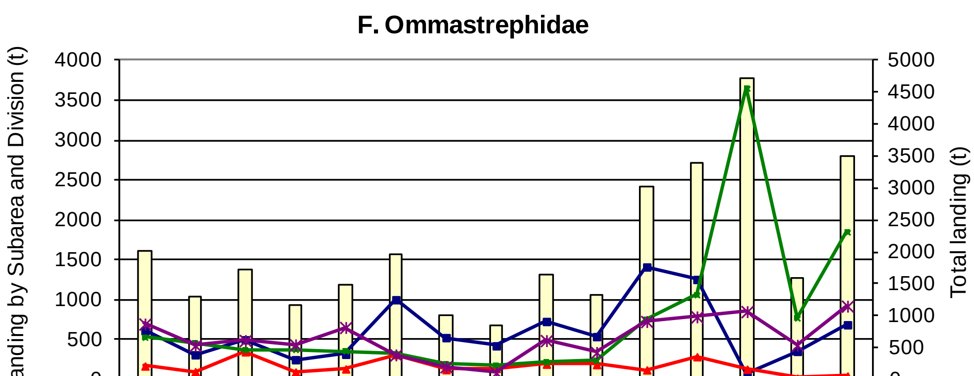
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
S.elegans	63.2	88.7	65.9	40.1	48.1	35.2	34.3	18.6	29.3	41.7	32.9	32.2	27.5	22.3	2.7
S.officinalis	718.3	500.3	514.0	637.0	500.7	830.2	652.1	560.9	731.1	642.3	839.3	629.2	609.0	1083.	633.6

Figure 6. Sepiidae landings by species in Subdivision IXa south during the 2000-2013 period.

Ommastrephidae

Short-finned squid landings (Fam. Ommastrephidae) comprise mainly broad-tail short-finned squid *Illex coindetii* and lesser flying squid *Todaropsis eblanae*. European flying squid *Todarodes sagittatus* also appears in catches, but it is very scarce. Figure 7 illustrates the trends of both total landings of short-finned squids and by Subarea/Division. Total landings presented an average value of 2020 t, with low values in the first half of the time-series. Afterwards, landings quickly dropped reaching a minimum in 2007 with 834 t. In 2008, this value doubled in relation to the previous year, with a new decrease in 2009. In the three last years of the time-series occurs a strong increase, reaching then the maximum values in 2012 with 4718 tonnes, as in the rest of cephalopod groups. However, a sharp decrease is observed in 2013, with a decline of 3000 t in relation to the previous year. Possibly, this decrease was related with the change of the origin of the fisheries information and the correct assignation of the name to the landed species. In 2014, an increase of 2000 t is observed in Figure 7, reaching the second maximum value in the time-series.

The analysis by area shows scarce landings in Subarea VI throughout the time-series. From 2000 to 2004, the Division IXa contributed with the highest landings, ranging between 700 and 430 t. Since 2004, landings from Subarea VII increased, reaching two maxima in 2005 and 2008 with 1000 and 730 tons, respectively. The rest of Divisions showed decreased landings, sharing similar levels below 200 t, with only the División IXa experiencing a significant recovery in 2008. In 2010, all the Subareas and Divisions reached the maxima values, except Division VIIIabd which presented a slightly decrease in relation to the previous years. At the end of the time-series, both Division IXa and VIIIc showed considerable increases, mainly in Division VIII c, reaching a value in 2012 of about 300% with regard to 2011 (3651 tonnes). Subdivision IXa–South accounts for the lower values of the time-series with landings below of 1% of the total of short-finned squid species landings. In 2013, the landing decrease in all Divisions, except in Division VII, which showed a significant recovery. The decrease was most important in Division VIIIc, with a deduction of 80% in 2013. The reason has been described in the first paragraph. In 2014, all Divisions showed a significant increase of about 100% in relation to the previous year.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Total	2017	1305	1718	1164	1471	1950	1018	834	1636	1314	3023	3397	4718	1580	3508
VI		0	0	0	0	0	0	0	0	0	0	0	0	0	0
VII	616	313	501	252	320	1003	528	426	731	541	1413	1257	79	356	689
VIIIabd	172	101	351	98	136	315	127	141	196	190	124	289	133	20	48
VIIIc	530	462	373	377	359	319	199	180	219	240	756	1062	3651	771	1848
IXa	699	429	492	438	656	312	164	87	491	342	730	788	854	433	923

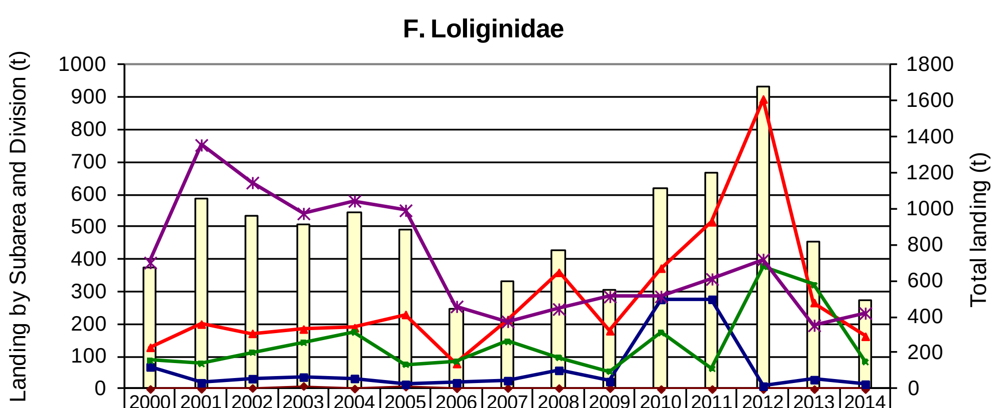
Figure 7. Spanish landings (in tons) of short-finned squid species (Fam. Ommastrephidae) by ICES Subarea/Division during the 2000-2013 period.

Loliginidae

Long-finned squid landings (F. *Loliginidae*) consist mainly of common European squid *Loligo vulgaris*. Three other species are present in unknown proportions. Of these, veined squid *Loligo forbesi* is currently thought to be very scarce, with variable presence in landings. Squids of the genus *Alloteuthis* (*Alloteuthis media* and *Alloteuthis subulata*) are mainly present in squid landings from Sub-Division IXa-South, showing low catch levels in Sub-Division IXa north during the same years.

Figure 8 shows the trend of total long-finned squid landings and by Subarea/Division. Total landings presented a maximum value in 2001 with 1052 t, and then they remain more o less stable at around 900 t until 2006, when they showed a drop, reaching the minimum value in the time-series with 441 t. An increasing trend is observed from this year to 2012, reaching the maximum values in this year with 1683 tonnes, indicating a considerable recovery of landings. However, the landings decrease in all Divisions in 2013, with only a slight recovery in Division VII, continuing in 2014 this decrease. The reason could be the same that in the case of ommastrephidae.

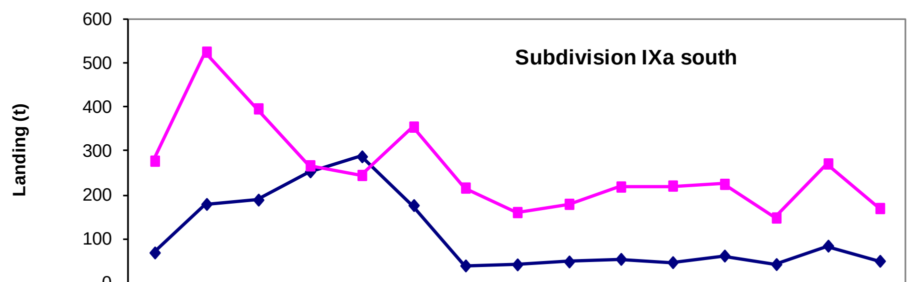
The analysis by Subarea/Division shows that the Division IXa recorded the highest landings from 2001 to 2005, with values ranging between 753 and 552 t, respectively. The 2007 landings fell to 200 t and remained stable during three years with an increasing trend up to 2012 where is reached the maximum values (401 t). In 2013, the landing decreased a 50% in relation to the previous year, with a slightly recover in 2014. Landings in Division VIIIabd and VIIIc were lower than in IXa, excep at the end of the time-series, oscillating between 128 t in 2000 and 895 t in 2012, and between 76 t in 2005 and 378 t in 2012, respectively. Landings in Subarea VII were also very low as compared with other areas, with average annual landings of only 30 t, but they showed a significant increase in 2010 and 2011, as also happened in Division VIIIc and VIIIabd. The Subarea VI showed very scarce landings, below 10 t, as it was also above mentioned described for the other analysed groups of cephalopod species, without landing in the last years.



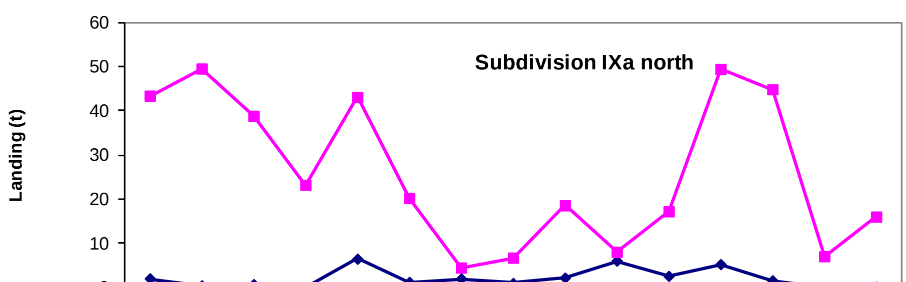
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Total	676	1052	958	917	980	880	441	598	765	546	1109	1196	1683	814	496
VI	0	1	3	10	2	8	2	3	3	3	0	0	0	0	0
VII	68	19	32	37	33	15	19	26	58	23	277	277	9	29	15
VIIIabd	129	201	172	185	190	230	79	214	360	180	373	516	895	267	163
VIIIc	88	78	113	144	175	76	85	146	97	55	173	63	378	321	84
IXa	390	753	637	542	581	552	255	209	247	286	286	340	401	197	234

Figure 8. Spanish landings (in tons) of long-finned squid species (Fam. *Loliginidae*) by ICES Subarea/Division during the 2000-2013 period.

Both in Sub-divisions IXa south and north, *Loligo spp* and *Alloteuthis* spp landings appear separated due to their high commercial importance. Figure 9 shows the proportion of each species group by Sub-Division. Both groups yielded higher landings in IXa south than in IXa north. *Alloteuthis* spp landings in IXa south ranged between 286 t in 2004 (i.e. higher landings than *Loligo* spp ones in this year) and 38 t in 2006, whereas in IXa north the highest record was 6.5 t in 2004. In both Subdivisions, the first half of the time-series in both Subdivisions recorded the highest landings, although *Loligo* spp. showed an importat increase in 2011-2012 in Subdivision IXa-north, with landing around 45 tonnes. In 2013, the landings of these species decreased significantly in Subdivison IXa-north, while in IXa south the increase was of 100% in relation to the previous year. Low values have been recorded in 2014. Finally, comment that in the last years *Alloteuthis africana* is also occasionally present in the Gulf of Cadiz (IXa-South) landings, mixed with the other *Alloteuthis* species (Silva *et al.*, 2011).



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Alloteuthis spp	68.0	178.4	188.2	252.5	286.8	175.8	38.5	40.9	47.5	53.4	46.0	60.9	41.6	83.4	49.0
Loligo spp	276.8	524.8	395.8	266.3	244.4	354.4	215.6	159.9	178.7	218.0	220.2	224.1	147.6	270.5	169.1



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Alloteuthis spp	2.1	0.5	0.8	0.1	6.5	1.3	2.1	1.0	2.3	6.1	2.6	5.31	1.65	0.1	0.2
Loligo spp	43.4	49.5	38.8	23.2	43.1	20.3	4.5	6.8	18.6	8.1	17.3	49.44	44.87	7.1	16.1

Figure 9. Long finned squid landings by species in Sub-Division IXa south and north during 2000-2013 period.

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Working Document 2.
ICES Working Group on the Cephalopod Fisheries and Life History
Tenerife (Spain), 8-11 June 20154

UPDATE OF THE BASQUE CEPHALOPOD FISHERY IN THE NORTHEASTERN ATLANTIC WATERS DURING THE PERIOD 1994-2014

Ane Iriondo[7], Marina Santurtún, Estanis Mugerza, Jon Ruiz

1. INTRODUCTION

Up to 2014 AZTI-Tecnalia is monitoring monthly cephalopod landings, catch, and discards, and fishing effort by gear and sea area of the Basque Country ports. Compilation and updating of the cephalopods catches made by the Spanish and Basque fleets landed at the Basque Country ports is updated every year.

Cephalopod catches were considered as by-catches of other directed demersal fisheries operated by the Basque fleet, targeting hake, anglerfish and megrim and more than other 30 species until some years ago. These demersal fisheries operate in different sea areas – ICES Sub-areas VI, VII and Divisions VIIIa,b,d (Bay of Biscay) and VIIIc (eastern Cantabrian Sea)- and different gears: bottom trawl, pair-trawlers, longliners, purse-seiners, nets, artisanal hook and lines and traps or pots. However, in the last years cephalopods obtained in mixed fisheries (mainly "Baka" Otter trawls) are becoming more important in relation to the species composition of the catch and for some trips nowadays they are target species.

In this document, data of the Basque Country cephalopod landings from 1994 to 2014 are presented. Catch data correspond to groups of similar species comprising more than two or three species, with similar appreciation in the markets. Data available were compiled in the following commercial species groups according to local names:

- Squid: mainly *Loligo vulgaris* and also, *L.forbesi*, *Alloteuthis media* and *A.subulata.*

- Cuttlefish: mainly *Sepia officinalis* and also *S.elegans* and *S.orbignyana.*

- Short-finned squid: mainly *Illex coindetii* and also *Todaropsis eblanae*, and European flying squid: *Todarodes sagitattus*,

-Octopus: mainly *Eledone cirrhosa* and also *Octopus vulgaris.*

Most of the large trawlers of the Basque Country catch cephalopods mainly in the Bay of Biscay (Div. VIIIa,b,d), but also in Sub-area VII (Celtic Sea and Porcupine Bank) and in Sub-area VI (both in the western part of Scotland and around Rockall Bank). Local trawls, artisanal gillneters and

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some pots or trap vessels working usually in the eastern Cantabrian Sea (Div. VIIIc) also catch some cephalopods.

The target species are usually mixed demersal fish, mainly hake, megrim or anglerfish, but together with those, variable quantities of cephalopods are caught. The proportion of these catches varies in relation to the sea area, the gear used and the distinct seasonality of these species. In the last years an important increase of cephalopod landings is observed in Basque trawling fleet.

2. RESULTS

2.1. Landings of cephalopods in Sub-areas VI, VII and Div. (VIIIa,b,d)

During 2014 and in Div. VIIIa,b,d, the largest landings of squids were recorded during November and December, reaching to 43 t in November. For cuttlefish landings reached a peak of around 42 t in February. Short-finned squid maximum landings occurred in December being around 13 t. Landings of octopus were higher in Div. VIIIa,b,d during January reaching around 14 t (Figure 1).

In **Error! Reference source not found.** percentage of landings by species groups and sea area in 2014 are presented. Landings from Div. VIIIa,b,d for squids comprise 96% and for cuttlefish 97%. In the case of short-finned squid 34% and for octopus the 90% of landings came from Div. VIIIa,b,d.

For 2014, each of the cephalopod groups contributed evenly to the total cephalopod catches, 29% squids, 35% cuttlefish, 14% short-finned squid and 22% octopus. 87% of total cephalopod landings came from Div. VIIIa,b,d (Figure 3).

Looking at the catch evolution of squid and cuttlefish during the period 1994-2014, the most remarkable feature is the continuous seasonality of the landings in all areas (**Error! Reference source not found.**). The largest landings occur from October to February for all cephalopod species, and also a marked alternation of years of rather high and low landings is observed mainly in squids. For all data series, no cuttlefish, short finned squid and octopus landings were registered in Sub-area VI. The great fishery *reservoir* for all species groups appears to be the sea area comprises within Div. VIIIa,b,d. Catches evolution of short-finned squid does not present the marked seasonality described for the other species groups, however maxima landings are registered from March and April almost till June. Octopus higher landings are registered during autumn and winter months.

Cephalopod historical landings deployed by Basque vessels show an important decreasing trend from 1994 to 2001 (**Error! Reference source not found.Error! Reference source not found.**). From 2002 onwards, the total landings of cephalopods remain quite stable but with inter-annual fluctuations. From 2009 and increasing trend is observed and in year 2012 landings are close to the maximum level of the time-series with the peak in 1994. For 2013 and 2014, an important decrease of cephalopod landings, mainly of squids, has been observed.

Focusing on fishing effort (Figure 6) it shows a decreasing trend from 1996 to 2013 which is caused by the disappearance of some Basque vessels in the last years due to regulation implementation and other different factors. In year 2014 a slight increase in Baka" otter trawler was observed in Division VIIIabd.

Nowadays, the most important Basque fleet targeting cephalopods are “Baka” bottom otter trawlers in the Division VIIIa,b,d. Within this fleet three different metiers have been defined following the criteria defined in the European Data Collection Framework:

-OTB_DEF_>=70 (otter trawlers targeting demersal fish).

-OTB_MCF_>=70 (otter trawlers targeting mixed cephalopod and demersal fish).

-OTB_MPD_>=70 (otter trawlers targeting mixed pelagic and demersal).

Landings of the different species have been included in one or other metier following the segmentation above. From 2009 to 2012, the metier targeting cephalopods OTB_MCF has increased its number of trips and its cephalopods catches but in the last year 2013 and 2014 it has decrease significantly (Figure 7**Error! Reference source not found.**). The decrease in the OTB_MCF metier seems to be related to the increase in OTB_DEF metier targeting demersal species like hake, megrim or anglerfish.

2.2. LPUE of cephalopods in Sub-areas VI, VII and Div. (VIIIa,b,d)

1. In the last years, fleet composition has changed in the Basque ports and nowadays there are mainly three fleets targeting cephalopods, which are:

2. . Baka-trawl-Ondarroa in Div. VIIIa,b,d

3. . Baka-trawl-Ondarroa in Sub-area VI

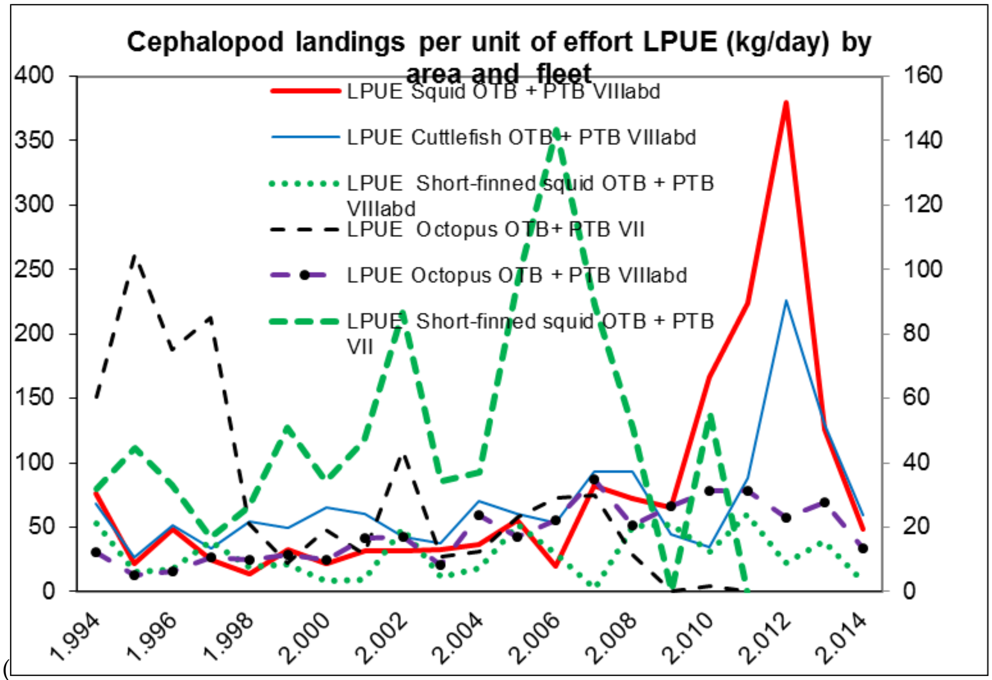
4. . VHVO Pair Trawl-Ondarroa in Div. VIIIa,b,d

5. All of them, together considered, represented close to 97% total cephalopod landings in the Basque Country ports in 2014.

6. In 2009 the Baka-trawl-Ondarroa in Sub-area VII did no effort and change its fishing area to Division VIIIa,b,d. So for the last years only 3 of them will be active and will provide effort information.

7. Effort for each fleet was obtained from the information provided yearly by the log books filled out by the skippers of most of vessels landing in Ondarroa and Pasajes, and processed by AZTI-Tecnalia. The effort unit used has been the fishing days.

