# ICES WGCEPH REPORT 2018

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

## 5–8 June 2018

## Pasaia, San Sebastian, Spain

ICES
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International Council for
the Exploration of the Sea

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Recommended format for purposes of citation:

# Contents

# Executive summary

The ICES Working Group on Cephalopod Fisheries and Life History (WGCEPH) met in Pasaia, San Sebastian, Spain, on 5–8 June 2018.

Annual summaries were presented for cephalopod fishery production in the ICES area, also a brief review of the use of morphometric and trace element data for stock identification (ToR A).

Outlines were written for two manuscripts, one on stock trends and the other on stock assessment and management of cephalopod fisheries, also a short review of stock assessment of cephalopods in Russia (ToR B).

An updated version of the review of relevant new research on cephalopods was presented as well as short reviews of cephalopod stock identification and Russian cephalopod studies (ToR C).

WGCEPH reviewed the socioeconomic importance of large-scale cephalopod fisheries. A manuscript on small-scale fisheries is almost complete (ToR D).

The structure of the proposed identification guide was presented, also an evaluation of current use of nationally collected monitoring data on cephalopods. Draft recommendations were written for future cephalopod fishery monitoring (ToR E).

# 1      Administrative details

| |
|---|
| **Working Group name** |
| Working Group on Cephalopod Fisheries and Life History (WGCEPH) |
| |
| **Year of Appointment within current cycle** |
| 2018 |
| **Reporting year within current cycle (1, 2 or 3)** |
| **2** |
| **Chair(s)** |
| Graham J. Pierce, Spain |
| Jean-Paul Robin, France |
| **Meeting dates** |
| 5–8 June 2018 |
| **Meeting venue** |
| Pasaia, San Sebastian, Spain |

# 2      Terms of Reference

a )  Report on cephalopod stock status and trends: Update, quality check and ana-
lyse relevant data on European fishery statistics (landings, directed effort, dis-
cards and survey.

b )  Conduct preliminary assessments of the main cephalopod species in the ICES
area by means of trends and/or analytical methods. Assess the relevance of in-
cluding environmental predictors.

c )  Update information on life history parameters including variability in these
parameters. Define cephalopod habitat requirements.

d )  Evaluate the social and economic profile of the cephalopod fisheries, with em-
phasis on small-scale fisheries and mechanisms that add value to cephalopod
products (e.g. certification).

e )  Recommend tools for identification cephalopod species and update best prac-
tices for data collection.

# 3      Summary of Work plan

| | |
|---|---|
| Year 1 (2017) | Report on updated trends in Cephalopod landings and abundance indices .(a) |
| | Report on updated cephalopod stock assessments (b) |
| | Report on scientific articles in relation to life-history and habitat requirements (c) |
| | Report on social and economic profile of cephalopod fisheries (d) |

| | Report on available information for species identification (e) |
|---|---|
| Year 2 (2018) | Report on status and trends in cephalopod stocks (a and b)) |
| | First draft of paper in relation to population modelling and assessment tools (b) |
| | Peer review paper on rearing conditions and/or habitat preferences (c) |
| | Report on mechanisms that add value to cephalopod products (e.g. certifications) (d) |
| | Draft of Manual for cephalopod field identification and data collection (e) |
| Year 3 (2019) | Report on updated trends in Cephalopod landings and abundance indices .(a) |
| | Peer-review paper on cephalopod population modelling and assessment tools (b) |
| | Report on socio-economic issues related to cephalopod management options |
| | Manual for cephalopod field identification and data collection guidelines (e) |

# 4 List of Outcomes and Achievements of the WG in this delivery period

The main outcomes of the work of WGCEPH in 2018:

- Annual summaries for cephalopod fishery production in the ICES area plus a brief review of the use of morphometric and trace element data for stock identification (ToR A);

- Outlines of two manuscripts, one on stock trends and the other on assessment and management of cephalopods, plus a short review of stock assessment of cephalopods in Russia (ToR B);

- An updated version of the review of relevant new research on cephalopods, plus short reviews of cephalopod stock identification and Russian cephalopod studies (ToR C);

- A brief review of the socioeconomic importance of large-scale cephalopod fisheries. A manuscript on small-scale fisheries is almost complete (ToR D);

- Proposals for the structure of the identification guide, an evaluation of current use of nationally collected monitoring data on cephalopods, and draft recommendations for future monitoring (ToR E).

# 5 Progress report on ToRs and workplan

## 5.1 Progress on ToR a) Report on cephalopod stock status and trends: Update, quality check and analyse relevant data on European fishery statistics (landings, directed effort, discards and survey catches) across the ICES area

### 5.1.1 Stock identification

While WGCEPH has carried out various preliminary assessments of cephalopods and has discussed fishery management options, for most cephalopods in European waters, no stocks have been formally designated. Historical molecular genetic (and allozyme) studies suggest that, in European Atlantic waters, the high mobility of squids means that it is unlikely that more than one stock of each species is present (at least if we exclude the

isolated population of *Loligo forbesii* in the Azores). In practice, smaller management units may be defined for convenience. For cuttlefish, which lack a planktonic paralarval stage, and octopus, which show little movement as adults, it is more likely that multiple stocks exist. In 2019, WGCEPH reviewed evidence available from non-genetic approaches to stock identification, including morphological studies, in particular considering the advances possible due to applying geometric morphometric analysis, and trace element analysis. The text of this section is adapted from a short review prepared by Jessica Jones and Fedor Lishchenko (Annex 3).

### 5.1.1.1 Morphological analysis

Historically, general observation of morphological traits, body shape and patterns of colouration has served as a tool for distinguishing stocks, populations, subspecies or races of animals. However, application of this approach to cephalopods may be limited by the high morphological plasticity and ability to change colouration and patterns using chromatophores.

Analysis of body shape was one of the earliest means of distinguishing between cephalopod populations from different areas (Borges 1995; Pierce *et al.* 1994a; Sabriov *et al.* 2012), to separate different forms (Chembian and Mathew, 2014), to identify putative stocks and management units (Pierce *et al.* 1994b) and to distinguish sympatric species with apparently similar body forms (Haefner 1964; Bonnaud *et al.* 1998; Barón and Ré 2002; Zaleski *et al.* 2012). Traditionally, a series of linear measurements (each representing the distance between two anatomical points) would be collected from soft tissue (i.e. mantle, head, arms, tentacles, fins, gills, siphon and reproductive organs) and hard structures (predominantly the gladius). To control for variation in body size, hence facilitating analysis of body shape, lengths of body parts as a percentage of mantle length (ML) or as ratios (e.g. fin length to fin width).

Multivariate analysis has been used to distinguish between animals from geographically distinct regions (Borges 1995). An example of this is a study conducted by Pierce *et al.* (1994b), in which geographic variation of *Loligo forbesii* was analysed using morphometric and meristic characters from 13 different areas of the northeast Atlantic Ocean. Results suggested that *L. forbesii* from the Azores can be regarded as a separate stock, differing significantly from those on the continental shelf (subsequently supported by allozyme and microsatellite results). Multivariate techniques also appear to be effective for differentiating between sympatric or cryptic species (Barón and Ré 2002; Pineda *et al.* 2002; Sin *et al.* 2009). Canonical variate analysis (CVA) on morphometric measurements from six groups of Loliginid squid along the Pacific coast of Mexico, separated a priori based on the shape of the funnel organ, supported the existence of four species previously identified in Mexican waters together with two forms of unclear taxonomic status, suggestive of greater species diversity had been previously reported for the Mexican Pacific (Granados-Amores *et al.* 2014).

Care must be taken during the collection of morphometric measurements, as there are often sources of error such as significant between-sampler bias (Pierce *et al.* 1994a). This can be exacerbated by the fact that soft-body parts are prone to stretching and warping. Using the same sampler to collect all morphological measurements is therefore recommended, in addition to the use of hard body parts that cannot be distorted such as the

gladius (Barón and Ré 2002), statoliths (Clarke 1978; Arkhipkin and Bizikov 1997; Arkhipkin 2005) and beaks (Borges 1995; Chen *et al.* 2012; Hu *et al.* 2018).

Measurements on hard structures can be used on their own or in combination with measurements of soft body parts for population discrimination. A discriminant analysis between putative *Doryteuthis gahi* populations from southern Chile, Peru and the Falkland Islands concluded that hard structures such as the gladius, beak and statolith were more useful than soft body parts to separate between populations (Vega *et al.* 2002). Hard structures were also shown to be more effective than soft body parts in the discrimination of *Dosidicus gigas* from Ecuador, Peru and Chile (Liu *et al.* 2015). Conversely, a spatial comparison of morphological characters throughout the distributional range of *Loligo reynaudii* showed the most consistent separation of samples from the south and west coast of South Africa and Angola was found when soft body parts were used (Van der Vyver *et al.* 2016). Morphological characters which best separate population units may therefore be species or site-specific and it would therefore be prudent to use a combination of hard and soft body parts in future morphological studies.

The traditional morphometrics approach has its limitations, such as the loss of information by simplifying the shape and the risk of selecting dimensions that do not adequately represent the actual shape variation (Braga *et al.* 2017). Geometric morphometrics is a promising alternative method that has been developed over the last few decades. In this technique, biologically definable landmarks or outlines of the entire shape (Fourier shape analysis) are used to visualise deformations, in theory retaining more detail about the geometry of the structure. Geometric morphometric techniques using landmarks have been used to determine body shape variation between regions (Braga *et al.* 2017), identify spawning groups (Crespi-Abril *et al.* 2010) and distinguish between animals using different migratory routes (Schroeder *et al.* 2017). Landmarks and semi-landmarks have also been collected on beaks to differentiate between stocks (Fang *et al.* 2017) and sympatric species (Díaz-Santana-Iturríos *et al.* 2017). The elliptical Fourier outline method has been applied to beaks of ommastrephids for species identification (Fang and Chen 2017) but it is most commonly applied to statoliths (Lishchenko *et al.* 2017). Comparisons of statolith, upper beak and lower beak landmarks indicated that geometric morphometrics using a combination of different hard structures was the best approach for discrimination between three loliginid species in the South China Sea (Jin *et al.* 2017), again highlighting the need for a combination of body parts (i.e. more than one independent character set) in future morphological analyses (see also Thorpe 1985 a,b, 1987 a,b).

Although the study of body shape originated several decades ago, it still remains one of the most popular methods for identification of cephalopod stocks and similar tasks, due to its low cost and relative simplicity.

### 5.1.1.2 Trace Elemental analysis

Hard structures such as statoliths grow continually throughout life, with accretion of new material occurring on a daily basis. Throughout this accretion process, trace elements are incorporated, with their uptake dependent on intrinsic factors and ambient conditions (Arkhipkin 2005; Zumholz *et al.* 2007). Thus, trace elemental concentrations are constantly changing throughout an individual's ontogeny. The success of investigations of the elemental signatures of fish otoliths (see Campana 1999 for a review)

prompted the application of this approach to statoliths as natural markers of cohort and population structure in squid (Arkhipkin 2005).

One of the earliest studies to analyse elemental data in a population structure context combined trace element analysis using a wavelet dispersive spectrometer with tag-recapture data, using a small sample (25 analysed for Sr/Ca and 12 tagged individuals) of *Todarodes pacificus* from the Sea of Japan (Ikeda *et al.* 2003). The two geographically separate groups had significant differences in Sr/Ca, reflecting different spawning grounds and transport routes. Since then, the elemental composition of statoliths has been used to distinguish between squid from different spawning cohorts (Liu *et al.* 2011) and geographical regions (Wang *et al.* 2012; Liu *et al.* 2013; Arbuckle and Wormuth 2014) in several species. Significant geographic variability was found when analysing six trace elements in *Doryteuthis gahi*, along with a significant difference between spring and autumn spawning cohorts (Arkhipkin *et al.* 2004). Significant differences between two geographic regions and seasonal cohorts were also found in *Sepioteuthis lessoniana* around Taiwan (Ching *et al.* 2017). However, both studies used solution-based inductively coupled plasma mass spectrometry (ICP-MS), which gives an integrated signal over an individual's lifetime. A subsequent analysis of the *D. gahi* population was able to produce high-resolution elemental chronologies by ageing individual ablation spots obtained using laser ablation ICP-MS analysis. These Sr/Ca and Ba/Ca chronologies differed significantly between the two spawning cohorts and were consistent over two consecutive years, suggesting that element chronologies could be used to assign individuals to cohorts (Jones *et al.* 2018).

Other studies have focused on the early life history and allocation of natal origins to determine population structure (Warner *et al.* 2009; Liu *et al.* 2015). Multi-elemental signatures within the pre-hatch region of two octopus species were used to investigate population structure and dispersal patterns in Tasmania, in both cases finding evidence of distinct groupings (Doubleday *et al.* 2008a,b). A robust machine-learning classification technique was successfully applied to natal elemental signatures of *Sepioteuthis australis*, showing that 55–84% of individuals derived from an area closed to commercial fishing during the peak spawning season (Pecl *et al.* 2011).

Trace element analysis was initially very expensive to undertake, and this was reflected in the small sample sizes in most early studies (often less than 20 individuals). Although it is still costly, procedures are becoming cheaper every year, which should permit increased sample sizes. Though expensive, this approach is suitable for stock discrimination but also for understanding life history traits and migration patterns.

Combining different population discrimination techniques is a promising area for future research. High resolution ICP-MS and statolith Fourier shape data were used to study temporal and spatial variation in *Nototodarus gouldi* (Green *et al.* 2015). Although shape analysis indicated the existence of two separate stocks, elemental analysis showed hatching of individuals from both stocks occurred throughout their distribution range. There was evidence that adults in Victoria were contributing more to the Great Australian Bight stock than vice versa, with implications for stock management (Green *et al.* 2015). Trace element analysis and morphometric measurements combined revealed the existence of three discrete cuttlefish populations in Algerian coastal waters (Kennouche and Nouar 2017). Another technique which can be combined with trace element and morphometric

analyses is stable isotope analysis – which was used to elucidate migration and trophic patterns in *Ommastrephes bartramii* (Kato *et al.* 2016).

### 5.1.2 Trends in abundance

Current trends for the four main cephalopod families fished in the ICES area are illustrated in Annex 4 and described in full in Annexes 5–8. As noted above, cephalopod populations / stocks are not assessed on a regular basis and there are no TACs or quotas for these resources in EU waters.

#### 5.1.2.1 Cuttlefish and bobtail squids (Sepioidea)

The main cuttlefish fishing grounds are the English Channel, the Bay of Biscay and Portuguese and Spanish waters. Throughout the time series, the bulk of the catches come from the English Channel, taken mainly by France and the UK. Although 2017 landings were close to the 2000–2017 average, several indicators (both from the fishery statistics and from independent surveys) indicate a trend of decreasing abundance. Unusually high catches were observed in the northwest part of the English Channel in late summer 2017 and are likely to indicate overfishing. Assessment exercises carried out at the scale of the whole English Channel stock could not be updated because 2013–2014 data sets were temporarily not available. However, the spatial heterogeneity of catches in 2017 underlines the need to take into account spatial distribution and interactions between fishing fleets. In Spanish and Portuguese waters, artisanal fisheries are relatively important but 75% of landings come from trawlers.

#### 5.1.2.2 Octopuses (Octopodidae)

Landings comprise three species, common octopus (*Octopus vulgaris*), horned octopus (*Eledone cirrhosa*) and musky octopus (*Eledone moschata*). Average annual landings into European ICES countries during 2000–2017 were 18771 t. Most catches in ICES Areas 27.3 to 27.7 were taken by trawlers and are expected to comprise mainly of *E. cirrhosa*, although catches are usually not identified to species. Only a small proportion of reported catches of Octopodidae derive from ICES areas 27.3 to 27.7.

In the southern ICES areas (27.8 abd, 27.8 c and 27.9 a), the main countries exploiting these species are Spain (27% on average during 2000–2017), Portugal (63%) and France (10%). During the last four years, on average 88% of all octopus landings into European ICES countries were caught in areas 27.8c and 27.9 a. Since Spain and Portugal identify the landings to species it can be added that the bulk of the catch in area 27.9.a consists of *Octopus vulgaris*. Survey abundance indices for octopus show wide year to year fluctuations but no clear trends are evident.

#### 5.1.2.3 Loliginid squids (Loliginidae)

Over the period 2000–2017, Landings of loliginid squids caught in the European ICES area ranged from around 7000 to 12 000 t annually, with 2017 landings being at the upper end of the range (very similar to 2003 and 2010). The most important area for these catches in 2017 was the English Channel (area 27.7 d,e; contributing 44% of the total), followed by the North Sea (area 27.4; 19%), northwest Scotland plus Ireland and Rockall (area 27.6a,b; 18%) and Cantabria/Bay of Biscay (area 27.8a,b,d; 12%). Areas with high catches seem to be areas with low discards.

Trends differ between areas with increases seen in 2017 in the English Channel and the northwest west coast of Scotland, Ireland and Rockall. In the latter area, catches increased substantially in 2017, mainly due to an increase at Rockall, a location that has supported squid fishing sporadically over the last 5 decades, notably in the early 1970s and again in the second half of the 1980s.

#### 5.1.2.4 Ommastrephid squids (Ommastrephidae)

Catches of this species group averaged around 3 200 t annually along the data series from 2000–2017, although with wide year-to-year variation. There was a peak in 2012, which is only the second year in the series, the other being 2000, in which total landings exceed 5000 t. , mainly due to the Spanish catches in Subarea 8. Landings in 2017 fell below 3000 t for the first time since 2009, reflecting very low landings from subarea 8, although landings from division 7.f-k (again mainly Spanish catches) were the highest seen in the whole time series.

Over the 18-year series, the geographic origin of landings has shifted markedly. In 2000–2001, subarea 9 was the most important, being gradually replaced over the next decade by subareas 1+2 and 8. From 2012–2014 and again in 2016, landings from subarea 8 dominated. Finally, landings from subarea 7f-k, which have substantial only in 2000–2002 and 2013–2017, dominated in 2015 and 2017.

Commercial catches of Ommastrephidae are thought to be composed mainly of *Illex coindetii*, *Todaropsis eblanae* and *Todarodes sagittatus*. The data call requests data by species, and some countries have been able to provide this but, overall, most landings are still identified only to family level. Provision of survey data is also patchy.

## 5.2 Progress on ToR b) Conduct preliminary assessments of the main cephalopod species in the ICES area by means of trends and/or analytical methods. Assess the relevance of including environmental predictors

### 5.2.1 Assessments

This is an ongoing task. Recent work by WGCEPH members has demonstrated the value of production models that include environmental predictors (effectively allowing environmental carrying capacity to vary between years) as well as the utility of empirical statistical models employing environmental predictors and survey-based recruitment indices. A comparative exercise using production models is planned for 2019 while a manuscript describing such a model for *Octopus vulgaris* in the Gulf of Cadiz has recently been submitted to Fisheries Research.

### 5.2.2 Assessment and management in Russian fisheries

Taking advantage of the presence of Russian WGCEPH member Fedor Lischenko the meeting agreed to include a brief review of assessment and management of Russian cephalopod fisheries.

Fishery management for aquatic biological resources in Russia is required to be consistent with the Code of Conduct for Responsible Fisheries (FAO, 1995), and the ecosystem approach and precautionary approaches to fisheries management. In practice, this means that assessments consider the impact of exploitation not only on the target species,

but also on the *biocenosis* with which the target species is associated. Compliance of management with the principles of precautionary exploitation and sustainable development is monitored (Babayan, 2000).

Exploited species are assigned to one of two lists, those subject to a total allowable catch (TAC) and those subject to a recommended catch (RC) determined according to the exploitation status, as well as the commercial, environmental and social value of the resource. Assignment of a species to one of these options determines whether management falls under the TAC regime or the RC regime, the latter being a simplified form of the former, typically applied to developing fisheries. For TAC species, quotas (representing a percentage of TAC) are allocated via auction and assigned to users for a period of up to 10 years. However, if a user takes less than 75% of the allocated quota during two consecutive years, the quota will be made available again. For RC species, permission fish is granted until the end of the calendar year or until approximately 100% of total RC has been taken.

Commercially exploited cephalopods in Russian waters are subject to these rules. Two species are included in the list of species for which the TAC is determined, the school-master gonate squid (*Berryteuthis magister* Berry, 1913) and the giant Pacific octopus (*Enteroctopus dofleini* Wülker, 1910). Another three, the Japanese flying squid (*Todarodes pacificus* Steenstrup, 1880), the neon flying squid (*Ommastrephes bartramii* Lesueur, 1821) and the chestnut octopus (*Octopus conispadiceus* Sasaki, 1917) are on the RC list.

When the status of the species and the approach to its fishery regulation have been determined, a forecast for the status of stock units of this species is prepared for the year ahead. The procedure for TAC and RC forecasts preparation is determined by the orders of the Federal Agency for Fisheries of the Ministry of Agriculture of the Russian Federation (No. 104 of February 6, 2015 and No. 287 of April 18, 2013, respectively) and includes selection of appropriate methods, analysis of current stock and fishery status, forecasting of future abundance and recommendation of appropriate TAC or RC, followed by a review/assessment of the outcomes.

Stock status and biomass are estimated, either by direct methods, using the data from scientific surveys (Aksyutina, 1968) or by analytical methods using fishery statistical data (Anon., 2005; Alekseev *et al.*, 2017). Forecasting is based on assessment results as well as other information such as data from recreational fishing, trends in population status or fishing effort changes and expert judgement. The value of TAC or RC is then calculated in accordance with fishery regulations (Babayan, 2000). Stock assessment and forecasting are carried out by federal state scientific institutions. The choice of methodology is based on the level of "information support", i.e. the data obtained from fishery statistics, scientific surveys and other studies; the amount of information available determines the choice of method for stock assessment. Three levels of information support are recognised each associated with particular sets of methods for stock assessment:

Level 1. information support includes historical data series on age structure, growth and maturation, yearly and age-specific natural mortality rates, catches, and catches per unit of fishing effort. In such cases, structured stock assessment models are used, e.g. cohort models, stock-replenishment models, etc. Due to the short lifespan (about 1 year) of cephalopods, wide fluctuations in abundance and natural mortality, and the fact that the

knowledge on their biology is limited in comparison with finfish, structured models are not used in their fishery management.

Level 2. Historical data series of catches and catches per unit of fishing effort are available. In this case, the stock assessment is carried out using production models. In two cephalopod species, the giant Pacific octopus and the chestnut octopus, information support is sufficient to use production models. Available information includes data from scientific surveys (both those directed at octopus and surveys for other species), Russian and Japanese fisheries data and species biology studies. Abundance estimation follows the methods of Golenkevich (1999) and Slobodsky (1986) and forecasts are made using the Schaefer's production model (1954). Estimation of the recommended catch (TAC and RC in case of giant Pacific octopus and the chestnut octopus, respectively) follows methods described by Babayan (Babayan, 2000). Since the octopuses are fished by specialized fishing gear (longlines and traps), the fisheries have minimal effects on the biocenosis.

Level 3. Available information is incomplete and/or of insufficient quality. In this case, the use of models is excluded and stock assessment is based on empirical, trend, or indicator methods. This applies to all other fished cephalopods in Russia. In some cases, it reflects the biology of the species (e.g., schoolmaster gonate squid has a complex and poorly studied spatiotemporal population structure). In others, Russian waters represent only a small part of the total species range (Japanese flying squid and neon flying squid, for which Russian waters represent the northern extreme of the feeding range). In most octopuses (excluding the Southern Kuril islands zone), activity in the fishery is insufficient to collect the information needed to apply models.

Stock assessments, forecasts and recommended catches are subject to scientific review and public consultation (during which representatives of industry and public organizations can suggest modifications). Independent scientific organizations check outcomes for conformity with the principles of the ecosystem and precautionary approach, considering the fishing gear used and its impact on the biocenosis, the scale of the fishery, and the uniqueness of the biocenosis at risk. Assessments and forecasts may be updated if relevant new information comes to light.

### 5.2.3 Manuscripts

Outlines were assembled for the two planned manuscripts proposed for this ToR (on trends and on assessment methodologies; see Annexes 9 and 10). It is planned to finish both in 2019.

## 5.3 Progress on ToR c) Update information on life history parameters including variability in these parameters. Define cephalopod habitat requirements

### 5.3.1 Life history review

This ToR was due to deliver a review paper in 2018 and a complete manuscript is now available (Annex 11), awaiting submission to a journal. The updated version of the review on recent cephalopod studies has covered 152 journal articles and conference abstracts, including work on the majority of cephalopod species inhabiting the ICES area and adjacent waters.

*Octopus vulgaris* and *Sepia officinalis* remain the most studied species, reflecting their relatively high importance as fishery resources as well as much work on development of rearing (culture) techniques. Less well-known species are represented by *Sepia orbignyana*, *Sepietta oweniana*, *Todarodes sagittatus* and *Todaropsis eblanae*, including species which may have low abundance in the ICES area, have low commercial value and/or of only local interest for fisheries and for research.

The fields of research included largely follow the Jereb *et al.* (2015) review. The highest numbers of publications were found in the fields of rearing techniques and impacts of climate change or pollution. Few studies concerned species population structure or distribution and, in some cases, knowledge on the basic life history traits remains limited. For some species, the marked disparities between the numbers of publications in different topics make it difficult to provide a balanced account. Some work is still needed to format current review for a journal.

### 5.3.2 Russian studies

Again, taking advantage of input from Russian colleagues, the meeting agreed to include a section on studies of cephalopod life history in Russia and (previously) in the Soviet Union.

During the second half of the 20th century, Soviet fishery institutes carried out a substantial number of studies on Atlantic cephalopods. Many of these studies were based on the results of scientific surveys and described the general and fishery biology of the species (e.g. Bekker *et al.*, 1982; Sushin, 1996). A typical example of such research is the work of A.N. Vovk on nutrition, reproductive biology of the longfin inshore squid (*Doryteuthis pealeii*; Lesueur, 1821), and prospects for fishery development, based on data from more than 20 expeditions undertaken by AtlantNIRO in the northern Atlantic (Vovk, 1969; Vovk, 1972 a; Vovk, 1972 b). These articles illustrate both the strengths and the limitations of Soviet studies in that period. On one hand they represent comprehensive research on various aspects of species biology but on the other hand, they are limited to species of interest for Soviet fisheries. Thus, the majority of studies targeted species inhabiting shelf and open waters of north-western, south-western and central-eastern Atlantic.

Few studies concerned cephalopods of the ICES area. These include two review papers (Vovk & Nigmatullin, 1972; Nesis, 1985). In their review of biology and fisheries, Vovk & Nigmatullin (1972) consider prospects for fisheries on oceanic cephalopods, such as *Sthenoteuthis pteropus* (Steenstrup, 1855) and *Ommastrephes bartramii* (Lesueur, 1821). Nesis (1985) attempts to estimate cephalopod abundance in the world´s oceans.

Three articles are of particular relevance to cephalopods that occur in the ICES area, concerning distribution and feeding of *Gonatus fabricii* (Lichtenstein, 1818) juveniles (Nesis, 1965), the biology of *Illex coindetii* (Vérany, 1839) and *Todaropsis eblanae* (Ball, 1841) in Angolan waters (Nigmatullin & Vovk, 1972) and a study on stock assessment for ommastrephid squids (Froerman, 1981).

Nesis (1965) provides information on biology, distribution and migratory routes of juveniles and adults of *G. fabricii*. Subsequent studies on this species have described variability of morphological and biological traits, temperature preferences and possible impacts

of climate change, and abundance in the eastern part of the species' range (Lubin & Sabirov, 2007; Golikov *et al.*, 2012, 2015; Golikov, 2014).

Nigmatullin & Vovk (1972) reported that *I. coindetii* and *T. eblanae* occur in mixed aggregations, in which individuals of both species were of similar size and maturity and showed similar feeding patterns (both feeding mainly fish and crustaceans).

Froerman (1981) derives from a survey of *Illex illecebrosus* (Lesueur, 1821) on the Nova Scotia shelf in 1979, providing information o  larval and juvenile distribution patterns in relation to time of day, water temperature and salinity and permitting estimation of correction coefficients (time and depth.based) for bottom trawl survey data. Application of these coefficients showed that use of the traditional methods of biomass assessment could lead to significant underestimation of ommastrephid biomass. On the other hand, annual studies on juvenile abundance and distribution allow assessment of stock biomass approximately four months before the beginning of the fishing season.

More recent studies consider the impact of climate change on several boreal-subtropical cephalopod species (*Sepietta oweniana* (d'Orbigny, 1839–1841), *Todaropsis eblanae* (Ball, 1841) and *Todarodes sagittatus* (Lamarck, 1798)). Warming of the Arctic waters has allowed these species to extend their ranges northwards into the Barents Sea, although they appear not to reproduce there (Sabirov *et al.*, 2009 a, b; Golikov, 2014; Golikov *et al.*, 2016)

## 5.4 Progress on ToR d) Evaluate the social and economic profile of the cephalopod fisheries, with emphasis on small scale fisheries and mechanisms that add value to cephalopod products (e.g. certification)

Work under this ToR reviewed the importance of large-scale cephalopod fisheries in Europe. According to EUROSTAT data, cephalopod products represent on average (for the period 2013–2017) 1.5% of the weight and 6.1% of the value of total landings of marine fish products. Spain, Italy, France, Portugal, Greece and the United Kingdom together account for more than 98% of the total catches and revenue generated by cephalopods fisheries in Europe. Prices at first sale increased substantially between 2006 and 2017, especially in the North Atlantic area.

The full report of this work appears in Annex 12 and includes case studies on the octopus fisheries in Portugal and Galicia and cephalopod fisheries in the Basque country.

The proposed manuscript on socioeconomic aspects of small-scale cephalopod fisheries will be finished in 2019.

## 5.5 Progress on ToR e) Recommend tools for identification cephalopod species and update best practices for data collection

### 5.5.1 Identification guide

As mentioned in the last year's report (ICES 2017), the background of this ToR is the need to identify cephalopods to species level in commercial catches and research surveys, to increase the quality of data available for assessing the status of cephalopod stocks. The main idea is to produce a cephalopod identification guide suitable for use on-board research and commercial vessels for different regions, to help with identification of the

main commercial species in the survey or fishing area. The guide should be quick and easy to use without a large amount of text. The focus will be on easily used identification criteria, shown by pictures and drawings.

Based on the discussed standards, a draft identification guide for the North Sea was produced including own high quality photos and drawings for an easy identification. The guide consists of

- A page to explain major identification criteria;
- A short overview of the families and species which will be encountered within the region and their identification;
- A chapter for regional identification of the main species within a family
- A chapter of additional information (one page per species 'wanted poster'): detailed text for identification, distribution map, similar species, additional information about the species in the region: maximal length, weight, depth of occurrence.

However, further details have to be added so that the North Sea draft will be finalised within the next weeks. It will be provided to the cruise leaders of the ICES coordinated North Sea International Bottom Trawl Survey quarter 3 to test the guide and to receive feedback.

During the WGCEPH meeting, standards and the next steps were discussed which include:

- Identification page: This will be region-specific; only selected identification characteristics to distinguish the common cephalopod fauna for the specific region should be mentioned; additional regional specific information about distribution, size, common names, etc., will be added.
- Wanted poster: Here we will present general information regardless of the region; all identification characteristics and total length as well as distribution e.g. will be described.
- A list of species which occur infrequently in the specific region will be added.

The working group discussed the regional scale of the next ID guides and defined the ICES regions as a possible scale. In addition, the opportunity to publish the ID guides as an ICES Cooperative Research Report (CRR) was discussed and the need for translation as a service for fishers was mentioned.

### 5.5.2 Data collection recommendations

#### 5.5.2.1 Current fishery data collection and use of these data

In recent years, cephalopod fishery data collection in the EU has occurred under the Data Collection Framework (DCF), which established a multi-annual programme for data collection (EU MAP). Under the framework the Member States (MS) collect, manage and make available a wide range of fisheries data needed for scientific advice. Under EU MAP, Member States are required to submit Working Plans (WP) (Article 4 of Reg. 199/2008). These Working Plans are set for three years (currently 2017–2019) and contain

the Member States' obligations to collect and provide data relevant to their region/fisheries/sectors pursuant to the EU Multiannual Programme.

MS Annual Reports, on the implementation of the yearly National Programme, provide information summaries in standard tables. These tables are updated every year for the entire duration of the multiannual plan and contain all variables to be recorded under the plan. The following tables are of particular relevance to WGCEPH:

- Table 1B- Planning of the sampling: Member State, species, region, RFMO/RFO/IO, area / stock, frequency, length, age, weight, sex ratio, sexual maturity and fecundity
- Table 1C- Sampling Intensity: Member State participating in sampling, sampling year, species, Region, RFMO/RFO/IO, area/Stock, variables, data sources, planned minimum no of individuals to be measured at the national level and planned minimum no of individuals to be measured at the regional level.