8. When summing up all cephalopod landings and divided them by main fleets fishing efforts, the landing per unit of effort are obtained (LPUE)



(

9. Figure 8). This figure shows a stable situation in LPUE from 1995 till 2002 but important fluctuations with high and low abundances are observed in short fined squids data series. During the last period of the series, and in relation to Div. VIIIabd, LPUEs for squid and cuttlefish have markedly increasing whilst, octopus and short-finned squid have, in general, decreased. In Subarea VII, Octopus LPUEs have markedly decreased since 2007, mainly driven by the decrease in the effort deployed by the Basque fleet in that area. Octopus caught in this area is mainly *Eledone cirrhosa* catches of this species in the last year are nil. Short finned squids LPUEs are maintained at low levels along data series despite a sharp increase in 2010 due to a high catch in a unique trip deployed by "Baka" otter trawlers in Subarea VII. In year 2013 and 2014 an important decrease in LPUE of squids and cuttlefish is observed in Div. VIIIabd.

2.3. Discard estimation of cephalopods

Since 2001, a discard sampling program has been carried out by the AZTI-Tecnalia on the Basque fleet (North Spain). Sampling developed during 2001 and 2002 correspond to the Study Contract (98/039). From 2003 onwards, AZTI-Tecnalia has continued sampling discards onboard commercial fleet under the National Sampling program. Only the trawl fleet is considered in this study, since the rest of the segments of the Basque fleet in the North East Atlantic like purse seine, etc. (Ruiz, *et al.* 2009) have negligible levels of discard.

1. The sampling strategy and the estimation methodology used in the "Discard Sampling Programme" have been established following the "*Workshop on Discard Sampling Methodology and Raising Procedures*" guidelines (Anon., 2003). The observers-on-board programme is based on a stratified random sampling, considering the Fishery Unit as stratum and the trip as sampling unit.

2. Landings and effort are used in the raising procedure; nevertheless, only discard estimates using effort as raising procedure are presented in this document.

Although the sampling tried to cover all species retained and discarded in the different fleets, no length sampling was carried out for any of them. Thus, no length distribution and numbers of all discarded and retained cephalopod species were estimated whilst weights retained and discarded were obtained.

In Table 1 the amount of estimated cephalopods discarded (in percentage) during 2003-2014 series is presented.

In general terms, it can be said that:

- Short-finned squid mainly and curled octopus (*Eledone cirrhosa)* in a lesser extent are the most discarded species because of their low price in market.

- In Subarea VII, there is no effort deployed by the fleet from 2012-2014, so no discard information is available.

- A revision of discard from year 2012 has been presented. An important change in the exploitation pattern of cephalopods was observed as discards in all fleets of the Basque fleets have reduced their discards significantly.

- Data presented in this document has to be considered as very preliminary. Thus, discard data here presented has to be taken just as reflect of the discard practices carried out by these fleets and never as absolute numbers.

2.4. Prices of cephalopods in Basque ports

Cephalopod prices in Basque ports from 2001 to 2014 are presented in Figure 9. The price given is the mean value of both landing ports Ondarroa and Pasajes. It can be observed that the mean value has remained quite stable in the last eleven years. Squids have the best price of landed cephalopod that goes from 6 euro in 2001 to 9.37 euro in 2013. Cuttlefish is the second better paid which goes from 2.50 euro in 2001 to 4.38 euro in 2014. Octopus had the peak in price in 2003 but after that it has decrease some years and in 2009 it was around 3.10 euro. Finally, the short-finned squid, which is the cephalopod with lower prices in the time-series, shows a price of 1.53 euro in 2014.

In general terms, prices of cephalopods hardly have increased in the last fourteen years. Only in squids and cuttlefish is observed a slight increase in the last three years.

3. CONCLUSIONS

Cephalopod historical landings trend from 1994 to 2014 should be more in detail analyzed. A study should be desirable to define if changes in landings are due to changes in fisheries/metiers (fishing strategies due to market reasons), differences in fishing capacity or a real change in the abundance of these species. The comparison of the historical landings of cephalopods and LPUE data shows that LPUE data present in the last three years of the time-series the same decreasing trend as landing data. Therefore, one conclusion could be that landings decrease and the abundance indices (LPUE data) of the fleets analyzed do show this decreasing trend in the abundance of some cephalopods mainly squids and cuttlefish.

The contribution of the different cephalopods species groups to the total landing composition has been updated from 2005 to 2014. From previous studies, cephalopod proportion in the landings markedly increased from around 8% in 1997 to almost twice in 2001 in "Baka" otter trawls operating in Div. VIIIa,b,d (Santurtun *et al.*, 2005, WD), coinciding with the bad shape of the hake stock. In the last studied five years, the cephalopod proportion in landings is around 15% with a peak of 28% in year 2007.

Cephalopods appears to be an important accessory species for the baka trawlers in division VIIIa,b,d due to, specially, reduction of quotas of some traditional demersal species during the period 2002-2005, with apparent constant availability and relatively good market prices. In the period 2009-2012 effort of the mixed cephalopod metier (OTB_MCF) has yearly increased and landings of the metier have also increased but in the last two years 2013 and 2014 the effort has decreased significantly. This shows a change in the fishing exploitation pattern if the Basque trawlers having cephalopods as target species in some periods of the year due to the good price of these species and the lack of quota for them.

The analysis of prices shows that in the last twelve years there has been hardly increase in prices of cephalopods, as it has also occurred for the rest of the main demersal commercial species. The squids remain being the cephalopod with highest price with an increasing trend in the last two years and the short-finned squid and octopus are the ones with lowest price.

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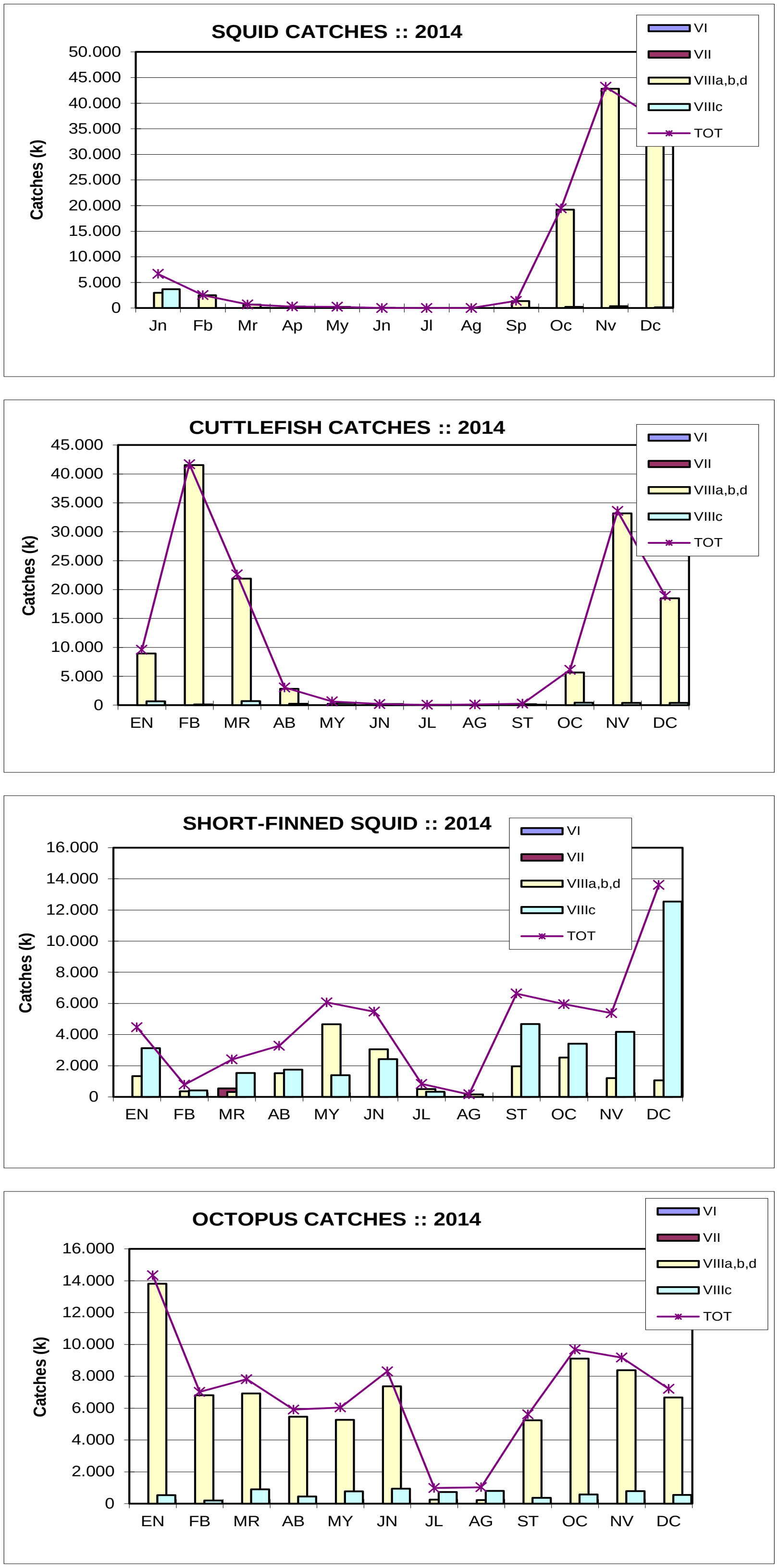
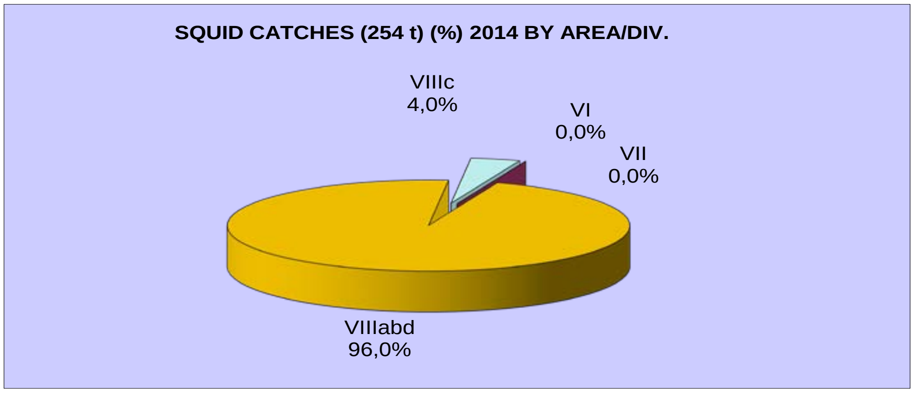
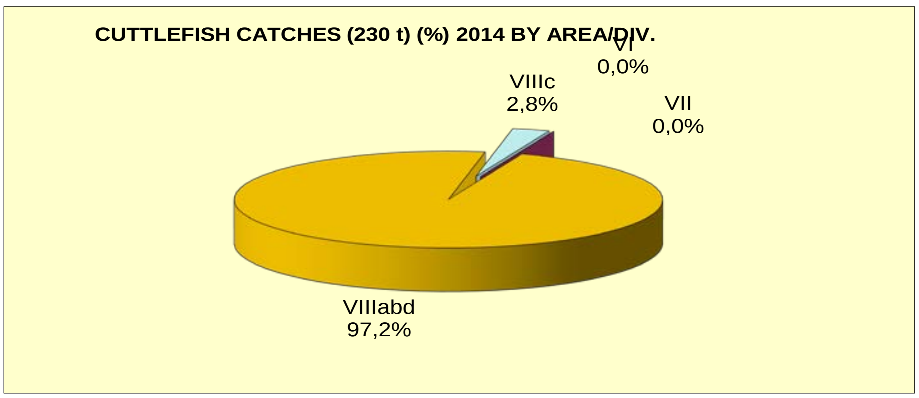
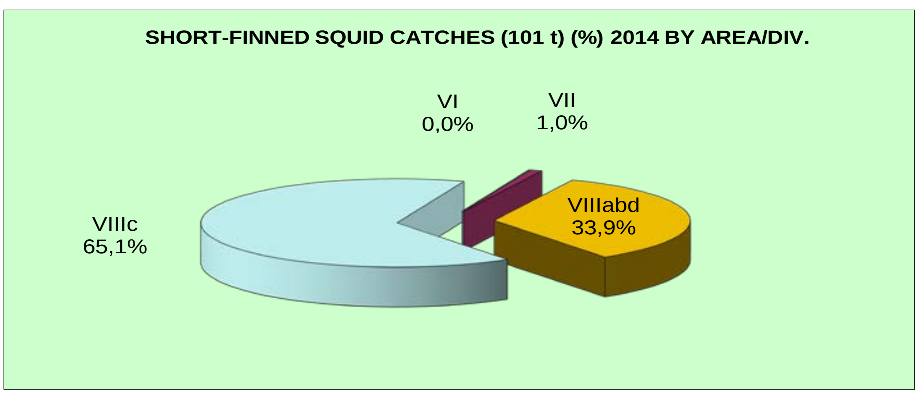


Figure 1. Monthly distribution of the Basque Country Catches (landings in kg) of Squid, Cuttlefish, Short-finned squid and Octopus by sea area, in 2014.







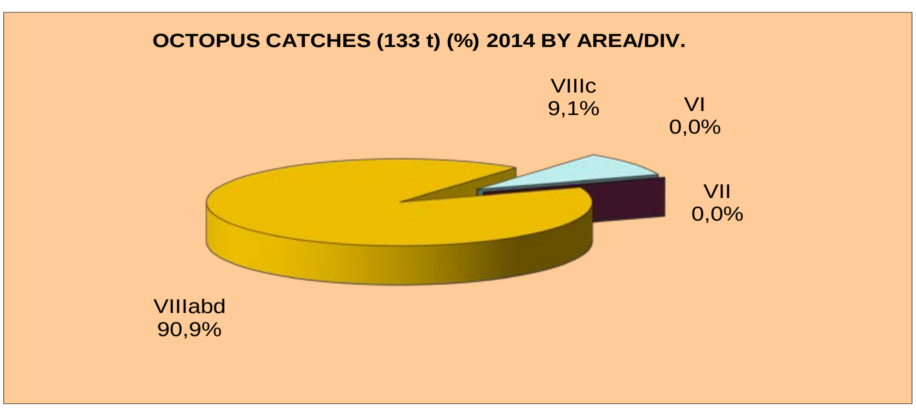
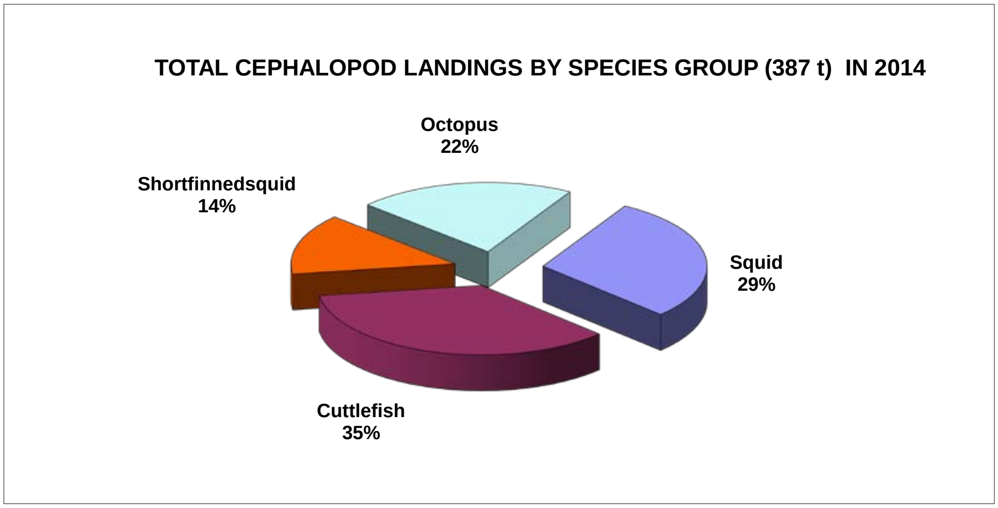


Figure 2. Percentage of the Basque Country landings of Squid, Cuttlefish, Short-finned squid and Octopus by sea area, in 2014.



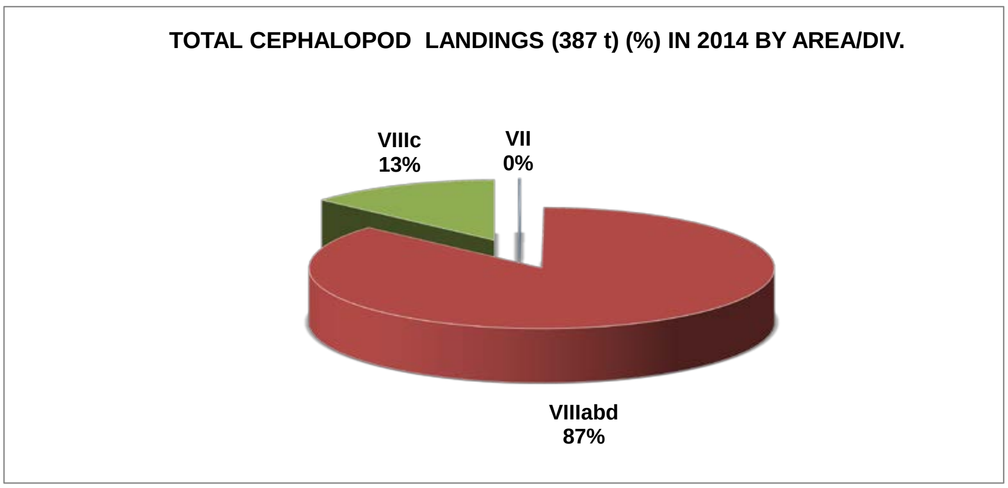


Figure 3. Total composition in percentage of the Basque Country landings. Above: By species group. Below: By sea area for 2014.

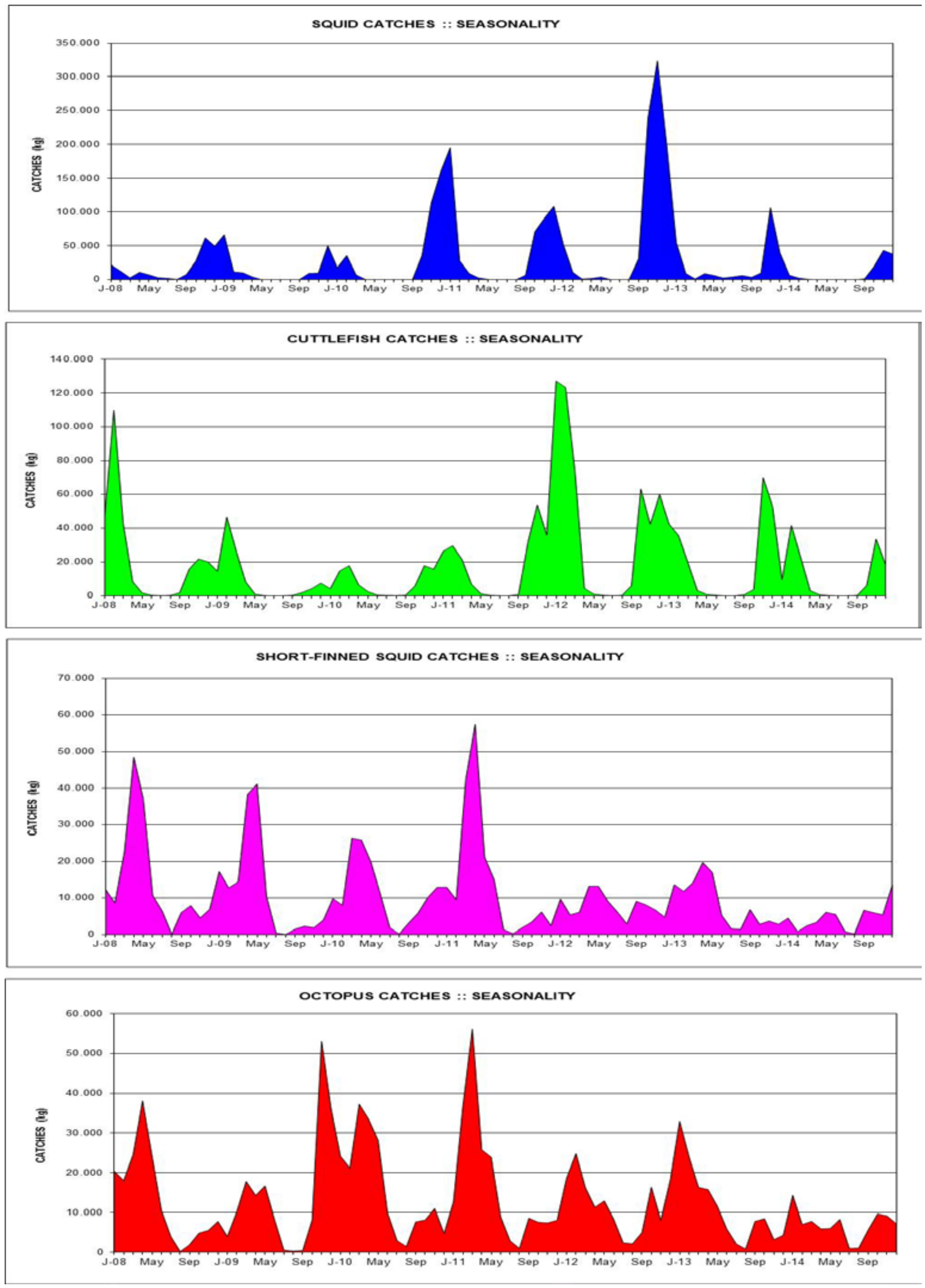


Figure 4. Cephalopods landing (in kg) evolution of the Basque Country by species group considering all areas together (VI, VII, VIIIabd and VIIIc) for the total period 1994-2014.