Cephalopods are included as species to be sampled under the new EU MAP. Monitoring data on the fisheries as well as biological data are being routinely collected.

To better understand the current use and utility of EU MAP data, WGCEPH designed a survey which was distributed to group members from countries with important commercial cephalopod catches and which include cephalopods in their sampling plans. These countries were Portugal, Spain, France and United Kingdom. The usefulness of the data is considered in relation to both assessment (qualitative and/or quantitative) and management.

Since answers could be provided at regional scale (within Member States), at country level and RMFO and European level, at European or RFMOs level, respondents were asked to indicate the scale to which they referred. Since current MS work plans started in 2017, and cover a 3-year period, it was understood that data might not be used immediately. Thus, a question about plans for future use of data was also asked. Results of the survey appear below.

France: France does not collect information about cephalopods within the Data Collection Framework. Information is however collected through surveys and the "Obsmer" programme. Numbers and weights of cephalopod species caught are recorded during EVHOE (Bay of Biscay) and CGFS (East English Channel) surveys. Under the "Obsmer" programme, observers on-board commercial vessels record catch, discards and landings. Again, numbers and weights of cephalopods are recorded but the quality of species identification is sometimes rather low.

In addition, the University of Caen samples cephalopods at the fish-market in Port-en-Bessin (monthly species composition and length structure of cuttlefish and Loliginid landings). In this harbour very small quantities of short finned squid and Eledone can also be observed but this happens very seldom and these species are not sampled.

Cephalopod data collected under EU-MAP are not used for management or advice. There is no information about any future plan to use cephalopod data.

United Kingdom: currently most of the use of the data for the UK cephalopods has been for academic studies of biology and ecology (e.g. on distribution and abundance and impact of climate change, Kooji *et al.*, 2016). Various studies on patterns and trends in

distribution and abundance (e.g. Pierce *et al.*, 1994, 1998; Waluda *et al.*, 1998; Bellido *et al.*, 2001; Pierce & Boyle 2003; Wang *et al.*, 2003; Zuur & Pierce 2004) and some preliminary stock assessment exercises have been carried out, e.g. a PhD thesis on Sepia by Matthew Dunn in 1999, papers by Young *et al.* (2004, 2006).

Data on cuttlefish abundance in the English Channel were used for stock assessment using the two-stage model (e.g., WGCEPH 2016). In 2017 Cefas began to collect data on occurrence of squid egg masses in catches of research hauls as well as taking reports from observation by divers and targeting to map spatial and temporal variability of *Loligo* spawning grounds.

UK cephalopod fishery data have also been used in the context of the EU Marine Strategy Framework Directive. In 2014 UK Defra commissioned a project to investigate the feasibility of cephalopod-based indicators (see Pierce *et al.* 2015).

It appears that, currently, the use of the UK data is driven more by potential importance for future decision-making than by formal use in assessment and management, although WGCEPH clearly has this latter ambition. CEFAS seem to be also to progress in this direction.

The main limitation in most of the UK cephalopod data in the past, and also now for most commercial fishery data, is the lack of reliable species identification. From 2016 onwards, the species identification in research surveys has been verified onshore, with simultaneous collection of data on maturity. Occasionally some reliable species-specific information including size, weight and maturity is collected from commercial squid landings.

### 5.5.2.2 Revised Data Collection guidelines

Not all Member States sample cephalopods. Where cephalopods are sampled, the periodicity of sampling is still quarterly or yearly. Some countries do not explain the number of individuals to be sampled and others used a 4s sampling approach (Statistically Sound Sampling Schemes) in which it is not possible to 'predict' or plan the number of any species to be sampled for biological parameters.

WGCEPH has repeatedly expressed its concern about the current sampling design in relation to the life history of cephalopod species. Given the short life cycles of most of these species (1 or 2 years), it is necessary to monitor biological variables regularly, ideally every week or month. Quarterly sampling is insufficient for cephalopod assessment and management. Length composition sampling should be carried out on a higher temporal resolution basis in situations where cephalopods represent a major (although not regulated) by-catch species. Extra sampling is needed, considering the seasonality of the landings and discards, with higher sampling intensity during times when cephalopod catches are highest. The identification of species group to species is also an important aspect of the Data Collection (see previous section on Updating ID identification guide).

WGCEPH proposes the following changes to cephalopod fishery data collection:

1 ) Species identification training should be given to people involved in sampling, to improve data collected from landings, discards and surveys;

2 ) Increases in the level of cephalopod sampling in métiers where these are highly valuable, considering the short life cycle of cephalopods. Thus, sampling of cephalopod species on a quarterly basis is not adequate.

3 ) Focus of the most 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.

4 ) 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 vs. the fishery, to assess trends in recruitment and length at 50% maturity (L50).

The obvious caveat in relation to these recommendations is that increased sampling effort is justified only if the data collected are then used. Although there is no formal stock assessment (indeed, no formal definition of stocks) and management is largely restricted to regional management of directed small-scale fisheries, there is a need to ensure that cephalopods are not overexploited. Monitoring trends in landings and stock status is essential to avoid overfishing.

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# 6    Revisions to the work plan and justification

No specific revisions to the working plan are envisaged.

# 7    Next meetings

The WGCEPH 2019 meeting will be hosted by HCMR (Greece), Athens, Greece, 4–7 June 2019.

# 8    Recommendations

There were no recommendations from the 2018 WGCEPH meeting. Note however that ToR e) will result in recommendations for fishery data collection, which will be included in the 2019 report.

# 9    List of annexes and working documents

Annex 1: List of participants

Annex 2: Agenda

Annex 3: ToR A. Jones – Lishchenko. Cephalopod stock identification

Annex 4: ToR A. Tables_WGCEPH_2018

Annex 5: ToR A. Section Sepiida 2018

Annex 6: ToR A. Section Loliginidae 2018

Annex 7: ToR A. Section Ommastraephidae 2018

Annex 8: ToR A. Section Octopodidae 2018

Annex 9: ToR B. Trends manuscript outline 2018

Annex 10: ToR B. Assessment manuscript outline 2018

Annex 11: ToR C. Updated review on the recent studies in the ICES area

Annex 12: ToR D. Socioeconomic report

Annex 13: Working Doc 01. Blanco *et al*. Cephalopods species captured in the bottom trawl surveys in the Porcupine Bank

Annex 14: Working Doc 02. Silva *et al*. Spanish Cephalopod landings and discards

Annex 15: Working Doc 03. González-Lorenz *et al.* Small scale fishery around Canary island

Annex 16: Working Doc 04. Oesterwind *et al*. Squid aging North Sea

## Annex 1: List of participants

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## Annex 2: Agenda

**Working group on Cephalopods Fisheries and Life History (WGCEPH), AZTI–Pasaia, 5 to 8 June 2018**

### Tuesday, 5 June 2018

| | |
|---|---|
| **09.00** | *WELCOME AND GENERAL INFORMATION + ESTABLISHMENT OF SKYPE LINKS* |
| 09.15 | Plenary: brief update on ICES guidelines for WGs + science priorities |
| 09.30 | Plenary: Terms of Reference; assignment of responsibilities + discussion<br><br>A.   Cephalopod stock status and trends<br><br>    Loliginids (Ana Moreno), Sepiids (Jean-Paul Robin), Ommastrephids (Ane Iriondo), Octopods (Luis Silva/ Ana Juarez) [remote participation]<br><br>    Data call (Jean-Paul Robin)<br><br>B.   Stock assessment<br><br>    Trends paper (Graham Pierce), Assessment paper (Jean-Paul Robin)<br><br>C.   Life history review (Fedor Lishchenko, Anastasia Lishchenko)<br>D.   Socioeconomics (Cristina Pita, by skype from Wednesday)<br>E.   ID tools and data collection<br><br>    ID guide (Daniel Oesterwind)<br><br>    Data collection (Marina Santurtun) |
| *10.30* | *Coffee break* |
| 11.00 | Individual/group work on ToRs |
| 12.30 | Presentations I: Cephalopod fisheries and the MSC – Carlos Montero |
| *13.00* | *Lunch break* |
| 14.30 | Individual/group work on ToRs |
| *16.00* | *Coffee break* |
| 16.30 | Individual/group work on ToRs |
| 17.30 | Plenary: round-up day 1 |
| 17.45 | End of day 1 |

### Wednesday, 6 June 2018

| | |
|---|---|
| **09.00** | **PLENARY: TOR D INTRODUCTION (CRISTINA PITA); TOR A + B PROGRESS + DISCUSSION** |
| 10.00 | Individual/group work on ToRs |
| *10.30* | *Coffee break* |

| | |
|---|---|
| 11.00 | Individual/group work on ToRs |
| 12.30 | Presentations II: The Cephs & chefs project – Graham / Jean-Paul |
| 13.00 | *Lunch break* |
| 14.30 | Plenary: Tor C, E progress + discussion |
| 15.00 | Individual/group work on ToRs |
| 16.00 | *Coffee break* |
| 16.30 | Individual/group work on ToRs |
| 17.00 | Presentations III: Analysis of cephalopod landings in the multispecies small-scale fishery, Canary Islands + Cephalopods caught by the Spanish fleet of freezer trawlers in Guinea Bissau (NW Africa) – Catalina Perales Raya |
| 17.30 | Plenary: round-up day 2 |
| 17.45 | End of day 2 |

### Thursday, 7 June 2018

| | |
|---|---|
| **09.00** | **PLENARY: TOR A + B PROGRESS + DISCUSSION** |
| 10.00 | Individual/group work on ToRs |
| 10.30 | *Coffee break* |
| 11.00 | Individual/group work on ToRs |
| 13.30 | *Lunch break* |
| 15.00 | Presentations IV: Flexible harvest control rules for cephalopods - Jean-Paul |
| 15.30 | Plenary: Tor C,D,E progress + discussion |
| 16.00 | *Coffee break* |
| 16.15 | Individual/group work on ToRs |
| 17.00 | Presentations V: Ageing studies - Fedor |
| 17.20 | Plenary: round-up day 3 |
| 17.30 | End of session day 3 |
| 20.00 | *Dinner* |

**Friday, 8 June 2018**

| | |
|---|---|
| **09.00** | **PLENARY: ToR A + B DISCUSSION** |
| *10.30* | *Coffee break* |
| 11.00 | Individual/group work on ToRs |
| 12.30 | Plenary: ToRs review, report planning, next meeting etc |
| *13.00* | *Close of meeting* |

**Annex 3.**

## Non-genetic tools for cephalopod stock identification

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Reliable stock identification is a fundamental basis of sustainable cephalopod fisheries. Nowadays three general approaches are applied to stock identification: genetic, morphological and trace elemental based analysis. Analysis of morphological traits is the oldest method of stock determination but modern approaches, such as geometric morphometrics, provide precise identification of cephalopod stocks. On the other hand analysis of trace element composition allows not only to identify stock affiliation with great precision but also to describe changes in the environmental conditions experienced by an animal during ontogeny.

Historically, general observation of morphological traits, body shape and patterns of colouration served as a tool for distinguishing stocks, populations, subspecies or races of animals. However, application of this approach to cephalopods could lead to confusion due to the high morphological plasticity and ability to change colouration and patterns using chromatophores.

The analysis of body shape was one of the earliest means of distinguishing between cephalopod populations from different areas (Borges 1995; Pierce et al. 1994a; Sabriov et al. 2012), of different forms (Chembian and Mathew, 2014), stocks and management units (Pierce et al. 1994b) or sympatric species that were visually alike (Haefner 1964; Bonnaud et al. 1998; Barón and Ré 2002; Zaleski et al. 2012). Traditionally, a series of linear measurements between two anatomical points would be collected from soft tissue (i.e. mantle, head, arms, tentacles, fins, gills, siphon and reproductive organs) and hard structures (predominantly the gladius). Indices were generated of body parts as a percentage of mantle length (ML) or ratios of lengths to widths (i.e. fin length to fin width) for simple comparisons.

Multivariate analysis would often be used to distinguish between geographically distinct regions (Borges 1995). A classic example of this is found in Pierce et al. (1994b), where geographic variation of *Loligo forbesii* was analysed using morphometric and meristic characters from 13 different areas of the northeast Atlantic Ocean. Results suggested that *L. forbesii* from the Azores can be regarded as a separate stock, differing significantly from ones on the continental shelf. Multivariate techniques also appear to be effective for differentiating between sympatric or cryptic species (Barón and Ré 2002; Pineda et al. 2002; Sin et al. 2009). Canonical variate analysis (CVA) on morphometric measurements of six groups of loliginid squid, separated a priori based on the shape of the funnel organ, was undertaken on the Pacific coast of Mexico (Granados-Amores et al. 2014). This multivariate analysis supported the existence of four species previously identified in Mexican waters together with two forms of unclear taxonomic status, suggestive of greater species diversity to what was previously reported for the Mexican Pacific.

However, care must be taken during the collection of morphometric measurements, as there are often sources of error such as significant between-sampler bias (Pierce et al. 1994a). This can often be exacerbated by the fact that soft-body parts are prone to stretching and warping. Using the same individual to collect all morphological measurements is therefore recommended, in addition to the use of hard body parts that cannot be distorted such as the; gladii (Barón and Ré 2002), statoliths (Clarke 1978; Arkhipkin and Bizikov 1997; see "Systematics" section in Arkhipkin 2005) and beaks (Borges 1995; Chen et al. 2012; Hu et al. 2018).

These hard structures can be used on an individual basis or in combination with soft body parts for population discrimination. A discriminant analysis between *Doryteuthis gahi* populations from southern Chile, Peru and the Falkland Islands concluded that hard structures such as the gladius, beak and statolith

were more accurate than soft body parts to separate between populations (Vega et al. 2002). Hard structures were also shown to be more effective than soft body parts in the discrimination of *Dosidicus gigas* from Ecuador, Peru and Chile (Liu et al. 2015). Conversely, a spatial comparison of morphological characters throughout the distributional range of *Loligo reynaudii* showed the most consistent separation of samples from the south and west coast of South Africa and Angola was found when soft body parts were used (Van der Vyver et al. 2016). Morphological characters which best separate population units may be species or site-specific and it would therefore be prudent to use a combination of hard and soft body parts in future morphological studies.

The traditional morphometrics approach has its limitations, such as the loss of information by simplifying the shape and the risk of selecting dimensions that do not adequately represent the actual shape variation (Braga et al. 2017). Geometric morphometrics is a promising alternative method which has been developed over the last few decades. In this technique, biologically definable 'landmarks' or outlines of the entire shape (Fourier shape analysis) visualise deformations, in theory retaining more detail about the geometry of the structure. Geometric morphometric techniques using 'landmarks' have been used to determine body shape variation between regions (Braga et al. 2017), spawning groups (Crespi-Abril et al. 2010) and between migratory routes (Schroeder et al. 2017). Landmarks and semi-landmarks have also been collected on beaks to differentiate between stocks (Fang et al. 2017) and sympatric species (Díaz-Santana-Iturríos et al. 2017). The elliptical Fourier outline method has been applied to beaks for species identification of ommastrephids (Fang and Chen 2017), but is most commonly applied to statoliths (Lishchenko et al. 2017). Comparisons of statolith, upper beak and lower beak landmarks indicated that geometric morphometrics using a combination of different hard structures was best for discrimination between three loliginid species in the South China Sea (Jin et al. 2017), again highlighting the need for a combination of body parts in future morphological analyses. Though the study of body shape has been happening for decades, it still remains one of the most population methods for identification of cephalopod stock affiliation, due to its low cost and relative simplicity.

Hard structures such as statoliths grow continually throughout life, with accretion of new material occurring on a daily basis. Throughout this accretion process, trace elements are incorporated with their uptake dependent on intrinsic factors and ambient conditions (Arkhipkin 2005; Zumholz et al. 2007). Thus, trace elemental concentrations are constantly changing throughout an individual's ontogeny. Efforts to investigate the otolith elemental signatures of fish (see Campana 1999 for a review) prompted the application of statoliths as natural markers of cohort and population structure in squid. An alternative technique where each individual is essentially 'tagged' already is preferable to traditional tagging techniques because the latter have low rates of return and are often difficult to implement on cephalopods, which are too fragile for an external tag and are lacking a suitable attachment site that does not inhibit their behaviour (Arkhipkin, 2005).

One of the earliest studies to analyse elemental data in a population structure context combined trace element analysis using a wavelet dispersive spectrometer with tag-recapture data, using a small sample (25 analysed for Sr/Ca and 12 tagged indiivudals) of *Todarodes pacificus* from the Sea of Japan (Ikeda et al. 2003). The two geographically separate groups had significant differences in Sr/Ca, reflecting different spawning grounds and transport routes. Since then, the elemental composition of statoliths has been used to distinguish between spawning cohorts (Liu et al. 2011) and geographical regions (Wang et al. 2012; Liu et al. 2013; Arbuckle and Wormuth 2014) for several species. Significant geographic variability was found when analysing 6 trace elements in *D. gahi*, along with a significant difference between spring and autumn spawning cohorts (Arkhipkin et al. 2004). Significant differences between two geographic regions and seasonal cohorts were also found in the *Sepioteuthis lessoniana* population around Taiwan (Ching et al. 2017). However, both studies used solution based inductively coupled plasma mass spectrometry (ICP-MS), which gives an integrated signal over an individual's lifetime. A subsequent analysis of the *D. gahi* population was able to produce high-resolution elemental chronologies by ageing individual ablation spots using laser ablation ICP-MS analysis. These Sr/Ca and Ba/Ca chronologies were significantly different between the two spawning cohorts and consistent between two consecutive years, suggesting that these chronologies have applications in stock discrimination (Jones et al. 2018).

Other studies have focused on the early life history and allocation of natal origins to determine population structure (Warner et al. 2009; Liu et al. 2015). Multi-elemental signatures within the pre-hatch region of two octopus species were used to investigate population structure and dispersal patterns in Tasmania, both of which found evidence of distinct groupings (Doubleday et al 2008a/b). A robust machine learning classification technique was successfully applied to natal elemental signatures of *Sepioteuthis*

*australis*, with 55-84% of individuals classified back to an area closed to commercial fishing over peak spawning (Pecl et al. 2011).

Combining different population discrimination techniques is a promising area of research. High resolution ICP-MS and statolith Fourier shape data were used to discriminate between temporal and spatial stocks of *Nototodarus gouldi* (Green et al. 2015). Though shape analysis indicated two separate stocks, elemental analysis showed hatching throughout their distribution. There was also evidence that adults in Victoria were contributing more to the Great Australian Bight stock than vice versa, with implications for stock management (Green et al. 2015). Trace element analysis and morphometric measurements combined found three discrete cuttlefish populations in Algerian coastal waters (Kennouche and Nouar 2017). A recent study used stable isotope analysis to elucidate migration and trophic patterns in *Ommastrephes bartramii* (Kato et al 2016). This could be combined with trace element analysis to provide exciting new insights into migratory behaviour in cephalopods, which can significantly benefit stock discrimination assessments in the future. Trace element analysis was initially incredibly expensive to undertake, which was reflected in the small sample sizes (often less than 20 individuals). Although it is still costly, the process is becoming cheaper with every year, which should be reflected by an increase in sample size. Though it comes at an expense, this sampling technique is beneficial not only for stock discrimination but also for understanding life history traits without the need for traditional tagging techniques.

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**Annex 4.**
**Table 1. Landings (in tonnes) of Cuttlefish (Sepiidae) and Bobtail Squid (Sepiolidae)**

| Country | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *ICES Area 27.3.a* | **0** | **2** | **6** | **18** | **21** | **29** | **58** | **50** | **37** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| Denmark | | 2 | 6 | 18 | 21 | 29 | 58 | 50 | 37 | | | | | | | | | |
| France | | | | | | | | | | | | | | | | | | 0 |
| Germany | | | | | | | | 0 | | | | | | | | | | |
| Netherlands | | | | | | | | | | | | | | 0 | | 0 | 0 | 0 |
| Sweden | | | | | | | | | | | | | | | | | | |
| *ICES Area 27.4.a* | **0** | **2** | **3** | **7** | **12** | **7** | **15** | **12** | **9** | **0** | **3** | **0** | **0** | **0** | **0** | **1** | **1** | **4** |
| Denmark | | 2 | 3 | 7 | 10 | 7 | 11 | 10 | 7 | | | | | | | | | |
| England, Wales & N. Ireland | | | | | | | | | | | | | | 0 | | 0 | | 1 |
| France | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 2 | 2 | 0 | 3 | 0 | | | | | | 0 |
| Germany | | | | | | | | | | | | | | | | | | |
| Scotland | | | | | 1 | | | 0 | 0 | | | | | | | 1 | 1 | 3 |
| *ICES Area 27.4.b* | **7** | **13** | **31** | **43** | **43** | **16** | **22** | **26** | **16** | **2** | **4** | **1** | **2** | **0** | **1** | **2** | **3** | **1** |
| Belgium | 7 | 12 | 12 | 4 | 4 | 1 | 1 | 2 | 4 | | | | | | | 1 | 1 | 0 |
| Denmark | | 1 | 13 | 35 | 36 | 13 | 21 | 23 | 12 | | | | | | | | | |
| England, Wales & N. Ireland | | 0 | 3 | 0 | 1 | 1 | | 0 | 0 | | | | 0 | 0 | 1 | 0 | 0 | 1 |
| France | 0 | 0 | 0 | 0 | | | | | | 1 | 4 | 1 | 2 | 0 | 0 | 0 | | 0 |
| Germany | | | | | | | | | | | | | | | | | | |
| Netherlands | 0 | 0 | 3 | 3 | 1 | 1 | 0 | 1 | 0 | 1 | | | | | | 0 | 2 | 0 |
| Scotland | | | | | 1 | | | 0 | 0 | | | | | 0 | | 0 | 0 | 0 |
| *ICES Area 27.4.c* | 491 | 273 | 728 | 415 | 557 | 305 | 424 | 282 | 286 | 132 | 234 | 34 | 48 | 117 | 38 | 224 | 284 | 107 |
| Belgium | 12 | | 206 | 64 | 103 | 57 | 57 | 33 | 53 | | | | | | | 41 | 21 | 16 |
| England, Wales & N. Ireland | 14 | 5 | 4 | 2 | 2 | 3 | 3 | 3 | 2 | | | | 7 | 3 | 5 | 11 | 10 | 22 |
| France | 381 | 173 | 184 | 135 | 120 | 103 | 77 | 84 | 108 | 77 | 89 | 34 | 41 | 114 | 33 | 82 | 61 | 63 |
| Netherlands | 83 | 95 | 333 | 214 | 330 | 141 | 287 | 161 | 123 | 55 | 145 | | | | | 90 | 192 | 6 |
| Scotland | | | | | 2 | 1 | | 1 | 0 | | | | | | | | | |
| *ICES Area 27.5.b* | 0 | 0 | 0 | 0 | 5 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| France | | | | | 5 | 2 | | | | | | | | | 0 | | | 0 |
| *ICES Areas 27.6.a,b* | 2 | 5 | 0 | 5 | 0 | 1 | 0 | 1 | 0 | 10 | 0 | 0 | 0 | 0 | 33 | 0 | 0 | 0 |
| England, Wales & N. Ireland | 0 | | | 0 | | | | 0 | 0 | | | | | | | 0 | 0 | 0 |
| France | 1 | 0 | 0 | 4 | 0 | 1 | 0 | 1 | 0 | 10 | 0 | 0 | | 0 | 33 | | 0 | 0 |
| Scotland | | 5 | | | | | | 0 | 0 | | | | | 0 | | | | 0 |
| Spain | 1 | 0 | 0 | 0 | 0 | | | 0 | 0 | 0 | | 0 | 0 | | | | | 0 |
| *ICES Area 27.7.a* | 3 | 3 | 5 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 19 | 0 | 0 | 0 | 2 | 0 | 1 |
| Belgium | 1 | 2 | 5 | 1 | 1 | 1 | | 0 | 0 | | | | | | | 0 | 0 | 0 |
| England, Wales & N. Ireland | 1 | 0 | 0 | 1 | | | | 0 | 0 | 0 | 0 | 0 | | 0 | | 1 | 0 | 0 |
| France | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 19 | 0 | 0 | 0 | | | 0 |
| Netherlands | | | | | | | | | | | 0 | | | | | | | |

**Table 1. Landings (in tonnes) of Cuttlefish (Sepiidae) and Bobtail Squid (Sepiolidae) Continued…**

| Country | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *ICES Areas 27.7.b,c* | 3 | 17 | 4 | 18 | 23 | 13 | 9 | 11 | 19 | 16 | 75 | 31 | 5 | 0 | 3 | 3 | 8 | 5 |
| England, Wales & N. Ireland | 0 | | 0 | 0 | | | | 0 | 0 | 4 | 1 | 0 | 1 | | | 0 | 1 | 0 |
| France | 0 | 0 | 1 | 14 | 13 | 1 | 0 | 2 | 0 | 1 | 2 | 2 | 3 | | 3 | 3 | 7 | 5 |
| Ireland | | | | | | | | | | 0 | 0 | 0 | | | | | | |
| Spain | 3 | 17 | 3 | 5 | 10 | 12 | 9 | 9 | 19 | 11 | 73 | 29 | 1 | | | 0 | 0 | 0 |
| *ICES Areas 27.7.d,e* | 11810 | 8515 | 14054 | 16046 | 18187 | 10938 | 12817 | 15295 | 9467 | 5117 | 9543 | 8266 | 12709 | 8507 | 6086 | 11939 | 10257 | 12494 |
| Belgium | 35 | 224 | 497 | 473 | 607 | 501 | 661 | 1331 | 801 | | | | | | | 642 | 824 | 802 |
| Channel Islands | 26 | 8 | 11 | 9 | 7 | 7 | 3 | | | | | | | | | | | |
| England, Wales & N. Ireland | 2910 | 2608 | 3407 | 4581 | 4858 | 2821 | 3412 | 4279 | 3416 | 1525 | 2637 | 2037 | 5222 | 3337 | 2752 | 5540 | 4834 | 6881 |
| France | 8835 | 5672 | 10133 | 10970 | 12683 | 7582 | 8726 | 9663 | 5212 | 3555 | 6826 | 6229 | 7310 | 5012 | 3333 | 5660 | 4524 | 4318 |
| Ireland | | | | | | | | | | | | | | 4 | | 7 | 36 | 395 |
| Netherlands | 4 | 3 | 6 | 13 | 32 | 28 | 15 | 12 | 31 | 37 | 81 | | | | | 90 | 38 | 79 |
| Scotland | | | | | | | | 11 | 7 | | | | 177 | 155 | | | | 19 |
| *ICES Area 27.7.f* | 30 | 44 | 35 | 87 | 116 | 47 | 30 | 59 | 43 | 8 | 13 | 17 | 46 | 22 | 13 | 52 | 22 | 140 |
| Belgium | 1 | 12 | 4 | 7 | 38 | 16 | 5 | 6 | 7 | | | | | | | 16 | 7 | 42 |
| England, Wales & N. Ireland | 12 | 7 | 19 | 39 | 28 | 11 | 8 | 12 | 6 | | | | 9 | 8 | 3 | 15 | 8 | 61 |
| France | 17 | 25 | 12 | 41 | 50 | 20 | 17 | 41 | 30 | 8 | 13 | 17 | 37 | 13 | 10 | 21 | 7 | 34 |
| Ireland | | | | | | | | | | | | | | 0 | | | 0 | 0 |
| Scotland | | | | | | | | | | | | | | | | | | 3 |
| *ICES Areas 27.7.g-k* | 161 | 93 | 113 | 350 | 211 | 197 | 189 | 143 | 170 | 974 | 1385 | 1920 | 530 | 22 | 866 | 1312 | 664 | 555 |
| Belgium | 2 | 3 | 6 | 15 | 55 | 20 | 5 | 5 | 4 | | | | | | | 20 | 23 | 40 |
| England, Wales & N. Ireland | 139 | 80 | 102 | 325 | 135 | 153 | 166 | 129 | 143 | 238 | 386 | 746 | 105 | 1 | 286 | 478 | 198 | 87 |
| France | 7 | 3 | 5 | 7 | 19 | 20 | 18 | 9 | 22 | 736 | 999 | 1.173 | 402 | 13 | 576 | 799 | 433 | 416 |
| Germany | | | | | | | | | | | | | | | | | | |
| Ireland | | | | | | 3 | | 0 | 1 | 0 | 0 | 1 | 22 | | | 5 | 2 | 9 |
| Netherlands | | | 0 | 1 | | | | 0 | 0 | | 1 | | | | | 0 | | 0 |
| Scotland | | | | | | | | | | | | | | | | | | |
| Spain | 13 | 6 | 0 | 1 | 1 | 1 | | 0 | | 0 | 0 | 0 | 0 | 8 | 4 | 10 | 9 | 4 |
| *ICES Area 27.8* | 5742 | 5328 | 3298 | 1495 | 6735 | 8214 | 4349 | 6189 | 2687 | 3914 | 3781 | 5585 | 6452 | 4594 | 3958 | 4975 | 4899 | 3717 |
| Belgium | 1 | 7 | 12 | 4 | 10 | 3 | | 17 | 2 | | | | | | | 13 | 9 | 1 |
| England, Wales & N. Ireland | 0 | | | 29 | 18 | 19 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | | | | 0 | |
| France | 5050 | 4908 | 2978 | 1156 | 6173 | 7753 | 3954 | 5586 | 2227 | 3.666 | 3.508 | 5.158 | 5.693 | 4.147 | 3.690 | 4.667 | 4.512 | 3.655 |
| Netherlands | | 38 | | | | | | 0 | 0 | 0 | | | | | | | | |
| Portugal | 8 | 10 | 6 | 18 | 40 | 32 | 37 | | | | | | 24 | 23 | 24 | 8 | 6 | |
| Spain | 683 | 365 | 302 | 288 | 494 | 407 | 357 | 586 | 458 | 248 | 273 | 403 | 735 | 423 | 268 | 288 | 373 | 61 |
| *ICES Area 27.9* | 2811 | 2103 | 2182 | 2178 | 2403 | 2937 | 2912 | 2553 | 2388 | 2224 | 3173 | 2502 | 2143 | 2857 | 2286 | 2115 | 2263 | 1799 |
| France | | | | | | | | | | | | | | | | 0 | | 0 |
| Portugal | 1357 | 1338 | 1362 | 1186 | 1514 | 1825 | 1822 | 1517 | 1453 | 1259 | 2009 | 1511 | 1165 | 1.302 | 1.302 | 1.193 | 1.266 | 1.023 |
| Spain | 1454 | 765 | 820 | 992 | 889 | 1112 | 1090 | 1036 | 935 | 965 | 1164 | 991 | 978 | 1.555 | 984 | 922 | 997 | 775 |
| **Total** | 21059 | 16397 | 20458 | 20666 | 28313 | 22706 | 20826 | 24621 | 15122 | 12397 | 18212 | 18376 | 21936 | 16119 | 13.284 | 20.625 | 18.400 | 18.824 |



Cuttlefish landings (Sepiidae) by area
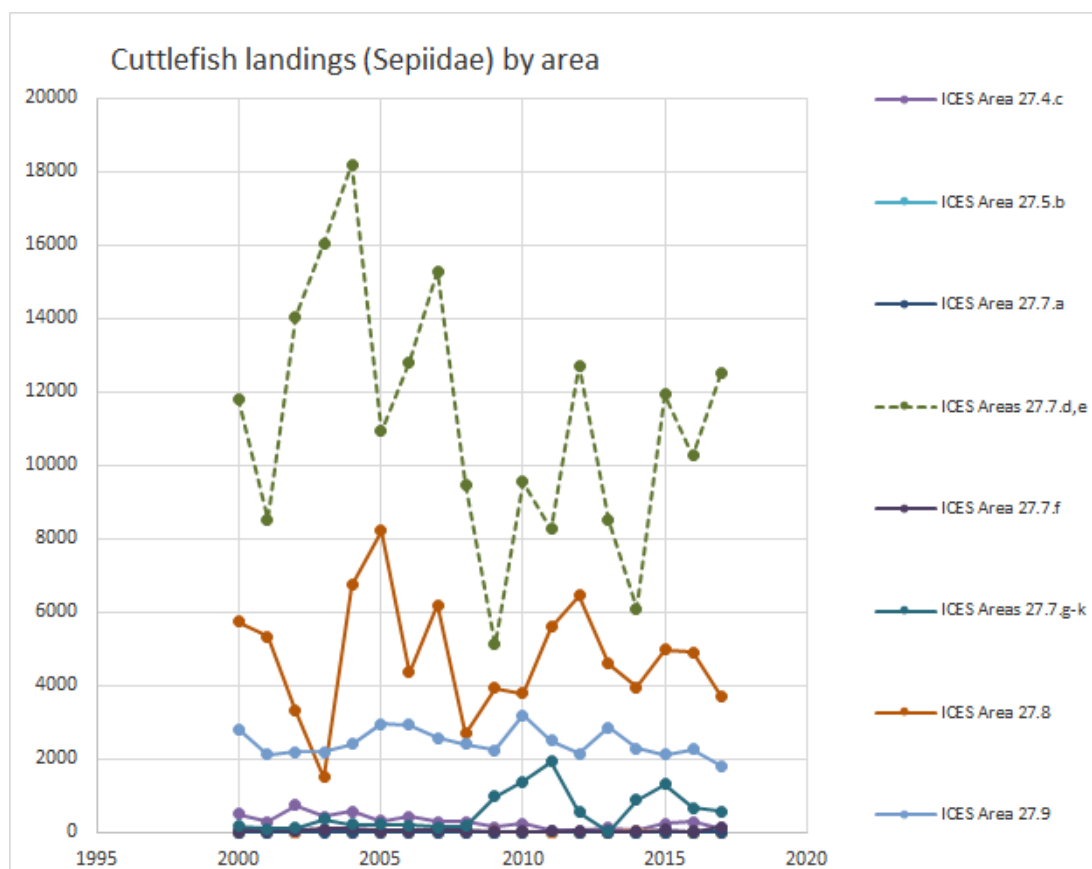
## Annex 5. ToR A Trends and status of Northeast Atlantic cuttlefish and bobtail squid stocks (Sepiida)

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### Summary

This WD presents the trends and status in cuttlefish and bobtail squid stocks (Sepiida). The stocks are not assessed on a regular basis and there is no TAC or quotas for these resources. The main cuttlefish fishing grounds are the English Channel, the Bay of Biscay and Portuguese and Spanish waters. In spite of 2017 landings close to the 2000-2017 average, there are several indicators (both from the fishery statistics and from independent surveys) that reveal decreasing trends. Unusually high catches were observed in the northwest part of the English Channel in late-summer 2017. This event still has to be analysed but is likely an episode of overfishing. The previous assessment exercises carried out at the scale of the whole English Channel stock could not be updated because 2013-2014 data sets were temporarily not available. However, the 2017 spatial heterogeneity underlines the need to take into account spatial distribution and interactions between fishing fleets. Cuttlefish are migrating species fished by a series of metiers. In Spanish and Portuguese waters artisanal gears dominate although on the whole trawlers make 75% of landings.

### 1 Data quality and data call

Landings are reported by most countries either as *Sepia officinalis* (CTC) or at the family level (CTL = Sepiidae, Sepiolidae) these two codes representing 56.6% and 43% of 2017 catches (landings and discards). *Sepia officinalis* represents obviously the bulk of cuttlefish resource in Northeast Atlantic fisheries. However, in the same areas some countries report at the species level and others at the family level. For example, in ICES div 27.4.c Belgium catches are 100% CTC and Netherland's 100% CTL. In div 27.7.d-e France catches are 100% CTC and UK catches 100%CTL. Since *Sepia elegans* has already been observed in the English Channel we cannot conclude that France records are more accurate than UK records. The 2018 WGCEPH data call requested landings, discards and effort data through Inter-Catch which worked well in the case of Sepiidae. The only issue that needs checking is the numerous metiers catching cuttlefish when apparently the initial proposed list of fishing activities was too short.

At the present time no country provides separate fisheries statistics for Sepiolidae (bobtail squid) and the species code for *Rossia macrosoma* (ROA) is included for completeness and in case it might appear in the observations of discards. This document will thus deal with cuttlefish sensus lato.

### 2 Cuttlefish fisheries

Cuttlefish is the main cephalopod resource fished in the Northeast Atlantic, representing 38% of average landings in the period 2000-2017 when Octopods, Common Squids

and Short Finned Squids share is 36% 19% and 6% respectively (Annex A.1, Table 6). Cuttlefish fisheries are mainly located in the English Channel (58% of average landings), Bay of Biscay (25%) and Portuguese and Spanish waters (13%) (Annex A.1, Table 1 and figure 1).

Landings in 2017 (18,800 tons) are only 3% below the average. Since 2000 a slightly decreasing trend in landings is observed (though not statistically significant - figure 2). However, a contrasting situation is observed in 2017 with English Channel landings +11% above the average and the two other areas -22% and -26% below.

The main countries exploiting cuttlefish are France and the UK (45% and 38% of 2017 landings respectively -figure 3). Although a number of metiers are reporting cuttlefish landings (45 different "level 5 fishing activities") the resource seems mainly exploited by trawlers (figure 4) even if some artisanal activities may be biased due to incomplete records (Denis et al, 2001 ; Royer et al, 2006).

Cuttlefish discards are generally negligible. In 2017 discards represented only 1.4 % of total catches. Although in some subareas, may exist 100% of discards, it is a general rule that areas with the higher discards have small catches and the areas with higher catches have small discards (table 1).

Currently Sepiida are not assessed on a regular basis and there is no TAC for the stocks.
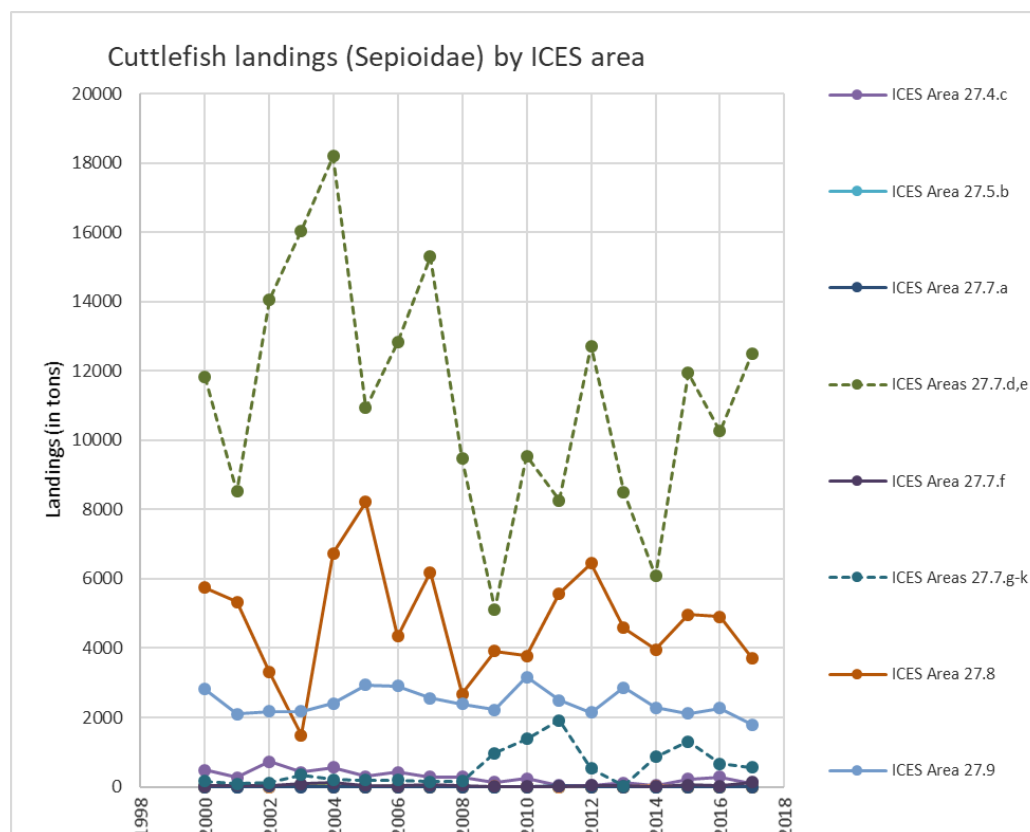


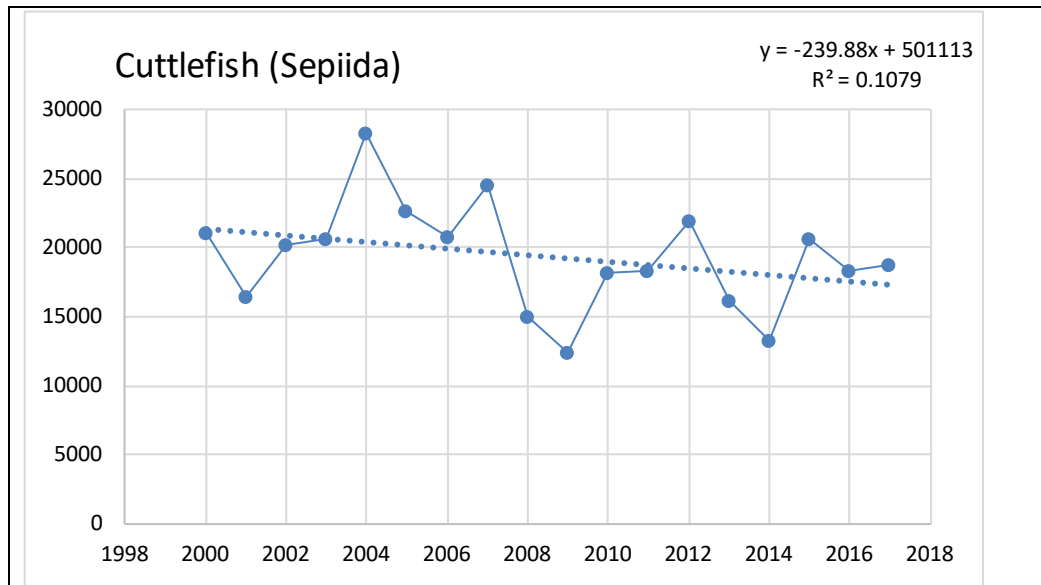Figure 1: Cuttlefish landings (Sepioidea) by ICES area in the period 2000 - 2017

Figure 2: Trends in cuttlefish overall landings in the northeast Atlantic
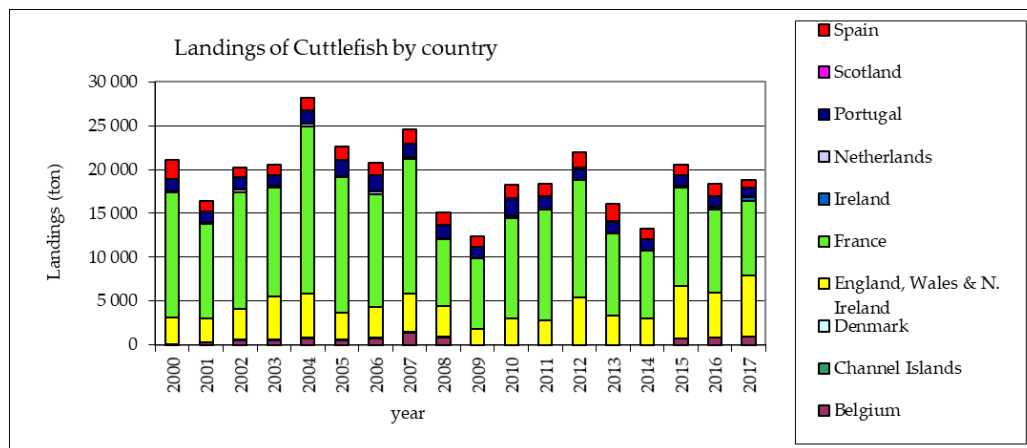


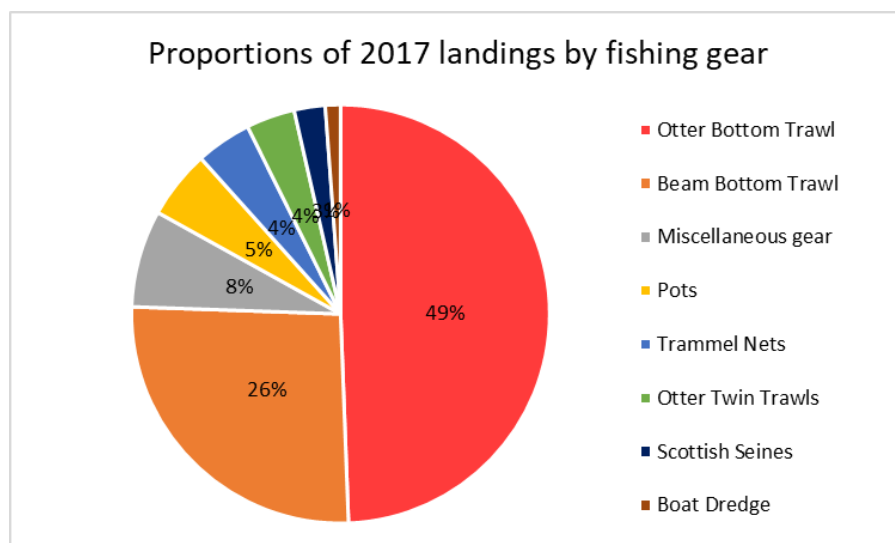Figure 3: Cuttlefish landings by country in the period 2000 - 2017



Figure 4: Main fishing gears contributing to cuttlefish landings in 2017

Table 1 Percentage of cuttlefish discards and catches by subarea in 2017

| Area | 2017 Discards | 2017 Catches | Area | 2017 Discards | 2017 Catches |
|------|---------------|--------------|------|---------------|--------------|
| 27.3.a | 100% | 0.0% | 27.7.f | 0% | 0.7% |
| 27.4.a | 0% | 0.0% | 27.7.g | 1% | 0.4% |
| 27.4.b | 0% | 0.0% | 27.7.h | 4% | 2.6% |
| 27.4.c | 0% | 0.6% | 27.7.j | 2% | 0.0% |
| 27.5.b | NA | 0.0% | 27.7.k | NA | 0.0% |
| 27.6.a | 0% | 0.0% | 27.8.a | 5% | 14.7% |
| 27.6.b | NA | 0.0% | 27.8.b | 1% | 5.5% |
| 27.7.a | 0% | 0.0% | 27.8.c | 0% | 0.0% |
| 27.7.b | 0% | 0.0% | 27.8.d | 0% | 0.0% |
| 27.7.c | 0% | 0.0% | 27.9.a | 0% | 5.4% |
| 27.7.d | 1% | 16.0% | 27.9.a.c | NA | 0.0% |
| 27.7.e | 1% | 50.0% | 27.9.a.n | 0% | 1.8% |
|  |  |  | 27.9.a.s | 0% | 2.2% |

## 2.1. Fishery in the English Channel

Cuttlefish in the English Channel is a shared resource fished mainly by France and by the UK and to a lesser extent by Belgium as shown in figure 5. Originally dominated by France (Royer et al, 2006) cuttlefish yields have switched and in 2017 UK landings represented 55% of the total.

In this particular year (2017) and especially in late summer-autumn very high catches were made by the English fleet along the southern coast of England. This event was reported in the media https://www.thesun.co.uk/news/4545062/huge-demand-for-cuttlefish-is-making-a-fortune-for-british-fishermen/ and confirmed by Devon and Severn IFCA who described it as "an early bonanza of cuttlefish being targeted by trawlers in south Devon" (Sarah Clark personal communication).

According to *Sepia officinalis* life-cycle the catches must have concerned one-year-old specimens (juvenile which migrate offshore in winter and come inshore in the next spring to spawn and die) and may be some young-of-the-year. The circumstances explaining high local abundance and the consequences of very high catches still have to be analysed. However, preliminary indications from the spring inshore fisheries suggest that 2018 was among the worst fishing seasons for coastal fleets.

The actual hypothesis is that the English Channel cuttlefish stock has suffered an episode of overfishing with a high fishing pressure in a limited part of its distribution range but with extended consequences in a migrating species like *Sepia officinalis*.

As a preliminary step the amount of cuttlefish caught by English trawlers during the second half of 2017 is mapped in figure 6 showing highest landings near Brixham.
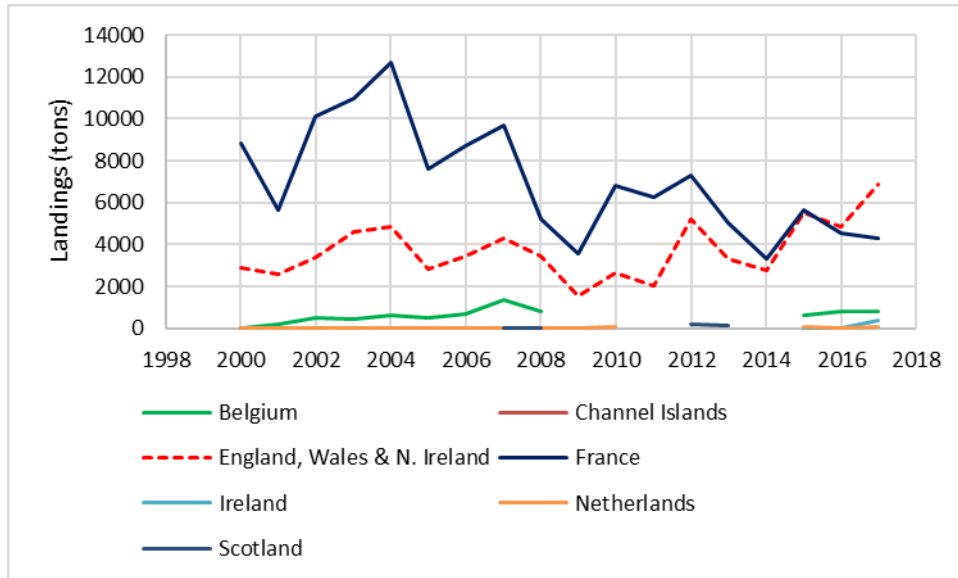
Figure 5: Trends in cuttlefish and bobtail squid landings from the English Channel (IDES divisions 27.7.d and 27.7.e) by countries in 2000 - 2017.
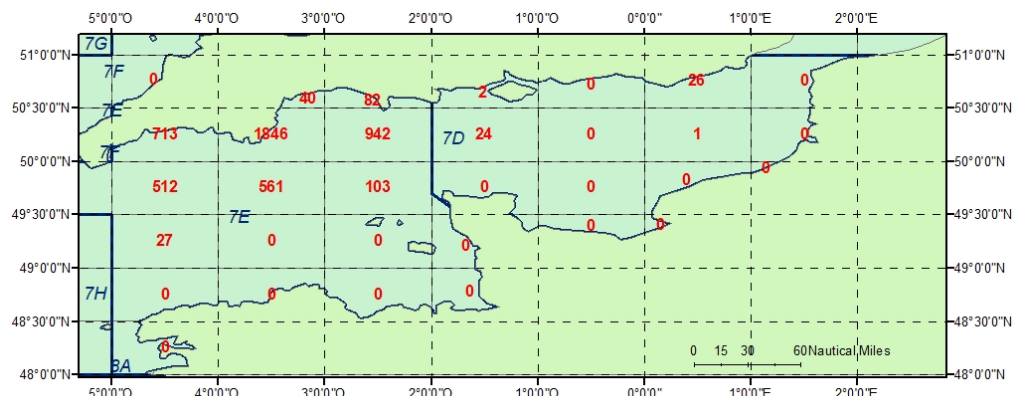


Figure 6: Map of the English Channel with 2017 (Q3 and Q4) landings by English trawlers per ICES rectangle (red figures = landings in tons).

## 2.2. Fishery in the Cantabrian and Bay of Biscay

In the Bay of Biscay and Cantabrian sea cuttlefish is mainly fished by France (figure 7). Landings in 2017 (3720 tons) are below the 2000-2017 average and at the same level as in 2010. This fishery is the only one with commercial records detailed at the species level and including *Sepia hierreda* and *Sepia orbignyana*. However these other species seem to be a very minor component of the catch (less than 1%).
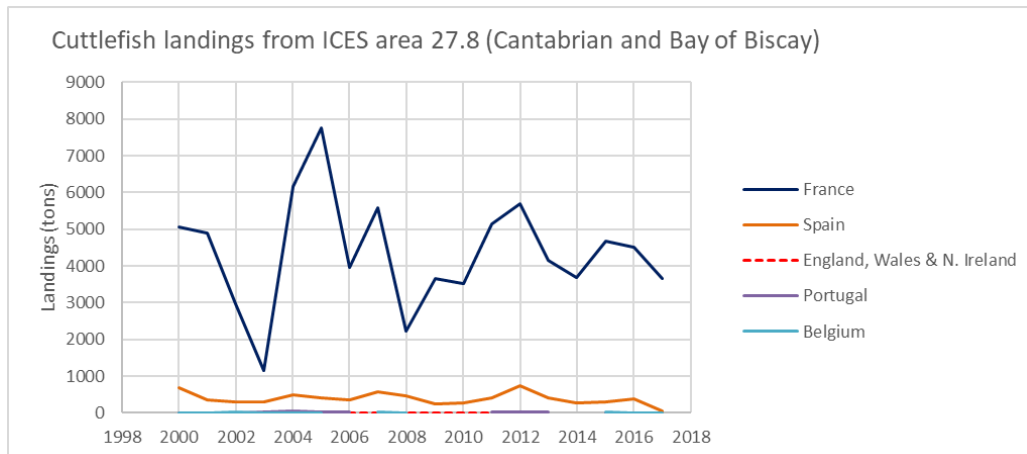
Figure 7: Trends in Cuttlefish and Bobtail Squid (O. *Sepioidea*) in the Cantabrian and Bay of Biscay (area 27.8) by countries.

## 2.3 Fisheries in NW Spain, Portuguese waters and Gulf of Cadiz

From Galicia to the Gulf of Cadiz cuttlefish is fished by Spain and Portugal. Landings show a decreasing trend since 2005 and 2017 (if not provisional) seems to be the lowest year since 2000. A decrease which is observed both in Spanish and Portuguese waters (figure 8).

The analysis of landings by fishing gear (figure 9) suggests that this resource is caught by a wide range of gears some of them used by artisanal fleets. In the case of Portugal it seems that this information was not uploaded to InterCatch with such detail and most landings are related to the "miscellaneous gears" category.
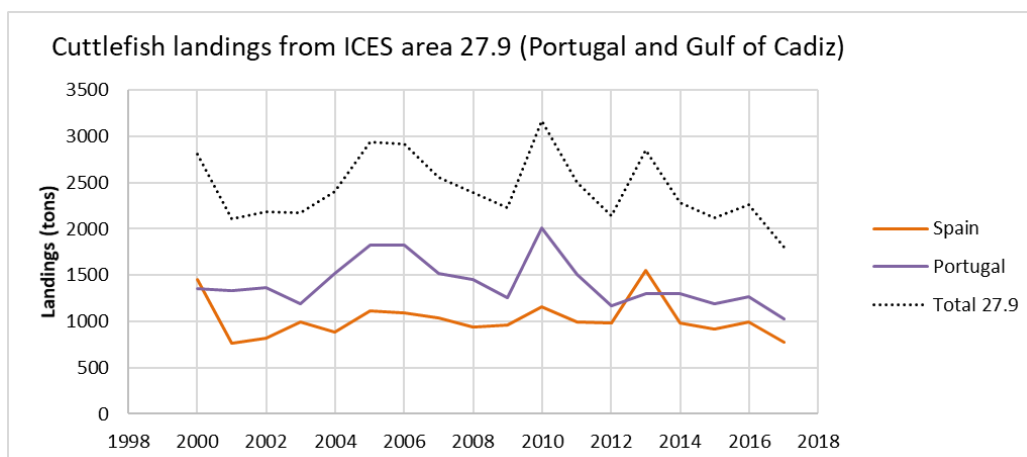


Figure 8: Trends in Cuttlefish and Bobtail Squid (O. *Sepioidea*) in area 27.9 (Portuguese waters and Gulf of Cadiz) by countries.
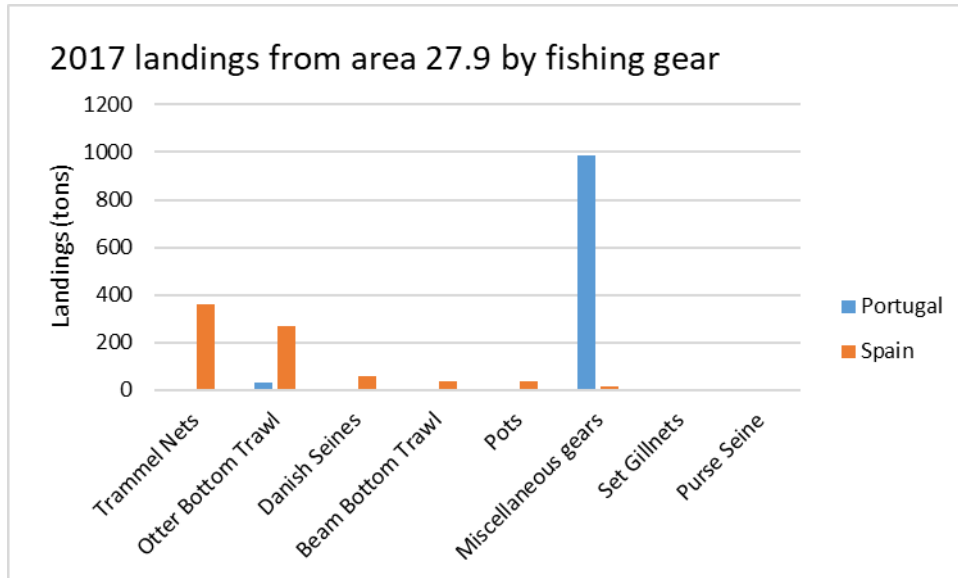
Figure 9 : Distribution of 2017 landings from area 27.9 per fishing gear and per country as provided to InterCatch.

## 3 Relative biomass indices

Biomass indices derived from commercial trawlers CPUEs have already been computed in English Channel cuttlefish in the past (Gras et al, 2014 ; Alemany et al, 2017). Detailed trawlers catch and effort data was obtained for 2016 and 2017 via the complementary section of the 2018 data call. However, the fitted time series of indices could not be updated because 2013 - 2014 data sets were temporarily unavailable.

It is worth noting that research surveys have more rigorous and repeatable protocols than fishery statistics but that they are generally undertaken once per year. In migrating species like cuttlefish the timing of the survey may not be always relevant to describe population abundance.

### 3.1. Research Surveys in the English Channel

CGFS survey indices suggest that *Sepia officinalis* biomass is decreasing in the eastern part of the Channel. The 2017 biomass index is the lowest observed in the time series. Since this time series is used (together with the UK BTS survey) to estimate the biomass of one-year-old recruits (B1 in the two stage biomass model - Gras et al 2014) it is a rather alarming sign. However, this situation is strikingly different from what was observed in the northwest part of the Channel at the same time (October) with the unusually high abundance along the southwest coast of England and high catches of Devon fishermen. A more detailed analysis of spatial distribution seems necessary to better understand such discrepancies.
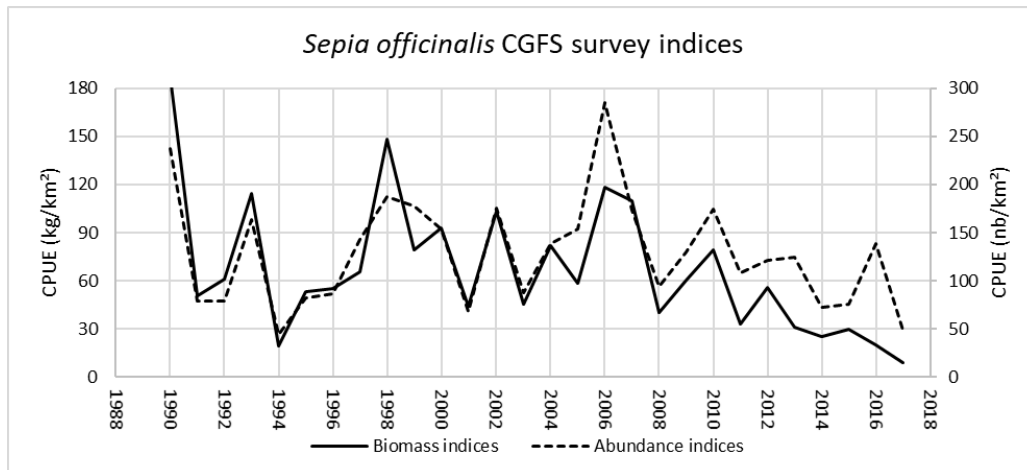
Figure 10: Trends in *Sepia officinalis* abundance derived from the CGFS survey (Eastern part of the English Channel: 27.7.d )

## 3.2. Research Surveys in the Bay of Biscay

The EVHOE survey was not carried out in 2017 and so this time series could not be updated. Previous results (figure 11) show rather high inter-annual fluctuations in *Sepia officinalis* which may as well illustrate spatial distribution shifts, changes in migration timing and/or abundance trends. It is worth noting that the peak observed in 2008 corresponds to the year with the second lowest commercial landings (figure 7).
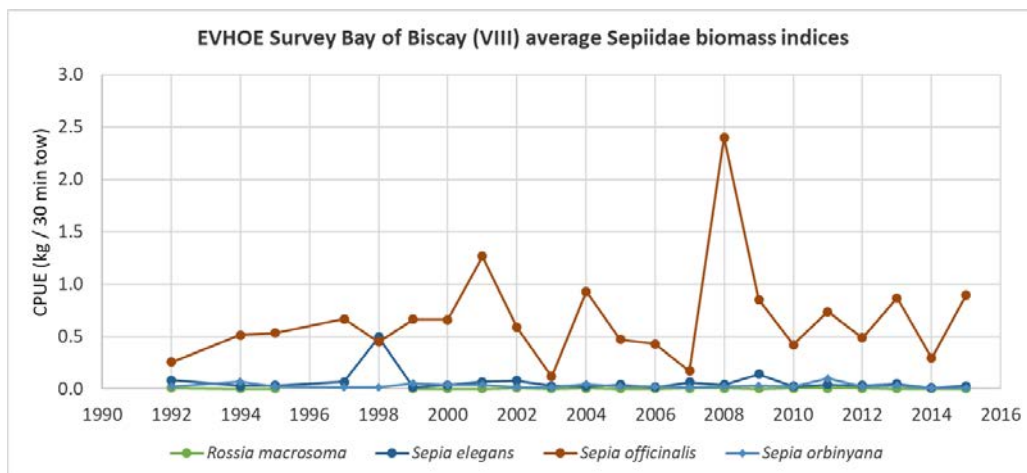


Figure 11: Trends in cuttlefish abundance derived from the EVHOE survey in the period 1992-2015.

## 3.5. Research Surveys in the NW Spain, Portuguese waters and Gulf of Cadiz

The surveys SP-NGFS4Q ; SP-GCGFS1Q ; SP-GCGFS4Q ; PT-IBTS4Q are considered not relevant to describe cuttlefish abundance trends in this area and thus are not presented here.

## 4  Summary of Trends and status

Cuttlefish resources show decreasing trends over the last decade in several areas and locally high landings possibly favoured by environmentally driven concentrations are more likely to illustrate overfishing.

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### Annex 6. Trends and status of long finned squid stocks (Loliginidae)

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**Summary**

This WD presents the trends and status in loliginid stocks. Loliginid landings and discards in 2017 are presented by ICES area/sub-area and Member State. Trends in landings and surveys are analysed between 2000 and 2017 for the 5 more important fishing areas. The use of a standardised CPUE will be discussed before to the 2019 WGCEPH meeting. Landings are still reported mainly at the family level (loliginidae) by most countries but a noticeable improvement is observed. In 2017, loliginid landings were above the mean in 27.4.a, 27.6.b and 27.7.d,e and below the mean in 27.7.f-k, 27.8 and 27.9.a. Loliginid discards are generally negligible and in 2017 represented 1% of total catches. To summarize the trends and status of loliginids we used landings and biomass indices as surveillance indicators of GES, considering that the mean of the most recent 3 years should be above the long-term historic average (ICES, 2014): M ratio= (recent mean-long term mean)/ long term sd.  Based on landings we conclude that loliginids populations may not be in good status in sub-area 27.9.a. However, using CPUEs from the several research surveys we conclude that *L. forbesi* is in good status and showing an increasing trend in area 27.4 and in sub-area 27.6.a, but not in the other areas. On the other hand, *L. vulgaris* landings are generally increasing, despite some indication of concern in sub-areas 27.8c and 27.9.aN. *Alloteuthis* sp., which started to be valued and landed in higher amounts in Spain and Portugal, presents an increasing trend and a recent mean CPUE above the historical mean in the English Channel and northern Bay of Biscay but the opposite in the other areas.