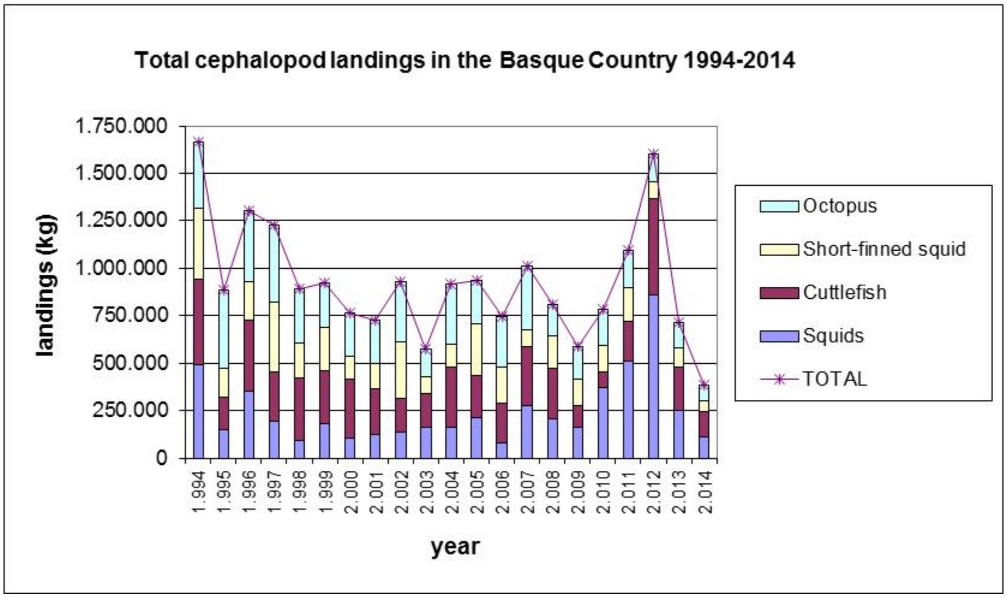


Figure 5. Cephalopods landing evolution of the Basque Country by species group for the total period 1994-2014.

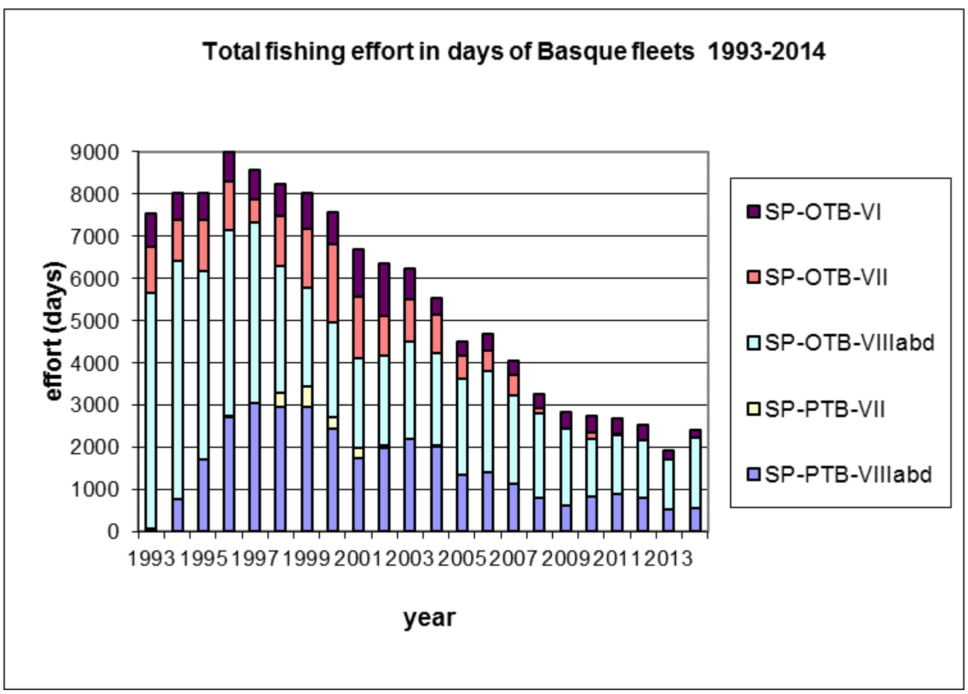


Figure 6. Total fishing effort of the Basque fleets from 1993 to 2014.

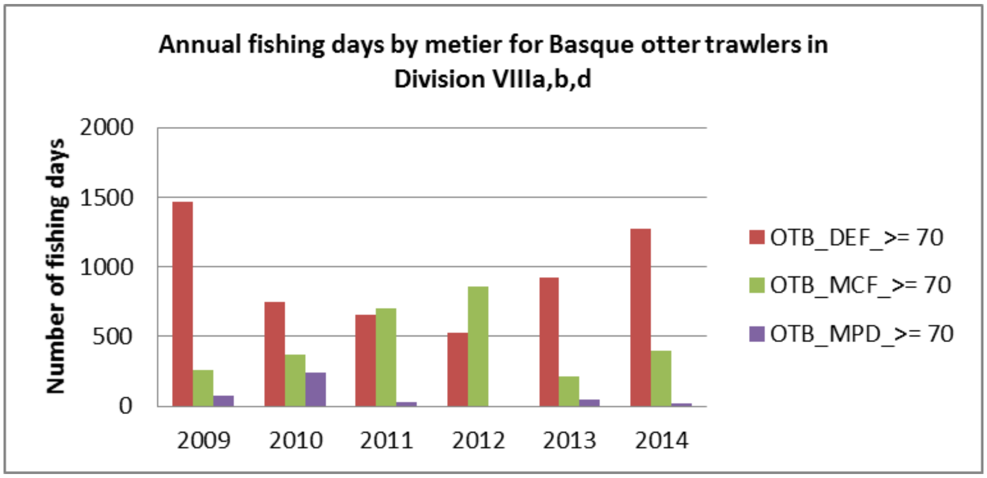


Figure 7. Annual fishing days by metier for Basque bottom otter trawlers operating in Division VIIIa,b,d during 2009 to 2014.

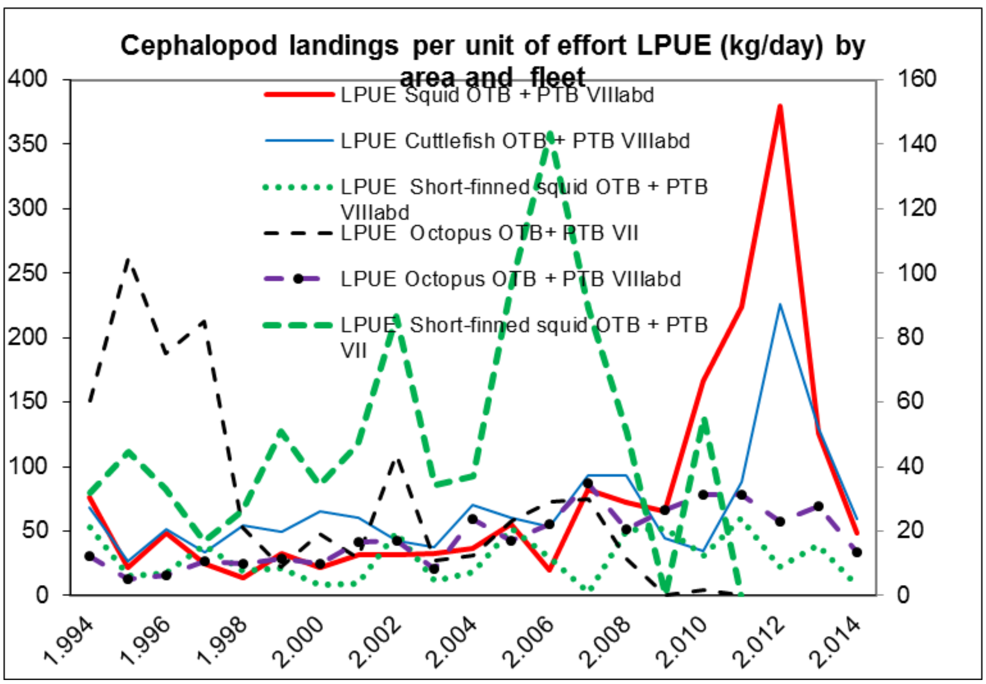


Figure 8. Cephalopod landings per unit of effort (kg/day) of the Basque fleet from 1994 to 2014.

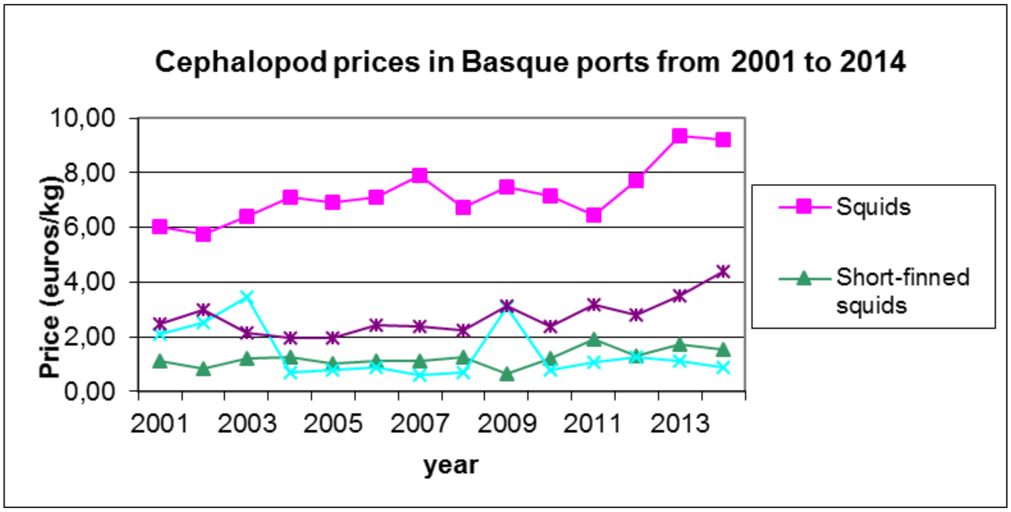


Figure 9. Cephalopod prices in Basque ports from 2001 to 2014.

Table 1. Estimated cephalopod discard (kg) during 2003-2014 series is presented.

Gear	Area	Species	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012*	2013	2014
OTB	VI	Short finned squid	100%	-	-	-	-	100%	100%	100%	100%	-	-	
		Curled octopus	-	-	-	-	-	-	-	-	-	-	-	
		Cuttlefish	-	-	-	-	-	-	-	-	-	-	-	
	VII	Short finned squid	61%	77%	19%	4%	52%	87%	-	-	-	-	-	
		Curled octopus	33%	1%	38%	12%	56%	-	-	-	-	-	-	
		Cuttlefish	12%	-	-	-	-	-	-	-	-	-	-	
	VIIIabd	Short finned squid	59%	57%	17%	35%	38%	12%	15%	31%	87%	16%	31%	67%
		Curled octopus	28%	5%	7%	0%	19%	2%	14%	5%	74%	1%	1%	7%
		Cuttlefish	0%	1%	2%	-	1%	-	8%	-	3%	0%	3%	0%

*Updated in year 2013.

% discard from total catches.

Working Document 3. for the ICES WGCEPH Working Group
on Cephalopod Fisheries and Life History.
Tenerife, Spain

Portuguese cephalopod fishery statistics (tor a) and population parameters (tor b) – updating status and trends in ICES division IXa

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Cephalopods fisheries, mainly common octopus fisheries is an important fishing activity for the Portuguese fishing fleet in area IXa. Is from general knowledge that the annual cephalopods landings reflect the resource availability to fisheries, mainly the common octopus abundance. Between 2000 and 2014 the cephalopods landings present an increasing tendency, with the common octopus landings representing in average 83% of the total cephalopod landings in area IXa. In terms of relative importance, the common octopus fisheries is followed by the cuttlefish fisheries (13%), longfinned squids (0.03%) and with a residual capture, the shortfinned squids (0.01%).

Table 1 - Cephalopods landings (in tonnes) by species group by the Portuguese fleet from the ICES sub-area IX between 2000 and 2014.

year	cephalopods	Cuttlefish (sepiidae)	Long-finned Squid (*Loliginidae*)	Octopuses (*Octopodidae*)	Short-finned squid (Ommas-trephidae)
2000	11312	1357	613	9018	323
2001	9690	1348	863	7246	232
2002	9568	1367	678	7316	204
2003	9656	958	253	8297	146
2004	9846	1211	885	7509	240
2005	12576	1308	191	10889	186
2006	8992	1787	89	7073	42
2007	10117	1517	127	8452	20
2008	15071	1453	339	13261	17
2009	9415	1258	198	7940	18
2010	12721	2009	5	10665	40
2011	9049	1498	217	7256	76
2012	11310	1165	267	9768	108

2013	14370	1295	179	12821	75
2014	12120*	1234*	171*	10637*	78*

* provisional data.

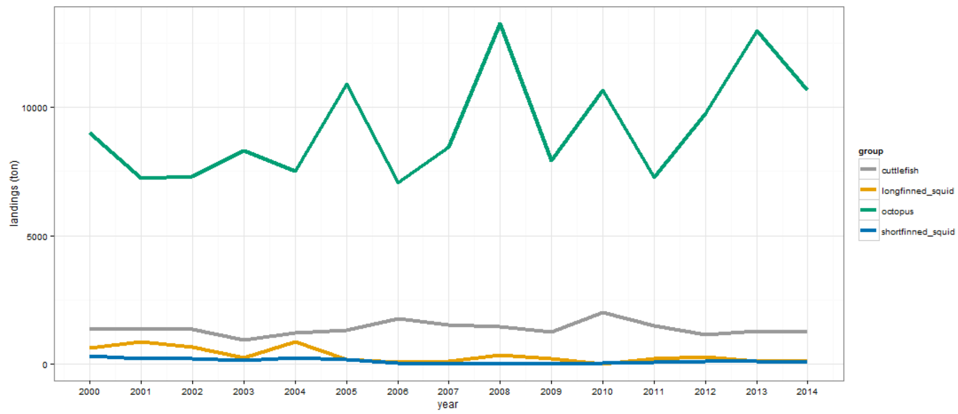

Figure 1 Portuguese fleet landings of cephalopods groups of species between 2000 and 2014.

Octopus by species

Since 2010, all the octopus landed in the Portuguese ports is identified to the species level. Figure 2 shows the annual evolution of landings of the two octopus species with commercial value, *Octopus vulgaris* and *Eledone cirrhosa.* For both species, landings are highly variable, but is possible to identify an increasing trend for *Octopus vulgaris* landings, while *Eledone cirrhosa* landings decreased between 2013 and 2014. The preliminar results show that in 2014 were landed 10 592 ton of *Octopus vulgaris* and 69 ton of *Eledone cirrhosa.*

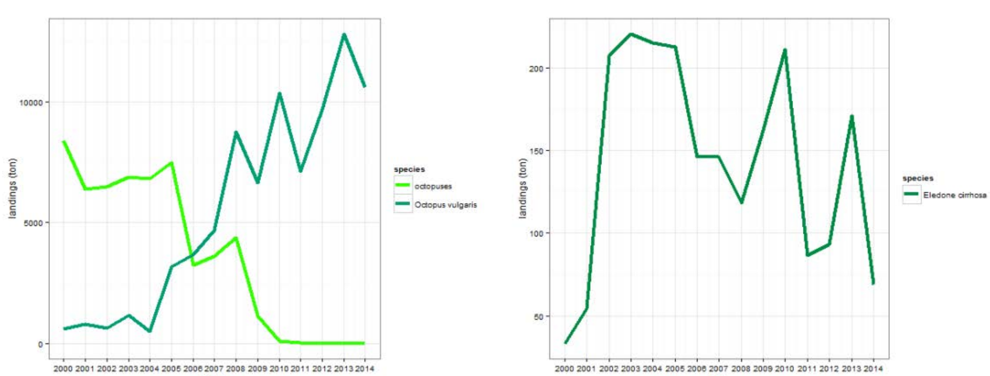

Figure 2 - Portuguese fleet landings of *Octopus vulgaris* and *Eledone cirrhosa* from area IXa.

Eledone cirrhosa is mainly captured by the fleet of vessel bigger than 24 m length (representing roughly the trawling fleet) with 72% of the species landings. *Octopus vulgaris* is captured mainly by the fleet of small vessels <10 m (comprising the local fleet) , with 40% (average) of landings and the vessel fleet of 12-18 m length with 36 % of landings.

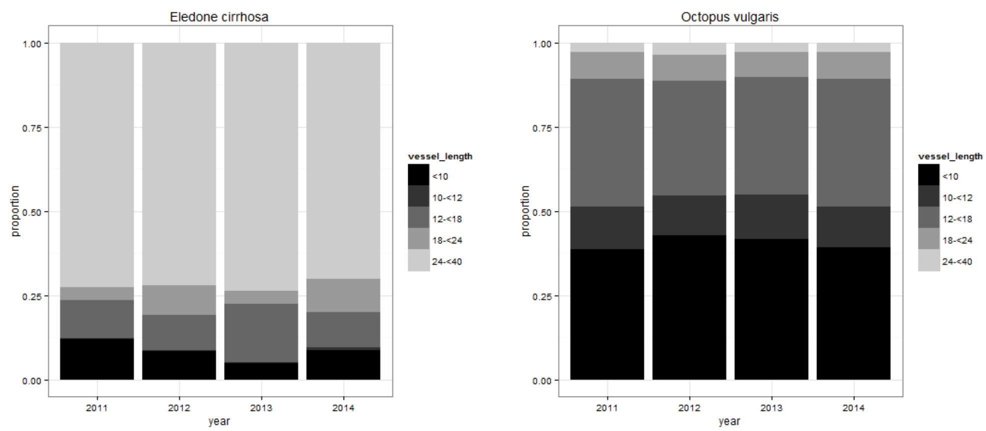

Figure 3 - Proportion of landings by vessel size category for *Eledone cirrhosa* and *Octopus vulgaris.* The data representing captures obtained in area IXa made by the Portuguese fleet and landed in Portuguese ports.

For Portuguese coast do not exist any abundance index fishery independent. The Portuguese Groundfish Survey operates with a NCT net with rouletes not adequated to determined abundance index for *Octopus vulgaris.* In absence of a better estimate of *Octopus vulgaris* abundance, we determined the landings by unit of effort (LPUE) based on the species landings by kw-days targeting cephalopods by vessel-length category. The LPUE data show a abundance decrease in late 2011 and 2012 winter, followed by a abudance increase from 2012 spring until the spring of 2013. This tendencies are observed for all vessel categories LPUE with exception to the bigger vessels category (roughly the trawling fleet) that operates outside the species distribution.

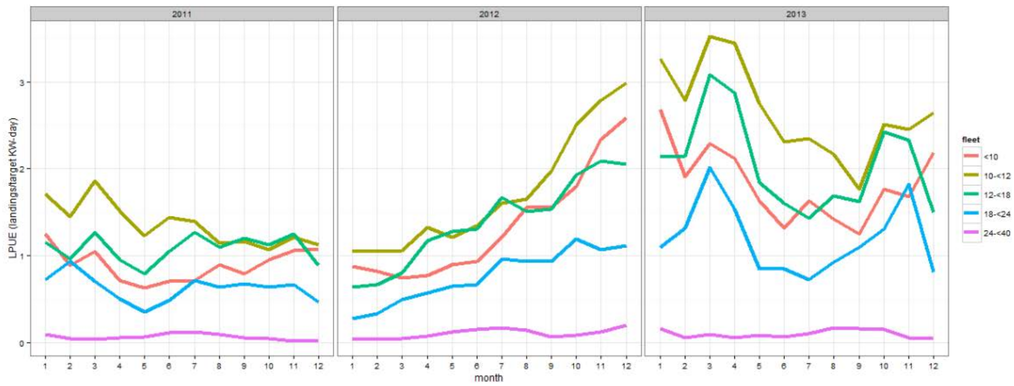

Figure 4 - *Octopus vulgaris* LPUE (landings by Kw-day) by month between January 2011 and December 2013. The LPUE was determined based in the *O. vulgaris* captured by Portuguese vessels in area IXa and landed in the Portuguese ports.

The area of distribution *Eledone cirrhosa* is deeper than *Octopus vulgaris* and is fully covered by the Portuguese UnderWater Survey TV (UWTV) and for that reason the data collected during this survey can be used to determine the species abundance index . The stratified biomass abundance index (Kg/hour) determined to *Eledone cirrhosa* (Figure 5) shows an highly variable abundance between 2000 and 2014 with a sharply decrease between 2006 and 2007, from what the species still do not recover. This pattern of species availability is followed by the commercial fleet landings pattern (Figure 2 *Eledone cirrhosa*).