### 1 Data quality and data call

Landings are still reported mainly at the family level (loliginidae) by most countries. In 2017 2% of landings were reported at species level (oul.27.nea and sqr.27.nea). Nevertheless, a noticeable improvement is being achieved with 48% of landings being reported at species or genus level in 2017 compared to 16 % in 2016 (oul.27.nea, ouw.27.nea, sqc.27.nea and sqr.27.nea). Nevertheless, landings reported as sqz.27.nea are expected to be composed mostly of *Loligo* spp. Portugal and Spain are the countries reporting the more discriminated data. Portugal (DGRM) did not submit effort data for 2017 and catch data was not available from the Azores. Effort data in the inter-catch was not analysed for loliginidade. WGCEPH data call specifically on effort for trawlers was shown to be useful to obtain a consistent LPUE and this was an improvement of the data calls issued by the group. Further improvements and discussions within the group are needed to obtain standardised CPUEs by species or groups of species.

### 2  Loliginid fisheries

Landings of unspecified loliginid landings between 2000 and 2017 by ICES Division/Sub-Area and country are presented Annex 4, Table 2. Catches of long-finned squid (Loliginidae) may be composed of *L. vulgaris*, *L. forbesii*, *A. subulata* and *A. media*.

Currently Loliginidae are not assessed at a regular basis and there is no TAC for the stocks.

Around 97% of northeastern Atlantic loliginid catches (landings+discards) are taken in only 5 areas. In 2017 the proportion of catches in these 5 areas was 18% in the North Sea (Div. 27.4), 19% in NW Scotland, Northern Ireland and Rockall (Div. 27.6a,b), 44% in the English Channel (Div. 27.7.d,e), 12% in the Cantabria/Bay of Biscay (Sub-area 27.8) and 3% in Galicia, Portuguese waters and the Gulf of Cadiz (Sub-area 27.9.a). There is a general slightly increasing trend in landings since the year 2000, with three important peaks in 2003, 2010 and 2017 (Fig. 1 and 2 left, Annex 4, Table 2). In 2017, loliginid landings were above the mean in divisions 27.4.a, 27.6.b and 27.7.d,e and below the mean in divisions 27.7.f-k, 27.8 and 27.9.a. (Fig. 2 right). Loliginid discards are generally negligible. In 2017 discards represented only 1% of total catches. Although in some subareas, may exist 100% of discards, it is a general rule that areas with the higher discards have small catches and the areas with higher catches have small discards Table 1.
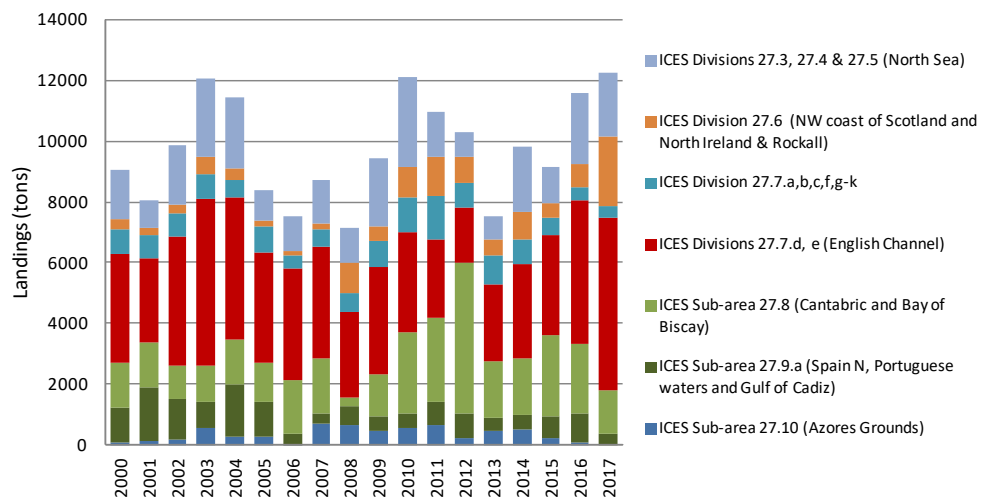


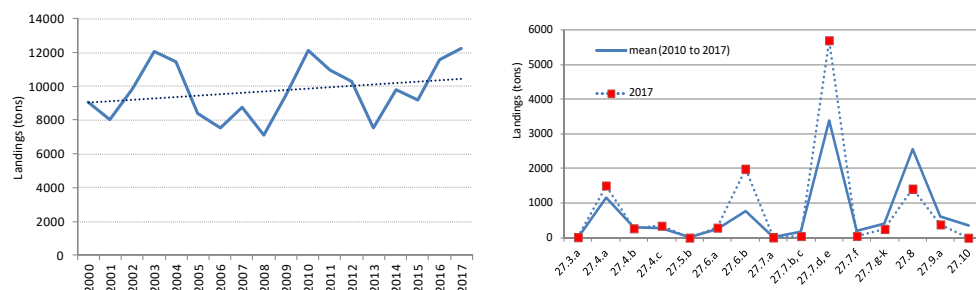Figure 1. Landings of loliginids by ICES areas and subareas between 2000 and 2017.

Figure 2. Trends in total loliginid landings in the ICES area for the years 2000 to 2017 (left) and landings in 2017 by sub-area/Division compared with 2010-2017 mean (right).
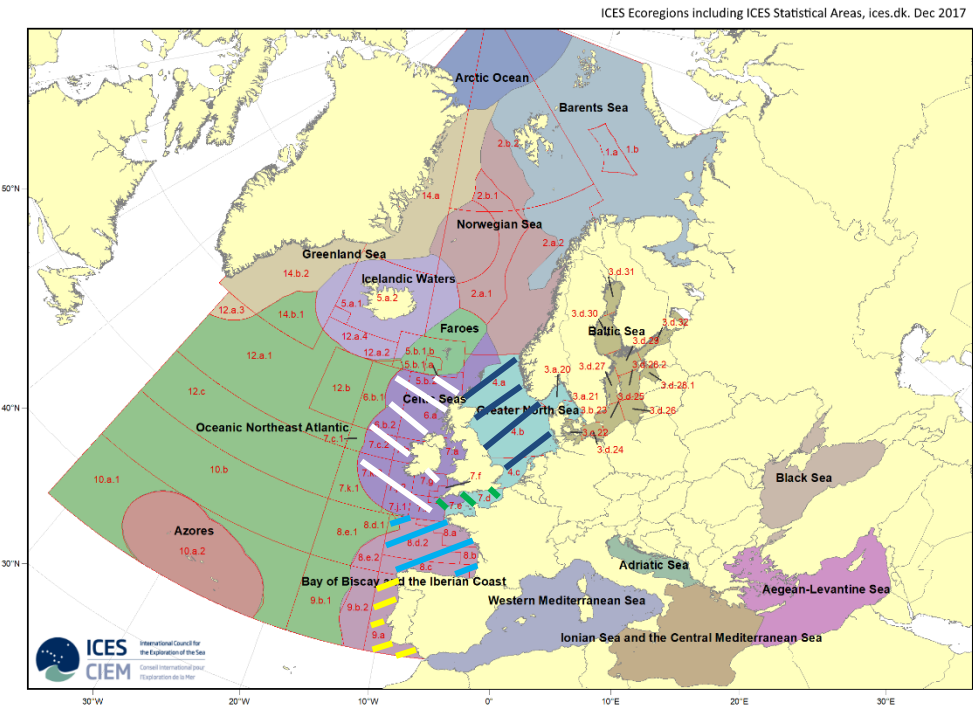


Figure 3. The five fishing areas analysed in detail for trends and status are represented in coloured lines

Table 1. Percentage of loliginid discards and catches by subarea in 2016 and 2017.

| Loliginids | 2016 | | 2017 | |
|---|---|---|---|---|
| | % Discards | % catches by area | % Discards | % catches by area |
| 2016 | 2 | | 1 | |
| 27.3.a | 45 | 0 | 26 | 0 |
| 27.4.a | 1 | 13 | 1 | 13 |
| 27.4.b | 0 | 2 | 0 | 2 |
| 27.4.c | 0 | 6 | 0 | 3 |
| 27.5.b | 0 | 0 | 0 | 0 |
| 27.6.a | 3 | 1 | 0 | 2 |
| 27.6.b | 0 | 5 | 0 | 17 |
| 27.7.a | 0 | 0 | 0 | 0 |
| 27.7.b | 1 | 0 | 1 | 0 |
| 27.7.c | 8 | 0 | 2 | 0 |
| 27.7.d | 0 | 29 | 0 | 36 |
| 27.7.e | 3 | 9 | 2 | 9 |
| 27.7.f | 3 | 1 | 0 | 0 |
| 27.7.g | 7 | 0 | 16 | 0 |
| 27.7.h | 12 | 1 | 1 | 1 |
| 27.7.j | 7 | 1 | 2 | 1 |
| 27.7.k | 0 | 0 | 0 | 0 |
| 27.8.a | 4 | 14 | 3 | 8 |
| 27.8.b | 3 | 7 | 2 | 4 |
| 27.8.c | 6 | 0 | 0 | 0 |
| 27.8.d | 8 | 0 | 0 | 0 |
| 27.9.a | 2 | 8 | 1 | 3 |
| areas with higher discards have small catches | | | | |
| areas with higher catches have small discards | | | | |

## 2.1. Fishery in the North Sea

Provisional fisheries statistics for the North Sea (27.4) indicate that catches in 2017 summed 2118 tons, a slight decrease from 2016. The decrease occurred only in the southern North Sea (27.4.c). The fishing fleets exploiting this resource are unchanged, with Scottish vessels dominating in the north and central North Sea and French vessels in the south. However, in 2016 and 2017, the Netherlands fleet reported a significant amount of landings of loliginids from the southern North Sea and some from the Central area (Fig. 4). Landings *Loligo vulgaris* and 0.1 tons of un  and this was reported by Engla
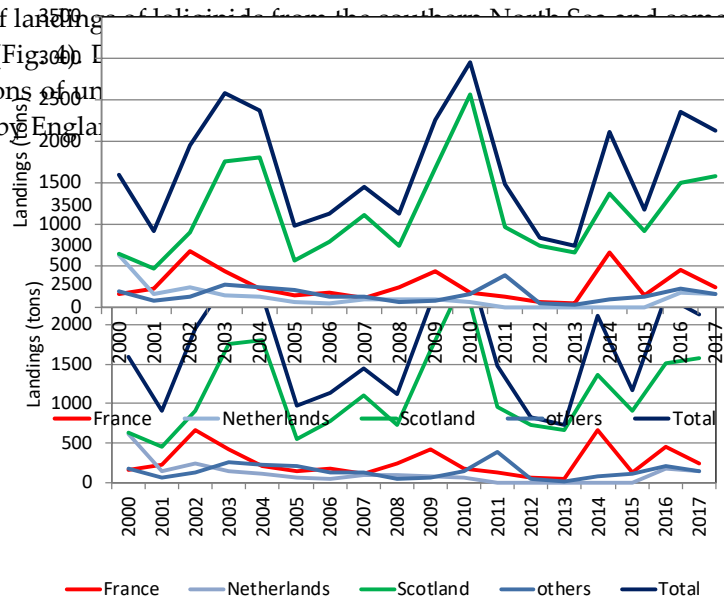


Figure 4. Trends in loliginid landings in the North Sea (27.4a,b,c) for the years 2000 to 2017 by national fleet.

## 2.2. Fishery in NW coast of Scotland, North Ireland and Rockall

Landings in NW coast of Scotland, North Ireland and Rockall (27.6.a,b) increase substantially in 2017, in particular in Rockall (27.6.b) and squid production amounted 2278 tons. Main fleets fishing in this area are from Scotland and in the two most recent years also from Ireland (Fig.5). Discards are generally very low. In 2017, only 0.2 tons of loliginids were discarded in this area.
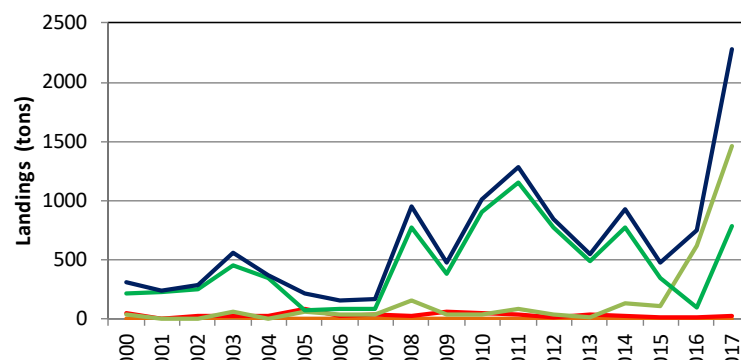
Figure 5. Trends in loliginid landings in the NW coast of Scotland, North Ireland and Rockall (27.6.a,b) for the years 2000 to 2017 by national fleet.

### 2.3. Fishery in the English Channel

English Channel (27.7.d,e) squid production of 5700 tons in 2017 confirms the consistent increase which is being observed since 2012. The fishing fleets exploiting this resource change in some years with significant contributions from the Netherlands equaling those of England, Wales & Northern Ireland (e.g. 2010, 2017). Nevertheless, France dominates landings (Fig. 6). A total of 24.9 tons of loliginids were discarded in this area in 2017 reported both by England and France. Most of this discards were reported as *L. vulgaris* (21.0 tons) and *Loligo* spp. (3.8 tons).
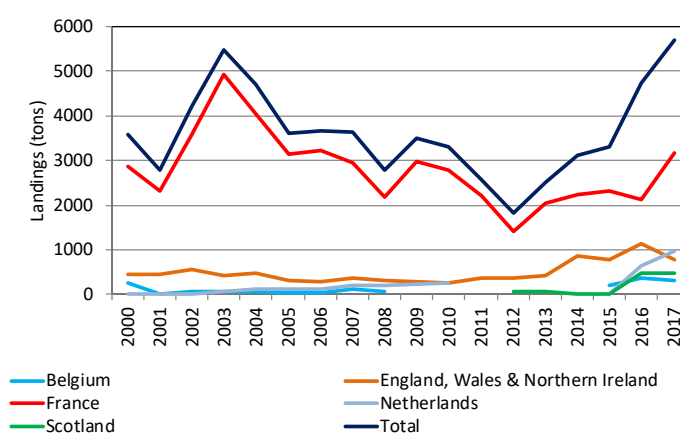


Figure 6. Trends in loliginid landings in the English Channel (27.7.d,e) for the years 2000 to 2017 by national fleet.

### 2.4. Fishery in the Cantabrian and Bay of Biscay

Catches 27.8.a,b,c,d in 2017 summed 1418 tons, confirming the decrease in relation to the 2015 landing level, already observed in 2016. This decrease was reported by both French and Spanish fleets. France dominates catches in divisions 27.8.a,b,d (ca. 95%) and Spain dominates catches in division 27.8.c (99%). Landings from other countries (Belgium, England, Wales & Northern Ireland, Netherlands, Portugal and Scotland) are generally residual (Fig.7). Loliginid discards in this area amounted 40.4 tons of *L. vulgaris* and 1.9 tons of *Alloteuthis* sp.. Most discards in 2017 were reported by France from 27.8.a and 27.8.b.

Figure 7. Trends in loliginid landings in the Cantabria and Bay of Biscay (27.8.a,b,c,d) area for the years 2000 to 2017 by national fleet.

## 2.5 Fisheries in NW Spain, Portuguese waters and Gulf of Cadiz

Loliginid landings from Subarea 27.9.a, dropped substantially in 2017 to 318 tons, which is the lowest landing amount since 2008. Catches in this area are taken mainly by Spain (ca. 60%) and Portugal (ca. 40%) and the landing pattern is similar. (Fig. **8**). Spain reported a total of 9.4 tons of *A. media*, 0.5 tons of *Alloteuthis* spp. and 4.0 tons of *L. vulgaris* discarded in sub-area 27.9.a.s. in 2017. Portugal didn't estimate discards of loliginids due to the low frequency of occurrence in sampling whish hinders the estimations of total discards. Percentage of discards in Portuguese trawl fleets may vary from 2-25% in the OTB-CRU and 7-48% in the OTB-DEF. The % of discards of the Spanish OTB fleet in 27.9a.s. is generally low (0-3%).
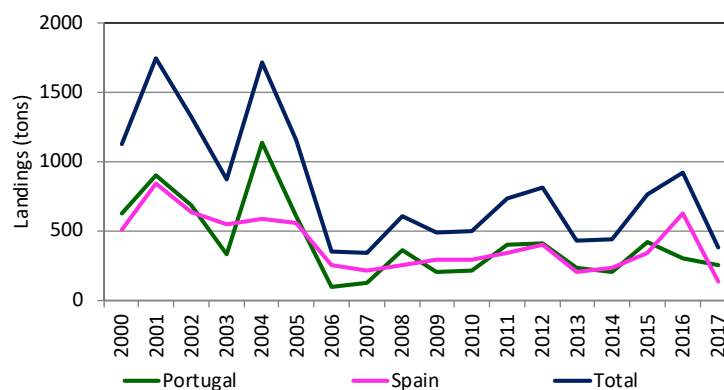


Figure 8. Trends in loliginid landings in Iberian waters (ICES Subarea 27.9.a) for the years 2000 to 2016 by national fleet.

## 3 Relative Loliginid biomass indices

Regional fishery CPUEs datasets by species or groups of species needs further improvement to be used as a proxy of biomass. This will be postponed to the WGCEPH 2019 meeting. The following bottom trawl research cruises, including those with data submitted in DATRAS, were analyzed as possible proxies of biomass of loliginid species: PT- IBTS, GER-IBTS, SP-NGFS, SP-GCGFS, IE-IGFS, FR-EVHOE, UK-BTS7D, FR-CGFS, SP-PorcGFS and UK-SWCGFS.

### 3.1. Research Surveys in the North Sea

Survey trends in the North Sea indicate an increase in biomass of *L. forbesi* in recent years, and a decrease in *Alloteuthis* sp. CPUE (Fig.9).
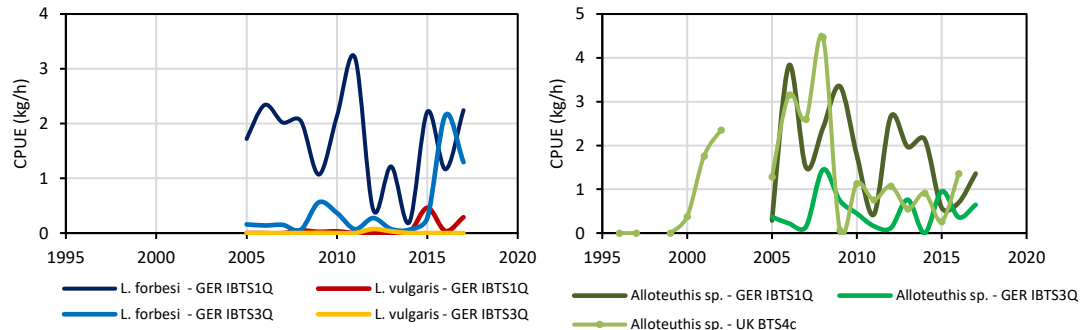
Figure 9. Trends in loliginid biomass survey indices in the North Sea (ICES Subareas 27.4.a,b,c).

CPUE in the 3rd quarter have higher correlation with the CPUE in the 1st quarter of the following year. The German IBTS of the 1st quarter also indicates the entrance of *L. vulgaris* in the North Sea in some years.

### 3.2. Research Surveys in the Celtic Seas

All the different surveys in the Celtic Seas indicate an increase in biomass of *L. forbesi* in 2017, in particular in subarea 27.6.a (Fig.10). Recent trends of *L. forbesi* are increasing in subarea 27.6.a and decreasing in the other subareas of the Celtic Seas. *Alloteuthis* sp. CPUE remains stable at very low level.
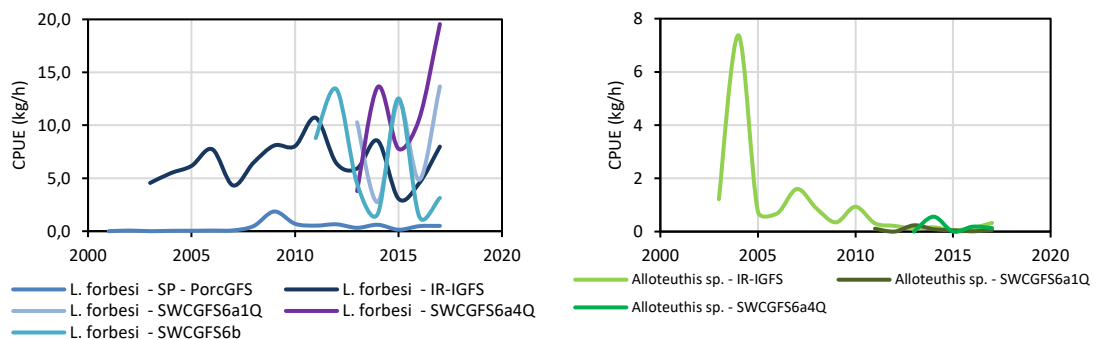
Figure 10. Trends in loliginid biomass survey indices in the NW coast of Scotland, North Ireland, Rockall, Porcupine Bank and Ireland (ICES Subareas 27.6.a,b & 27.7.a-c,e-k).

### 3.3. Research Surveys in the English Channel

The French CGFS survey is the longest and the best data series to derive biomass or abundance indices independent of fisheries for Loligo species in the English Channel (Fig.11). Although, both species had an increase in biomass in 2016 (2017 data not available), *L. forbesi* is still at very low CPUE compared to the historical mean. *L. vulgaris*

was in 2016 at an average level with an increasing trend. The trend of *Alloteuthis* sp. CPUE in the English Channel is descendent.
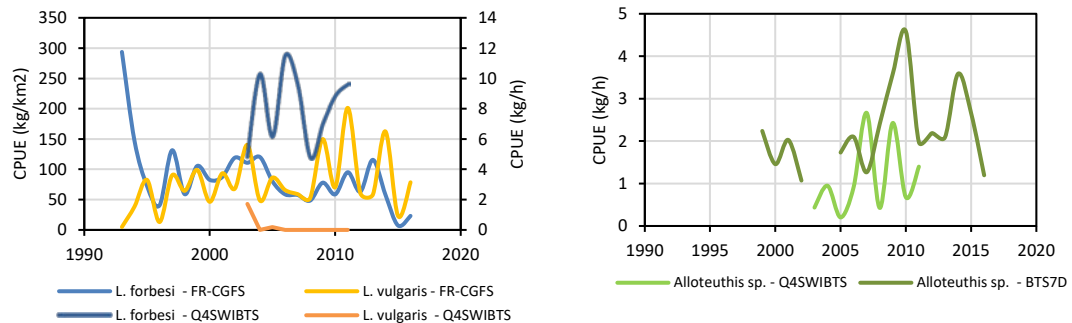


Figure 11. Trends in loliginid biomass survey indices in the English Channel (ICES Subareas 27.7.d,e). FR-CGFS in kg/km² and SWIBTS in Kg/h.

## 3.4. Research Surveys in the Bay of Biscay

*L. forbesi* have generally low biomass indices in the Bay of Biscay and recent values have a decreasing trend (Fig. 12). On the contrary, *L. vulgaris* cpue is increasing (2017 data missing). *Alloteuthis* sp. biomass indices show high yearly fluctuations and a slight increasing trend in the recent period.
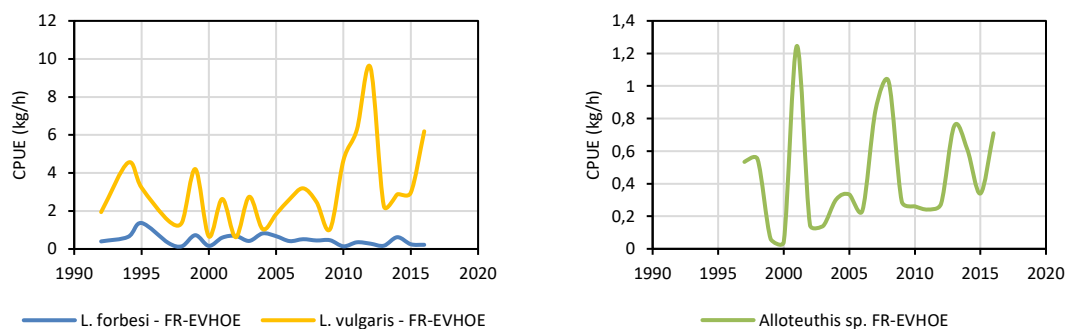


Figure 12. Trends in loliginid biomass survey indices in the Northern Bay of Biscay (ICES Subareas 27.8.a,b,d).

## 3.5. Research Surveys in the NW Spain, Portuguese waters and Gulf of Cadiz

*L. forbesi* biomass indices in subareas 27.8.c and 27.9.a.n are comparable to those in the Bay of Biscay and slightly lower in the Gulf of Cadiz (Fig. 13). The distribution of *L. forbesi* has an interruption in Portuguese waters where the species occurs generally in very low levels. The recent CPUE indices show a decreasing trend.

On the contrary, the biomass of L. vulgaris in the last few years presented the lowest levels in the subareas 27.8.c and 27.9.a.n and increase towards the south through the Portuguese western coast and the Gulf of Cadiz. The recent trend is increasing in these

two sub areas. Despite this recent positive trend, there was a significant drop in L. vulgaris CPUE in 2017. The recent trend of Alloteuthis sp. biomass is decreasing in subareas 27.8.c and 9.a
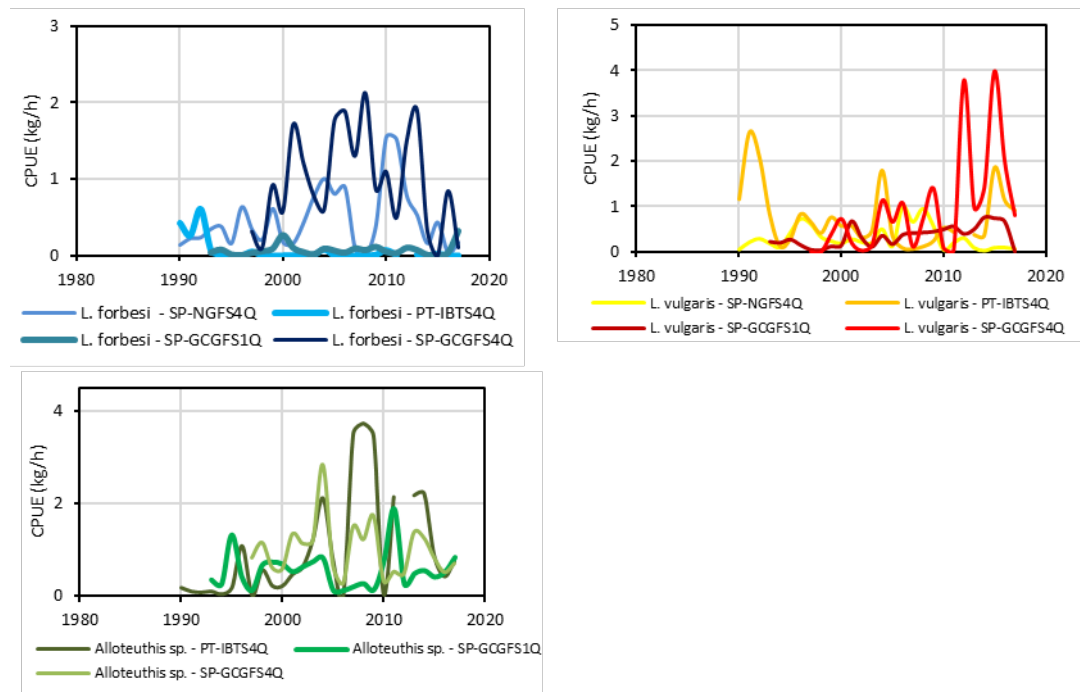


Figure 13. Trends in loliginid biomass survey indices in the NW Spain, Portuguese waters and Gulf of Cadiz (ICES Subareas 27.8.c & 27.9.a).

## 4 Summary of Trends and status

Table 2 summarizes the trends and status of loliginids using landings and biomass indices as surveillance indicators of GES, considering that the mean of the most recent 3 years should be above the long-term historic average (ICES, 2014): M ratio= (recent mean-long term mean)/ long term sd.

Table 2. Summary of trends and status of loliginids.

| Loliginids | | 2000-2017 mean tons | 2015-2017 mean tons | M ratio | Tendency |
|---|---|---|---|---|---|
| North Sea (27.4) | | 1670 | 1877 | **0.31** | ↑ |
| NW Scotland, North Ireland and Rockall (27.6.a,b) | | 659 | 1168 | **0.97** | ↑ |
| English Channel (27.7.d,e) | | 3614 | 4586 | **0.94** | ↑ |
| Cantabria and Bay of Biscay (27.8) | | 1880 | 2119 | **0.24** | ↑ |
| Spain NW, Portuguese waters and Gulf of Cadiz (27.9.a) | | 814 | 686 | **-0.29** | ↓ |
| ***Alloteuthis spp.*** | survey series | long mean kg/h | recent 3y mean kg/h | M ratio | Tendency |
| North Sea (27.4) | UK-BTS 27.4c | 1,23 | 0,81 | **-0,34** | ↓ |
| | GER-IBTS1Q | 1,77 | 0,88 | **-0,80** | |
| | GER-IBTS3Q | 0,49 | 0,65 | **0,40** | ↑ |
| Celtic Seas (27.6.a & 27.7.bcgj) | S-WCGFS6a1Q | 0,08 | 0,04 | **-0,49** | |
| | S-WCGFS6a4Q | 0,18 | 0,11 | **-0,30** | ↓ |
| | IR-IGFS | 1,01 | 0,17 | **-0,46** | |
| English Channel (27.7.d,e) | UK-BTS 27.7d | 2,26 | 2,48 | **0,23** | ↑ |
| Northern Bay of Biscay (27.8ab) | FR-EVHOE | 0,45 | 0,55 | **0,32** | ↑ |
| Spain NW, Portuguese waters and Gulf of Cadiz (27.8c&27.9.a) | PT-PGFS4Q | 1,01 | 0,68 | **-0,28** | ↓ |
| | SP-GCGFS4Q | 1,01 | 0,69 | **-0,55** | |
| ***Loligo vulgaris*** | survey series | long mean kg/h | recent 3y mean kg/h | M ratio | Tendency |
| North Sea (27.4) | GER-IBTS1Q | 0,07 | 0,26 | NR | NR |
| | GER-IBTS3Q | 0,01 | 0 | NR | NR |
| Celtic Seas (27.6.a & 27.7.bcgj) | SP-PorcGFS (27.7.bck) | 0 | 0 | NR | NR |
| | IR-IGFS | 0 | 0 | NR | NR |
| | S-WCGFS6a | 0 | 0 | NR | NR |
| English Channel (27.7.d,e) | FR-CGFS* | 77,41 | 88,09 | **0,23** | ↑ |
| Northern Bay of Biscay (27.8ab) | FR-EVHOE | 3,06 | 4,01 | **0,45** | ↑ |
| Spain NW, Portuguese waters and Gulf of Cadiz (27.8c&27.9.a) | SP-NGFS4Q | 0,30 | 0,07 | **-0,85** | ↓ |
| | PT-PGFS4Q | 0,74 | 1,31 | **0,86** | ↑ |
| | SP-GCGFS4Q | 0,94 | 2,26 | **1,17** | ↑ |
| ***Loligo forbesi*** | survey series | long mean kg/h | recent 3y mean kg/h | M ratio | Tendency |
| North Sea (27.4) | GER-IBTS1Q | 1,69 | 1,87 | **0,22** | ↑ |
| | GER-IBTS3Q | 0,43 | 1,24 | **1,31** | |
| Celtic Seas (27.6.ab & 27.7.bcgj) | S-WCGFS6a1Q | 10,21 | 10,26 | **0,01** | ↑ |
| | S-WCGFS6a4Q | 10,80 | 12,65 | **0,34** | |
| | SP-PorcGFS (27.7.bck) | 0,38 | 0,37 | **-0,03** | |
| | IR-IGFS | 6,54 | 5,20 | **-0,67** | ↓ |
| | S-WCGFS6b | 6,49 | 5,69 | **-0,16** | |
| English Channel (27.7.d,e) | FR-CGFS* | 88,09 | 29,55 | **-1,05** | ↓ |
| | UK-BTS 27.7d | 0,03 | 0,01 | **-0,60** | ↓ |
| Northern Bay of Biscay (27.8ab) | FR-EVHOE | 0,47 | 0,36 | **-0,38** | ↓ |
| Spain NW, Portuguese waters and Gulf of Cadiz (27.8c&27.9.a) | SP-NGFS4Q | 0,47 | 0,22 | **-0,63** | |
| | PT-PGFS4Q | 0,06 | 0,01 | **-0,37** | ↓ |
| | SP-GCGFS4Q | 0,97 | 0,32 | **-1,00** | |

* kg/km$^2$

References:

ICES. 2014. Report of the Workshop on guidance for the review of MSFD Decision Descriptor 3 - commercial fish and shellfish (WKGMSFDD3), 4-5 September 2014, IC-ES HQ, Denmark. ICES CM 2014\ACOM:59. 47 pp.

## Annex 7. Trends and status of short finned squid stocks (Ommastraephidae)

Ane Iriondo, Marina Santurtún

AZTI. Gestión pesquera sostenible. Sustainable fisheries management. Arrantza-kudeaketa jasangarria. Txatxarramendi Ugartea z/g. E-48395 Sukarrieta - BIZKAIA (Spain)

### Summary

Landings of Ommastrephidae from all countries combined are presented by ICES divisions. Catches of this species group averaged around 3 200 t annually along the data series. There was a peak in 2012, mainly due to the Spanish catches in Subarea 8 and afterwards there are fluctuations in the time series. In year 2017, a decrease of landings was observed, but an increase of % of landings from division 7.f-k are observed, mainly comprising Spanish catches.

Commercial catches of Ommastrephidae are thought to be composed mainly of *Illex coindetii*, *Todaropsis eblanae* and *Todarodes sagittatus*. Due to data call by species, some countries provide data by species but few species identification has been provided. Survey data for several areas was provided by species but quite a lot of variability was also observed.

## *Ommastrephidae* in Subarea 2-7 and Divisions 8abd, 8c & 9a

### 1    Fishery

The short-finned squids of the family Ommastrephidae (broadtail shortfin squid *Illex coindetii*, lesser flying squid *Todaropsis eblanae*, European flying squid *Todarodes sagittatus* and neon flying squid *Ommastrephes bartrami*) and other less frequently captured families and species of decapod cephalopods are included in this section. All these species occur within the area that includes ICES Subarea 3 to Div. 9a, Mediterranean waters and North African coast.
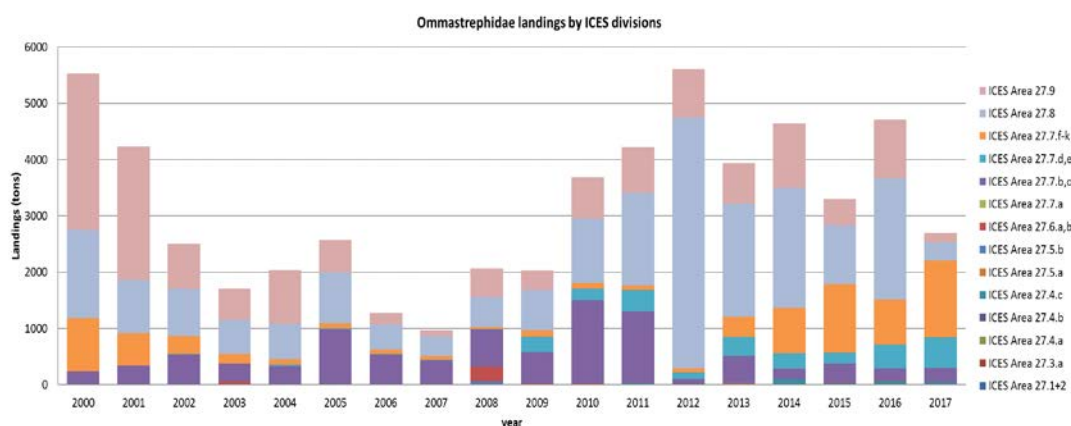


**Figure 1.** Ommastrephidae landings from year 2000 to 2017 for all countries and ICES divisions.

In Figure 1 landings of Ommastrephidae from all countries combined are presented by ICES divisions. Catches of this species group averaged around 3 200 t annually along the data series. There was a peak in 2012, mainly due to the Spanish catches in Subarea 8 and afterwards there are fluctuations in the time series. In year 2017, a decrease of landings was observed, but the increase of % of landings from division 7.f-k are observed, mainly comprising Spanish catches.

For southern areas (Div. 8abd, 8c and 9a), the main countries exploiting these species are France, Spain and Portugal, with no catches recorded by England, Scotland or Ireland. Ommastrephidae are usually exploited by multispecies and mixed fisheries trawlers.

Catches of Ommastrephidae are thought to be composed mainly of *Illex coindetii, Todaropsis eblanae* and *Todarodes sagittatus*. Despite due to data call by species some countries provide data by species but few species identification has been provided for any country or area. WGCEPH reported on the species composition of ommastrephid squid in Galicia (NW Spain) in 2009 and 2010 (ICES 2009, 2010); but no similar information for other areas or more up-to-date information for Galicia has been reported to WGCEPH.

Discard information by country was provided in the data call for 2017. Discard percentage in relation to total catch is estimated to be around 8% of total catches. Analizing data by ICES division, the discard percentage is higher for areas with small catches and however, areas with higher catches have smaller discards.

**Tabla 1**. Percentage of Ommastrephidae discards and catches by subarea in 2017.

| Ommastrephids | | 2017 |
| --- | --- | --- |
| ICES Division | % Discards | % catches by area |
| 27.3.a | 8% | 0% |
| 27.4.a | 14% | 0% |
| 27.4.b | 0% | 0% |
| 27.4.c | 0% | 1% |
| 27.5.b | 100% | 0% |
| 27.6.a | 99% | 0% |
| 27.6.b | 45% | 0% |
| 27.7.a | 0% | 0% |
| 27.7.b | 3% | 2% |
| 27.7.c | 2% | 7% |
| 27.7.d | 0% | 17% |
| 27.7.e | 7% | 1% |
| 27.7.f | 0% | 0% |
| 27.7.g | 69% | 1% |
| 27.7.h | 44% | 2% |
| 27.7.j | 3% | 46% |
| 27.7.k | 0% | 1% |
| 27.8.a | 29% | 6% |
| 27.8.b | 24% | 8% |
| 27.8.c | 51% | 1% |
| 27.8.d | 5% | 0% |
| 27.9.a | 0% | 0% |
| 27.9.a.c | 0% | 1% |
| 27.9.a.n | 6% | 5% |
| 27.9.a.s | 13% | 0% |
| Total | 8% | 100% |
| | areas with higher discards have small catches | |
| | areas with higher catches have small discards | |

## 1.1 Fisheries in ICES Division 7abcdegk

Available commercial landings data indicate that between 300 and 1400 t are landed per year in area 7. Most of these landings were reported by Spain in 7 b+c and 7g+k and by France in 7d+e and 7g+k. However, data from England, Scotland, Northern Ire-

land, Ireland, Wales, Netherland and Germany report undifferentiated landings of lo-liginids and ommastrephids. Therefore, it is questionable how useful these available landings data are.

## 1.2 Fisheries in ICES Division 8abd

The countries contributing to ommastrephid catches in Division 8abd were France and Spain. In 2017, France landed 154 t of ommastrephids (50% of catches) from Div. 8abd, while Spanish landings amounted for 156 t (50%).

## 1.3 Fisheries in ICES Division 8c & 9a

Overall, landings of ommastrephids amounted to 183 t caught by Spain and Portugal, 9% from ICES Div. 8c and around 91% from Div. 9a. The total amount in division 8c and 9a have decreased significantly, from 1618 t to 17 t and from 1047 to 166 t in 9.a.

## 2 Survey

### 2.1 ICES Division 4

CPUE per length class per area data from the IBTS quarter 1 were downloaded from ICES DATRAS (downloaded 6th of June 2018) and included data from DEN, FRA, GER, NED, NOR, SCO, SWE and, for some years, ENG. Data were filtered for om-mastrephids (incl. the following classifications: *Illex coindetii*, Ommastrephidae, *Todarodes*, *Todarodes sagittatus*, *Todadropsis eblanae*) and cpue per length class per area values were summed for each area and in total for RFA 1-7. As mentioned last year, the quality of the data seems to be insufficient at least for 2011 and 2012 because some species were listed as 'teuthida' (and hence not included in the data presenting here), showing that problems with species identification occurred.

The trend analysis of the data show that there is a strong increase of CPUE values since 2006 with an exception in 2011 until 2013 with very low CPUE values which might be due to identification problems or that species were listed as 'teuthidae'. The strong in-crease in the total area is mainly based on the increased CPUE values in RFA 1 and RFA 2 where the strongest increase in CPUE values is observable. However, an in-crease in CPUE is also illustrated for RFA 3, 4 and 7. In RFA 5 and RFA 6 om-mastrephids seems to be very rare.
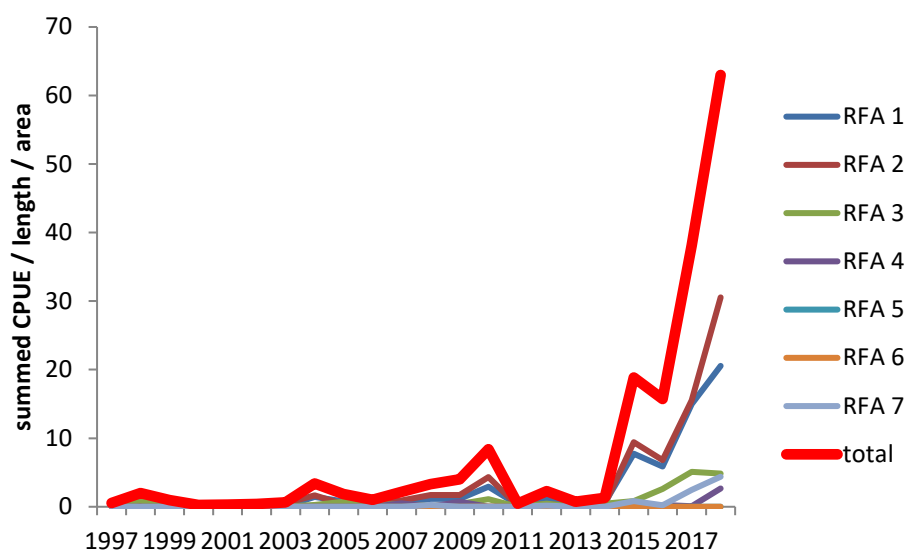


**Figure 2.** Summed CPUE per length class per RFA (1-7 and total) based on the ICES IBTS Q1 DATRAS database (download 6th of June 2018).

## 2.2 ICES Division 7abcdegk

Cefas survey data trends in subarea 7 are shown on the Fig. 3a. The 7d beam trawl survey (BTS7D) and the northwest ground fish survey NWGFS caught too few ommastrephids to examine trends. Trends extracted from other survey programmes look rather different and in all cases confidence limits are wide (Fig. 3b). Catch rates were low in Q1SWBEAM (quarter 1) as a beam trawl probably is not an appropriate gear to catch ommastrephids. Catch rates in Q4WIBTS (quarter 4) were also low, rising from 2003 to a peak in 2008 and then falling again to 2011. Catch rates in WCGFS (quarter 1-2) 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.
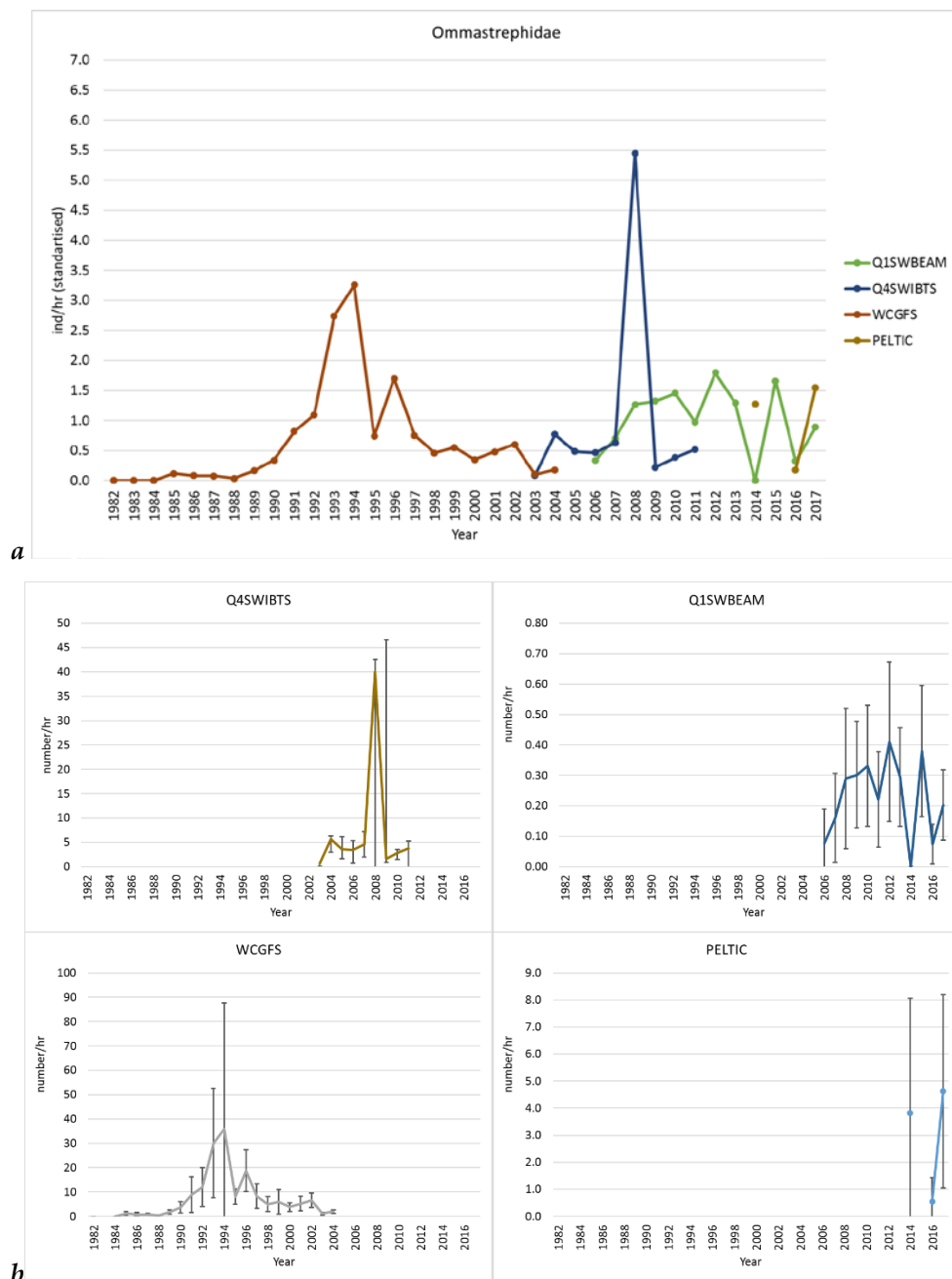


*a*



*b*

**Figure 3.** Trends in ommastrephid catch rates (numbers per hour of towing) in area 7 from Cefas surveys: (a) all available data combined (b) selected surveys with error bars showing confidence intervals.

From 2016 the taxonomic resolution in the data does not cause any concerns, though suitability of some of the trawl gears used (like a beam trawl) is under doubts.

## 2.3   ICES Division 7c and 7k (Porcupine bank)

Results on main cephalopods species captured in the bottom trawl surveys in the Porcupine Bank (Division 7c and 7k).

European flying squid (Todarodes sagittatus)

*T. sagittatus* represented about 22% of the cephalopods mean stratified biomass caught while it just showed about 4% of the stratified abundance caught. The stratified biomass slightly decreased this last survey but remained similar to the values of the last seven years. However, the abundance decreased markedly after the peak of 2016. Other three peaks were showed in 2003, 2008/2009 (Figure 4).



**Figure 4.** Evolution of *Todarodes sagitattus* biomass index and abundance during the Porcupine bank bottom trawl survey time series (2001-2017). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a= 0.80, bootstrap iterations = 1000)

Lesser flying squid (Todaropsis eblanae)

This species represented a small percentage of the cephalopods mean stratified abundance caught (5%) and of the stratified biomass caught (6%). The stratified biomass showed a smoother trend than stratified abundance trend. The abundance peaks in 2005, 2009, 2012 and 2016 represented little increases in biomass (Figure 5).
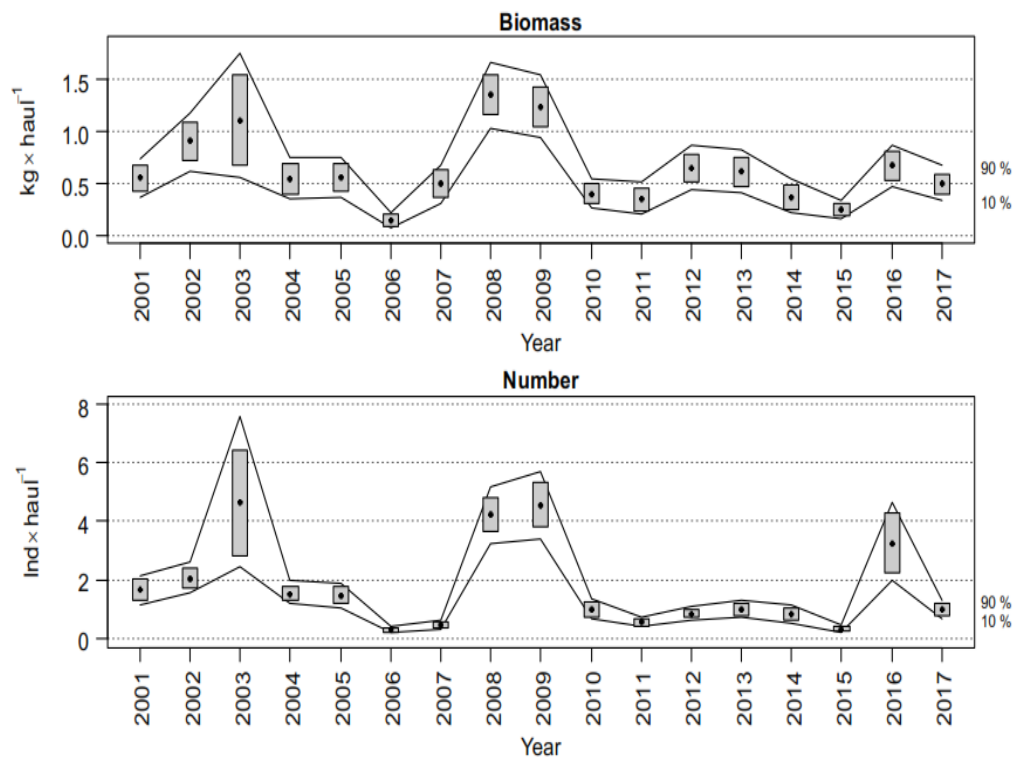
**Figure 5.** Evolution of Todaropsis eblanae biomass index and abundance during the Porcupine bank bottom trawl survey time series (2001-2017). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a= 0.80, bootstrap iterations = 1000).

Broadtail shortfin squid (Illex coindetii)

This species was absent in the last survey. The stratified biomass and abundance were low in the overall time series, although two marked peaks were found in 2007 and 2009, being the former year quite lower in the stratified biomass trend (Figure 6).
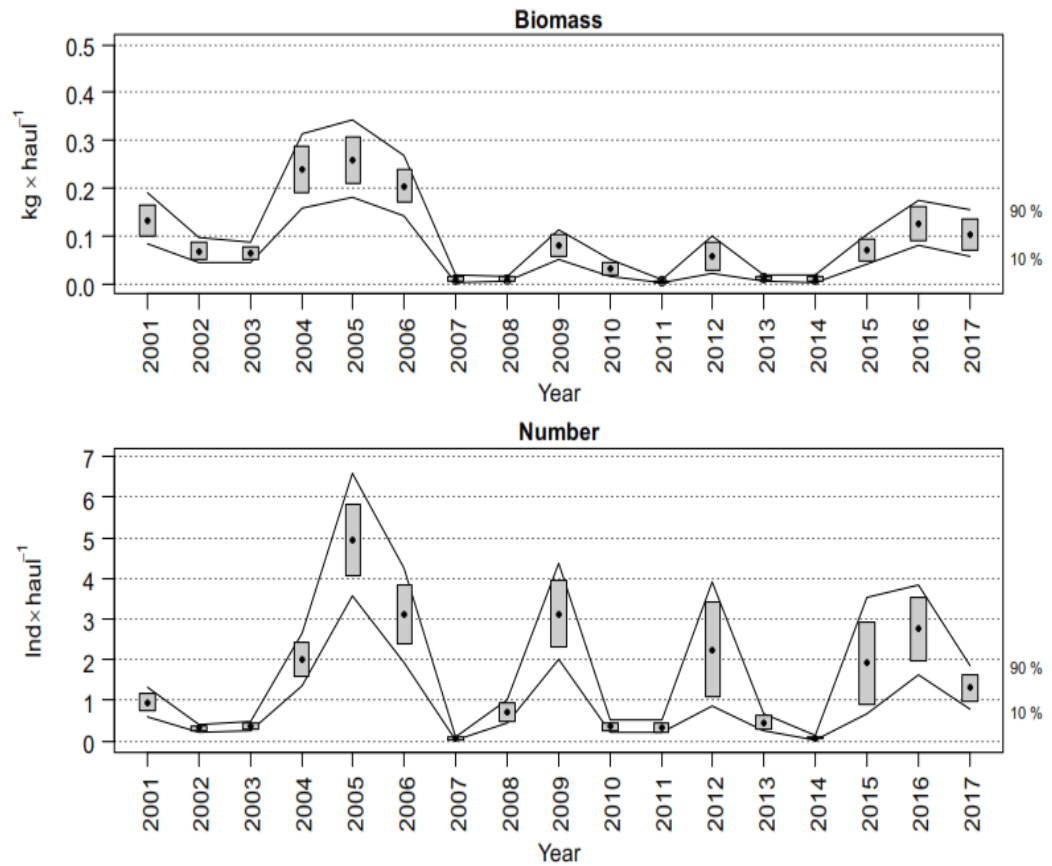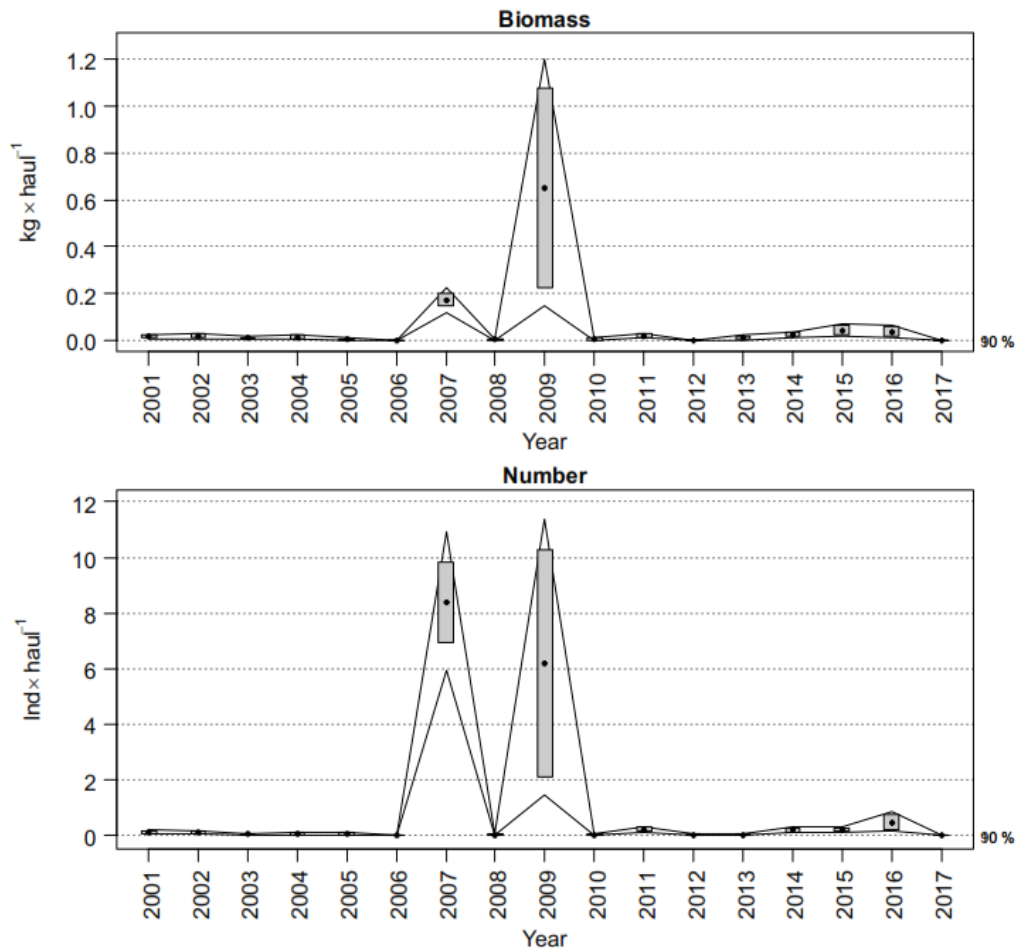
**Figure 6.** Evolution of Illex coindetti biomass index and abundance during the Porcupine bank bottom trawl survey time series (2001-2017). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a= 0.80, bootstrap iterations = 1000).

## 2.4　ICES Division 8ab

There are no updated data for EVHOE survey in year 2017.

From EVHOE survey, abundance indices for three species of Ommastrephids have been extracted: *Illex coindetii, Todaropsis eblanae* and *Todarodes sagittatus*. The time series is from 1992 to 2016 and the area covered are Divisions 8ab. The abundance indices show fluctuating trends with a peak in year 2008 for both species *Illex coindetii* and *Todaropsis eblanae*.
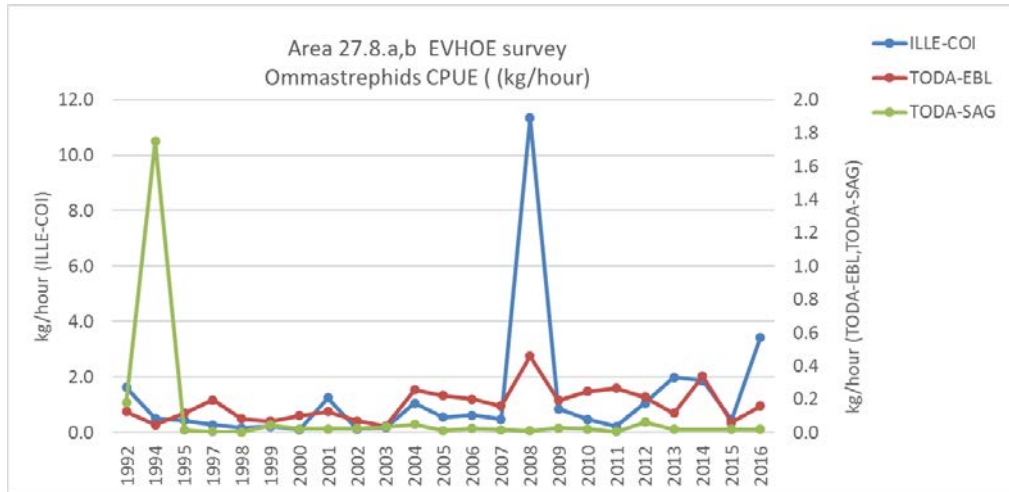
**Figure 7**. EVHOE survey CPUE for Ommastrephids selected species in Divisions 8ab. (Standardized values for a swept area per tow of 0.02 mi² (= 0.0686 km²)).

## 2.5 Division 8c and 9a.North

The SPNSGFS (Spanish Northern Shelf ground fish survey) covered ICES Div. 8c and the Northern part of 9a corresponding to the Cantabrian Sea and off Galicia waters. The main ommastrephid species caught in the survey are *Illex coindetti*, *Todarodes sagitattus* y *Todaropsis eblanae*. Abundances of Ommastrephids in this survey are low and there is a important variability. In the year 2016 a significant increase was observed for *Todaropsis eblanae* and *Illex coindetti*.