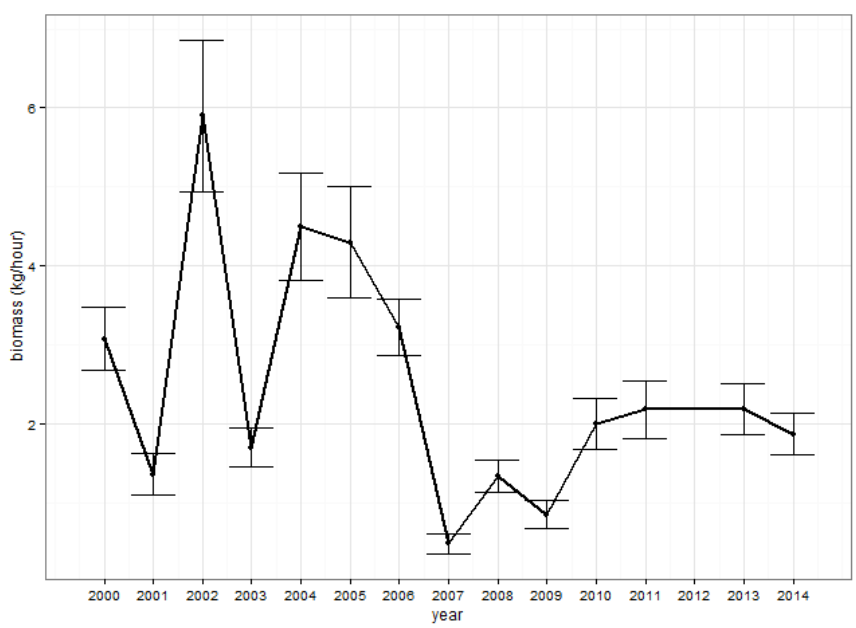

Figure 5 - *Eledone cirrhosa* abundance index (Kg/hour) obtained from the captures obtained from the Portuguese underwater survey TV conducted between 2000 and 2014.

Long-finned squid by species

As for the *Octopodidae*, since 2009 all the specimens of the *Loliginidae* group are identified to the species level in the Portuguese landing ports. The long-finned squids captured in the Portuguese coast belong the three species (or group of species): *Loligo vulgaris*, *Loligo forbesi* and *Alloteuthis spp*. While the *Loligo forbesi* is seldom landed in the Portuguese landing ports, the other two are commonly landed here. Notwithstanding, the landings of long-finned squids sharply decreased between 2005 and 2006 (Table 1, Lourenço *et al.*, 2014) and still did not recovered to the levels of the earlier 2000's. During the year of 2014 were landed in the Portuguese ports 134.72 ton of *Loligo vulgaris* and 36.27 tons of *Alloteuthis spp* (Figure 6). *Loligo vulgaris*, the species that attains higher market prices, is mostly landed by the bigger than 24 m vessels (roughly the trawling fleet) with 68% of total landings between 2011 and 2014, followed by the fleet comprising the vessels smaller than 10 m (roughly the local fleet) with 20% of the total landings in the same period (Figure 7).

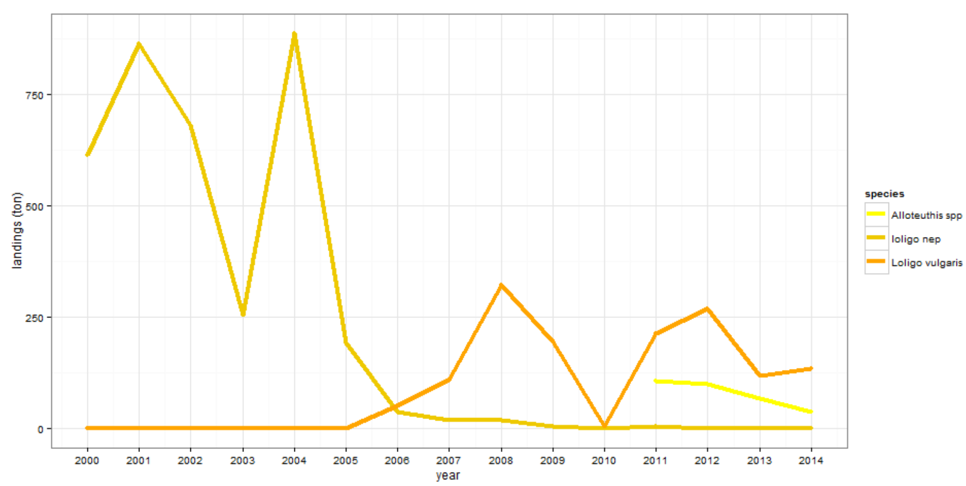

Figure 6 - Portuguese fleet landings of *Alloteuthis spp*, *Loligo vulgaris* and *Loligo spp* from area IXa.

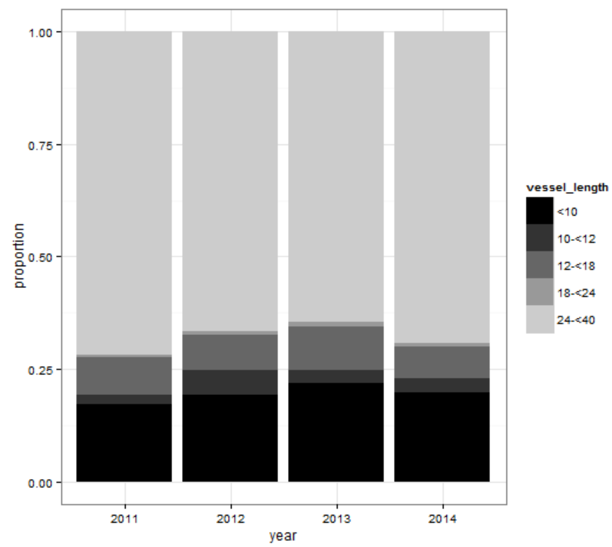

Figure 7 - *Loligo vulgaris* landings by vessel length category.

Data collected from the Portuguese Groundfish survey (PGFS) allows to partially determine the abundance index for *Loligo vulgaris*. The results show that the year of 2004 was and year of significantly high abundance of *Loligo vulgaris* droping to values similar to 2003 in the next year followed by a sligthly decrease between 2005 and 2007. Since 2007 the abundance of *Loligo vulgaris* increased and stabilized in the latest years. *Alloteuthis spp* is very abundant in the Portuguese coastal waters. The abundance of the species have been increasing since the earlier 2000's with exception to the period between 2004 and 2006 where abundance levels dropped. It is noteworthy the fact that Alloteuthis landings in the commercial fleet do not follow this increasing trend in the abundance levels.

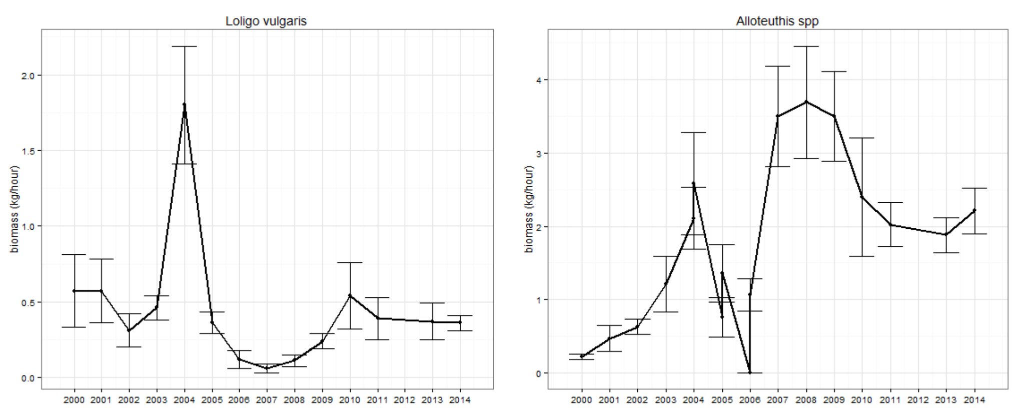

Figure 8 - *Loligo vulgaris* and *Alloteuthis spp* abundance index (biomass in Kg/hour) determined based on the Portuguese Groundfish survey between 2000 and 2014.

Cuttlefishes

The cuttlefish species with most important commercial value is the *Sepia officinalis.* No other *Sepia* or *Sepiolidae* species attain sizes of commercial value and for that reason we assume that all the cuttlefish specimens landed in the portuguese landing ports belong to the *S. officinalis*. After an high decrease in landings between 2011 and 2012, the cuttlefish fisheries seemed to get some stability between 2013 and 2014, with the fishing fleet landing 1302 ton in 2013 and 1249 ton in 2014 (Figure 9-cuttlefish annual landings). The cuttlefish is mostly fished by the small-scale fleet of vessels. The vessels with length smaller then 10 m are responsible by 76 % of the cuttlefish landings in the Portuguese, followed by the vessels with length between 12-18 m landing 15% of the species total landings (Figure 9 - cuttlefish landings by vessel category).

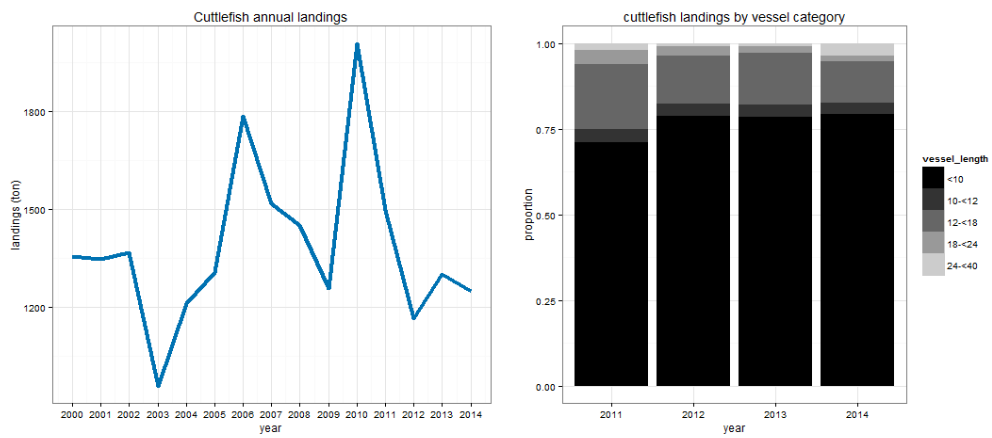

Figure 9 - *Sepia officinalis* from area IXa landed by the Portuguese fleet in Portuguese ports and the proportion of landings by vessel-size category based in the landings data obtained for the period between 2000 and 2014.

As for the *O. vulgaris*, for Portuguese coast do not exist any abundance index fishery independent because the PGFS operates with a NCT net with rouletes not adequated to determined abundance index both for the common octopus as for the *S. officinalis.* Again, in absence of a better estimate of abundance, we determined the landings by unit of effort (LPUE) based on the species landings by kw-days targeting cephalopods for the <10m and 12-<18 m vessel-length categories.

S. officinalis LPUE (kg/Kw-days) shows a pronounced seasonal effect (Figure 10). LPUE is higher during the winter and spring, decreasing in the summer months attaining the minimum value in September in the three years analyzed (2011 to 2013).

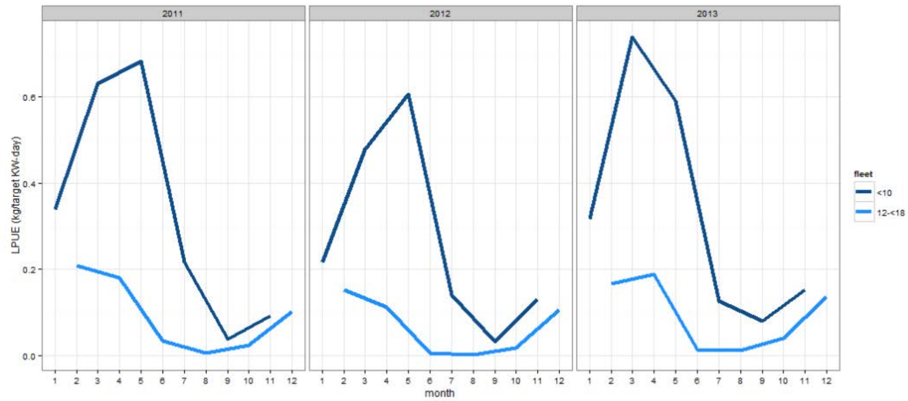

Figure 10 - *Sepia officinalis* LPUE by month based on the landings conducted between 2011 and 2013 by the two vessel-length categories Portuguese fleets that most contribute for the cuttlefish fisheries (<10 m and 12-<18 m). The landings data used represent captures conducted in area IXa.

Cephalopods Biodiversity in the Portuguese Sector of Area IXa

IPMA collects annually data on the biodiversity, distribution and abundance (in number and weight) of cephalopod species. The Underwater Survey TV (USTV) and the Portuguese Groundfish survey (PGFS) conducted annually in the second and fourth trimester of the year respectively since 1994 (with exception to 2012) results in an extremely valuable time-series in biodiversity status and changes. Table 2 presents both species frequently identified, abundance (in numbers/hour and Kg/hour) by survey for the entire 20 years time-series.

Table 2 - Cephalopod species more frequently identified in the scientific surveys Underwater TV survey (UWTV) and the Portuguese Groundfish survey (PGFS). Abundance and Biomass are averages of the abundances and biomass obtained in each survey between 2000 and 2014.

Species	survey	abundance (n/hour)	biomass (kg/hour)
Sepia officinalis	PGFS	0.069	0.021
Sepia officinalis	UWTV	0.304	0.011
Eledone moschata	PGFS	0.858	0.154
Eledone moschata	UWTV	1.299	0.217
Sepia elegans	PGFS	3.450	0.035
Sepia elegans	UWTV	2.630	0.039
Eledone cirrhosa	PGFS	3.594	0.345
Eledone cirrhosa	UWTV	8.229	2.496
Sepia orbignyana	PGFS	1.098	0.021
Sepia orbignyana	UWTV	1.235	0.039
Octopus vulgaris	PGFS	0.650	0.486

Octopus vulgaris	UWTV	1.264	1.001
Alloteuthis spp	PGFS	353.376	1.061
Alloteuthis spp	UWTV	1.342	0.005
Rossia macrosoma	PGFS	0.204	0.005
Rossia macrosoma	UWTV	2.659	0.130
Todarodes sagittatus	PGFS	0.021	0.025
Todarodes sagittatus	UWTV	0.384	0.149
Loligo forbesi	PGFS	0.181	0.014
Loligo forbesi	UWTV	0.002	0.001
Illex coindetii	PGFS	7.996	0.426
Illex coindetii	UWTV	1.906	0.294
Loligo vulgaris	PGFS	4.612	0.447
Loligo vulgaris	UWTV	0.037	0.031
Todaropsis eblanae	PGFS	1.111	0.069
Todaropsis eblanae	UWTV	1.686	0.278

Figures 11 and 12 present the evolution of the abundance index for the most abundant cephalopods species identified in the PGFS and in the UWTV surveys respectively.

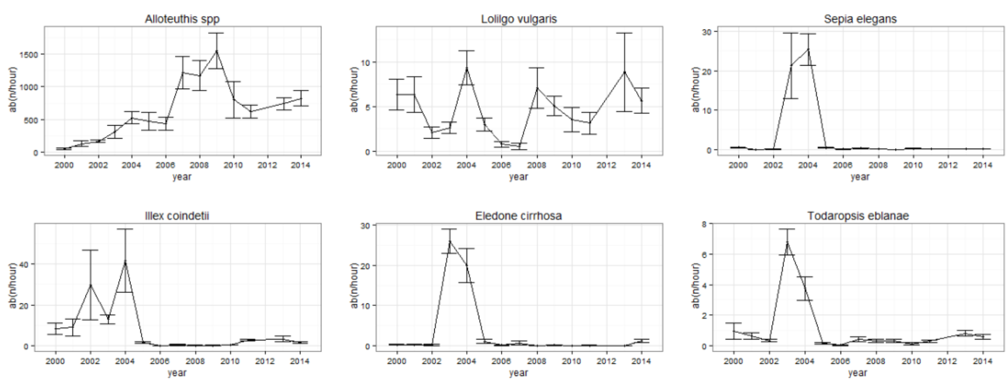

Figure 11 - Abundance index in n/hour by year for the six more abundant cephalopod species identified in the Portuguese Groundfish survey in the area IXa.

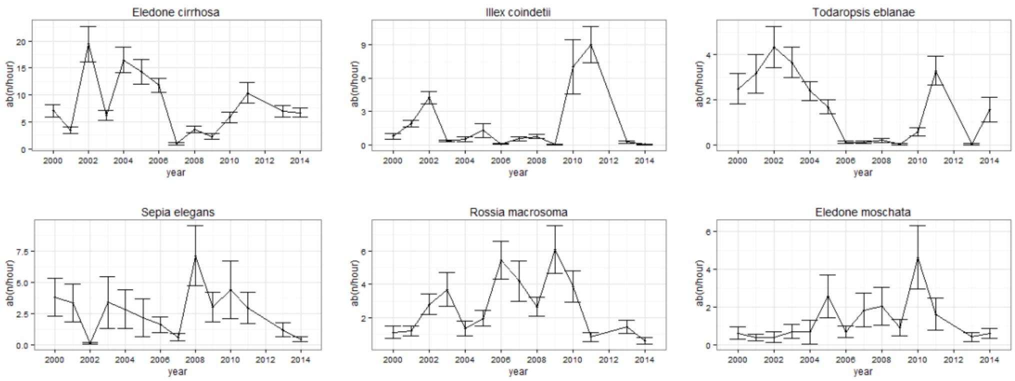

Figure 12 - Abundance index in n/hour by year for the six more abundant cephalopod species identified in the Underwater TV survey in the area IXa.

A Statistical time-series approach for the monitoring of cephalopod fisheries (Prista *et al.*, 2014)[8]

In the present study we report on an application of a statistical time-series quality control framework (Prista *et al.*, 2011) to the analysis of landings of two Portuguese cephalopod fisheries for which no routine ICES advice is presently given (common octopus and European squid) and show how it can be used to quickly draw forecasts of future landings and detect changes in the underlying fisheries process improving advice to fishers and managers and helping to set priorities in data-limited contexts.

We obtained small and moderately-sized time-series of monthly landings of common octopus and European squid in different regions of the Portuguese coast and made by different fleet segments from the Directorate-General for Natural Resources, Safety and Maritime Services (DGRM) and modeled them using Seasonal Autoregressive Integrated Moving-Average models (SARIMA). SARIMA models are simple time-series models that assume monthly data are the output of a stochastic process, generated by unknown causes, from which future values can be predicted as a linear combination of past observations and estimates of current and past random shocks to the system (Box *et al.*, 2008). SARIMA models are applicable to many already-available univariate data sets and have been found to provide forecasts of both annual and monthly landings that are comparable to or even better than forecasts obtained from many multivariate models (see review in Prista *et al.*, 2011). In addition to good forecasting, these models also possess significant capabilities

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[8] This study was presented in the ICES Annual Science Conference in theme session dedicated to Theme Session P: *Operational solutions for cephalopod fisheries and culture.*

for monitoring landings that become apparent when the forecasts of SARIMA models are approached from a statistical process-control perspective (Box *et al.*, 2008; Prista *et al.*, 2011). Briefly, appropriately fit models will only provide good landing forecasts as long as significant changes do not take place in the fishery during the course of the forecasting period. Consequently, large forecast errors indicate that changes in the underlying data-generating process (i.e., in the unknown relationship between biological, oceanographic and anthropogenic factors that ultimately drives fishery landings) took place that require further research and/or deserve attention of fishers and managers. Under such setup the prediction intervals of SARIMA forecasts are statistically valid guidelines that can be used to assess the significance of future changes in landings (Prista el al., 2011). In the present study, SARIMA models, forecasts and prediction intervals were derived using an improved version of the semi-automated AICC-based approach developed by Prista *et al.* (2011) that now allows careful modeling and monitoring of each time-series to be carried out in about 30 minutes.

All models adequately fitted the landings data. Trends were only identified in 1 out of 7 octopus data sets (2003-2013) but an improvement in fit was obtained after considering trend in the modeling of 4 out of 7 European squid time-series (1995-2013). Strong seasonality was detected in the landings of European squid but not in octopus landings, with the exception of the trawl fisheries taking place in the northwestern and southern coasts. Strong correlations were found between present landings and landings registered in previous months and previous years. Model parameterization closely reflected presently known facts from the life cycle and fisheries of common octopus and European squid, namely their short life-span, recruitment seasons and typical fisheries practices, thus sustaining the application of the models. SARIMA model forecasts outperformed an array of simpler alternatives indicating an overall usefulness of SARIMA modeling and forecasting in these data-limited scenarios. Most importantly, the prediction intervals of SARIMA models allowed the detection of a recruitment failure in the 2nd semester of 2006 that came to affect the production of European squid by trawl fishery in the following years. In 2013 all time-series were found to be "in-control" from a statistical quality control perspective indicating no evidence for significant changes in the underlying data generating process, i.e., in the presently unknown combination of biological, oceanographic and anthropogenic factors that drives the landings. However, European squid landings were somewhat lower than expected in the 2nd semester of 2013 signaling a lowering of fisheries production that deserves attention and further investigation. Altogether these results highlight that SARIMA forecasts and prediction intervals are useful tools for the regular monitoring of cephalopod landings when more sophisticated data-intensive alternatives are not available (or cannot be routinely implemented), thus contributing to the identification and setting of research priorities and advice to fishers and managers dealing with data-limited resources.

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Working document 4. presented to the ICES Working Group on Cephalopod Biology and Life History, Tenerife (Spain), 8-11 June 2014

Stock assessment of the English Channel stock of cuttlefish with a two-stage biomass model

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ABSTRACT

Among the English Channel fishery, the importance of cuttlefish stock has increased, following the cephalopods global landings and market trend. The stock is currently managed at regional scale but not by European regulations, although it is a shared species targeted by French and British fishing fleets at several stages of its life-cycle and across much of its distributional range.

An assessment of this stock was conducted in June 2014 by fitting a two-stage biomass model on a 22 years' time-series (1992-2013). We present the last update of cuttlefish stock assessment using the same model on years 1992-2014. As the outputs of the model are sensitive to a fix growth parameter, we explore possibilities to improve the model.

The use of a Bayesian framework is particularly adapted for decision making, allowing the propagation of uncertainty in the model and the use of prior knowledge on some parameter distributions. Therefore, we implemented the two-stage biomass model into a Bayesian framework and compared the results with the outputs of the initial fit. We found similar trends of biomass estimates for both models. The Bayesian model outputs showed a smaller range of variation than the initial fit.

These results are only a first step toward an improvement of the two-stage biomass model currently used for cuttlefish stock assessment in the English Channel. The Bayesian model could indeed be improved and particular attention should be paid to the growth parameter *g* because of the high sensitivity of model outputs to its value. We discuss future directions of this work.

Keywords: *stock assessment, short-lived species, data-limited, cuttlefish, Sepia officinalis, English Channel, two-stage biomass model, Bayesian methods*

INTRODUCTION

Stock assessment for short-lived species is a delicate matter because of the difficulty of swift data collection as well as the challenge of modelling population dynamics. Cephalopod populations are fast growing short-lived ecological opportunists. Age based methods in these species are hampered by time consuming age determination with statoliths. In spite of trials with a wide range of models

(Pierce and Guerra 1994) there is no routine stock assessment in most of cephalopods fisheries, although a precautionary approach is often advocated (Rodhouse *et al.* 2014).

The English Channel cuttlefish stock is one of the most important resource for the Channel fisheries and is exploited by French and English fishermen (Engelhard *et al.* 2012). Inshore exploitation is managed by local rules, but no EU regulation apply to the whole stock. It experiences a short life-span (considered of 2 years in the English Channel) and performs seasonal migrations. Cuttlefish concentrates in the central western Channel during winter and in coastal areas during spring and summer (Boucaud-Camou and Boismery 1991). One argument for an English Channel stock unit was that migration takes place almost entirely within the English Channel. Boundaries of the stock were set as ICES division VIId and VIIe, which was also coherent with the concentration of high Catch Per Unit Effort (CPUE) inside these boundaries (Wang 2003).

Analytical methods have been used to occasionally assess the stock (Royer *et al.* 2006), but because of the difficulty to correctly describe catch structure, less data-demanding models were sought (Gras *et al.* 2014), which could be used routinely (Duhem *et al.* in WGCEPH 2014). The two-stage biomass model (Roel and Butterworth 2000) is not too much data-demanding and is therefore well suited for data-limited stocks. It assumes that the exploited population can be observed at two different stages: recruitment and full exploitation. It has been adapted to the English Channel cuttlefish stock (Gras *et al.* 2014), based on a simplification of cuttlefish life-cycle, and with bootstrap estimated uncertainties. Ibaibarriaga *et al.* (2008) highlights the advantage of using Bayesian methods for estimating uncertainties in these models and to face the lack of data. The main idea of Bayesian inference is to use the initial knowledge (prior distribution), update it with the most recent information (observed data, interpreted via the likelihood function) and form the posterior distribution, which is the new understanding about the studied phenomenon (Pulkkinen 2015).

This study presents the update of cuttlefish stock assessment using the two-stage biomass model from Gras *et al.* (2014). The evolution of biomass estimates from 1992 to 2012 using a Bayesian implementation of this model is also presented. Outputs are compared with the initial fit. This study is a first step in the improvement of the two stag-biomass model currently used for the English Channel stock of cuttlefish, and further work will be done as explained in the discussion part.

MATERIALS AND METHODS

Data used in the model

The implementation of the two-stage biomass model required abundance indices from the Bottom Trawl Survey (BTS) and the Channel Ground Fish Survey (CGFS), as well as landings and effort from French and UK trawlers, and total catch of cuttlefish among the English Channel ($C_{1+,y}$). BTS abundance indices and data from UK trawlers were extracted from the Centre for Environment, Fisheries and Aquaculture Science (Cefas), and data from CGFS and French trawlers were extracted from the French Research Institute for Exploitation of the Sea (Ifremer).

The BTS is carried out each year in July (when cuttlefish recruitment occurs), and the CGFS is carried out in the eastern English Channel one quarter later, in October. Trawling lasts approximately 30 minutes at each station for both surveys (Carpentier *et al.* 2009). Effort data consist on hours of trawling for the trip considered and engine power of the vessel considered. The weight of specimens of one year old and more caught in the English Channel was also required. This last information could be estimated from sale data, by calculating the percentage of cuttlefish belonging to commercial categories 1 or 2 (i.e. animals above 300g).

Two-stage biomass model

A package with the version of a two-stage biomass model adapted to cuttlefish was coded in R (Gras and Robin 2014). The model (Gras *et al.*, 2014) assumes a simplified life cycle of cuttlefish. It assumes that the exploited population can be observed at two different stages: recruitment and full exploitation. Recruited biomass (B_1) is estimated with abundance indices from BTS and CGFS surveys. Spawning stock biomass (B_2) is estimated with Landings Per Unit Effort (LPUE) from French and UK bottom trawl fisheries. A biomass growth parameter g is fixed externally. It is composed by the natural mortality rate, assumed to be equal to 1.2 (Royer *et al.* 2006, Gras *et al.* 2014) and the growth rate, derived from mean weight at age using historical data collected by the University of Caen.

A first step is to calculate standardized LPUE, using the delta-glm function of the cuttlefish.model package. LPUE variability is explained by 4 variables: year, month, ICES rectangle and engine power of the vessel.

Total catch of one year old cuttlefish ($C_{1+,y}$) is assumed to happen as a pulse in the middle of the fishing season (on 1st January Y). Spawning stock biomass $B_{2,y}$ of the year y at the end of the life cycle is therefore expressed as:

$$B_{2,y} = \left[B_{1,y}e^{-\frac{g}{2}} - C_{1+,y}\right]e^{-\frac{g}{2}}$$

Abundance $B_{1,y}$ at the beginning of the fishing season can be estimated with BTS and CGFS survey index:

$$S_y^1 = k_1 B_{1,y} e^{\varepsilon_y} \; ; \; S_y^2 = k_2 B_{1,y} e^{-\frac{g}{4}} e^{\delta_y}$$

Where S_y^1 is the BTS survey index for year y, k_1 is the BTS survey catchability, ε_y is the observation error for year y, S_y^2 is the CGFS survey index, k_2 the CGFS survey catchability, and δ_y is the observation error.

LPUE are modelled based on the mean biomass in the fishing season. UK standardized LPUE (U_y^{uk}) and French standardized LPUE (U_y^{fr}) can be expressed as:

$$U_y^{uk} = \frac{1}{2} q_{uk} \left[B_{1,y}e^{-\frac{g}{4}} + \left(B_{1,y}e^{-\frac{g}{2}} - C'_{1+,y}\right)e^{-\frac{g}{4}}\right]$$

$$U_y^{fr} = \frac{1}{2} q_{fr} \left[B_{1,y} + \left(B_{1,y}e^{-\frac{g}{2}} - C_{1+,y}\right)e^{-\frac{g}{2}}\right]$$

Where q_{uk} is the catchability of UK trawlers, q_{fr} the catchability of French trawlers, and $C'_{1+,y}$ the landings from July, year *y* to April, year *y+1*, considering that UK trawlers exploit cuttlefish only in autumn and winter. The model is finally fitted by minimizing the sum of squares residuals.

The exploitation rate can be expressed as the total landings of year *y* divided by the biomass estimated on 1st January ($B_{1.jan}$), year *y*:

$$E_y = C_{1+,y}/(B_{1,y}e^{-\frac{g}{2}})$$

In a first step, we updated the stock assessment of the English Channel stock of cuttlefish. Then, we implemented the model used by Gras *et al.* (2014) into a Bayesian framework and coded it with Openbugs. The Bayesian fit required prior distributions for B_1 and catchability rates. Priors were the same for each year. We chose normal distributions, with a mean of 15000 and a CV of 2.5 for B_1, and a mean of 0.0001 and a CV of 0.0067 for catchability rates to stay close to the work of Gras *et al.* (2014). We also used the same value for *g* as in Gras *et al.* (2014): g=-1.01. Posterior distribution of B1 was obtained by combining the likelihood function with the prior distribution.

Chain convergence was checked with the BGR diagnostic suggested by Brooks and Gelman (1998) and a sensitivity analysis was conducted on B_1 prior distribution and *g* value. A 20% variation was applied on the mean of B_1 prior distribution, and values of g=-0.5 and -1.5 were tested in order to compare results with the sensitivity analysis conducted in Gras *et al.* (2014). Initial and Bayesian fit of the two-stage biomass model were applied on years 1992-2013. 1000 iterations were conducted for the initial model with bootstrap methods, and 100 000 iterations for the Bayesian model using Markov chain Monte Carlo (MCMC) methods. Update took longer for the initial fit than for the Bayesian fit.

RESULTS

Stock assessment update

Total landings of cuttlefish in the English Channel have increased between 1992 and 2004 (Figure 1), mostly because of the French landings evolution. Between 2004 and 2009, French landings have decreased, leading in 2009 to the smallest value of total landings among the entire time-series. Since 2009, French and UK landings are of the same order of magnitude, with no clear trend in total landings evolution.

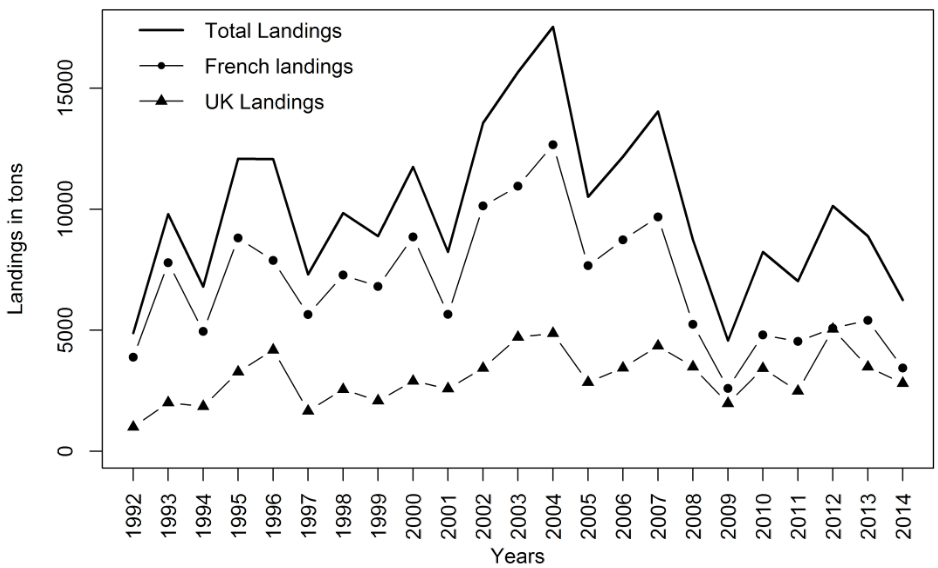

Figure 1: Evolution of cuttlefish landings in the English Channel from 1992 to 2014

Comparison of predicted and observed abundance indices (Figure 2) permits the evaluation of the model fit. In general, observed abundance indices are within the confidence intervals of the model prediction. However, this is not true for years 2000 and 2011. It is interesting to notice that BTS and CGFS survey observed abundance indices seem to follow a same trend, slightly different from the trend of UK and French LPUE. The 95% confidence intervals for years 2001 and 2013 are small, with low abundance indices observed for all data sources.

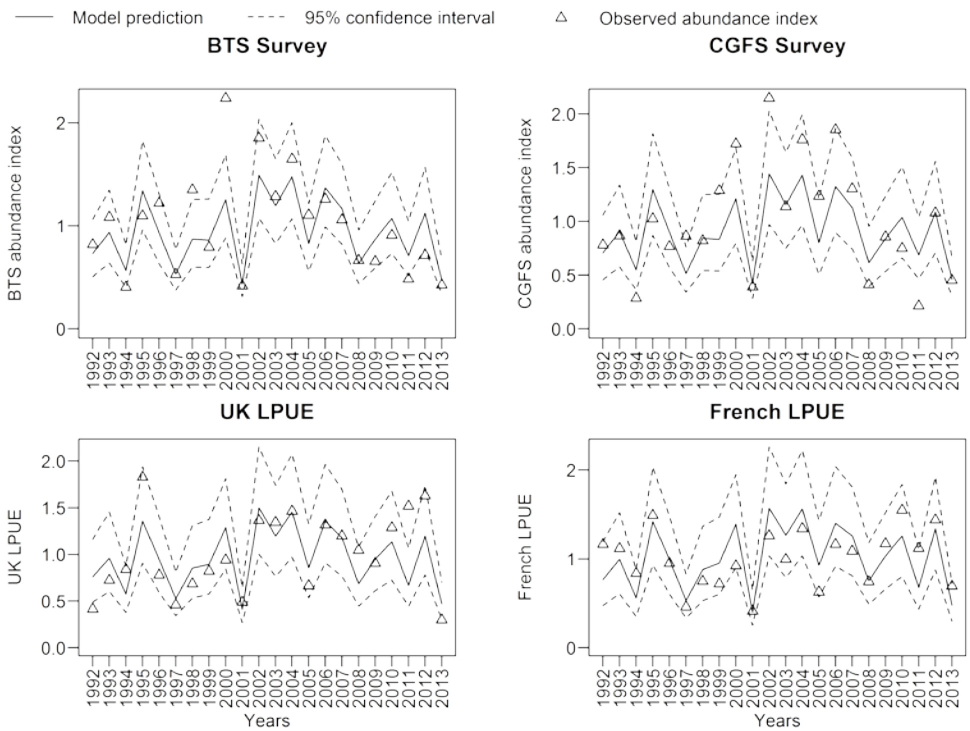

Figure 2: Time-series of the observed and predicted abundance indices for the two-stage biomass model fit with 95% confidence interval from fishing season 1992 (July 1992 to June 1993) to 2013 (July 2013 to June 2014).

As expected in the light of Figure 2 observations, predicted recruited and spawning stock biomass have decreased between 2012 and 2013 (Figure 3), whereas exploitation rate has increased (Figure 4). Although no clear trend of B_1 and B_2 evolution is observed between 1992 and 2002, there seem to be a slight decreasing trend of biomass since 2002. However, no stock-recruitment relationship was observed between spawning stock biomass and recruited biomass (Figure 5). In Gras *et al.* (2014), the minimum estimated B_2 (11 000 tons) was proposed as B_{lim} for English Channel cuttlefish, based on the precautionary principle. As the stock assessment update didn't produce any B_{lim} value smaller than Gras *et al.* (2014) result, conclusions remain unchanged.

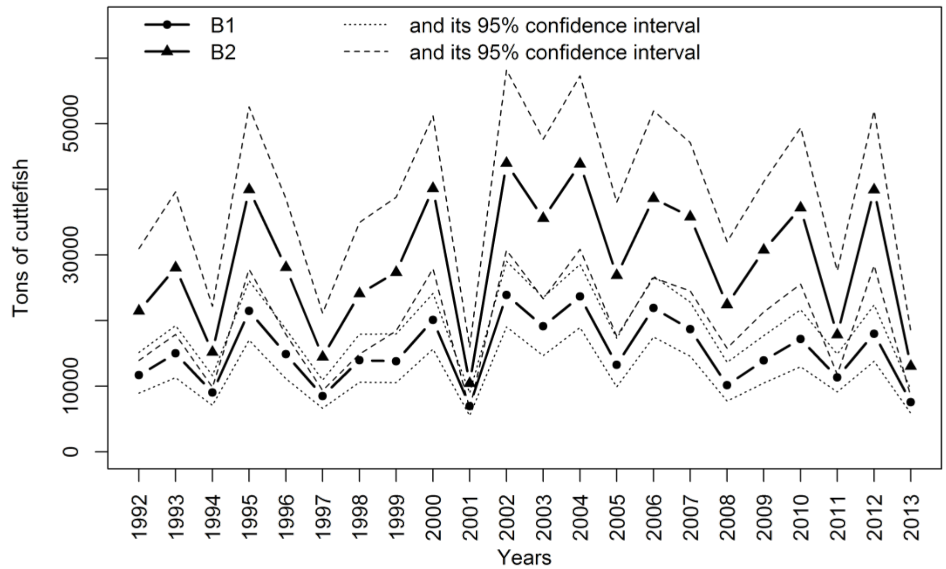

Figure 3: Evolution of cuttlefish recruited biomass (B_1) and spawning stock biomass (B2) from fishing season 1992 (July 1992 to June 1993) to 2013 (July 2013 to June 2014).

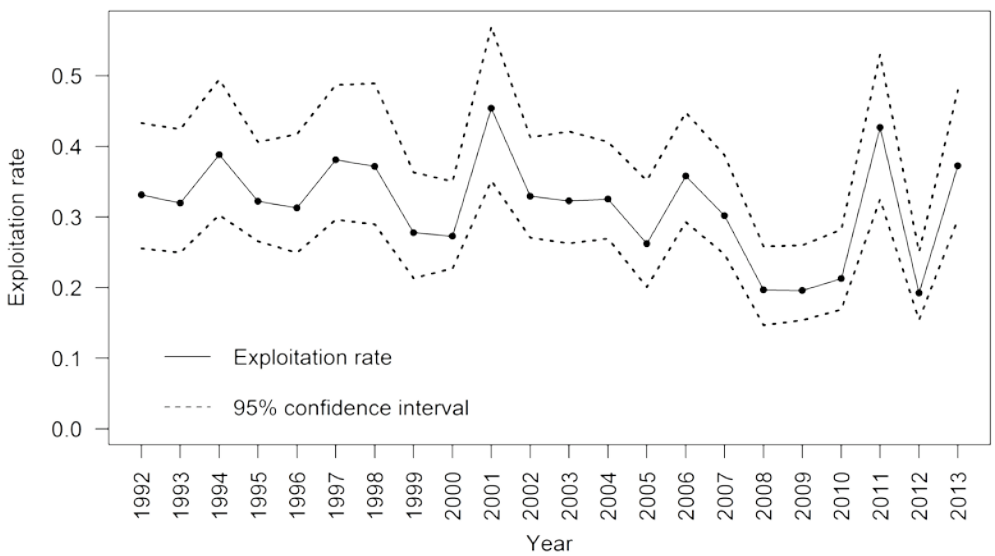

Figure 4: Evolution of cuttlefish exploitation rate from fishing season 1992 (July 1992 to June 1993) to 2013 (July 2013 to June 2014).

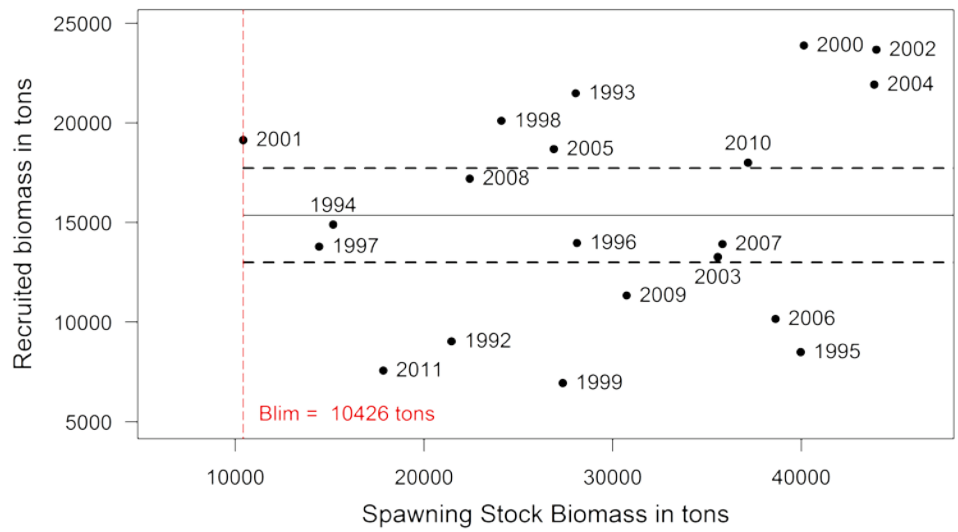

Figure 5: Stock-recruitment relationship with the average annual recruitment (solid line) and its 95% confidence interval (horizontal dashed lines). Years plotted are the years of spawning stock biomass estimates (year Y), which are linked to the recruited biomass (year Y+2).

Comparison of initial and Bayesian fit of the two-stage biomass model

The evolution of estimated abundance indices (Figure 6) shows a better fit of the initial model for BTS and CGFS surveys, but a better fit of the Bayesian model for French and UK LPUE. The models do not succeed in estimating high values of BTS and CGFS abundance indices (e.g. 2000, 2002 for both surveys, and 2006 for CGFS survey). Survey abundance indices in 2012 pull model fit downward, whereas LPUE abundance indices pull it upward.

Evolution of recruited biomass estimates (Figure 7a) and spawning stock biomass estimates (Figure 7b) are similar between initial fit and Bayesian fit of the two-stage biomass model. But outputs from Bayesian fit show a smaller range of variation than the initial fit. Confidence intervals are smaller for Bayesian fit, except during years of small biomass estimate (i.e. 1994, 1997 and 2001).