**Figure 8.** Evolution of *Todarodes sagitattus* biomass index and abundance during the Spanish Northern Shelf ground fish survey time series (2000-2017). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a= 0.80, bootstrap iterations = 1000)
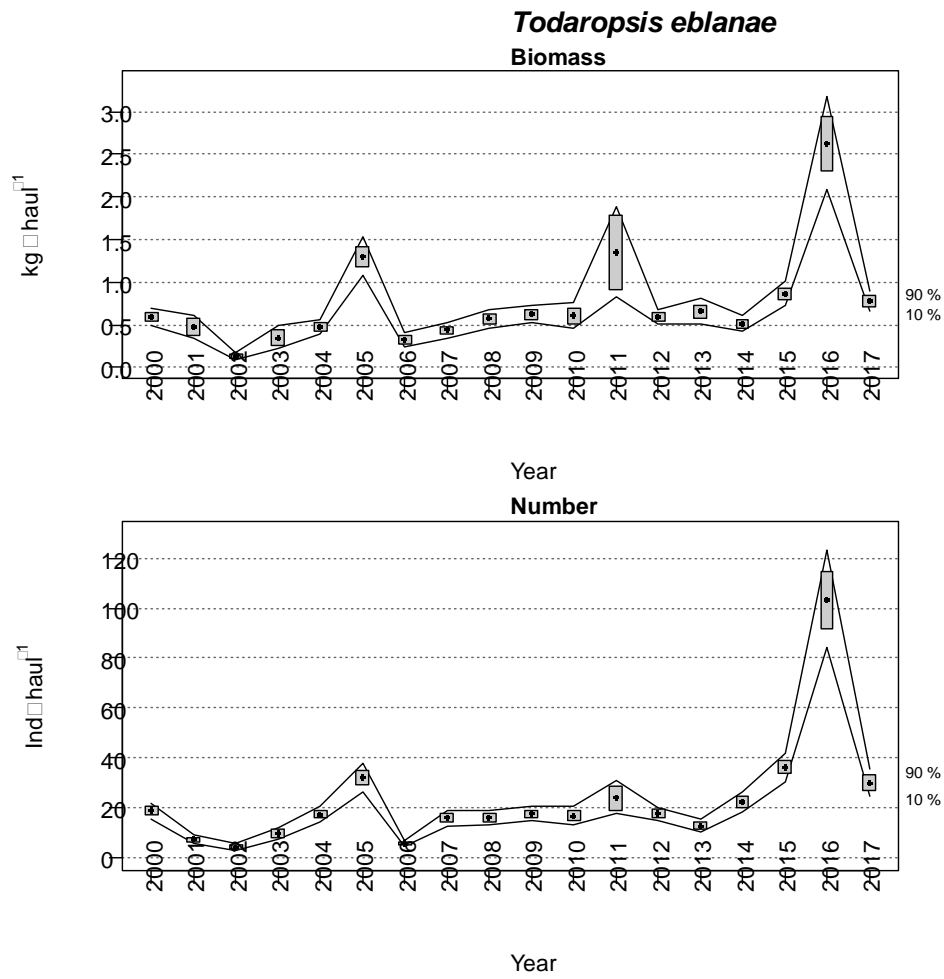
**Figure 9.** Evolution of *Todaropsis eblanae* biomass index and abundance during the Spanish Northern Shelf ground fish survey time series (2000-2017). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a= 0.80, bootstrap iterations = 1000).
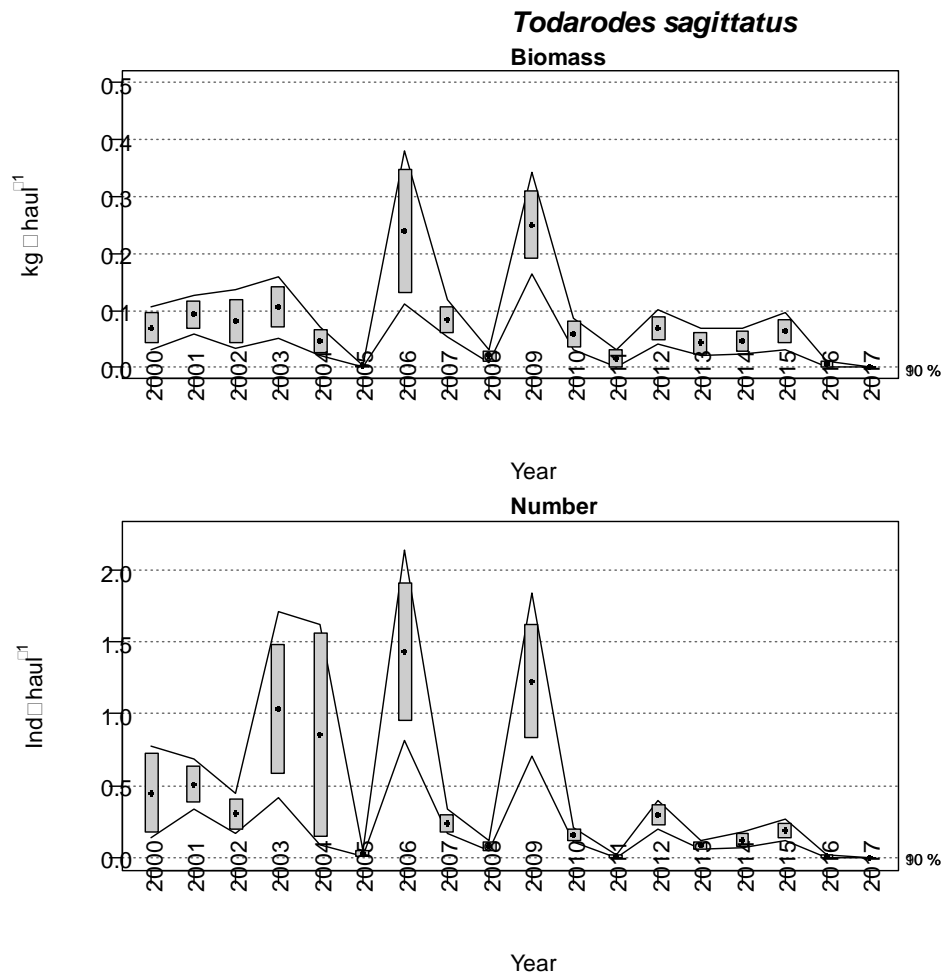
## *Illex coindetii*
### Biomass



### Number
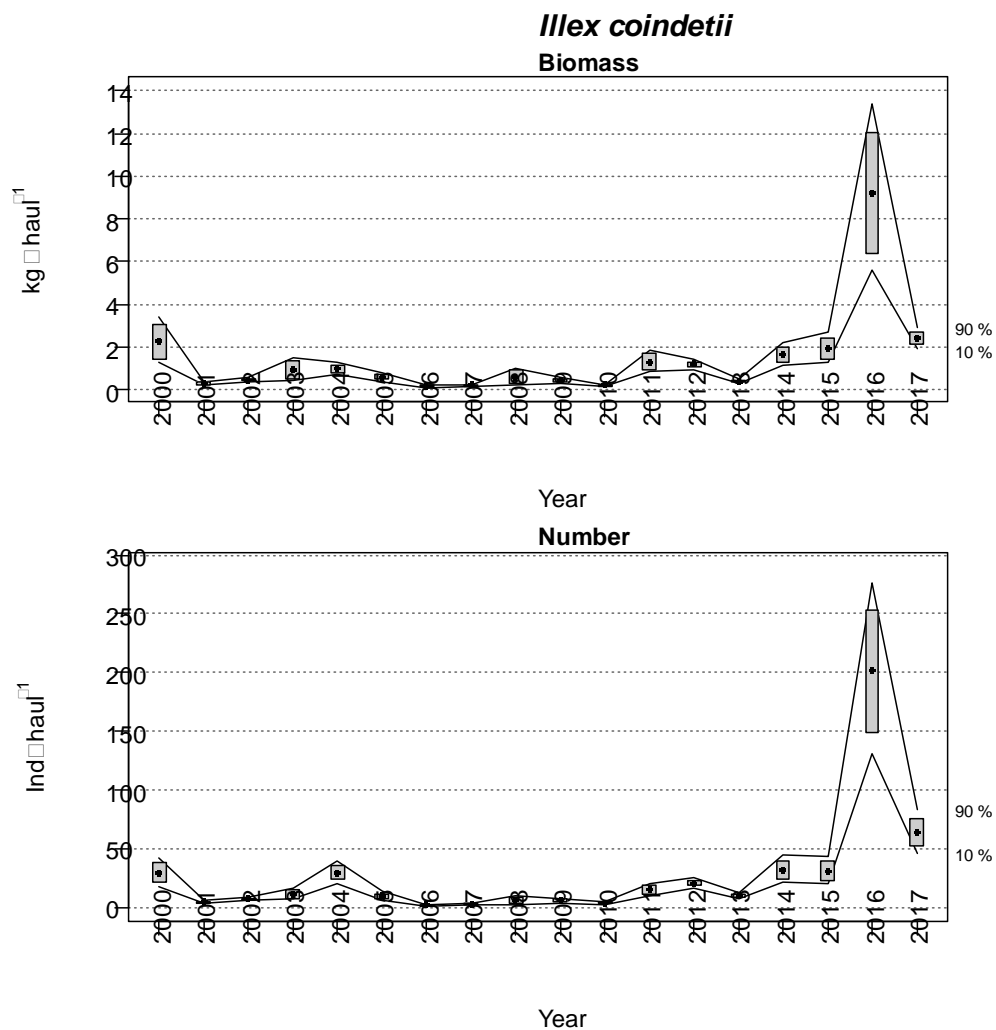


**Figure 10.** Evolution of *Illex coindetii* biomass index and abundance during the Spanish Northern Shelf ground fish survey time series (2000-2017). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a= 0.80, bootstrap iterations = 1000).

### 2.6 ICES Division 9a.south

The South Spanish Groundfish Survey (ARSA/SPGFS) is conducted in the southern part of ICES Div. 9a, the Gulf of Cadiz. SPGFS aims to collect data on the distribution and relative abundance, and biological information of commercial fish and it is ejecuted in November and March each year. Some species of ommastrephids yields are compiled, for instance *Illex coindetii* and *Todaropsis eblanae*. For *Illex coindetii* there is a peak in 2001 reaching a maximum of 10 kg per hour in March survey. A fluctuating trend in abundance is observed in the data series. For *Todaropsis eblanae*, the peak was observed in 2011 in November survey and a fluctuating and decreasing trend has been observed in the last years.
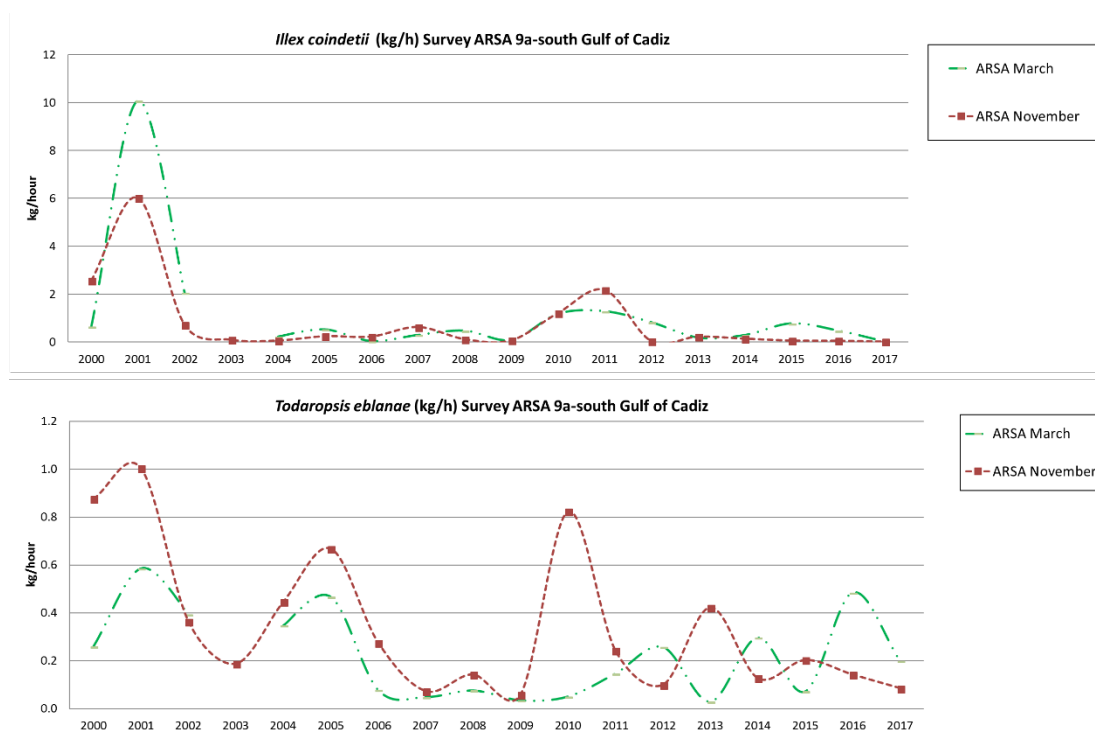
**Figure 11.** Abundance Indices of of Ommastrephids, *Illex coindetii* (top) and *Todaropsis eblanae* (bottom) in (kg/h) of the Spanish Scientific Surveys in Divisions 9a South (Gulf of Cadiz).

Portugal provide data on Ommastrephids abundance by main species calculated in Portuguese Groundfish Survey for Div. 9a in Portuguese continental waters. *Illex coindetii, Todaropsis eblanae and Todarodes sagittatus* abundance indices are presented in Figure 10. *Illex coindetti* presents a peak in year 1986 but in the following years present a stable abundance index. *Todarodes sagittatus* and *Todaropsis eblanae* show also isolated peaks but they do not show any abundance trends.
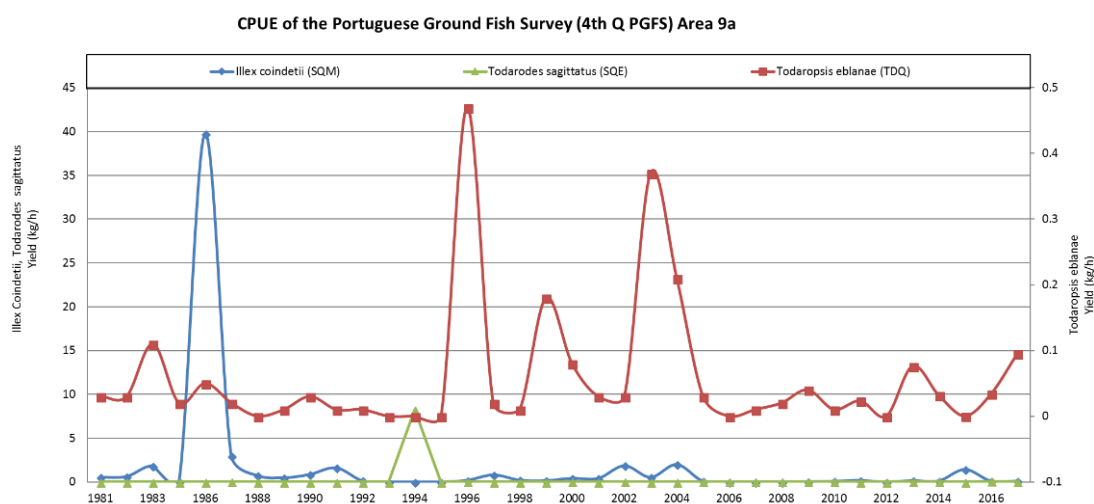


**Figure 12.** CPUE of Ommastrephidae main species of Portuguese Ground Fish Survey from 1981 to 2017.

## 3    Assessment/trends

### 3.1    ICES Division 8abd

No assessment was attempted. Spanish Commercial LPUE and French EVHOE Survey abundance indices until 2016 present conflicting trends. As Ommastrephidae are not

among the target species for those fleets and, in particular, catches may not always be landed, the LPUE and CPUE values obtained could not be considered as abundance indices for this group of species.

## 3.2 ICES Division 8c & 9a

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.
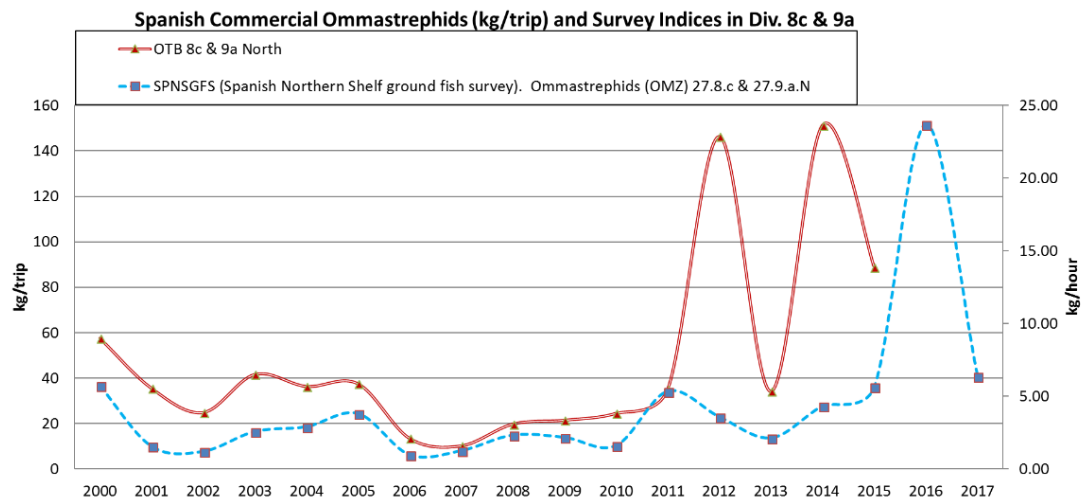


**Figure 13. Comparison between commercial LPUE (kg/trip) and survey CPUE abundance Indices (kg/h), from the Spanish commercial fleet and scientific surveys in Divisions 8c & 9a North respectively.**

The coincidence in trends of the indices obtained in the Spanish surveys has to be treated with some caution. A survey may generate a representative abundance index if it covers the whole area of distribution of the species and if the gear used and timing of survey were appropriate 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. 9a south, commercial and survey data series provided by Spain again appear to coincide in trends and in peaks of abundance detected. However, the survey index did not show the marked high abundance seen in the commercial LPUE series in 2011. As commented above, for Div. 8c and 9a, high abundances were seen the first years (2000-2003) of the data series and in 2010-2012. These promising results enhance the possibility of using these data series as abundance indices for ommastrephids.
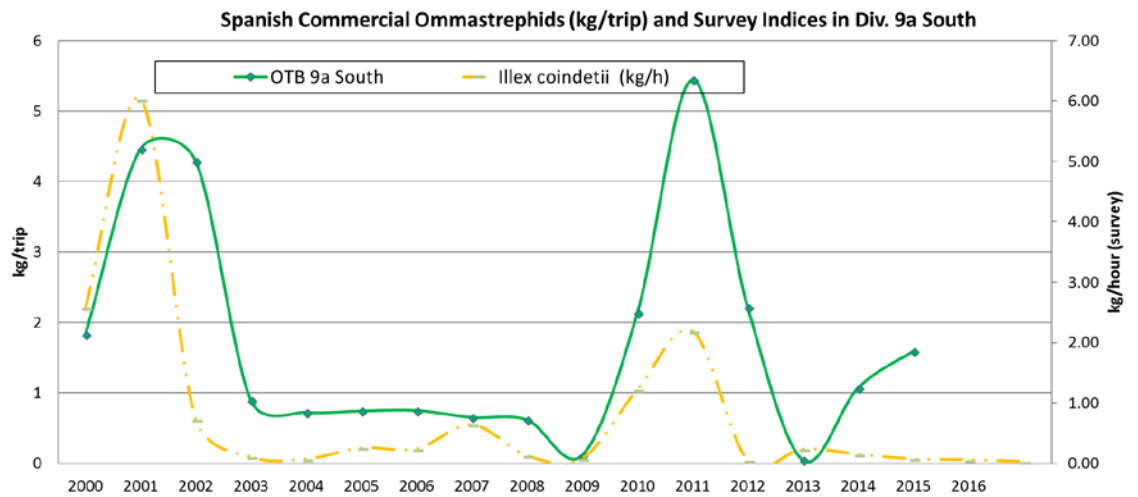
**Figure 14. Comparison between LPUEs (kg/trip) and Abundance Indices (kg/h) trips of the Spanish commercial fleet and Scientific Surveys in Divisions 9a south.**

## 4 Conclusions

In some survey series 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. However, despite there is an improvement, in general the identification to species in both survey and commercial data should continue imcreasing.

## Annex 8. ToR A Trends in Octopod resources (Octopodidae)

Ana Juárez, Luis Silva, Instituto Español de Oceanografía, Cadiz (Spain).

## Octopodidae in Subarea 27.2, 27.4, 27.5, 27.6, 27.7, 27.8.abd and Divisions 27.8.c & 27.9.a

### A6.1 Fishery

Octopus (*Octopus vulgaris*), horned octopus (*Eledone cirrhosa*) and musky octopus (*Eledone moschata)* are included in this section. The first two species are distributed from ICES Area 27.3 to ICES Area 27.9.a, Mediterranean waters and North African coast. *E. moschata* inhabits southern waters from ICES Area 27.9.a towards the south.

Most of the catches recorded from ICES Area 27.3 to 7 were taken by trawlers and are expected to comprise mainly of *E. cirrhosa* although catches are usually not identified to species. Only a small proportion of reported catches of Octopodidae derive from ICES Area 27.3, 27.4, 27.5 and 27.6. Anecdotal evidence from Scotland indicates that *E. cirrhosa* is usually discarded, although its presence is confirmed by regular occurrence in small numbers in survey trawls (see MacLeod *et al.*, 2014).

For more southern ICES areas (27.8.abd, 27.8.c and 27.9.a), the main countries exploiting these species are Spain, Portugal and France. These countries provide the greatest catches of octopods, with 63% reported by Portugal and 27% by Spain on average for the 2000-2017 period, mainly in ICES areas 27.8.c and 27.9.a. Species identification has been provided only for Spain and Portugal in Div. 8.c and 9.a. The annual average landings for the 2000-2017 period account for 18771 t, with minimum in 2006 (9003 t) and maximum in 2008 (21652 t) (Figure A6.1.1).
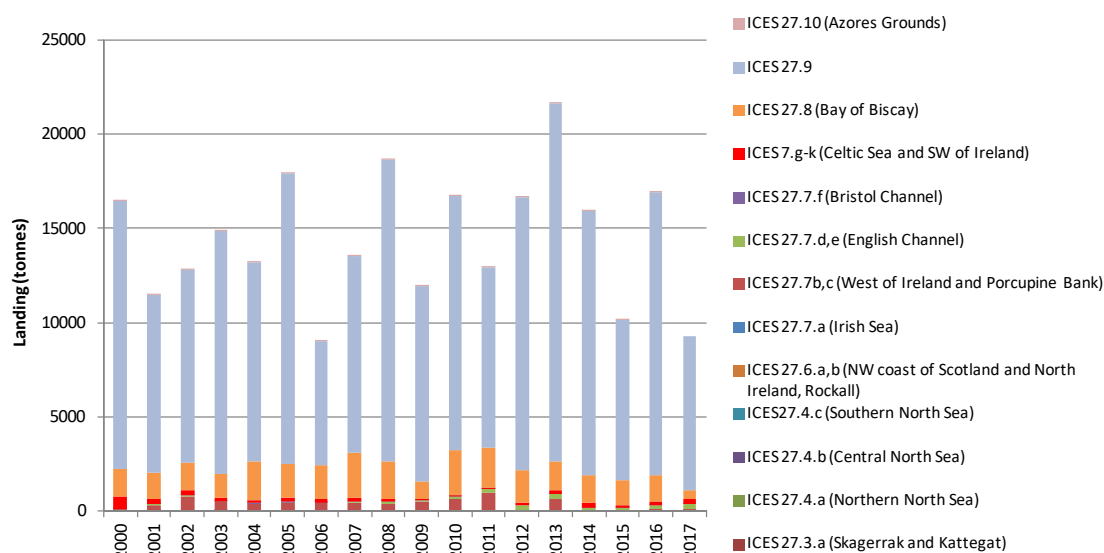


Figure A6.1.1. Octopodidae landings by ICES Division during 2000-2017

Discard information by country was provided in the data call for 2017. Discard percentage in relation to total catch is estimated to be around 1,8% of total catches. Analizing data by ICES division, the discard percentage is higher for areas with small catches and however, the only area with higher catches (27.9.a) has smaller discards.

Table 6.1.1. Percentage of Octopodidae discards and catches by subarea in 2017.

| Octopodidae | | 2017 |
|---|---|---|
| ICES Division | % Discards | % catches by area |
| 27.3.a | 12,4 | 0,1 |
| 27.4.a | 0,0 | 0,2 |
| 27.4.b | 14,3 | 0,1 |
| 27.4.c | 0,0 | 0,0 |
| 27.6.a | 0,0 | 0,0 |
| 27.6.b | 95,7 | 0,0 |
| 27.7.a | 0,0 | 0,0 |
| 27.7.b | 37,8 | 0,3 |
| 27.7.c | 47,7 | 0,5 |
| 27.7.d | 0,0 | 0,0 |
| 27.7.e | 12,4 | 3,5 |
| 27.7.f | 4,6 | 0,3 |
| 27.7.g | 11,3 | 0,4 |
| 27.7.h | 40,8 | 0,4 |
| 27.7.j | 42,0 | 1,9 |
| 27.7.k | 0,4 | 0,0 |
| 27.8.a | 49,3 | 2,5 |
| 27.8.b | 14,1 | 2,7 |
| 27.8.c | 4,9 | 0,4 |
| 27.8.d | 46,3 | 0,0 |
| 27.9.a | 1,4 | 86,8 |
| 27.10 | 0,0 | 0,0 |
| | areas with higher discards have small catches | |
| | areas with higher catches have small discards | |

## A6.1.1. Fishery in Subarea 27.7

Landings in Div. 7.d,e are almost all (>90%) reported by England, Wales and Northern Ireland, with 111 t on average for the 2000-2017 period. French landings in these Divisions are minimal. Reported English landings of this group averaged around 19 t from 2000 to 2006 although they have subsequently increased, to a maximum of 248 t in 2012 with a similar amount in 2013. In the three last years, the English average landings were about 194 t.

Landings in ICES Divisions 7.g-k (Celtic Sea and SW of Ireland) in 2013 were reported by England, Scotland, Ireland and France. Spain presented important landings of Octopodidae in the first years of the data series, but since 2008 catches decreased and no data were provided for 2011 and 2013. The annual average landings for the 2000-2017 period were 208 t. In 2015, only Spain and France reported landings, with 112 and 37 t, respectively. English landings (generally the largest amounts) averaged around 88 t annually, with a minimum of 13 t in 2013. In 2016, Spain reported the higher catch with 81 t, followed by England with 66 t and France with 48 t. The caught species was *Eledone cirrhosa* by trawlers. In 2017, the amount of these landings was similar to 2016. Spanish, English and French 2017- landings were 84 t, 62 t and 45 t, respectively.

Sweden, United Kingdom, The Netherlands, Germany and Ireland provided data in relation to discards, landings and effort in Subarea 27.3, 27.4 and 27.7 respectively for at least 2011 and 2013, and Belgium for 2016 and 2017, only catches. Also for both areas survey data are provided. The Netherlands and Germany did not record any Octopodidae records in its waters.

### A6.1.2. Fishery for Division 27.8.a,b,d (Bay of Biscay)

In ICES Divisions 8.a,b,d, catches of Octopodidae species are generally low. In the logbooks *Eledone spp*. are recorded as well as Octopodidae which enables to indicate that *Eledone spp* accounts for more than 80% of the total 2017 landings in this area. These catches, with 322 t on average Octopodidae landings in the last four years, derive mainly from OTB_DEF_70-99_0_0. The countries contributing to Octopodidae catches in Division 8.a,b,d were France and Spain, with 53% and 42%, respectively. The rest was accounted for by Belgium.

French landings of Octopodidae in Div. 8.a,b,d have followed a stable trend with an average of 203 t for the 2000-2017 period. The peaks were of 205 t in 2008 and 184 t in 2013. The Spanish commercial fleet operating in Division 8.a,b,d is mostly composed of vessels with base ports in the Basque country. For Spain, landings from Division 8.a,b,d varied from 2 t in 2009 to 300 t in 2007, reaching 130 t in 2013, decreasing in 2014-2015 but increasing in 2016 and 2017 to 113 t and 202 t, respectively.

AZTI-Tecnalia is responsible for monitoring cephalopod discards (monthly, by gear) in Div. 8.a,b,d for the Basque Country, thus covering around 95 % of the Spanish fleet operating in the Bay of Biscay. As was the case for landings by the Spanish fleet, Octopodidae discards appear to be highly variable, ranging from a minimum of 2% of catches in 2008 y 2017, to a maximum of 74% in 2011.
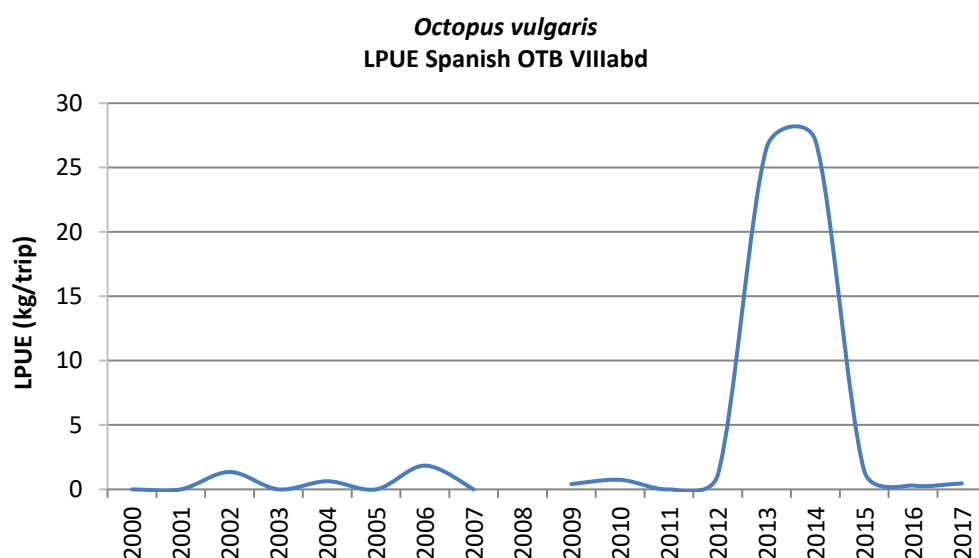


Figure A6.1.2.1. Commercial LPUE trends of the Spanish (kg/trip) OTB fleet in Div. 8.a,b,d for *O. vulgaris*

LPUEs (kg per fishing trip) for the Basque country fleet were calculated for *O. vulgaris* and *E. cirrhosa* separately, pooling data for Bottom Otter trawl and Bottom Pair trawl. LPUE for *Octopus vulgaris* LPUEs were low during 2000-2012, never exceeding 2 k/trip (Figure A6.1.2.1.). In 2013 and 2014, LPUE increased to almost 30 kg/trip, returning to the low values in the three last years. Horned octopus LPUEs were generally higher than those for *O. vulgaris* (Figure A6.1.2.2.) and ranged from 0 kg per trip in 2008 to more than 230 kg per trip in 2013 (this peak

corresponding to that seen in *O. vulgaris*), with a decreasing trend from 2014 to 2016. In 2017, a small increase was registered of this LPUE.
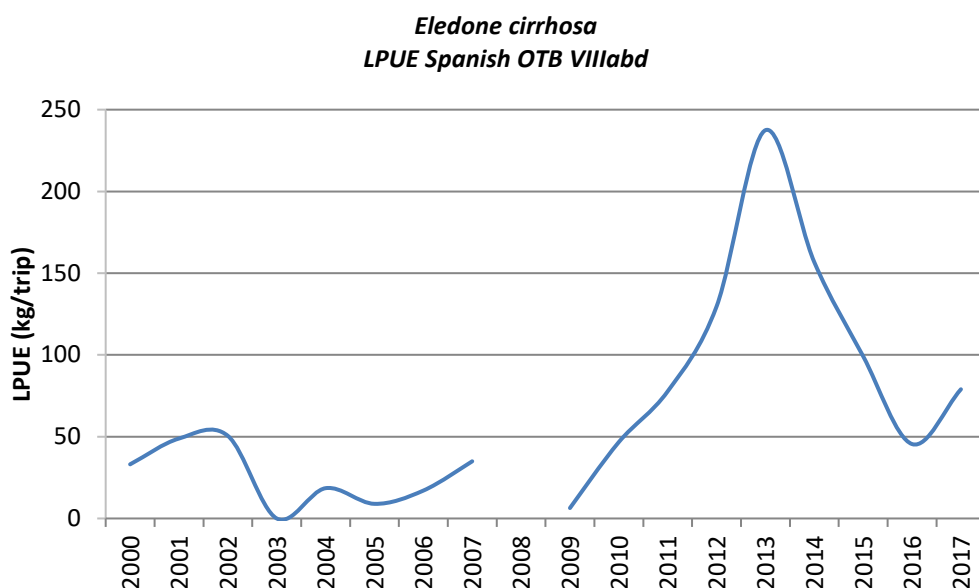
**Eledone cirrhosa**
**LPUE Spanish OTB VIIIabd**



Figure A6.1.2.2. Commercial LPUE trends of the Spanish (kg/trip) OTB fleet in Div. 8.a,b,d for *Eledone cirrhosa*

The recent high LPUE values for Octopodidae by Basque trawlers may reflect increased targeting of cephalopods. In 2009-2012, the metier targeting cephalopods (OTB_MCF) showed an increased number of trips and increased cephalopods catches. The increase in the OTB_MCF metier in 2103-2014 seems to be related to the decrease in the metier targeting demersal species like hake, megrim or anglerfish (OTB_DEF).

No data on Octopodidae from the survey taking place in Div. 8.a,b,d, FR-EVHOE were delivered to the group. No exploratory assessment was attempted due to the lack of French Survey data for Div. 8.a,b,d.

In Div. 8.a,b,d, the relative importance of the two main gears (Bottom Otter trawl and Bottom Pair trawl) changes along the data series (WD 2, in ICES WGCEPH Report 2016 ). It will be useful to analyse LPUE series from both gears separately and carry out a more detailed analysis based on metiers and species. It will also be useful to monitor the future importance of the cephalopod-targeting metier in the Basque trawl fleet, to see whether there has been a real shift in fishing strategies to increase targeting of species without TAC or Quota limits or if the situation during 2009-2013 simply represented a tactial response to high abundances of cephalopods.

### A6.1.3.  Fisheries in Division 27.8.c & 27.9.a

The landings in Division 9.a account for 88% on average in the last four years of the time series for all Subarea/Division, followed by Division 8.c with 6%. The countries contributing to Octopodidae catches in Division 8.c & 9.a were Portugal and Spain, *Octopus vulgaris* being the main species caught.

In Spain, *O. vulgaris* is caught by artisanal and trawler fleet. In the Cantabrian Sea (Division 8.c) and Galician waters (Subdivision 9.a north), the artisanal fleet accounts for more than 98% of *O. vulgaris* landings mostly from traps. In Portuguese waters (Subdivision 9.a-centre), a large

percentage of *O. vulgaris* come from the polyvalent (artisanal) fleet (91-97%), using a range of gears which includes gillnets, trammel nets, traps, pots and hooks lines. In the Gulf of Cadiz (Sub-division 9.a south), over most of the time series the bottom-trawl fleet accounted for around 60% of the *O. vulgaris* catch on average and the remaining 40% is taken by the artisanal fleet using mainly clay pots and hand-jigs. From 2014 to 2016, the proportion of catches attributed to the artisanal fleet increased to 77% and to 85% in 2017, due possibly to tighter official control of landings (i.e. artisanal catches may not have changed but the proportion recorded in official statistics has increased).

Total landings of *O. vulgaris* in 2017 in Division 8.c and 9.a were 8135 t (around 7000 t lower than in 2015), mainly by the artisanal fleet. Portugal contributed around 75 % of these landings from subdivision 9.a in 2017. Spanish bottom trawling contributed significantly to landings only in Subdivision 9.a-south, with 97 t and 6% of discard (6 t).

The available landings data for *O. vulgaris* in Spain covers eighteen years, from 2000 to 2017. In Portuguese waters (Subdivision 9.a-center) the series starts in 2003. Total landings ranged from 6542 t in 2006 to 18967 t in 2013. The marked year to year changes in amounts landed may be related with environmental changes such as rainfall and discharges of rivers, as it was demonstrated in waters of the Gulf of Cádiz in subdivision 9.a south (Sobrino *et al.*, 2002).