Similar trends of exploitation rate are observed for both fit of the two-stage biomass model (Figure 8). An important decrease in exploitation rate is observed between 2006 and 2008 for both fit, but the following 2011 spike predicted by the Bayesian fit is not as high as the one predicted by the initial fit.

Catchability rates estimated by Bayesian model are higher than estimations from initial fit (Table 1), from +3.3% to +12.6%. Biggest differences between the two fit are observed for CGFS catchability rate (k_2). Table 3 shows the percentage of variation between outputs from Bayesian and initial fit of the two-stage biomass model. In average, biggest differences between both fits are observed for the exploitation rate.

Results of the sensitivity analysis conducted on the Bayesian two-stage model (Table 2) show that B_2 estimates are very sensitive to variation of g. A change of 20% in the mean value of B_1 prior distribution leads to 30% variation of B_2 estimates. Estimates of exploitation rates are most sensitive to underestimation of B_1 prior distribution and overestimation of g. Survey catchability estimates are most sensitive to variation of B_1 prior distribution, whereas UK and French fleet catchability estimates are most sensitive to variation of *g*.

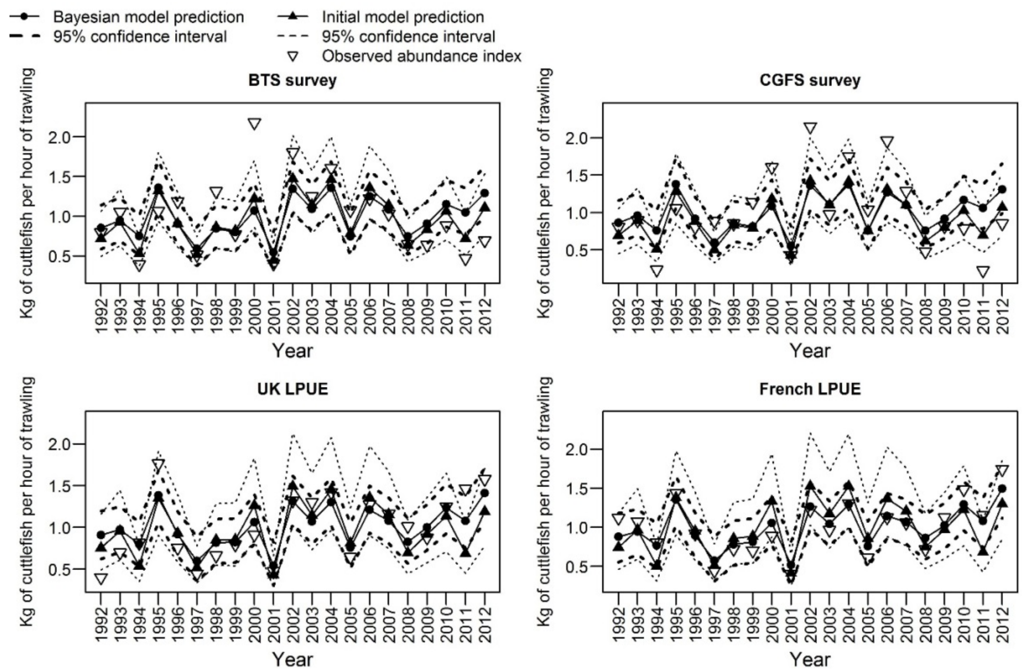

Figure 6: Time-series of the observed and predicted abundance indices for initial model and Bayesian model fit with 95% confidence interval from fishing season 1992 (July 1992 to June 1993) to 2012 (July 2012 to June 2013).

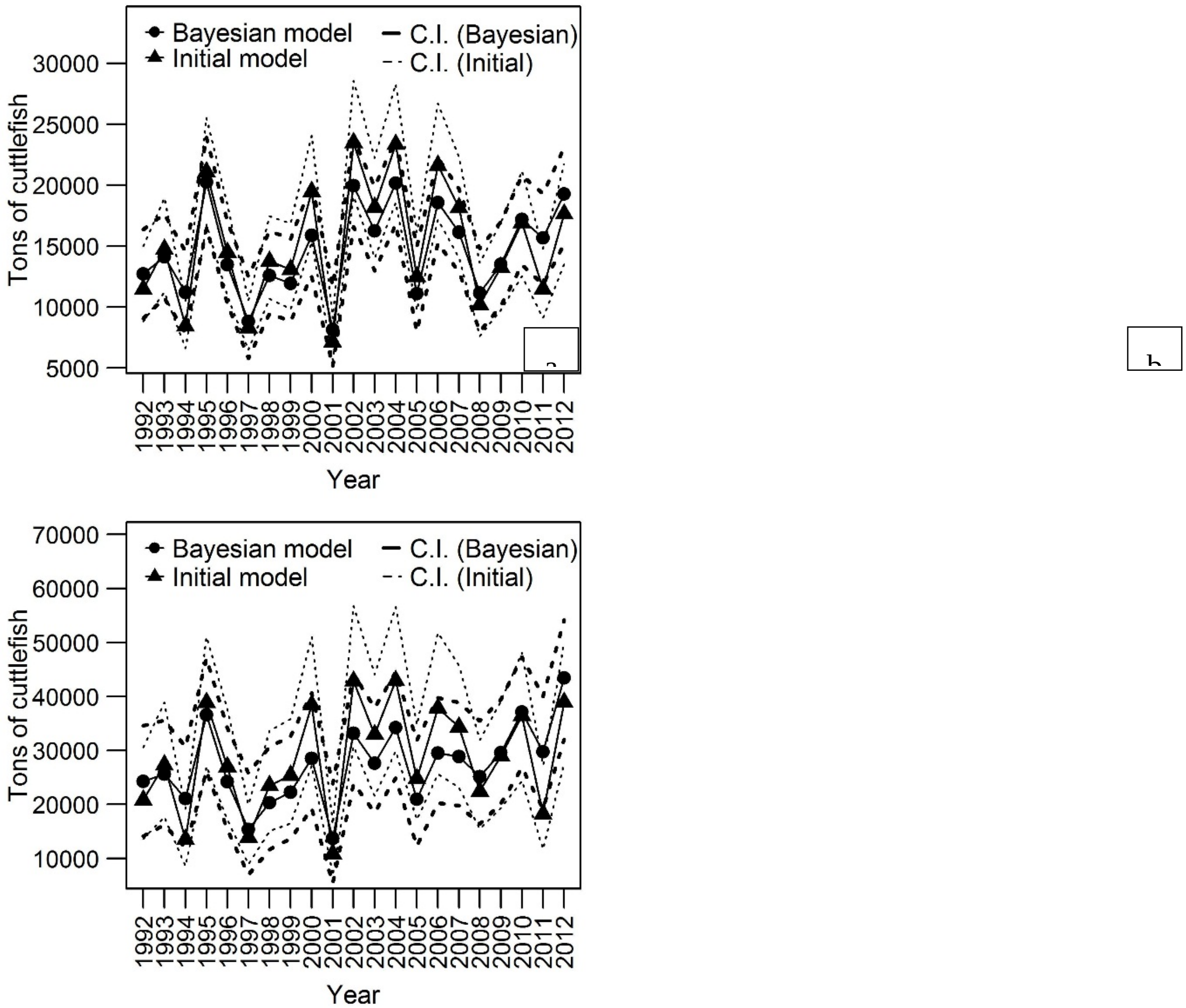

Figure 7: Comparison of the evolution of a) recruited biomass B_1 and b) spawning stock biomass B_2 for initial and Bayesian fit of the two-stage biomass model.

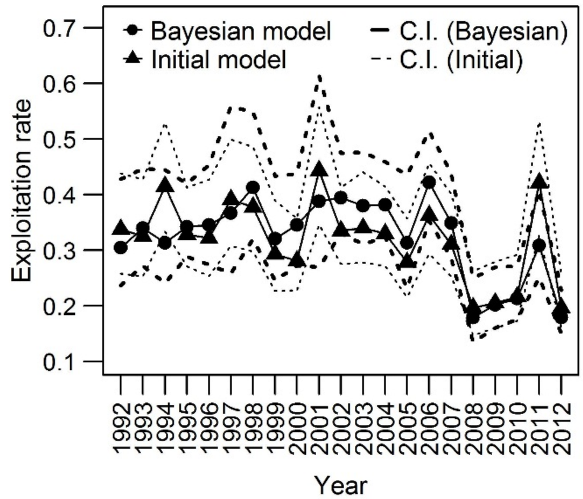

Figure 8: Comparison of the evolution of exploitation rate for initial and Bayesian fit of the two-stage biomass model.

Table 1: Variability between initial model and Bayesian model estimates of catchability rates (in percentage).

k_1	k_2	q_{uk}	q_{fr}
7.258	12.64	7.197	3.253

k_1 = catchability rate of BTS survey, k_2 = catchability rate of CGFS survey, q_{uk} = catchability rate of French trawlers, q_{fr} = catchability rate of UK trawlers.

Table 2: Sensitivity analysis of the Bayesian two-stage biomass model

	B1_mean = 12000	B1_mean = 18000	g = -0.5	g = -1.5
B_1	-19.96	20.06	-2.657×10^{-2}	2.249×10^{-3}
B_2	-29.72	29.87	-48.56	80.64
$B_{1.jan}$	-19.96	20.06	-22.53	27.77
Exp	24.95	-16.71	29.09	-21.73
k_1	-25.02	16.67	0.0742	0.0297
k_2	-24.98	16.71	13.7	-11.5
q_{uk}	-30.44	20.69	35.9	-34.2
q_{fr}	-35.03	18.95	45.6	-26.4

B1_mean = value of the mean for B_1 normal prior distribution

Table 3: Percentage of variation between Bayesian model outputs and initial model outputs.

year	B_1	B_2	$B_{1.jan}$	Exp
1992	10.89	10.84	16.45	-9.802

1993	-4.283	-4.311	-6.332	4.513
1994	32.43	32.42	55.59	-24.49
1995	-3.977	-3.959	-5.866	4.138
1996	-6.940	-6.925	-10.14	7.444
1997	6.548	6.576	10.91	-6.136
1998	-8.488	-8.494	-13.57	9.289
1999	-8.695	-8.669	-12.20	9.491
2000	-18.56	-18.55	-25.77	22.77
2001	14.25	14.27	25.79	-12.46
2002	-15.04	-15.04	-22.58	17.69
2003	-10.62	-10.64	-16.05	11.88
2004	-13.64	-13.66	-20.31	15.81
2005	-11.14	-11.11	-15.34	12.52
2006	-14.07	-14.06	-22.06	16.38
2007	-11.00	-11.00	-15.93	12.38
2008	9.677	9.725	12.16	-8.846
2009	1.698	1.686	2.176	-1.639
2010	1.504	1.515	1.938	-1.476
2011	36.43	36.46	63.07	-26.73
2012	9.375	9.364	11.67	-8.558
Mean variation	-0.1742	-0.1695	0.6482	2.103
SD	14.95	14.59	24.22	13.67

B_1 = Recruited biomass, B_2 = spawning stock biomass, $B_{1.jan}$ = biomass estimated on 1st January in the middle of the fishing season, Exp = exploitation rate, SD = standard deviation.

DISCUSSION

This work presents the stock assessment update of the English Channel stock of cuttlefish. The R package used for the assessment (Gras and Robin 2014) has proven itself effective as a tool to assess the stock routinely. From next year on, the French scientific survey CGFS will be carried out with a new scientific vessel. This raises the issue of the abundance index time-series future. Some inter-calibration exercises have been carried out, showing that time-series can’t be continued for some species. Fortunately, the inter-calibration worked well for cuttlefish, as both scientific vessels exhibited similar catchability rates and selectivity.

In this work, we also wanted to implement the two stage biomass model in a Bayesian framework and check if results were similar. Estimates obtained from the initial fit (Duhem *et al.* in WGCEPH 2014) and from the Bayesian fit of the two-stage biomass model showed similar trends. But the model still doesn’t succeed in estimating some values of abundance indices (Figure 6). Outputs from Bayesian fit showed high sensitivity to prior distribution of B_1 and to g value. The need to give good prior estimations is a common issue of Bayesian methods. Gras *et al.* (2014) identified a significant positive correlation between the sea surface temperature during the third quarter (summer) of the year before recruitment and B_1. This result could be a starting point to investigate a Bayesian model including environmental factors, in order to give better prior distributions for B_1.

High sensitivity to *g* was already highlighted by Gras *et al.* (2014) and further work also needs to be done on this particular point. Growth used for the two-stage biomass model is assumed to be the same for each year, which is a strong assumption for cephalopod species. One possibility would be to build an informative prior for *g*, using meta-analysis on other cephalopod stocks. Ideally, variations of *g* in other stocks could be used to infer *g* annual variations of the English Channel cuttlefish stock in the Bayesian fit. But this information might be hard to obtain, as no regular evaluation of growth seem to be conducted for cephalopods stocks in the English Channel.

Parameter *g* could also vary with season, as suggested in Dunn (1999). He found that fastest growth in length took place between July and October in males, and between August and October in females. The slowest growth rates were recorded from the winter before spawning in the spawning period. If we could for example find a relationship between sea surface temperature and cuttlefish growth, we could use this link to infer information on annual growth variation. Finally, size frequency data could be an additional source of information on growth variation. To better model reality, the Bayesian two-stage biomass model could also be improved by integrating migration. Massiot-Granier *et al.* (2014) developed an integrated hierarchical Bayesian life cycle modelling framework which could be a starting point to build such a model adapted to cuttlefish.

Another idea is to use the Stock Synthesis (SS) framework (Methot and Wetzel 2013) to compute an adapted model, using all available information, including data used by the two-stage biomass model, as well as mean individual weight by month and length composition data. This framework offers many possibilities to use different sources of data and can be adapted to complex life histories. The model can account for time-varying growth, as well as cohort specific growth rate, environmental factors, and could also include migration. An SS model has for example been adapted for bigeye tuna *Thunnus obesus*, using five areas (Aires-da-Silva and Maunder 2012).

In Gras *et al.* (2014), an exploitation rate below 40% is recommended, and a threshold of 11 000 tons is proposed for the spawning stock biomass. Setting quotas to manage the English Channel cuttlefish stock is unlikely to be efficient because of the high variability in cephalopod stock sizes (Caddy 1983, Beddington *et al.* 1990). Currently, the stock is managed at regional scale. In Normandy, fishing of cuttlefish is forbidden within the 3-miles inshore zone, except during 2 weeks at the end of August, and during another 6 weeks in spring. In order to better manage the stock, a management strategy evaluation could be conducted. Reduction of effort at particular times or in particular areas could be tested. Best management rules could thus be predicted, with good uncertainty estimates, thanks to the Bayesian framework.

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Estimating the abundance of squid (*Loligo vulgaris*) in the Bay of Biscay

by

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Introduction

Nowadays the majority of the commercially exploited stocks lack a scientific assessment and therefore they are exploited while their abundance, productivity and sustainability are undetermined or highly uncertain. Such is the case of the cephalopods in the ICES area, which support large- and small-scale fisheries. However, they remain essentially outside the scope of the European Community's Common Fisheries Policy and understanding of their stock dynamics, particularly in European coastal waters, remains variable (ICES, 2013b).

ICES provides advice on policies and management issues related to the sustainable use of living resources and the impact of human activities on marine living resources to the competent authorities (ICES, 2013a). In the last years there has been an increasing effort to compile all the information available (regarding biology, landings …) on cephalopods in the North East Atlantic that would allow ICES to provide management advice.

Squid (*Loligo vulgaris*) in the Bay of Biscay (ICES areas VIIIabd) has become in the last years a species of increased interest for the Basque fleet. Cephalopod catches were in the past by-catches of other demersal fisheries that target hake, anglerfish or megrim among others. However, in the last years cephalopods in general and squid in particular obtained in mixed fisheries (mainly "Baka" otter trawls) are becoming more important in relation to the species composition of the catch and are even the target species for some trips. The fact that this stock has no TAC (total allowable catch) and the good price they get make it an appealing alternative for the Basque fleet.

The objective of this work is to update the preliminary assessment of squid in the Bay of Biscay conducted last year. First, the case study is presented and available data are summarised. Then a surplus production model is applied for an updated time-series of abundance from the EVHOE survey. Finally, the results are briefly discussed.

Case study: squid in the Bay of Biscay

The squid (*Loligo vulgaris*) is a short lived species (living a maximum of 15 months), characterized by its high natural mortality. It is distributed from ICES Subarea III to Division IXa, Mediterranean waters and North African coast. Currently there is no study that could help on the definition of the stock, but ICES considers all the information in VIIIabd as a unit (Figure 1). Other available biological information like growth rate, spawning or fecundity is summarized by ICES (2013b).

For this stock a fishery-independent abundance index is available from the French groundfish survey called EVHOE (ICES, 2013b). The index is available either in numbers or in mass per tow from 1992 to 2012, except 1993 and 1996, and it is obtained following the North-Eastern Atlantic IBTS surveys protocols. Similar abundance indices are obtained for other cephalopod species. This will allow estimating the percentage of common squid (*Loligo vulgaris*) with respect to all the *Loliginidae* observed in the survey.

Currently Bay of Biscay common squid is not assessed and there is not a TAC constraint for the stock. *Loliginidae* are usually exploited in a multi-specific and mix-fisheries trawlers (ICES, 2013b). Catches are usually composed by *Loligo vulgaris*, *Loligo forbesii*, *Alloteuthis subulata* and *Alloteuthis media*. Information on landings by country and ICES area is available yearly (ICES, 2013b; AZTI-Tecnalia database). No species identification has been provided for all countries and areas for commercial catches. Although most of the species in the catch are expected to be *Loligo spp*. in order to make available a value for the catches of *L. vulgaris*, the same percentages by species as in the survey fishing hauls has been assumed.

Methods

The available information (an abundance index and total landings) and the population biology (short lived species with high and variable natural mortality) restrict the variety of methods that can be applied to assess the state of squid in the Bay of Biscay (Pierce and Boyle, 2003). For example, depletion methods of stock assessment, as DCAC (MacCall, 2009), based solely on catches information, are considered inadequate for this population due to its high natural mortality. Similarly, two-stage biomass dynamic models applied to similar species (Roel and Butterworth, 2000; Gras *et al*., 2013) cannot be applied due to the lack of data disaggregated by age. In this section two alternative methods are presented. The first attempt to fit a surplus production model conducted last year is updated using the new time-series from EVHOE.

Surplus production models

Production or biomass dynamic models are the simplest models used for stock assessment (Hilborn and Walters, 1992). They describe the population dynamics in terms of biomass and combine the main biological processes (recruitment, growth and natural mortality) in a single biomass function called surplus production function. It only requires an abundance index (fishery independent index or catch per unit effort from commercial fisheries) and total harvest.

The deterministic state equation of a production model is given by

$$B_{t+1} = B_t + g(B_t) - C_t ,$$

where B_t is the biomass at the start of the year t, C_t is the catch during year t and $g(B_t)$ is the surplus production function that determines the overall change in biomass due to growth, recruitment and natural mortality.

A particular case is the Pella-Tomlinson model (Pella and Tomlinson, 1969) in which the surplus production function is given by

$$g(B_t) = \frac{r}{p} \cdot B_t \left(1 - \left(\frac{B_t}{k}\right)^p\right) .$$

being r the intrinsic growth rate parameter, k the carrying capacity and p the asymmetry parameter. In biological terms the intrinsic growth rate (r) is determined by combining the effect of prematuration survival, adult fecundity, and age (or size) at maturity (Myers and Mertz, 1998). Carrying capacity (k) is related to environmental conditions, such as habitat and food resources. The parameter p allows the surplus production function being asymmetric with respect to the biomass and determines the maximum level of productivity $\left(B_{MAX} = \frac{k}{(p+1)^{1/p}}\right)$. When the asymmetry parameter (p) is equal to 1 the model reduces to the Schaeffer model (Schaeffer, 1954).

In both models if fishing begins in the first year, it is common to assume that the virgin biomass is equal to the carrying capacity ($B_1 = k$).

The deterministic observation equation is

$$I_t = qB_t \,,$$

where I_t is the relative biomass index in year t and q is the catchability coefficient. This index can be either a CPUE (catch per unit effort) index calculated from commercial fishing data or an abundance index from a research survey.

The model defined by these two equations can be fitted allowing random errors only in one or in both equations (see for instance Polacheck *et al.*, 1993). In this document, first random errors are introduced in the observation equation and the corresponding likelihood function is analysed. Then, these results are used to construct the prior distributions of a Bayesian state-space version of the model including both observation and process errors (Millar and Meyer, 2000).

Maximum likelihood version

Multiplicative log-normal errors are assumed in the observation equation as follows:

$$\log(\hat{I}_t) \sim \mathrm{Normal}\left(\log(q) + \log(B_t), \sigma_I^2\right) \,,$$

where $\hat{I}_t$ is the observed relative biomass index in year t and σ_I^2 is the variance (in log-scale) of the observation equation for the abundance index. This means that the coefficient of variation (in natural scale) of the abundance index is $cv(I_t) = \sqrt{\exp(\sigma_I^2) - 1}$.

The corresponding likelihood function of the observations is

$$L = \prod_{t=1}^{n} \frac{1}{\sqrt{2\pi\sigma_I^2}} \exp\left\{-\frac{1}{2\sigma_I^2}(\log(I_t) - \log(q) - \log(B_t))^2\right\} \,,$$

and the logarithm of the likelihood is

$$l = \log(L) = -\frac{n}{2}\log\left(2\pi\sigma_I^2\right) - \frac{1}{2\sigma_I^2}\sum_{t=1}^{n}(\log(I_t) - \log(q) - \log(B_t))^2 \,.$$

By maximum likelihood it is necessary to find the values of the parameters B_1, r, k, q, p and σ_I^2 that maximise the likelihood function. By looking at the partial derivatives of the likelihood the following closed-form estimates of q and σ_I^2 are obtained:

$$q = \exp\left\{\frac{1}{n}\sum_{t=1}^{n}\left(\log\left(\hat{I}_t\right) - \log(B_t)\right)\right\}$$

and

$$\sigma_I^2 = \frac{1}{n}\sum_{t=1}^{n}\left(\log\left(\hat{I}_t\right) - \log(q) - \log(B_t)\right)^2 .$$

So that the problem reduces to find the values of B_1, r, k, and p that maximise the likelihood function. This was implemented in R (http://www.r-project.org) and applied to the squid in the Bay of Biscay.

Bayesian state-space version

If both observation and process errors are included a Bayesian state-space model version of the production model can be constructed (Millar and Meyer, 2000). The Bayesian paradigm allows including preliminary knowledge on the stock via the prior distributions. In addition, uncertainty can be fully represented and the results provide full statistical distributions that help decision making (Punt and Hilborn 1997).

If including log-normal errors in both the observation and the state equation and re-parameterizing the population states in terms of $P_t = B_t/k$ instead of B_t, the model can be fully described by the following equations:

$$\log\left(\hat{I}_t\right) \sim \text{Normal}\left(\log(q) + \log(k) + \log(P_t), \sigma_I^2\right),$$

$$\log(P_1) \sim \text{Normal}\left(\log(P_0), \sigma_P^2\right) \quad \text{and}$$

$$\log(P_{t+1}) \sim \text{Normal}\left(\log\left(P_t + \frac{r}{p}P_t(1 - P_t^{\,p}) - \frac{C_t}{k}\right), \sigma_P^2\right).$$

The unknowns are r, k, q, p, P_0, σ_I^2, σ_P^2 and all the states $P_1, \dots, P_n$. From Bayes' theorem, the joint posterior probability density function (pdf) of the unknowns (parameters and states) in a state-space model is proportional to the product of the pdf's of observations, states and priors:

$$p(param, states|obs) \propto p(obs|param, states)\, p(states|param)\, p(param)$$

In particular,

$$p(r, k, q, p, P_0, \sigma_I^2, \sigma_P^2, P_1, \dots, P_n|\hat{I}_1, \dots, \hat{I}_n) \propto p(\hat{I}_1, \dots, \hat{I}_n|r, k, q, p, P_0, \sigma_I^2, \sigma_P^2, P_1, \dots, P_n)$$

$$p(P_1, \dots, P_n|r, k, q, p, P_0, \sigma_I^2, \sigma_P^2)\, p(r, k, q, p, P_0, \sigma_I^2, \sigma_{P_1}^2)$$

Assuming that all parameters are independent a priori, the joint prior distribution is the product of the individual prior distributions, which are chosen to be:

$$\log(r) \sim \text{Normal}\left(\mu_{\log(r)}, 1/\psi_{\log(r)}\right)$$

$$\log(k) \sim \text{Normal}\left(\mu_{\log(k)}, 1/\psi_{\log(k)}\right)$$

$$\log(p) \sim \text{Normal}\left(\mu_{\log(p)}, 1/\psi_{\log(p)}\right)$$

$$\log(q) \sim \text{Normal}\left(\mu_{\log(q)}, 1/\psi_{\log(q)}\right)$$

$$P_0 \sim \text{Unif}\left(a_{P_o}, b_{P_o}\right)$$

$$\psi_I \sim \text{Gamma}\left(a_{\psi_I}, b_{\psi_I}\right)$$

$$\psi_P \sim \text{Gamma}\left(a_{\psi_P}, b_{\psi_P}\right)$$

The model was implemented in JAGS which uses a MCMC (Markov chain Monte Carlo) algorithm to sample from the posterior distribution.

As an alternative, a uniform prior distribution on r was also considered:

$r \sim Unif\ (a_r, b_r).$

Results

The squid landings in the Bay of Biscay show fluctuations in the time-series with a sharp increase since 2010 (Figure 2) and decreasing to levels before 2009 in 2013. Similar inter-annual changes and the last three years rise is also observed in the biomass index from the EVHOE surveys (Figure 2).

Surplus production models

The Schaeffer production model (p=1) was considered for squid in the Bay of Biscay using data from 1997 to 2013. Given that there was exploitation before 1997 the initial biomass was considered different from the carrying capacity (i.e. $P_0 \neq 1$).

First, assuming only observation errors the logarithm of the likelihood function was evaluated depending on the value of the intrinsic growth rate r, the carrying capacity k and the initial state (P_0). As a result of the restrictions imposed by the catches (the biomass has to be large enough to support the level of observed catches), not all the combinations of parameters are suitable (Figure 3). The zones close to that border are numerically unstable and in some cases there seem to be local optimums, making difficult the optimization of this function. However, this grid search method allows defining areas of suitable values where approximately the maximum will be located. The largest likelihood values are obtained when the initial state P_0 is at 0.3. For that value, the intrinsic growth rate r can be small (below 1) or high (around 3) with a corresponding wide set of plausible values for the carrying capacity k. However short-lived species like squid with high fecundity are expected to have large intrinsic growth rates (r>1) favouring the later area.

The Bayesian state-space version of the Schaeffer model that incorporated both observation and process error was applied to squid in the Bay of Biscay. Two sets of prior distributions were used (Table 2). In both cases the prior distribution of the process error was tighter that the observation error. Various chains with random starting values sampled from the prior distributions were run for each set of prior distributions. Chain behaviour was examined by visually inspecting traces, cumulative plots, and autocorrelation functions.

The comparison between the prior and posterior distributions is shown in Figure 4. The posterior median and corresponding 90% probability intervals are given in Table 3. Results were very similar for both cases, except for the intrinsic growth parameter that resulted in a larger posterior median for the second set of priors. The results based on the second set of priors were considered as more reliable and were analysed further. The time-series of relative biomass with respect to Bmsy and relative fishing mortality with respect to Fmsy are shown in Figure 5. In general the relative biomasses are always above 1, indicating that the estimated biomasses are above Bmsy. The time-series show some fluctuations but is rather stable around 1.7. Similarly the relative fishing mortalities are also slightly above 1, suggesting that fishing mortality is slightly larger than Fmsy. The uncertainty in both relative biomass and relative fishing mortality time-series is large. The posterior distributions of Bmsy, Fmsy and MSY are shown in Figure 6.

Finally, the Pearson residuals are shown in Figure 7. The residuals are within the range of expected values, but it can be seen that the model is not able to capture large fluctuations like the large index values from 2010 to 2013.

Discussion and conclusions

- In the last years there have been efforts to improve the knowledge on cephalopod biology and fisheries. However, there are many data issues not fully resolved yet like species identification.

- Despite the inter-annual peaks and the uncertainty in the posterior distributions, the stock seems to be in a rather stable situation.

- Having additional biological information incorporated through the prior distribution could help to improve the results.

- Additional information on the stock, like a recruitment index would allow considering alternative models, more suitable for short-lived stocks.

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Table 2: Hyper-parameters of the two sets of prior distributions.

	Priors 1	Priors 2
r	$\mu_{\log(r)} = 0 \quad \psi_{\log(r)} = 1$	$a_r = 0 \quad b_r = 5$
k	$\mu_{\log(k)} = \log(10000) \quad \psi_{\log(k)} = 1$	$\mu_{\log(k)} = \log(10000) \quad \psi_{\log(k)} = 1$
q	$\mu_{\log(q)} = \log(1e-4) \quad \psi_{\log(q)} = 1$	$\mu_{\log(q)} = \log(1e-4) \quad \psi_{\log(q)} = 1$
P_0	$a_{P_0} = 0 \quad b_{P_0} = 1$	$a_{P_0} = 0 \quad b_{P_0} = 1$
ψ_{I}	$a_{\psi_{\mathrm{I}}} = 1 \quad b_{\psi_I} = 0.01$	$a_{\psi_{\mathrm{I}}} = 1 \quad b_{\psi_I} = 0.01$
ψ_{P}	$a_{\psi_P} = 1 \quad b_{\psi_P} = 0.0025$	$a_{\psi_P} = 1 \quad b_{\psi_P} = 0.0025$

Table 3: Posterior 5, 50 and 95th percentiles of the parameters of the Schaeffer production model for squid in the Bay of Biscay for the first and second set of priors.

	PRIOR 1			PRIOR 2		
	5	50	95	5	50	95
P0	0.240	0.564	0.955	0.224	0.534	0.962
r	0.244	1.012	2.461	0.291	1.700	2.732
k	8804	23930	84373	7149	19927	79848
q	2.727E-05	1.052E-04	3.202E-04	2.893E-05	1.223E-04	3.829E-04
psi.logI	1.050	1.977	3.527	1.031	1.986	3.586
psi.logP	24.036	268.651	1187.038	28.756	278.362	1176.965
Fmsy	0.122	0.506	1.230	0.146	0.850	1.366
Bmsy	4402	11965	42187	3574	9964	39924
MSY	3263	10965	45152	3826	13760	56601

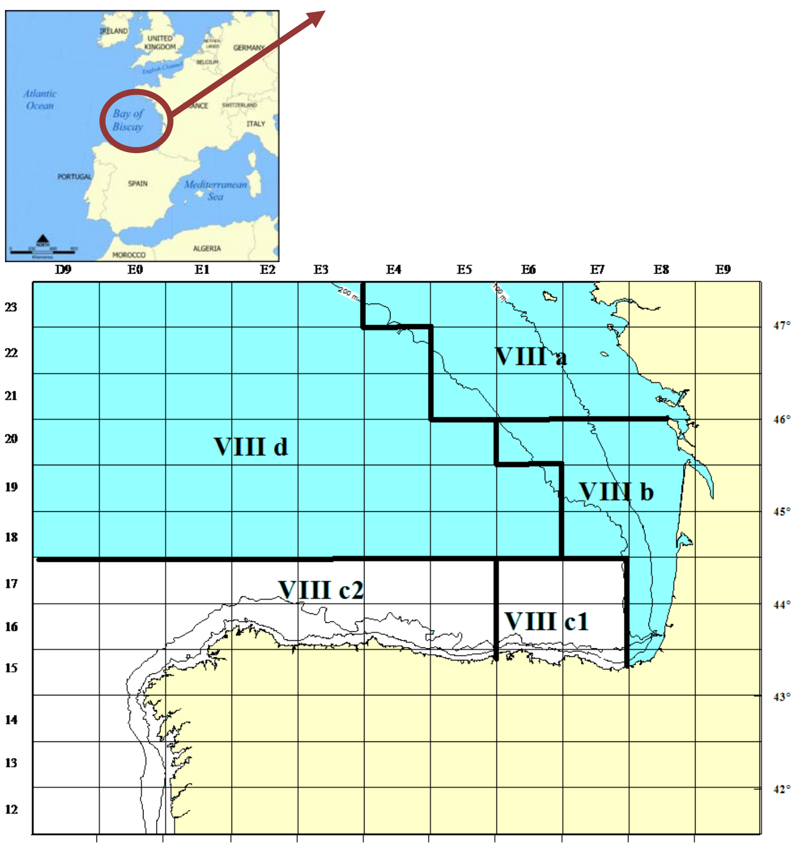

Figure 2: Location map of the Bay of Biscay. In blue the distribution area of the squid stock assessed (ICES Areas VIIIabd).

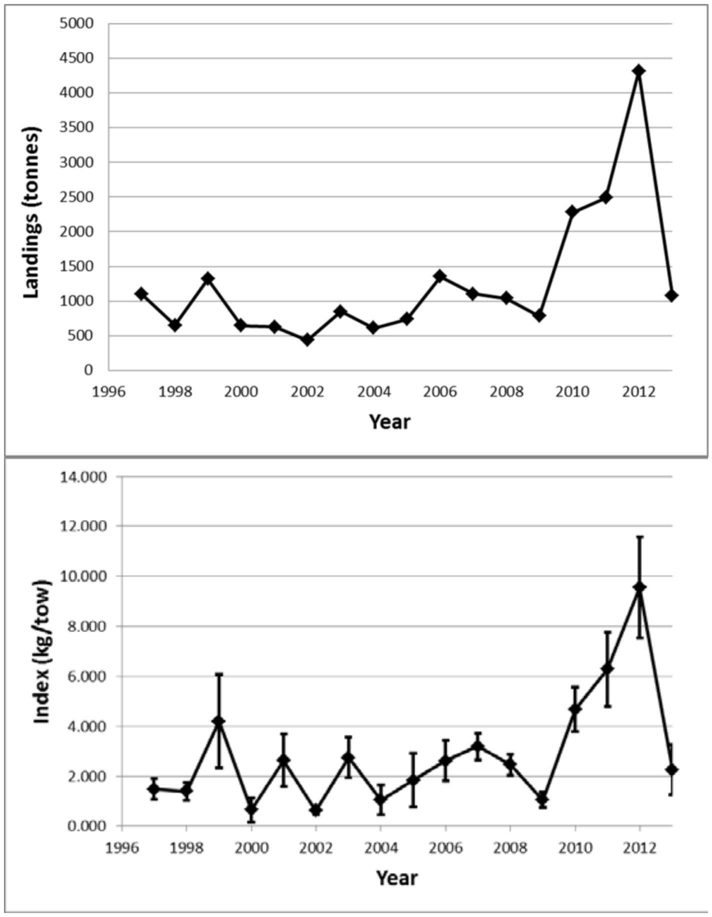

Figure 3: Squid data from 1997 to 2013 used for the Schaeffer surplus production model. Total catch of squid (in tonnes) in the top and biomass index from the EVHOE survey in the bottom. The error bars in the bottom represent +/- the standard error of the survey index.

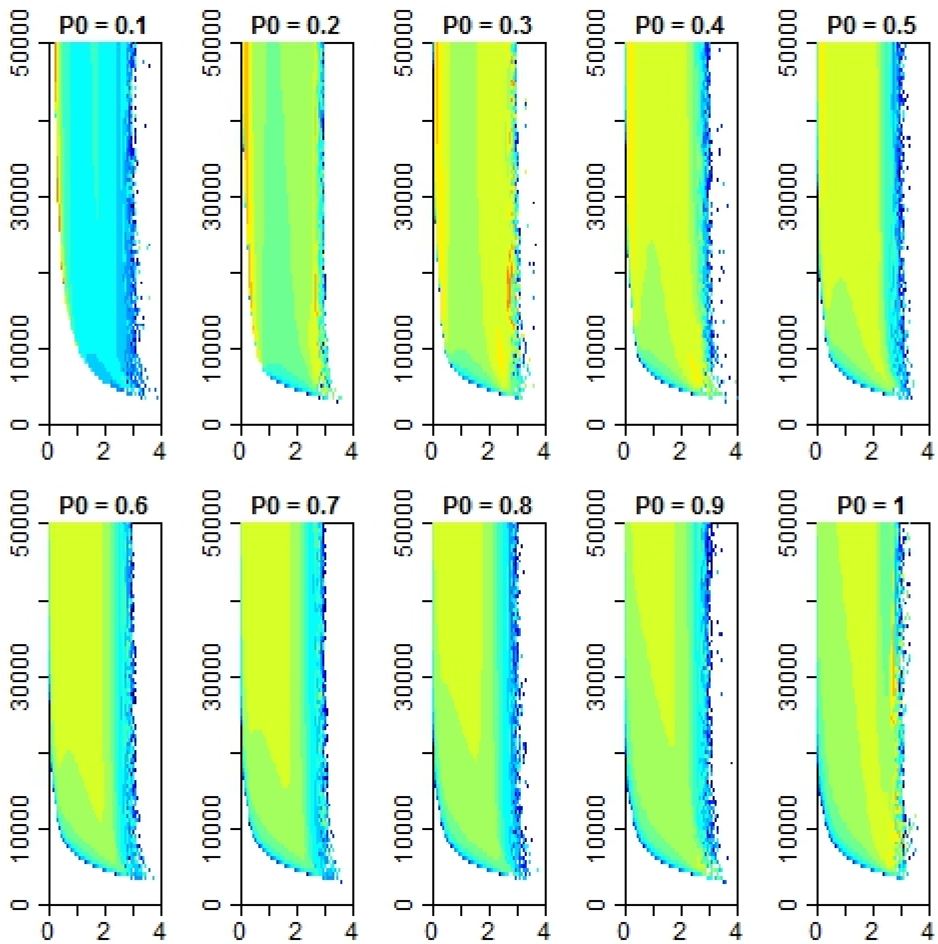

Figure 4: Log-likelihood values (blue being lowest and red highest) depending on the parameters r in the x-axis and k in the y-axis. The white colour represent combinations of values that do not fulfilled the restrictions imposed by the catches (i.e biomass is smaller than the reported catches). Each panel corresponds to a value of the P0 parameter.

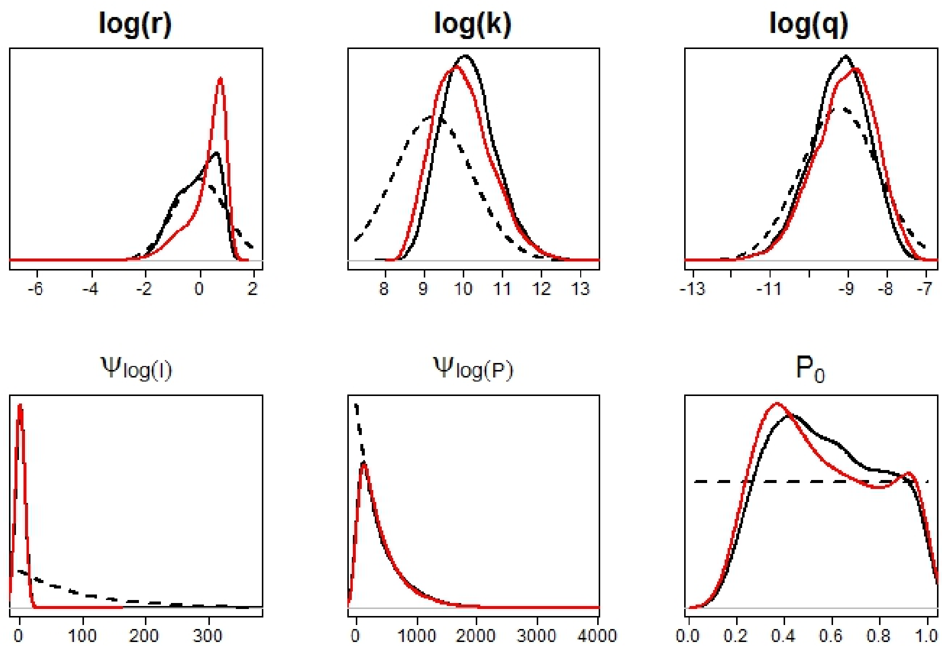

Figure 5: Prior (dashed line) and posterior (solid line) distribution of the parameters estimated in the Schaeffer production model (black for the first set of priors and red for the second set of priors).

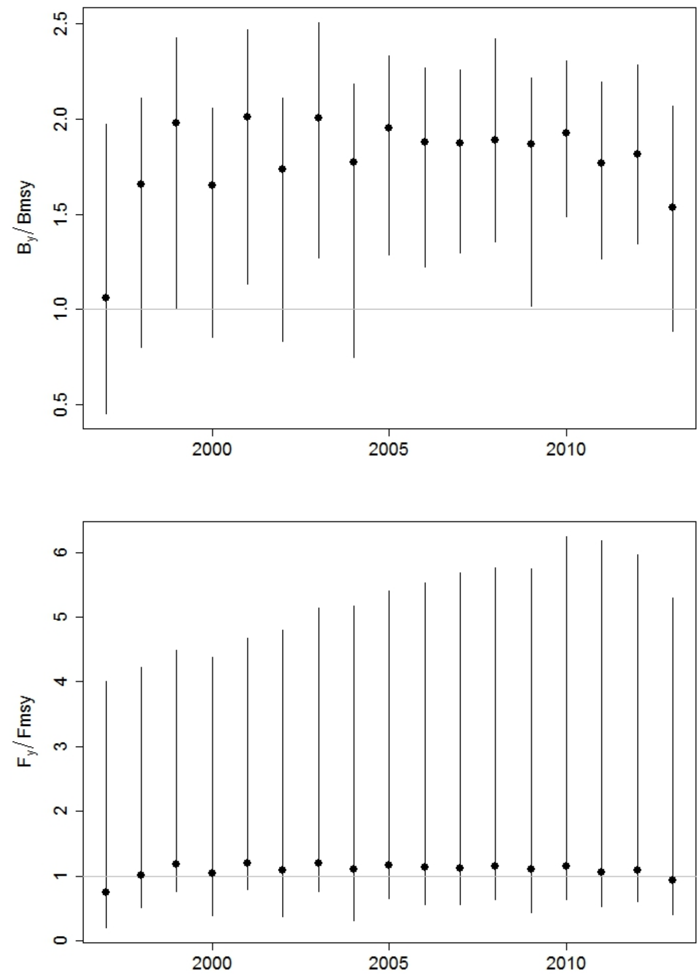

Figure 6: Median and posterior 95% probability intervals for the ratio of biomass and Bmsy (top panel) and for the ratio of fishing mortality and Fmsy (bottom panel) when the second set of prior distributions is used.