Data on commercial discards of *O. vulgaris* in Iberian waters are only available for bottom otter trawl metiers that operate in this area. The data were collected by the on-board sampling programme (EU-DCR) during last eight years. In 8.c and 9.a north the pair bottom trawler (PTB) metier is also sampled, although no *O. vulgaris* was discarded. In subdivision 9.a south was estimated only an 6% (6 t) of discard in the Spanish bottom trawl fleet in 2017. The sampling methodologies are described in WDa.3 (Spain) and WDa.4 (Portugal) of the WGCEPH 2012 report. Generally, amounts discarded were low or zero, possibly related with the high commercial value of this species (see also WD 2.4, WGCEPH 2014).

The two *Eledone* species are not separated in landings statistics but, except in the Gulf of Cadiz (Subdivision 9.a south) where both *E. cirrhosa* with *E. moschata* are present, landings of *Eledone* will normally be *E. cirrhosa*. *E. cirrhosa* is caught by trawlers in both Divisions, mainly as a by-catch due its low commercial value. Monthly landings of *E. cirrhosa* in 9.a-centre show a marked seasonality, with much higher landings during spring months.

Total landings of *Eledone* spp in Div. 8.c and 9.a in 2017 were 107 t in Portugueses fleets (subdivision 9.a) and 380 t in Spanish fleets (8.c and 9.a). The landings data for *Eledone* spp. in Spain cover 18 years, from 2000 to 2017. Annual landings ranged from 1333 t in 2000 to 460 t in 2008. Landings decreased from 2003 to 2008 in all areas, with a slight increase at the end of the time series (mainly in 9.a-south), with 1003 tonnes landed in 2015, but with a new decrease in 2016. Discards of horned octopus by Portuguese vessels seem to be low with about 7% in OTB metier in 2017. In the case of Spanish vessels, average discards from the OTB metier varied between areas and years but were always less than 20%, with lower values in subdivision 9.a south than in 8.c &9.a north.

Fishing effort data are available for the Spanish OTB metier, in terms of numbers of fishing trips, in all areas of the Iberian waters. The LPUE series (*O. vulgaris* catches/fishing trip) for the OTB metier in the north (Division 8.c and 9.a north) and south (Div.9.a-south) indicate a much higher LPUE in the south, and the trends are also different in the two areas (Figure A6.1.3.1.).

Portuguese LPUEs (catcher per day) are available for a shorter period but indices for trawl and polyvalent fleets show similarities, with peaks in 2010 and 2013 and the sharp decline from 2013 seen for Spanish trawlers in the south is also seen for Portuguese trawlers in 9.a centre.

Figure A6.1.3.2. shows the trends in LPUE (*Eledone* spp./fishing trip) for the Spanish OTB metier in the north (8.c, 9.a-north) and south (9.a-south). As was the case for *O. vulgaris* both absolute values and trends differ between the two areas.

**_O.vulgaris_ in Div. VIIIc & IXa**
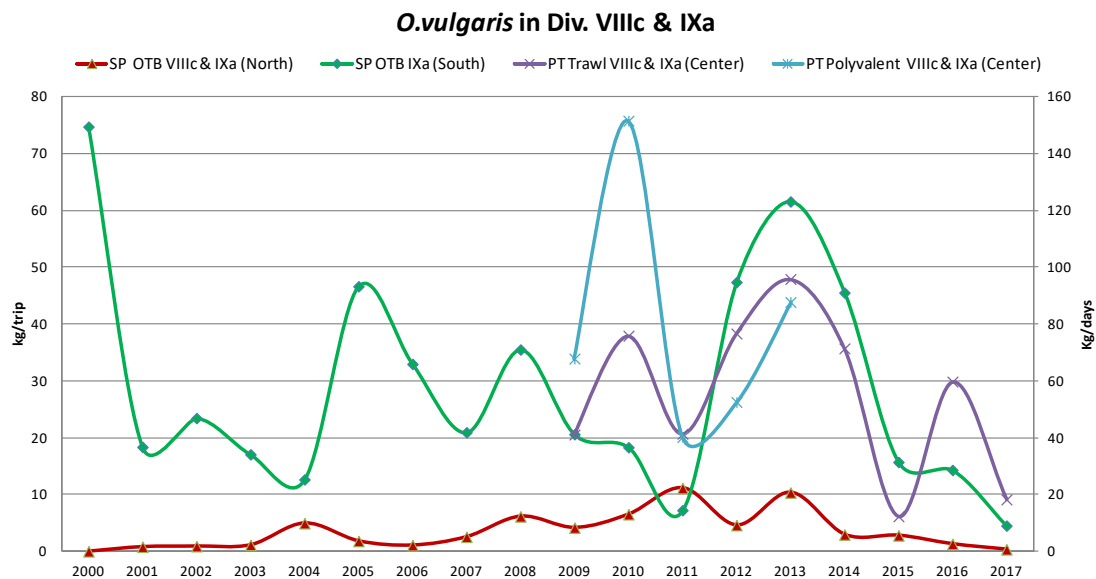


Figure A6.1.3.1. Commercial LPUE trends for *O. vulgaris*: Spanish trawlers (SP) bottom (kg/trip) in the north (8.c, 9.a north) and south (9.a south), and Portuguese (PT) (kg/d) fleets in Div. 9.a centre.

**Eledone spp in Div. VIIIc & IXa and IXa south**
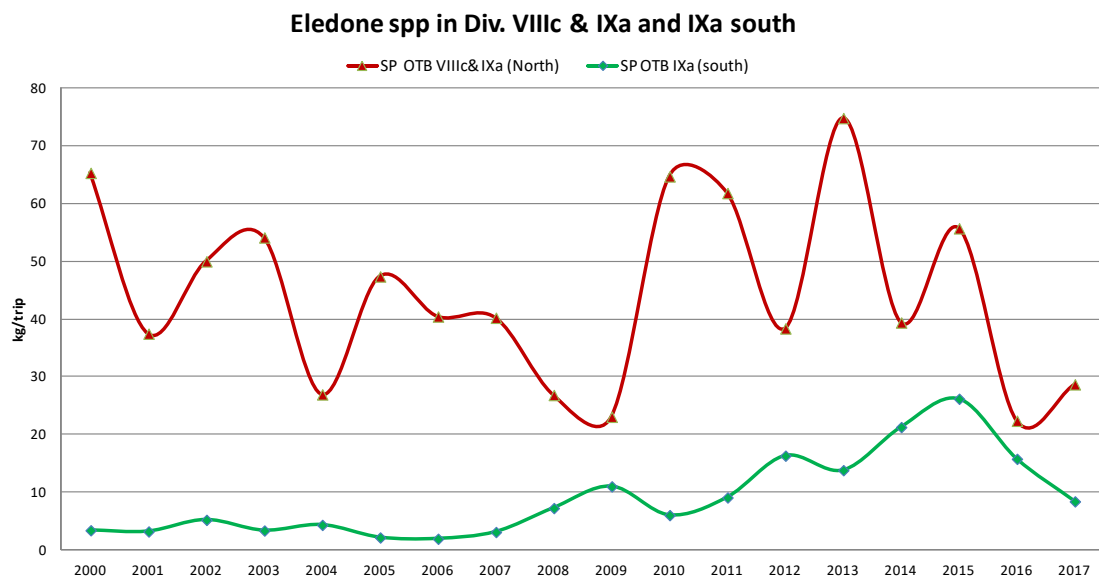


Figure A6.1.3.2. Commercial LPUE for *Eledone* spp.: trends for the Spanish (kg/trip) fleets in the north (8.c, 9.a north) and south (9.a south)

## A6.2.  Surveys

Fishery-independent information was supplied for different surveys carried out annually in Iberian waters by Portugal and Spain: SP-NGPS "DEMERSALES" carried out in 8.c and 9.a north, PGFS in 9.a-centre by Portugal and SP-GCGFS "ARSA" in 9.a-south by Spain. The ARSA

survey is carried out in spring and in autumn, and the mean values derived from both spring and autumn series are used in the Figures below.

The estimated yields (kg/hour) of *Octopus vulgaris* in Spanish DEMERSALES survey in the north during 2000-2017 (figure A6.2.1.) fluctuated widely, reaching a maximum values in 2012 (2.5 kg/h) but dropping to minimum (0.15 kg/h), in 2015. In the ARSA survey in the south, again strong fluctuations are evident, with a peak in 2013 (6.9 kg/h) and a minimum of around 1 kg/h seen in six years in the series, most recently in 2014. In both series, an increase is detected in 2016, followed by a new decrease in 2017. The information of the Portuguese survey is not relevant, with values lesser than 0.5 kg/hour. Only 203-2004 showed high values of around 2 kg/hour.

### *O.vulgaris* in Div. VIIIc & IXa
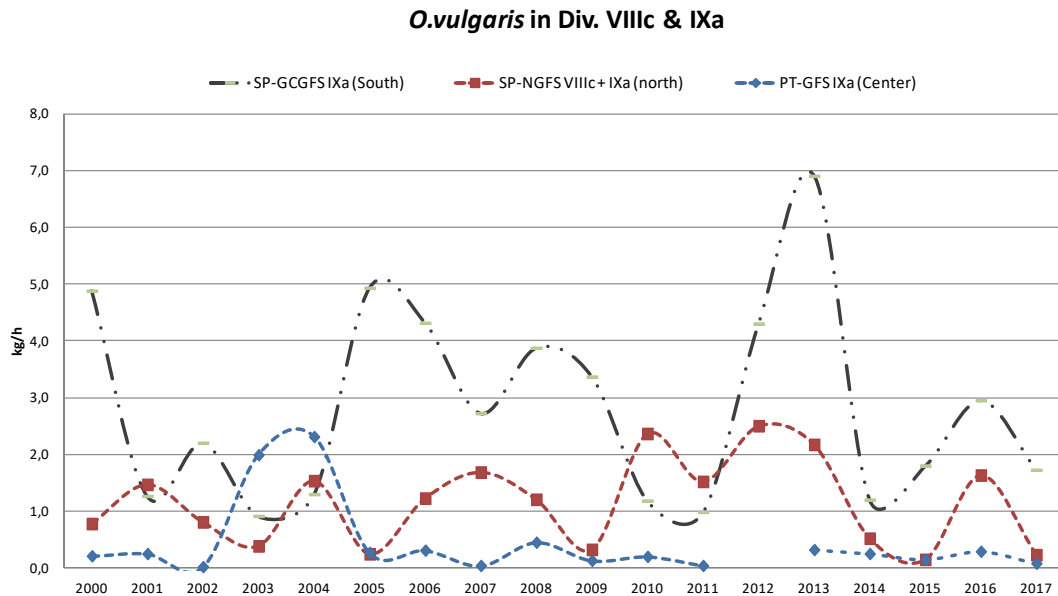


Figure A6.2.1. *Octopus vulgaris*. Abundance indices (Kg/h) of the Spanish (SP-GCGFS; SP-NGFS) scientific surveys in Div. 8.c and 9.a, and Portuguese survey (PT-GFS 9.a center). 2000-2017 period.

The estimated yields (kg/hour) of *E. cirrhosa* in the DEMERSALES survey also fluctuated over the time series with a sharp increase in 2013, tending to be slightly higher than values for *O. vulgaris* as shown in Figure A6.2.1 (above). In the ARSA survey, CPUE reached its highest value in 2015-2017 with around 4 kg/h (Figure A6.2.2), as compared to the peak of 8 kg/h seen in the DEMERSALES series in 2013. Generally yields in both series (ARSA and DEMERSALES) ranged from 1-3 kg/h.
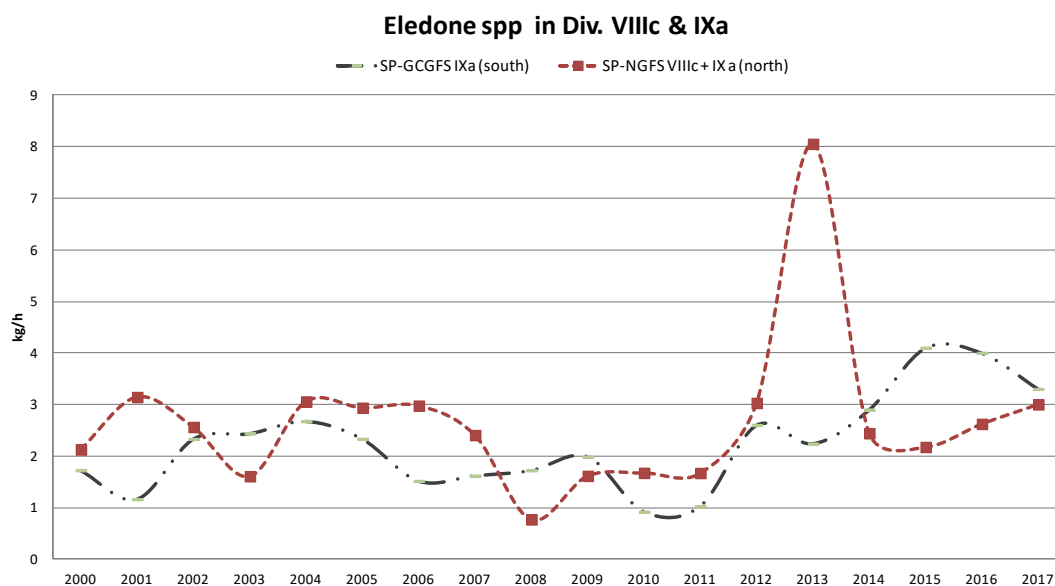
**Eledone spp in Div. VIIIc & IXa**

Figure A6.2.2. *Eledone* sp. Abundance indices (Kg/h) of the Spanish scientific survey in Div. 8.c and 9.a north and 9.a south. 2000-2017 period.

## A6.3. Assessment/trends

In order to evaluate the quality of the LPUE series as abundance indices, these have been plotted alongside with corresponding commercial fishing LPUE series for "Baca" Otter trawlers are used in the analysis. In all series, it should be noted that the fishing effort was not effort directed at catching *O. vulgaris* (or *Eledone*). The LPUE series in the north of Spain refers to 8.c and 9.a north together, since the "DEMERSALES" survey covers these two areas. In division 9.a south, Gulf of Cádiz, the survey index used is the average value of the two survey carried out during the year in this area (Spring-Autumn).

Figure A6.3.1. shows the Spanish DEMERSALES and Portuguese survey biomass index for *O. vulgaris* plotted jointly with annual data series coming from the Spanish commercial bottom trawl fleet "Baca" (OTB) in 8.c and 9.a north and LPUE indices for Portuguese trawl and polyvalent gears. In this species the main similarities in the trends are the peak in 2010 (not evident in the Spanish survey) and a clear decrease from 2013 to 2015 in all series. Portuguese LPUE data show a similar trend along the short period represented. The Portuguese survey biomass indices also show a similar trend with the LPUE series in spite of the low obtained values. The abundance index series for *O. vulgaris* taken by the commercial fleet (OTB) and ARSA survey biomass index in Subdivision 9.a south are shown in Figure A6.3.2. In this case, the trend of both sets of data show high similarities along 2000-2017 time series, reaching the lowest value of the time series for LPUE (OTB) in 2017.

The DEMERSALES survey biomass index for *E. cirrhosa* in 8.c and 9.a north is plotted alongside the annual CPUE series from commercial bottom trawl fleet "Baca" (OTB) in Figure A6.3.3. In this species can be observer some similarities in the trend of the series in same periods, the trends were opposite during 2001 to 2004 and 2010 to 2012. Both series show a strong peak in 2013 with similar trend at the end of the time series. The ARSA survey biomass for *Eledone* spp and LPUE series of the otter bottom trawl fleet "Baca" (OTB metier) in subdivision 9.a south are plotted together in Figure A6.3.4. The trends in both series are quite similar, especially since 2009 to 2017..
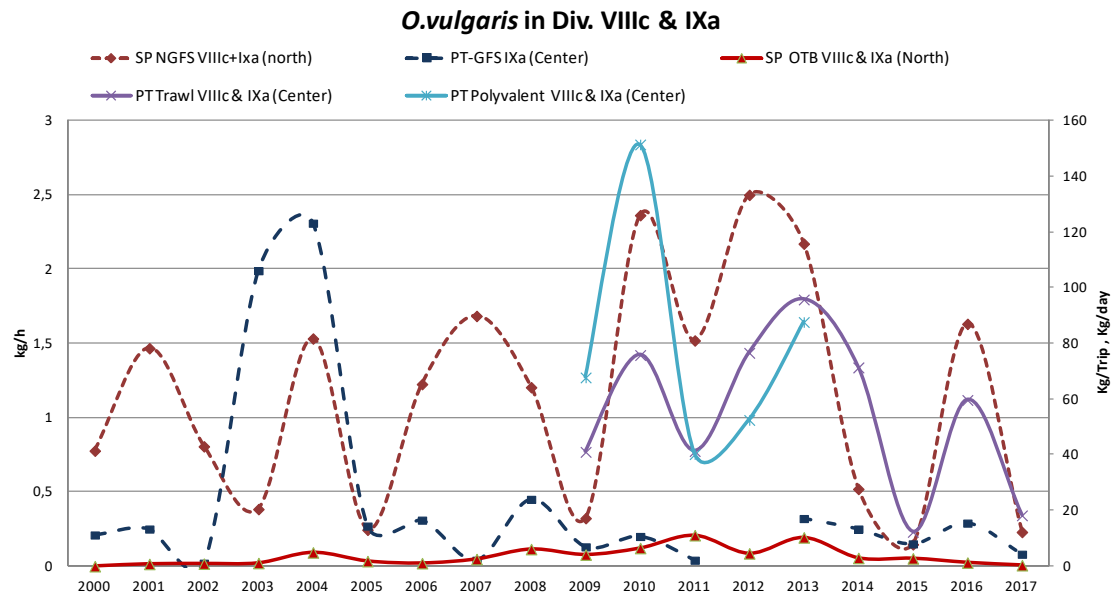
Figure A6.3.1. Comparison of commercial LPUE trends of the Spanish and Portuguese (kg/trip; kg/d) fleets and Spanish scientific survey (kg/h) in 8.c, 9.a north and 9.a centre, for *Octopus vulgaris*.
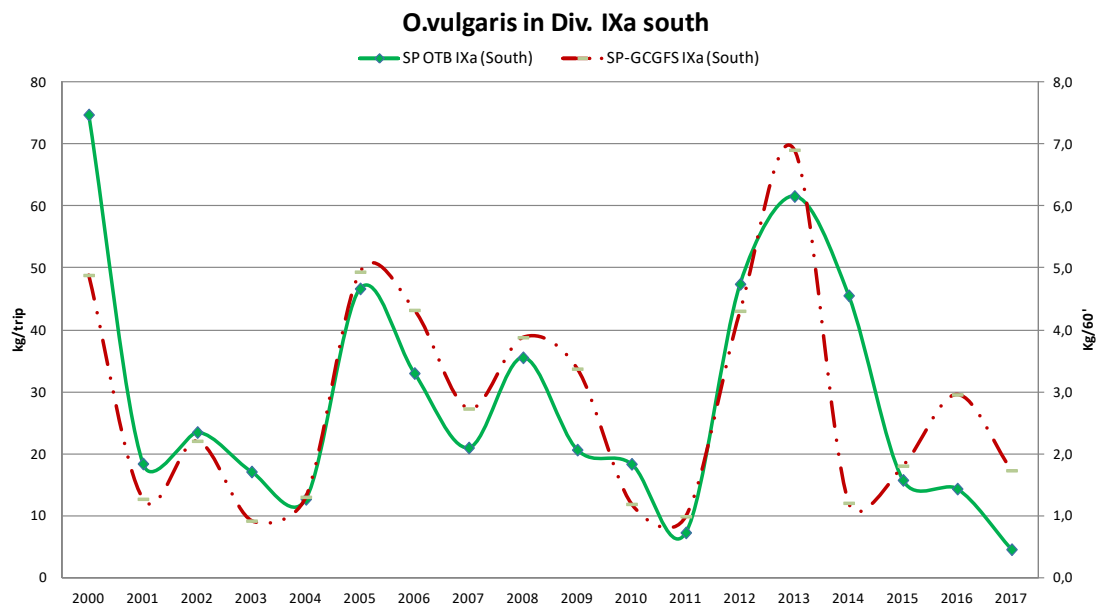


Figure A6.3.2. Comparison of commercial LPUE trends of the Spanish (kg/trip) fleets and Spanish scientific survey (kg/h) in Div. 9.a south, for *Octopus vulgaris*. 2000-2017 period.

**Eledone spp in Div. VIIIc & IXa (North)**
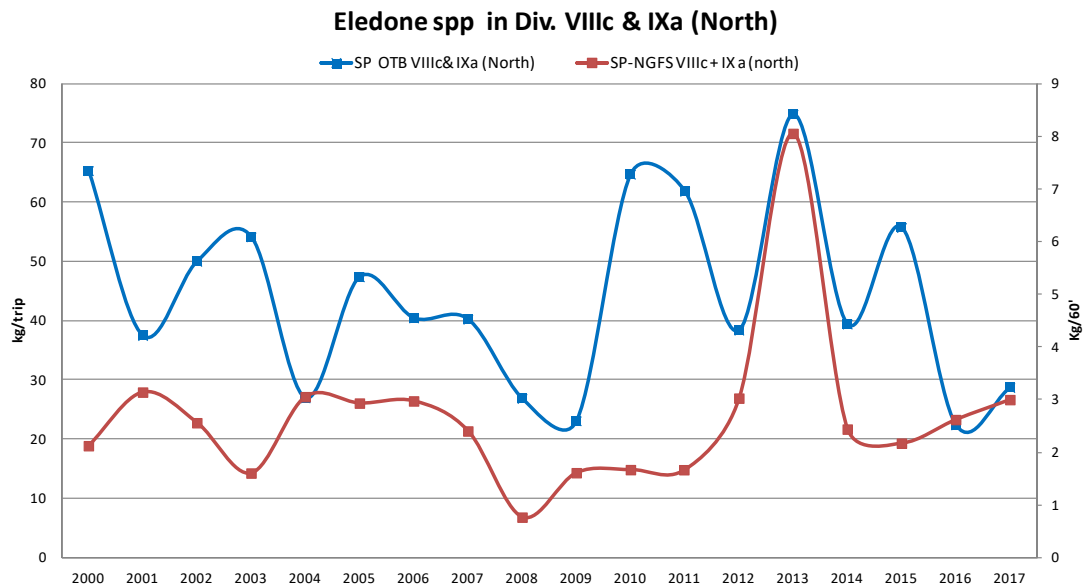
Figure A6.3.3. Comparison of commercial LPUE trends of the Spanish (kg/trip) fleets and Spanish scientific survey (kg/h) in 8.c and 9.a north for *Eledone* spp. 2000-2017 period.



**Eledone spp in Div. IXa south**
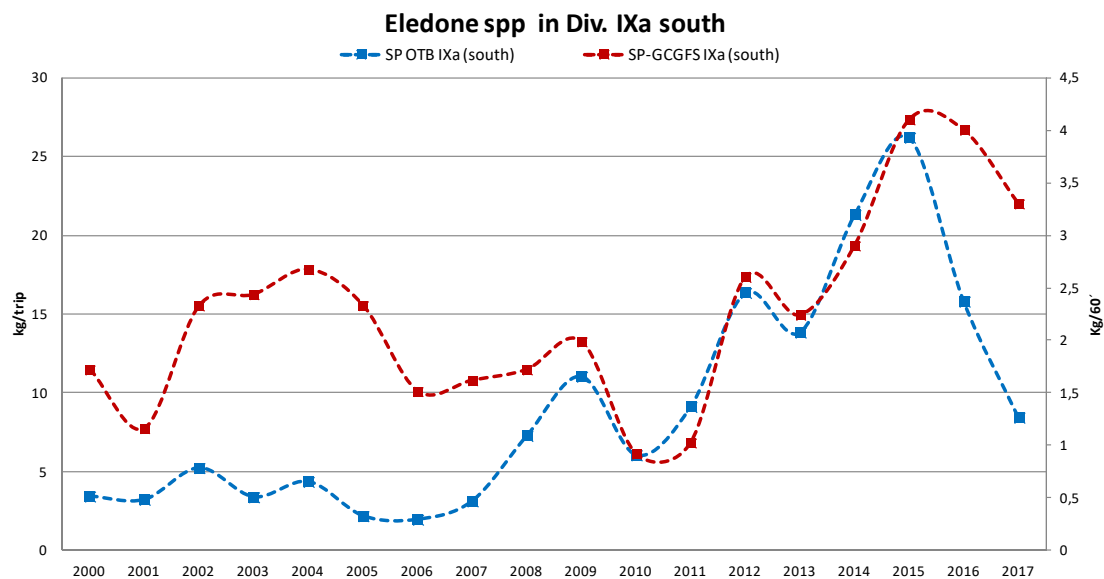
Figure A6.3.4. Comparison of commercial LPUE trends of the Spanish (kg/trip) fleets and Spanish scientific survey (kg/h) in Div. 9.a-south for *Eledone* spp. 2000-2017 period.

Looking at the above figures, the correspondence of survey and commercial abundance series is much more apparent in 9.a south than in the northern area, possibly because the northern area is much larger and encompasses a wider range of habitat conditions. Indices in the north may need to be refined, for example dividing the region into smaller areas. In any case, survey indices did capture peaks and troughs of octopod abundance at least in the most recent years of the years showed the marked high and low abundances shown by the commercial LPUEs series. Discards are negligible for *O. vulgaris* but more variable in *E. cirrhosa*, which needs to be considered when using commercial data. We can be cautiously optimistic that these data series can in future be used as abundance indices for octopods.

**A6.3.1 . Assessment of Octopus in the Gulf of Cadiz.**

In relation with *Octopus vulgaris* in the Gulf of Cadiz, it has been analyzed the influence of environmental parameters on the abundance of this species. In the working document presented we have worked with different hydrography and oceanography parameters (Sea Surface Temperature; Sea Surface Salinity; Surface Chlorophyll; Surface turbidity; NAO Index; Rain; WeMoi Index; AMO index; River discharges and abundance index of octopus). Also has been used a recruit index obtained during a demersal survey carry out in the zone to predict catches in the next year.

The main conclusions were that the abundance of octopus in the Gulf of Cadiz is influenced mainly by rain in the previous year and secondary by the surface sea temperature in April of the previous year. The recruit index obtained in autumn survey can be used to forecast the landing in the next year but this index it is influenced by the number of stations doing in the recruitment zone.

The model to forecast the landing was

$$Landing_{i+1} = s(Recluit_i) + s(Rain_i) + as.factor(ZoneReclu_i)$$

When we applies the model with the data of 2016 (Recruit Index in November and rain during October 2015 to July 2016), the model predict 706 tn for 2016-2017. In June of 2017 the total landing was about 750 tn and the fisheries is close for spawning period until 15th June and will be close again in September and October for recruitment period. Probably the total landing for period 2016-2017 will be about 800 tn and the model had predicted 706 tn.

**Annex 9. ToR A (2016) and ToR B (2017): proposed manuscript**

DELIVERABLE: Peer-review paper in relation to status and trends (original target date: Year 3: 2016).

Process

- Write outline
- Figure out the best commercial effort data and LPUE
- Upload lists of datasets
- Upload datasets
- Upload graphical analyses and descriptions including descriptions of issues with data
- Compile
- Exploratory analysis to identify best series, decide on standardisation if any
- Simple indices based on comparisons of recent years (e.g. ratio of last 2 years sum or average to previous 3 years' sum or average
- Identify relevant fishery pressure and environmental data series
- Run analysis, e.g. GAM (single data series), DFA (multiple series)

Issues

- Data quality changes over time (short series of good data)
- Landings data may be fine but effort data less likely to be trustworthy (are they the right effort?) (if we get only effort from bots catching cephalopods, CPUE could appear to go down in good years!)
- Survey series may have used different nets or boats over the years
- Species ID incomplete and inconsistent in some cases. May need to analyse trends at family level (even if species are identified in all years the proportion of catches identified to species may not be consistent between years
- Analyse numbers or weights?
- Wide range in absolute catch rates (e.g. with different gears); some gears may be less good at sampling particular species

**Status and trends of European cephalopod stocks**

Authors: all contributing WGCEPH (and C&C) members

**Introduction**

WGCEPH aims to undertake exploratory and retrospective stock assessments for commercially exploited cephalopods in European Atlantic waters. It issued formal data calls in 2017 and 2018. Trend evaluation is a first step towards formal assessment. One of the intended deliverables of the previous iteration of WGCEPH was a manuscript on trends in cephalopod stocks in ICES waters.

*Cephalopods - squid, octopus and cuttlefish – are increasingly important fishery resources*

Many authors have highlighted the potential for cephalopods (squid, cuttlefish and octopus) to replace overfished finfish stocks, ecologically and/or as fishery resources (Caddy & Rodhouse, 1998; Balguerias et al., 2000; Jackson & O´Dor, 2001; Hunsicker et al., 2010). FAO statistics indicate the cephalopod landings have continued to increase at a time when global fishery production is declining and recent global analysis (Caddy & Rodhouse, 1998; Doubleday et al., 2016) suggests a general upward trend in cephalopod abundance. Increasing abundance is a plausible consequence of ocean warming and may also follow from depletion of finfish stocks (see Caddy & Rodhouse, 1998).

The purpose of the present paper is to provide a more in-depth evaluation of trends in cephalopod abundance at a regional scale, integrating data from fisheries and surveys for the various commercially important cephalopod families in European Atlantic waters. This in part updates a previous exercise (Pierce et al., 1995).

*Cephalopods are sensitive to climate and resilient to fisheries*

Cephalopods are notoriously sensitive to climatic variation (e.g. Summers, 1985; O´Dor, 1992; Hanlon & Messenger, 1996; Jackson & O´Dor, 2001; Pierce et al., 2008; Rodhouse et al., 2014). They show marked year to year fluctuations in abundance, distribution and phenology - Summers (1985) described cephalopod stocks as "fickle"! This reflects their high metabolic rates, phenotypic plasticity and short life cycles; the lack of overlap between successive generations in most species means there is no buffer against poor recruitment but the high phenotypic variability likely confers resilience to overfishing. Even in strongly seasonal species, often two or more cohorts or micro-cohorts may be distinguished within each generation – cephalopods do not put all their eggs in one basket, as it were.

In examining environmentally-driven variation we would need to be able to control variation caused by fishing mortality and due to density-dependent population regulation (if it exists in these species). Where trends appear to be fishery–induced it would be interesting to try to identify the root (presumably socioeconomic) causes.

*Management: cephalopods as environmental indicators*

Aside from project-based work and the work of ICES WGCEPH there is essentially no assessment of cephalopod stocks and indeed stocks are generally undefined. However, suitable methods exist, as shown by the above-mentioned activities and the approaches taken to assessment in range of cephalopod fisheries around the world. Documenting and understanding patterns and trends in cephalopod abundance is essential to underpin sustainable fishing of cephalopods. In Europe it

remains the case that a large proportion of cephalopod landings are taken as bycatch in fisheries for other species. Even if this situation were to continue, the need for assessment in those fisheries targeting cephalopods is evident, not least from the uncontrolled harvesting of cuttlefish in the English Channel in autumn 2017[1] during a period of apparently exceptionally high local abundance. Of course, the need for assessment also implies the need for management measures, including precautionary measures, to ensure sustainable extraction. Currently large-scale metiers taking cephalopods are subject to the general (e.g. EU and national) regulations applying to all European fishing boats operating in European waters but there are few measures specific to cephalopod fishing. Some EU countries apply minimum landing sizes for cephalopods while the UK government permits trawlers targeting squid to use a smaller mesh size when targeting squid. Small-scale (artisanal) directed fisheries are in theory relatively tightly controlled in southern Europe, under a plethora of regulations concerning the fishing gear(s) deployed and where and when fishing is allowed. However, in practice there is little control either of total catch or of total effort (the latter is especially evident in the case of pot fisheries for octopus), and indeed monitoring of fishing activity is poor.

In the wider context of an ecosystem-based approach to fishery management, the important trophic role of cephalopods and their high production to biomass ratio mean that documenting their abundance and trophic relationships is a key component of understanding ecosystem structure and function. Their importance has also led to cephalopods being considered as indicators under several descriptors of the Marine Strategy Framework Directive.

*Data sources*

We anticipated some limitations with the planned analysis. In commercial landings and many fishery surveys, cephalopods are not identified to species level (often only to family level). Although information on genetic stock structure is available for many species, there has generally been no formal definition of populations or stocks or (almost inevitably given the lack of management) management units. Consequently, knowledge of the range of stocks is lacking and by default we will use the distribution range covered by the fisheries and survey programmes which provide data.