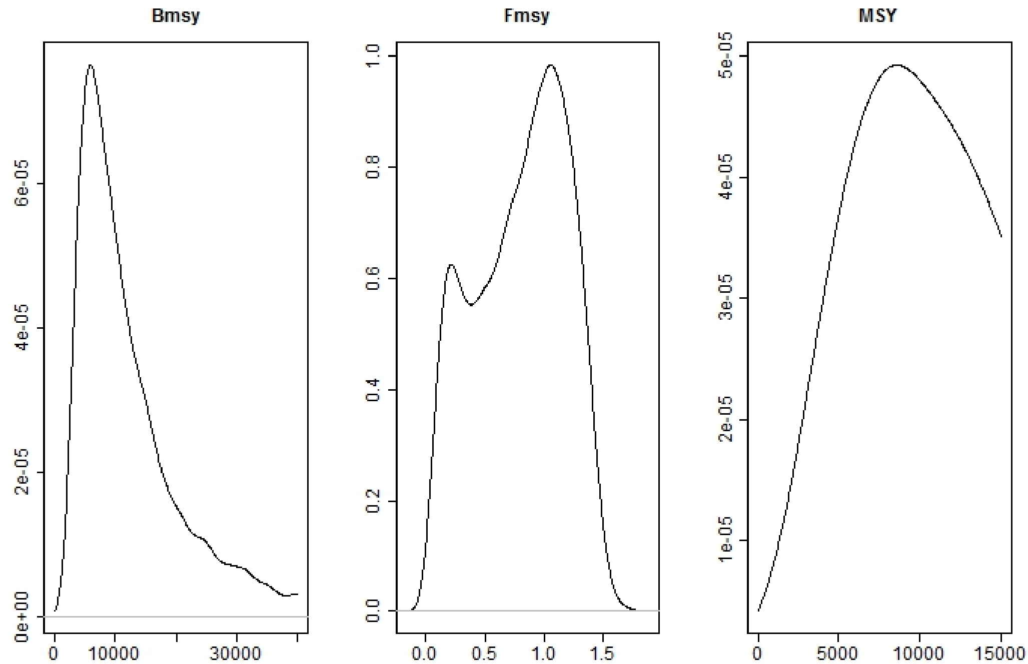

Figure 7: Posterior distribution of Bmsy, Fmsy and MSY when the second set of prior distributions is used.

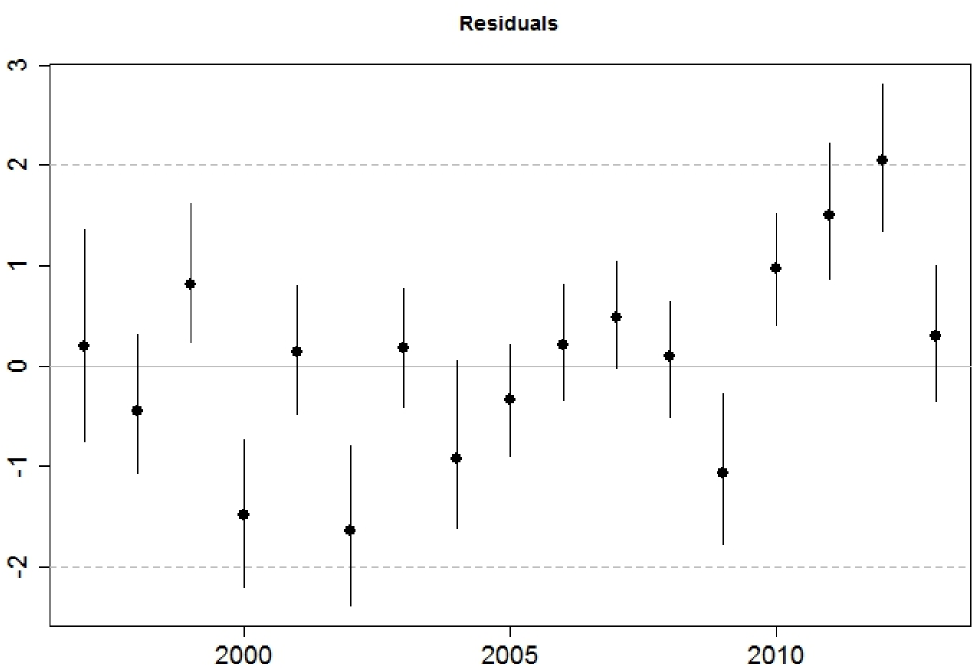

Figure 8: Median and 95% posterior probability intervals for the Pearson residuals when the second set of prior distributions is used.

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Cephalopod studies by the IEO-Tenerife team in Central-East Atlantic waters, past and present

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ABSTRACT

The area off the Northwest African coast is one of the richest fishing grounds in the world. Cephalopod fishery in this area takes place on the continental shelf along the coasts of Western Sahara, Mauritania, Senegal, Gambia, Guinea Bissau and Guinea. Bottom trawlers started operating in the sixties; number of vessels increased to 297 in 1980 and has been oscillating since then. Target species are octopus (*Octopus vulgaris* Cuvier, 1797), cuttlefish (*Sepia hierredda* Rang, 1835 and *Sepia officinalis* Linnaeus, 1758) and squid (*Loligo vulgaris* Lamark, 1798). The main landing port of this fishery in EU has been "Puerto de La Luz y Las Palmas" in Gran Canaria Island.

Since the early seventies, scientists from the Centro Oceanográfico de Canarias (COC) settled in Tenerife have developed a sampling and monitoring system in order to collect and manage fishery data to contribute for the assessment of cephalopod stocks in this area. Thirty two exploratory trawl-fishing surveys have been conducted and a great amount of studies have been carried out: reproductive and growth cycles, estimation of population parameters as well as dynamics, environmental variables causing changes in abundance, feeding habits and differences between populations are the main fields of research.

Keywords: *Cephalopod fishery, Northwest African coast, assessments and stock evaluation.*

BACKGROUND

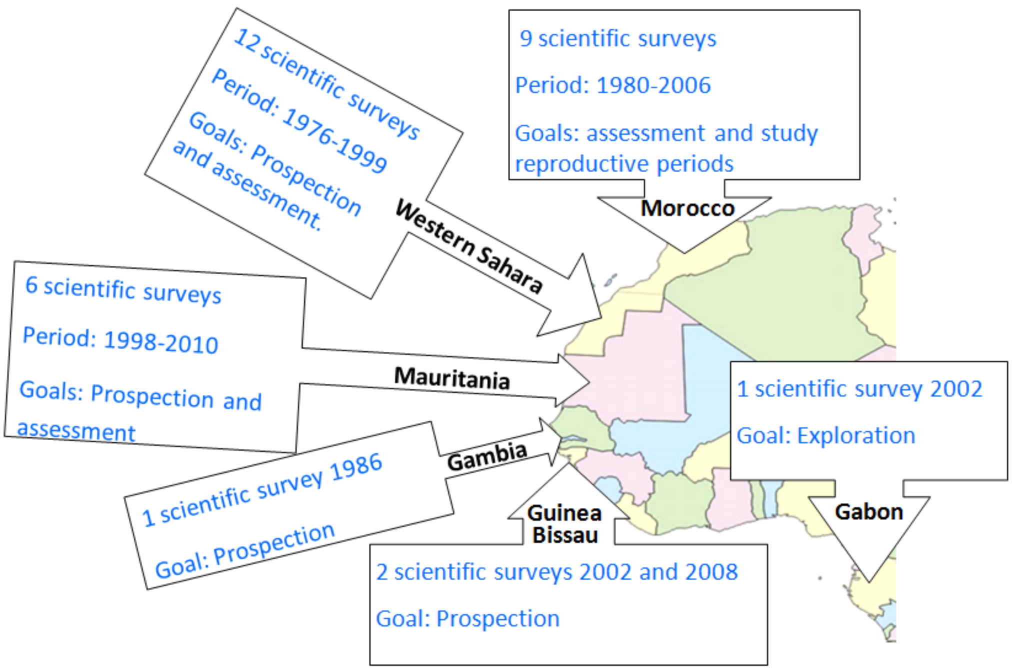
The area off the Northwest African coast is characterized by the occurrence of a permanent upwelling caused by the almost constant Northeast trade wind and the Canary Current flowing parallel to the coast in south direction. This is the cause of an extremely high productivity and holds one of the richest fishing grounds in the world (Valdés *et al.*, 2015).

Cephalopod fishery in this area started operating during the sixties. In the seventies bottom-trawls freezers replaced fresh fish trawlers and the number of vessels increased during the eighties, oscillating up to the present, depending on the number of fishing agreements between Spain or the EU and third countries. The main port of landing, until 2008, was Puerto de La Luz and Las Palmas in Gran Canaria Island. From 2008 to 2012 (when finished the agreement between Mauritania and EU) most of the landings took place at Nouadhibou (Mauritania) being after transported by freighters to Gran Canaria Island. At this moment, there is only one fishing agreement between EU and Guinea Bissau (signed in 2014) and the main landing port is Dakar (Senegal).

SCIENTIFIC SURVEYS

In 1971 took place the first Spanish exploratory trawl-fishing survey in the area (between 27º40′N and 17ºN), called Sahara I, onboard the Spanish Oceanographic vessel "*Cornide de Saavedra*" (Bas, 1974). *Octopus vulgaris* was found all over the sampled area, the highest density between 23º and 25º N, near the coast and 20m deep. The highest abundance of *Loligo vulgaris* and *Loligo forbesii* was northern of Cape Blanc, *L. vulgaris* in more coastal waters whereas *L. forbesii* in offshore and deeper waters. *Sepia officinalis* was found in all the area.

After this first survey there have been 31 more:



FIELDS OF RESEARCH

Since the end of seventies, a sampling and monitoring system have been carried out by the scientific team of the COC. That has allowed information gathering on size composition of the catches and recruitment. Catch and effort data have been also available at customs and/or shipping agents. During nineties, the biological sampling program for cephalopods focused on the estimation of growth and reproductive parameters, allowed to obtain significant achievements in the life-cycle of cephalopod populations. Moreover, surveys have provided information about the relative biomass and abundance indexes for these stocks (Bravo de Laguna, 1999). In 2003 the Data Collection Framework ("Programa Nacional de Datos Básicos" in Spain) an EU framework for the collection and management of fisheries data have been placed. One of the fisheries to be monitored has been the Spanish Cephalopod Fishery (freezer trawlers vessels) in waters off third countries, under European fishing agreements. Biological data such as length, weight, sex, and maturity state, as well as catch and effort data have been reported. The main results and achievements by species are:

- **Octopus (*Octopus vulgaris*)**

First information-gathering system was established in the seventies, when the fishery became relevant in terms of landings and economical value. The first data about size composition of catches and growth parameters estimation based on size distribution is available for the period 76-80 (Bravo de Laguna, 1988).

In 1996 a new study was developed to update and complete the knowledge on the key aspects of reproductive cycle of Saharan *O. vulgaris* in order to provide the basis for optimizing the management of this resource (Fernández-Núñez *et al.*, 1996).

The oscillation on the spatio-temporal abundance of octopus in Western Sahara was studied by means of Geographic Information System (GIS) and by applying Generalized Addictive Models (GAM) as exploratory tools (Balguerías *et al.*, 2002). They observed an important regular intra-annual fluctuation but a major change at an inter-annual level; annual oscillation of octopus production in the area was clearly linked to the success or the failure in the recruitment. They also observed maximum abundances in years with SST below the average.

Fishers in the region reported that octopuses from Mauritania and Western Sahara were different in texture and coloration though no systematic comparisons have been carried out. A study about genetic differences between octopus in both areas proved the presence of a degree of genetic isolation, which meant that the octopus from the Mauritanian fishery were not supported by inflow of paralarvae from the Western Sahara fishing area, or vice versa (Murphy *et al.,* 2002).

At the same time, and due to the need of information about octopus' feeding habits in the area, a preliminary research of octopus' diet analysing 373 individuals was conducted. The study showed that the diet is mainly based on crustaceans (55%), fishes (33%) and molluscs (12%). Moreover, it was proved that the ratio is not constant during the year and it changes with the size of octopuses (Rodríguez-Pino *et al.*, 2002).

An image compilation of octopus' gonads in the different reproductive stages were compiled for an ICES Workshop on Cephalopods Maturity stages in 2010 in order to review the maturity scales used in different laboratories and to come to an agreement on the adoption of common maturity scales. Knowledge of the maturation process is vital in understanding the life cycle of octopus, in recognising spawning populations and in identifying possible control factors (Jurado-Ruzafa *et al.*, 2010).

In 2009 there was a need to know the real state of octopus stock in Mauritania in order to renew the fishing agreement for the Spanish-trawler fleet. A total of 4044 octopuses were analyzed from January 2010 to September 2011 and a review of reproductive aspects was addressed (Jurado-Ruzafa *et al.*, 2014). Using some of these samples, an inventory of organisms trapped in octopus' mantle during the trawling was documented, including 38 species of fish and 44 of invertebrates (Jurado-Ruzafa *et al.* 2012). Furthermore, sustainable strategies for the study and exploitation of octopus stock in Mauritania were reported to FAO in order to get to a geometric approach and sustainable total allowed catches (S-TAC's) (Solari, 2012).

In the nineties started a very important field of work in the COC, the cephalopod's age and growth studies, analysing the increments in calcified structures of the target species in the area (cuttlefish, squid and octopus). Beaks, statoliths, lens and stylets were tested and the team developed, for the first time, the age estimation in an octopus species (Raya and Hernández-González, 1998). Afterwards, the two methods available for age estimation in octopus beaks were improved to reduce the time of sample preparation and to enhance the appearance of the increments. These techniques aim to observe and analyse growth increments in the rostrum sagittal sections (RSS) and lateral wall surfaces (LWS) of octopus beaks. The study recommends counting growth increments in LWS of beaks to age adult common octopus (Perales-Raya *et al.*, 2010). Octopus' maximum age in nature was estimated counting increments on beaks of senescent males and females. During this study the team detected, for the first time, stress marks in beaks of wild octopuses which were related to SST fluctuations (Perales-Raya *et al.*, 2014a).

Recently, daily increments in octopus' beaks have been validated for the whole size and age range of the species using chemical and environmental marking, as well as known-age specimens, for both RSS and LWS in octopus beaks (Perales-Raya *et al.*, 2014b). Currently the team is working on the stress registered in beak microstructures (capture, handling, environmental changes...) to analyze environmental and biological factors that affect the life of octopuses, both in the pelagic-paralarval (Franco-Santos *et al.*, 2015) and benthic-adult stages (Perales-Raya *et al.*, in preparation).

- **Cuttlefish (*Sepia hierredda* and *Sepia officinalis*)**

The first specific study of cuttlefish caught off the northwest African coast was accomplished from 15 July to 12 August 1970 onboard the Spanish vessel "*Isla Alegranza*". Five species of *Sepia* were found and described (*Sepia oficinalis officinalis, Sepia officinales hierredda, Sepia bertheloti, Sepia elegans, Sepia orbignyana and Sepia elobyana*). The distribution and reproductive aspects of *S. officinalis hierredda* were also studied (García Cabrera, 1970).

In 1989 fishing effort regulations established seasonal fishing closures in the area, in order to protect spawning and recruitment periods of the main cephalopod species. Identifying the basic key aspects of life cycle in the Saharan *S. hierreda* population was essential to estimate the effects of those management measures. In 1994 data on size at first maturity, sex ratio, spawning periods and recruitment indexes were provided (Fernández-Núñez *et al.* 1994).

There was also a need to elucidate the age of these species to provide this information for the stock assessment in FAO Working Groups. The COC team developed, for the first time, age estimation in a *Sepia* species. It was an innovative study about direct age estimation using micro increments related to age in statoliths of *S. hierredda*, the team suggested a daily deposition (Perales-Raya *et al.*, 1994). Direct ageing using statoliths of *S. officinalis* in captivity was the first attempt to validate daily deposition. This study showed that rings are formed before hatching. Marks were used to calibrate ring periodicity and to establish the temporal relationship between ring number and age (Fernández-Núñez *et al.*, 1995). Daily deposition of statolith increments in *Sepia officinalis* in captivity were later validated by Bettencourt and Guerra (2001).

An image compilation of cuttlefish's gonads in the different reproductive stages were compiled for an ICES Workshop on Cephalopods Maturity stages in 2010 in order to review scales used in different laboratories and to come to an agreement on the adoption of common maturity scales (Duque Nogal *et al.*, 2010)

New studies about age and growth estimation of *S. hierredda* were carried out by (Perales-Raya, 2001). She estimated the maximum age (near a year) in the Saharan Bank, and compared the sequence of growth lamellae in cuttlebones with daily increments in statoliths.

- **Squid (*Loligo vulgaris*)**

It is the third cephalopod species most caught by the Spanish freezer-trawler fleet operating in the Northwest coast of Africa. Although the Saharan Bank fishery had been described by many authors, a specific study on the reproductive biology of this species has not been conducted until 1999 (Raya *et al.*, 1999). Authors used monthly samples during a year (May 1993-April 1994) to estimate maturation and recruitment patterns as well as the age and growth using statoliths in order to complete the life cycle of *L. vulgaris* on the Saharan Bank.

Years later, in the context of the DCF Program, an image compilation of squid's gonads in the different reproductive stages were compiled for an ICES Workshop on Cephalopods Maturity stages in 2010 in order to review scales used in different laboratories and to come to an agreement on the adoption of common maturity scales (Carrasco Henarejos *et al.*, 2010).

In collaboration with international institutions, differences in biological characteristics of *L. vulgaris* from North France, Northwest Portugal, the Saharan Bank, and the Greek Seas were analyzed (Moreno *et al.*, 2002). They found a high degree of biological variation across its geographic distribution.

The COC team has also collaborated with other Research Centres to study the embryonic development of *L. vulgaris* (Villanueva *et al.*, 2003). The two objectives of the study were analyse the relationship between egg incubation temperature and embryonic statolith growth (studding eggs incubated under laboratory conditions) and measure the width of the embryonic increments in statoliths of wild *L. vulgaris* individuals from different, well differentiated, geographic regions (North-West Iberian Peninsula, Sahara Bank, Central Mediterranean and Eastern Mediterranean). Based on this study, embryonic development lasts from a few weeks to a few months depending on the environmental water temperature, and analysing the embryonic areas of statoliths we can obtain information about past events in squid's early life.

There is very little published information about the biology and diet of the pelagic cephalopod *Architeuthis* (giant squid). In 1994 was reported the first specimen in the South of Tenerife (Fernández-Núñez *et al.*, 1995). A total of fourteen specimens have been analyzed since then in waters off Tenerife Island. When possible, length, weight, sex, maturity and all biological characteristics have been registered.

ON–GOING AND FUTURE STUDIES

Recent agreement between EU and Guinea Bissau allowed some Spanish trawlers to start fishing cephalopods in this country in 2015. An observers program for sampling on board of this fleet is planned in order complete the DCF requirements (concurrent sampling of captured species at sea, capture and discards, etc.).

CephsInAction (COST-Action) is a research network created to improve cephalopod welfare in aquaculture and fisheries. One of the goals of the COC team within this project is to analyze the stress produced by different capture methods in the wild and the stress produced during physiology experiments in captivity (2013-2017).

Project **OCTOWELF** studies health and welfare in first stages of life of *O. vulgaris* and the effects caused by diet and environmental aspects (2014-2016).

To know more about octopus' habitat and the organisms that share its living grounds, taxonomical and ecological studies of species trapped into the octopus' mantle would be conducted.

New studies of octopus' necrotic feeding habits in fishing grounds are planned to compare among discarded species, octopuses from fishing grounds and octopuses from other grounds based on stable isotopes analyses.

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Annex 6: ToR g Socio-economic studies on cephalopod fisheries

Definition of data bases with socioeconomic parameters and variables to be collected:

											If not available, from literature		
Landing country*	Year	Total national landings weight (Kg.)	Total cephalopods landings weight (kg.)	Total national landings value (€)	Total cephalopods landings in value (€)	Licenses for cephalopods (n)	Total number registered vessels (n)	Total number of SSF vessels (n)	Total number of vessels targeting cephalopods	Total official number registered fishers	Number registered fishers in SSF	Number fishers involved in cephalopods fishery	references

Data base with governance information to be collected:

Country*	**Region**	**Input control measures**			**Output control measures**			**Output control measures**			**Other**	**Hierarchical/top-down**	**Co-management**	**Bottom-up/self management**	**Other**	**Property rights** (collective, none…)	**Participation of fishers in management**
		Gear restrictions	Licensing	Time restrictions	TAC	Quotas	MLS	TURF	MPA	Time-area closures	List any other						

Annex 7: References

6.1 References in Sepiidae
6.2 References in Loliginids
6.3 References in *Octopodidae*
6.4 References in Ommastrephidae
6.5 References from Policies (ToR c)
6.6 References from Biological parameters (ToR d)
6.7 References from knowledge update (ToR e)
6.8 References from MSFD (ToR f)

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