Many fish surveys also record cephalopods but survey data present multiple  issues, including incomplete and inconsistent species identification, questionable suitability of the gear (e.g. bottom trawling is likely to be a poor indicator of both benthic species like octopus and pelagic squids), little knowledge on gear selectivity, inappropriate times of year (cephalopod abundance is very seasonal, seasonality differs between species and life cycle phenology can vary with latitude and ocean climate (e.g. Sims et al., 2001), limited spatial coverage (many surveys cover only small parts of the range of cephalopod species and trends can differ between areas) and inadequate sampling intensity (most fish surveys aim to take one haul per ICES rectangle but cephalopods can have very patchy distributions). Acoustic surveys tend not to be useful as the signal from a cephalopod tends to be weak and in any case their acoustic signals are poorly known. Finally, some cephalopods are vertical migrators so catch rate can follow a diurnal cycle. Given the variability in local abundance and patchiness of distribution, it may be necessary to standardize catch rates (e.g. to control for local spatial and temporal variation) and consider the use of non-standard statistical distributions when doing so.

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[1] https://www.devonlive.com/news/devon-news/ugly-fish-sparked-multi-million-517743

Commercial fishery data does not suffer from all these issues. Certainly, there is better coverage in space and time, albeit with a mixture of fishing gears, although species identification is even more limited than in the case of survey data. In addition, except in coastal artisanal cephalopod fisheries, most fishing effort is not directed at cephalopods, making it difficult to select an appropriate measure of effort. In practice, total fishing effort may be an adequate indicator, especially if effort is effectively randomly distributed in relation to cephalopod presence, and given the absence of quota restrictions on cephalopod landings, provided that cephalopods are landed and not discarded.

In some fisheries, landings and LPUE give almost identical signals and landings may be a useful index of abundance. The meaning of fishery catch per unit effort may well differ between target catches and bycatch. In the bycatch fisheries, the relevant fishing effort may be difficult to define and, unless discarding is important, landings may provide a useful abundance index. Otherwise, landings (or catches) per unit effort are likely to be more useful. Nevertheless, caution is always needed when using landings as an abundance index since external factors can modify the relationship between landings and abundance, e.g. changes in fishing practices, new regulations, etc, even if such changes are driven by the status of other fished stocks.

*Objectives*

We aim to answer the following questions:

- Can we identify (and where necessary account for) trends, cycles and autocorrelation in the data series?
- Are all exploited cephalopods in European Atlantic waters increasing and/or are some increasing more than others?
- Is year-to-year variation consistent (collinear) across taxonomic groups and across areas; can this be used to inform decisions about management units?
- Can we relate the patterns and trends seen to external (environment, fisheries) and internal (density dependent processes) drivers? Where change is fishery-driven, can we identify the ultimate causes, e.g. was it market-driven?
- Can we determine stock status and can we identify species, stocks and/or regions where uncertain or poor stock status justifies the swift introduction of fishery monitoring, assessment and management?

We also address pertinent methodological questions
- Do surveys and fisheries provide similar abundance signals; do surveys at different times of year and in different localities provide similar signals? If not, which is more reliable?
- Are landings data useful to provide an abundance index if no effort data are available?
- How much spatial variation is seen in local abundance trends within the range of what might be assumed to be a stock?
- What is the effect of standardisation of the time series (e.g. for variation in time of day, location and date on which individual trawl hauls are taken) and is it justified?
- What changes in data collection (if any) are necessary to allow appropriate stock assessment?

**Methods**

*Selection of data sources*

Of the four main cephalopod categories, fishery data on loliginids and ommastrephids tend to mix multiple species. In a few areas, for example Galicia for ommastrephids and the English Channel for loliginids, data exist on the proportions of different species in landings. In other areas, such as Scotland for *Loligo forbesii* and much of the Iberian Peninsula for *L.* vulgaris, catches can probably be assumed to be monospecific. For cuttlefish, most landings will be *Sepia officinalis* while in octopus, *Octopus vulgaris* is generally separated from *Eledone* spp. For each family, a decision about taxonomic resolution (e.g. family, genus, species or mixed) will be made after preliminary examination of the data.

In relation to survey data, past experience suggests that cephalopod catches from some countries have not been uploaded onto the ICES database and in others, species identification is only to family level. As such, again it is necessary to be selective about the data sets used.

In general, we need datasets with reliable species identification, based on appropriate gear and offering a reasonable length of time series (not less than 10 years). All candidate data sets will require detailed exploration. As far as possible, survey data are needed by haul, allowing some estimation of uncertainty around annual estimates – and potentially permitting some standardisation (e.g. to account for year to year variation in timing and location of the survey.

Both commercial landings + effort and trawl surveys provide possible abundance indices, as do some preliminary assessments. Available data series will almost certainly start at different times. Thus in Spain and Portugal, data quality I probably highest in the last decade and some data are available going back to around 1980 and 1992 respectively.

What is the right temporal/spatial scale and resolution? (annual or by fishing season)? Default is by year but where possible do it by fishing season?

*More methods notes: data collation and processing*

1. Update, quality check and collate 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

2. Description of series from each country

   For CPUEs

   - Fleets & metiers for description of CPUEs: brief description of the metier including whether cephalopods are targets or just by-catches
   - Description on how catches are raised, so include description of data collection and raising procedure
   - Comment on effort sampling and best units used for each of the commercial fleets.
   - For those CPUEs that are standarised,there is a need to explain how it has been done.

   For Surveys:

- Brief description of the Surveys: area coverage, seasonallity, data series (years)
- IBTS: go to the descriptions of each of the surveys for methodologies for abundance calculation ( stratified random sampled). Check for biomass or individuals (most of the surves use bionass)

3. Assemble abundance series into common format:
4. Standardise some or all series (default is not!)
5. Produce and update CPUEs for the main cephalopod métiers and species if feasible, also survey CPUE data series, and assess the possibility of their use as abundance indices.
6. Source environmental series (annual, seasonal indices, time lags)
7. Explore socioeconomic time series (market forces)? Use economic data collected under Data Call (?)

*Methods: data presentation and analysis*

1. Visual/graphical/statistical exploratory analysis:
   - Examine year-to-year trends in landings/catches/CPUE (use Graham´s CIAC 2015 presentation as an example on regional comparison between CEFAS surveys of Loliginids)
   - consider relationships to fishing pressure and environmental conditions
2. Time series decomposition and autocorrelation analyses

3. Analysis of trends and relationships: GAM, GAMM, DFA
   - Identification of common trends
   - Comparisons across regions, species, and different data sources (commercial *versus* surveys)
   - Analysis of environmental (and fishery and stock) effects: Can we use previous year´s landings as an index of fishing pressure?
   - Are fishery-driven trends related to specific market pressures?

4. Estimate relative exploitation rates if available (e.g., catch/ biomass) to evaluate stock status

Table 1 List of data sets

**Results**

**Discussion**

- Comment on utility for fishery stock assessment and MSFD monitoring

**References**

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**Annex 10. Assessment of cephalopods in European waters: state of the art and ways forward**

Authors: All WGCEPH (and C&C) contributors to the contents

Note also that this is more of a review paper than a paper with new data.

INTRODUCTION

*The need for assessment*

Cephalopod fisheries in EU waters are managed only at national and regional levels; there are no catch quotas and no formal stock assessment, although data on some stocks are collected through the DCF. ICES does not issue advice on cephalopod stocks. However, the increasing focus on cephalopod fishing, as finfish stocks decline and cephalopod stocks apparently generally increase (Doubleday et al 2016), is likely to necessitate routine assessment and management intervention in the foreseeable future. This comes at a time when the EU has embraced the concept (if not the mechanisms to achieve) integrated ecosystem assessment (IEA) for fisheries, coupled with and integrated ecosystem-based approach to management, to be delivered through maritime spatial planning. The known sensitivity of cephalopods to environmental change, arising from their "live fast, die young" life history, suggests that an integrated ecosystem approach might be particularly appropriate for these species.

*What kind of assessment?*

Integrated ecosystem assessment (IEA) and integrated (marine) management (IMM) were central concepts of the (2009-2013) ICES Science Plan (ICES ***), aiming to put fishery impacts, and fishery benefits in the wider context of ecosystems and the connected human systems. In relation to current single- and multi-species assessments, the implementation of these concepts seemed to imply a step increase in data collection, modelling capability and the complexity of decision-making. However, arguably, more data and more complex analytical assessments and decision-making systems may not be the best or only route to achieve IEA and IMM.

Progress towards IEA has been limited due both to the real logistic (and budgetary) challenges and the perception that it is unachievable. However, in the field of conservation, the Marine Strategy Framework Directive (MSFD), by setting the goal of Good Environmental Status (GES) in European seas, effectively requires an overall assessment of ocean health, which is being delivered through a series of indicators. For exploited species (descriptor 3 of 11) existing stock assessments will provide some of the indicators. In addition, the development of conceptual frameworks such as the three pillars of sustainability and "ecosystem services" and tools such as the Ocean Health Index and fishery certification procedures, along with advances in ecosystem modelling, help to promote a more holistic view of the costs and benefits of fishery exploitation and how they might be assessed (e.g. considering stock, ecosystem, social and economic outcomes). Again existing stock assessments may be included in the process but such approaches also potentially provide mechanisms to combine quantitative and qualitative information, plus expert judgement, to deliver semi-quantitative and non-analytical solutions for IEA and to design

and test (through exploration of scenarios) appropriate management procedures and governance options.

*The cephalopods and cephalopod stocks*

Cephalopods present particular challenges due to their short-lives, fast metabolism and environmental sensitivity, expressed through highly variable growth rates, variation in life cycle phenology both within and between years, distribution hits and wide fluctuations in abundance. The jury is out in terms of their susceptibility to overfishing. Cephalopods characteristics can affect resilience to fishing both negatively (e.g. non-overlapping generations) and positively (e.g. life cycle variability and plasticity). Some examples of stock declines (or disappearances) especially in the ommastrephid squids, may have been due at least in part to overfishing.

It is generally believed that discrete stocks are most likely to be identifiable in the less mobile species (octopus) and least likely in migratory oceanic squids. The current paucity of information on cephalopod stocks is one barrier to future assessment.

*Past achievements*

Despite their "unusual" life history (compared to most finfish), a wide range of traditional stock assessment approaches has been applied to cephalopods (Pierce & Guerra, 1994) and possible approaches have been explored under the auspices of several European projects. The short life cycle suggests the use of in-season assessments such as depletion methods, as applied for many years in the Falkland Islands, coupled with real-time management. At the opposite extreme, production models have also been successfully applied, as in the Saharan bank cephalopod fisheries even though variable carrying capacity (due to environmental sensitivity) undoubtedly introduces noise.

*Objectives*

Thus, in this review of assessment of cephalopod stocks and fisheries we aim to look beyond formal analytical stock assessment to the range of alternative approaches currently available, including:

> *Where we are*
> 1. The current importance of cephalopod fisheries (Daniel)
> 2. Species and stock identification (Louise)
> 3. Relevance of the cephalopod life cycle
> 4. The role of cephalopods in the ecosystem (Daniel)
> 5. The meaning and purpose of assessment
> 6. Information currently available: surveys, DCF, fishery data
> 7. State of the art cephalopod stock assessment (Jean-Paul, Lisa)
> 8. The Russian approach to cephalopod fisheries (Fedor)
> 9. Lessons learned from past research and data collection projects (Graham et al)
> 10. Current management (Christopher, Graham, Cristina)
> 11. The elephant in the room: cephalopods and climate change
>
> *Moving forwards*
> 12. Better understanding of life-cycles (Jessica, Anne Marie, Graham)
> 13. Making better use of the DCF (Marina, Catalina)

14. Using surveys (Daniel, Ana)
15. Simple tools to assess stock status (Lisa)
16. Introducing environmental variation into assessment models (Jean-Paul, Ignacio)
17. Cephalopod-based indicators for the MSFD (Graham, Begoña)
18. Socioeconomic fishery assessment (Sebastian)
19. Realising the potential of cephalopod fishing, especially in areas where cephalopods are not targeted (Daniel, Anne Marie)
20. Cephalopod fishery certification (Carlos, Angel)
21. Future management of large-scale cephalopod fisheries (Ana, Ane, Marina)
22. Small-scale cephalopod fisheries: management, governance (Cristina)


**Brief notes on individual sections**

**Section A: where we are, state of the art**

1. The current importance of cephalopod fisheries; amounts landed, value, contribution to protein supply, contribution to trade – by region (Daniel, … ??)

2. Species and stock identification (Louise)
   - How and why to identify to species
   - What are the stocks/management units?
   - The methods (genetics, trace elements, etc)

3. Relevance of the cephalopod life cycles
- How are cephalopods different and what are the consequences? (short-lived, fast growth, high P/B, many from SSF, data poor)
4. Cephalopod role(s) in the ecosystem (Daniel): roles as prey and predators, high P/B ratio, pioneer species replacing fish?, keystoneness (see Brazil ecosystem model, unpublished Moray Firth model (Sansanee Wangvoralak); cephalopods as ecosystem engineers – link to an (integrated) ecosystem-based approach

5. The meaning and purpose of assessment (Lisa, Jean-Paul, Graham?)
- What is assessment, what is assessed and what is it for? (e.g. traditional stock assessment)
- MSFD environmental status assessment, MSC criteria and assessment
- Ecosystem approach, integrated ecosystem assessment
- Assessment to management; basis for sustainability

6. Information available for assessment: surveys, DCF, fishery data (Ana, Marina?)
7. State of the art cephalopod stock assessment (Jean-Paul, Lisa)
- What has been done for cephalopods in the ICES area?
- Assessment methods that work
- Accounting for discards – is it important?
- What else could be done?
- What has been done outside the ICES area

8. The Russian approach to assessing cephalopod fisheries (Fedor)

9. Lessons learned from past projects (Eurosquid, data collection projects, etc) and from WGCEPH (Graham,Jean-Paul, Uwe)
10. Current management and governance (Christopher, Graham, Cristina)
- Approaches used, what has been successful, where stocks have decreased due to target fishing
- Other systems, e.g. management by results
11. Climate change and cephalopods

## Section B Looking forward

12. Better understanding of life-cycles (Jessica, Anne Marie, Graham)
13. Making better use of the DCF (Marina, Catalina)
14. Using surveys (Daniel, Ana)
15. Simple tools to assess stock status (Lisa)
    o Simple stock status metrics (survey catch rate, exploitation rate)


16. Introducing environmental variation into assessment models (Jean-Paul, Ignacio)
17. Cephalopod-based indicators for the MSFD (Graham, Bego, Julio, Ester)
- D1 indicators (diversity), D3 indicators (fisheries), Other descriptors

18. Socioeconomic fishery assessment (Sebastian, Cristina)
19. Realising the potential of cephalopod fishing, especially in areas where cephalopods are not targeted – building the case for future assessment and management (Daniel, Anne Marie)
20. Cephalopod fishery certification (Carlos, Angel)
- MSC criteria (prescriptive of achievement and not necessarily of the methodology)
21. Large-scale fisheries management (Ana, Ane, Marina)
22. Small-scale cephalopod fisheries: management, governance (Cristina)

**Annex 11. ToR C Updated review of recent publications about life-history parameters in Cephalopods exploited in ICES waters**

Lead author : Fedor Lishchenko

*A11.1 Introduction*

This section presents an update on a review of the recent publications on the major cephalopod species commercially exploited in the ICES area and adjacent waters. The following species were chosen for review based on the level of commercial exploitation and distribution: octopuses – *Octopus vulgaris, Eledone cirrhosa, Eledone moschata*; cuttlefishes – *Sepia officinalis, S. elegans* and *S. orbignyana*; sepiolids – *Sepietta oweniana* and squids – *Loligo vulgaris, Loligo forbesii, Alloteuthis subulata, Alloteuthis media, Illex coindetti, Todarodes sagittatus, Todaropsis eblanae, Ommastrephes bartramii* and *Gonatus fabricii*. Over 200 journal articles devoted to studies of life history, distribution, trophic relationships, taxonomy, fisheries and impact of climate change on these species were published during the last six years (2013-2018).

Most of studies were devoted to 5 cephalopod species - *O. vulgaris, S. officinalis, L. vulgaris, I. coindetti* and *O. bartramii*. Such interest in *O. vulgaris* and *S. officinalis* reflects their exceptional importance for European fisheries and the interest in aquaculture. Thanks to well-developed methods of rearing in captivity, common octopus and common cuttlefish serve as models in a wide variety of studies. Both species are exploited across their range, providing the highest catches among cephalopods in the European waters. The next two species, *L. vulgaris* and *I. coindetti*, are the main commercially exploited squid species in Europe among the Myopsids and Oegopsids, respectively. Depending on region and season, *L. vulgaris* can contribute up to 90% of total loliginid catch while *I. coindetti* makes up to 80% of ommastrephid landings (Jereb et al., 2015). In contrast to the aforementioned species, *O. bartramii* is mainly studied in the Pacific and more than 90% of articles reviewed were devoted to studies of Pacific populations of this squid. However, a number of these outputs are also relevant to Atlantic populations.

Other commercially exploited cephalopod species in the ICES area (*E. cirrhosa, E. moschata, S. elegans, S. orbignyana, S. oweniana, L. forbesii, A. subulata, A. media, T. sagittatus, T. eblanae* and *G. fabricii*) have been the subject of fewer studies in the last 6 years.

*A11.2. Octopus vulgaris*

*A11.2.1. Introduction and overview*

More than 90 journal articles connected with studies on this species were published during the period from 2013 to 2018. Recent studies on environmental effects not allowed only identification of factors affecting the distribution, migration and survival of adult octopuses, but also provided information on the impact of waters conditions on the paralarvae. This knowledge contributes to improvement of quality of life for reared larvae, which facilitates achievement of faster growth and better survival. Studies of various approaches to feeding octopus paralarvae, and an analysis of the effect of dietary nutritional composition on the composition and development of octopus tissues, contributed to better understanding of the nutritional requirements of hatchlings and juveniles. In addition, a considerable number of recent studies concerned age estimation, growth rates, parasite infections, morphology and reproductive biology of *O. vulgaris*.

Jereb et al. (2015) identified the following topics as important for future research: investigations on (1) early life stages, (2) the influence of environmental conditions on wild *Octopus vulgaris* populations and (3) development of inert diets or microencapsulated products to produce enriched Artemia for feeding paralarvae. Topics 1 and 3 continue to be areas in which further work is needed.

*A11.2.2. Early life stages and environmental effects*

Previous studies on *Octopus vulgaris* have highlighted the need to develop topics such as early life stages and the influence of environmental conditions on the wild populations. Moreno et al. (2014a) showed that changes in bottom salinity and river runoff are major influences on *O. vulgaris* distribution and abundance.

Salinity change affects the intensity of feeding and survival of octopuses (Amado et al., 2015; Iglesias et al., 2016). Low salinity leads to decreased food consumption and ultimately to the cessation of feeding. Decreased salinity during runoff events can be fatal to octopus, due to disruption of osmoregulation (Raimundo et al., 2017). However, octopuses can survive reduced water salinity (not lower than 30 psu) at least for short periods. In paralarvae of *O. vulgaris* Type II, tolerance to seawater dilution has been tested by Castellanos et al. (2018). They concluded that paralarvae tolerate some deviation from seawater salinity, displaying osmoconforming behavior, maintain body hydration, high ability of tissue volume/water regulation in short periods of time. This capacity might be one factor allowing their dispersal and survival along environments with moderate deviations from seawater salinity.

Investigation of the spatio-temporal dynamics of the post-settlement population sex ratio of *O. vulgaris* off the NE Atlantic showed that sex ratio varied along a bathymetric gradient and between seasons (Alonso-Fernandez et al., 2017). Male dominance was observed in summer, while autumn populations were female-biased. A larger proportion of females was observed in deeper waters during winter and spring. New information on environmental impacts on octopus abundance and the period of reproduction in the Northern Alboran Sea is described by Garcia-Martinez et al. (2017), who concluded that embryonic and paralarval phases will depend on the spawning day and the annual cycle of water temperature. A direct-observation study in the waters of the Atlantic Galician Islands (NW Spain) showed that the type of dens, substrate, abundance and availability of food are the main factors influencing octopus distribution. Juveniles *O. vulgaris* generally occupied holes sunk perpendicular into the substrate. Some of the old and well-built dens occupied by older individuals may be used successively by several generations of octopus (Guerra et al., 2014). The availability of shelters can be a limiting factor for octopus distribution, and several studies of different species have described home choice and suggested characteristics used in the selection of hiding places (Mather 1982, Altman 1967, Katsenevakis and Verriopoulos 2004b). A mark-recapture experiment in the Sardinian Sea revealed the significance of food and shelter availability (especially for females) for the migratory activity of *O. vulgaris* (Mereu et al., 2015). Physiological responses of *O. vulgaris* to different coastal environments in the Mediterranean Sea have been analyzed by Sillero Rios (2017). Oxidative stress mechanisms have been studied in areas with different degrees of human activities or impacts. Antioxidant enzyme activity in the marine reserve area was significantly lower than in the two anthropogenic areas. Using a capture-recapture model, Arechavala et al. (2018) reported that human-altered coastal habitats, which are characterized by abundant shelters, abundant food and absence of predators, can act as settlement and growth areas for juveniles and adults of *O. vulgaris*.

There is still relatively little information available on *O. vulgaris* early life stages. However, some recent studies have contributed to fill this gap. Observation of brooding, female octopus in their natural habitat showed that hatching took place when water temperature increased to ~20°C. During hatching, the females slightly opened and closed the den entrance to provide a way out for the small groups of hatchlings (Hernandez-Urcera et al., 2014). Newly hatched paralarvae use external yolk to grow before they become able to catch prey. The intensity of yolk utilization is highly influenced by the ambient temperature. Lower temperatures reduce the energy requirements and increase the duration of yolk consumption, facilitating the survival of hatchlings (Nande et al., 2017).

Paralarval abundance is influenced by the hydrography and circulation of inhabited waters. For instance, the North-West Iberian upwelling system provides the high water temperature and low water column stability preferred by octopus paralarvae (Otero et al., 2016). Recent studies revealed that *O. vulgaris* paralarvae are not retained over the shelf, but have an oceanic strategy different from the other neritic species (loliginids and sepiolids) (Roura et al., 2015, 2016). Daily rings in beaks from the full ontogenetic range, including early stages, of *O. vulgaris* have been validated by Perales-Raya et al. (2014), and later used for age estimation (Garrido et al. 2016) and to identify potential rearing stress in captive paralarvae (Franco-Santos et al. 2016). Perales-Raya et al. (2017) estimated ages of wild and captive *Octopus vulgaris* paralarvae supporting the hypothesis that in East Atlantic Waters the species leaves the coastal area and develops in the open ocean transported by upwelling filaments. Their experiments in captivity showed that increment deposition was not affected by diet but influenced by low temperature. Daily increment deposition was confirmed at 21°C (optimal rearing conditions) but <1 increment per day was recorded at 14°C. At this "adverse" rearing temperature, the authors observed higher variability and very slow growth of beak and

body weight. Low rearing temperature could result in cessation of paralarval growth, and slower increment deposition or overlapping increments. Recent analysis of embryonic development in octopus beaks (Armelloni et al. 2017) confirmed the hatching mark in the rostrum surface of beak which corresponds to the first increment. They also reported the presence some increments in the lateral walls before hatching and described the effect of temperature on the embryonic beak growth.

### A11.2.3. Diet and nutrition

Recent studies on diets of octopus paralarvae included both experiments in captivity and investigation of the prey spectrum of wild individuals. Experiments revealed that enrichment of live prey by marine phospholipids has a beneficial effect on paralarval growth and improves animal survival rate (Garrido et al., 2016a; Morales et al., 2017; Roo et al., 2017). However, analysis of diet nutritional composition showed that cultured paralarval rations differed significantly from those of wild ones (Garrido e. al., 2016b). *O. vulgaris* paralarvae are highly selective predators and changes in diet are driven by seasonal and spatial changes in availability of prey (Olmos-Pérez et al., 2017; Roura et al., 2017). Comparison of live prey and extruded diets, based on different fish, squid and crabs, revealed that the both types of food apparently promote growth and survival of octopus juveniles equally. Thus, dry, pelleted meals can be used in aquaculture, although optimization is needed as assimilation efficiency is still lower than for natural diets (Querol et al., 2015, Rodríguez-González et al., 2015). Culturing paralarvae in an upwelling system supplying natural zooplankton, Dan et al. (2018) significantly improved paralarval growth and survival rate. The authors suggest that inadequate water-flow environment and poor food quality and quantity are the main causes of paralarval mortality.

Diets of wild *O. vulgaris* from Atlantic and Mediterranean coasts were analyzed by Ajana et al. (2018) using stomach contents and concluded that bivalve mollusks as the most frequent prey group, followed by brachyuran crustaceans and teleosts. In small and large specimens, crustaceans and bivalves, respectively, were dominant and no differences were observed by sex and season.

### A11.3. Eledone spp.

Jereb et al. (2015) highlighted five priority fields for future research on *E. cirrhosa* and *E. moschata*, namely (1) spawning sites, (2) fecundity, (3) studies on early life stages, (4) age increment reading of beaks and stylets, and (5) genetic studies for stock identification of these species. Of these, only three have received substantial attention. Additional research is still needed on stock separation in both *E. cirrhosa* and *E. moschata*¸ spawning sites and early life stages in *E. cirrhosa* and reproductive biology and stock status evaluation in *E. moschata*.

The age of *E. cirrhosa* was estimated using stylets (Regueira et al., 2015) and it was found that lifespan could reach 17 months, with instantaneous growth rates ranging from 0.03% to 2.17% of body weight per day. Regueira et al. (2017) observed that captive females of *Eledone cirrhosa* spawn within a shelter, within which they remain during egg development, and block the entrance with stones and other materials found near the burrow. Reproductive biology of this species in Atlantic Iberian waters and Tunisian waters was described by Regueira et al. (2013) and Rjeibi et al. (2013) respectively. Parasites of *E. cirrhosa* in the Bay of Biskay and Gulf of Tunis were investigated by Souidenne et al. (2016), who examined an 18S rDNA sequence for *D. eledones* which showed genetic differences from other dicyemids. Other studies of *E. cirrhosa* concern distribution (DeLaHoz et al. 2018), diet (Regueira et al. (2016), beak morphometry (Ikica et al. 2014) and impact of environmental variation and trophic relationships (Lauria et al., 2016, Regueira et al., 2014; Regueira, 2017; Puerta et al., 2014; 2015; 2016).

Recent studies on *E. moschata* concerned distribution (Gajic et al., 2014, Ikica et al., 2015) and environmental effects on abundance and distribution (Lauria et al., 2016, Torres et al., 2017).

### A11.4. Sepia officinalis

In the most recent review of studies on cephalopod life cycle biology (Jereb et al., 2015), the following fields of study were highlighted as important future research directions of common cuttlefish (*Sepia officinalis*): (1) separation of stocks and populations, (2) studies on trace element and isotope composition of hard structures, (3) development of age estimation methods, and (4) investigation of climate change impact on cuttlefish populations.

In past six years, only two of the four topics indicated as priority fields of research by Jereb et al. (2015) (the second and fourth listed above) have been covered adequately. Significant advances in stock assessment were also reported. Nevertheless, further studies on climate change impact and the effects of pollution on cuttlefish are still needed, despite the relatively high level of knowledge in this field. Studies on the effect of coastal waste (including plastics, heavy metals, oil industry waste) and sound/light pollution on cuttlefish are of a great interest. Monitoring the exploited stocks' status is essential due to the considerable commercial value of cuttlefish. Protected areas are of great importance, which could benefit the widely-migrating species of cephalopods, and the development of fishery management options for cases of stock depletions. Research is still needed to develop a simple and reliable tool for age estimation.

Methods for cuttlefish age determination are still not very effective (Raya et al., 1994; Le Goff et al., 1998, Bettencourt & Guerra, 2001, Challier et al., 2002, Domingues et al., 2006). Beaks could possibly be used as a practical and reliable tool for age determination but additional studies (validation of increments deposition periodicity, study on the time of the first increment formation, investigation of erosion of the tip, etc.) are needed. Studies on the spatial structure of cuttlefish populations remain relevant; the great potential of electronic tags in this field should be noted (Wearmouth et al., 2013). In addition, important results on population structure can be achieved using morphometric analysis of hard structure shape, trace-element composition analysis and molecular methods (Fang et al., 2014 b, Fang et al., 2016 a, Fang et al., 2016 b, Green et al., 2015, Lishchenko et al., 2017; McKeown et al., 2015).

Some studies on cuttlefish published over the last 6 years were not so closely related to these major goals. However, they significantly broaden our knowledge in respect of species biology, its behaviour, study methodologies and fishery management.

*A11.4.2. Insights from studies on stable isotopes and trace elements and impact of pollution on cuttlefish stocks*

In a study on the variation of $\delta^{13}C$ and $\delta^{18}O$ in the cuttlebones of three cuttlefish species, Dance et al. (2014) showed that the values of $\delta^{13}C$ and $\delta^{18}O$ increased from cuttlebone core to its edge, which may be a consequence of ontogenetic migration nearshore nurseries (lower seawater $\delta^{13}C$ and $\delta^{18}O$ values) to offshore overwintering habitats (higher seawater $\delta^{13}C$ and $\delta^{18}O$ values). Additionally, this study showed lower values of $\delta^{13}C$ and $\delta^{18}O$ in *S. officinalis* in comparison with *S. elegans* and *S. orbigniana,* reflecting different spawning behaviours of these species.

Variability in trace element concentration and its effects on juvenile cuttlefish have been investigated in several recent studies (Raimundo et al., 2014, Le Pabic et al., 2014, Rjeibi et al., 2014, Le Pabic et al., 2015, Lacoue-Labarthe et al., 2016). Trace elements are consistently accumulated in the tissues of cuttlefish, with the highest levels in the digestive gland tissue and the lowest in muscles (Rjeibi et al., 2014; Rodrigo & Costa, 2017). The second study also indicates the role of the digestive gland in the detoxication process. This problem is comprehensively examined in the study of Penicaud et al. (2017). In particular, subcellular locations of the trace elements and rates of their accumulation and detoxication rates are studied. Study on trace element accumulation in the highly contaminated area in Central Mediterranean (Signa et al., 2017) shows that cuttlefish have relatively higher concentrations of Hg in their tissues in comparison with other cephalopod representatives of benthic communities. Several studies concern the effects on cuttlefish of high concentrations of dissolved Zn in seawater (Le Pabic et al., 2014, 2015, Lacoue-Labarthe et al., 2016). The studies highlighted Zn-induced growth reduction (at a concentration of 108 µg·l-1) and mortality (at 185-230 µg·l-1) as well as effects on digestion, behaviour and immunity (Le Pabic et al., 2015). Pharmaceuticals released in the environment are also a cause for concern. Antidepressants released into the environment can affect the camouflage patterns and hunting behaviour of cuttlefish, leading to lower rates of survival

(Di Poi et al., 2013, 2014, Lacoue-Labarthe et al., 2016). These studies, and studies on the effect of sediment contamination (Rodrigo et al., 2013), have suggested the use of common cuttlefish as a widely distributed and highly sensitive bioindicator of pollution. Finally, the impact of sound pollution was studied (Solé et al., 2017). In this study scanning electron microscopy examination revealed that noise pollution could lead to injury of statocysts. The experimental study on cuttlefish reactions to different levels and frequencies of sound (Samson et al., 2014) showed that cuttlefish demonstrate escape responses to frequencies from 80 to 300 Hz at sound levels above 140 dB. These findings could be used for estimation of the sound pollution impact on cuttlefish stocks.

### A11.4.3. Climate change impacts

The impacts of climate change on distribution and abundance of cuttlefish was the second most popular field of study (see Dorey et al., 2013, Giansante et al., 2014, Keller et al., 2014, Xavier et al., 2016). Dorey et al. (2013) showed how increasing ocean acidification would affect the development of cuttlefish. Although growth rate was apparently not affected by lower pH, incorporation of $^{45}$Ca (i.e. a radiotracer) into cuttlebones significantly decreased with increases of acidification. The authors state that "a decrease in seawater pH by 0.25–0.50 units, as expected in average for the end of the century in global oceans, would increase the accumulation of calcium in the internal calcareous structure by 17–80 % in embryonic and juvenile cuttlefish, respectively." Impact of another warming induced factor, hypoxia, on the common cuttlefish were examined by Capaz et al. (2017). They found that a decrease of dissolved oxygen to 50% causes a significant increase in ventilation rates (85%) against a background of 37% decrease in oxygen consumption.

Migration in Mediterranean populations of cuttlefish is affected by increasing annual SST but, with the exception of a shift in the cuttlefish population dynamics in the early 1980s, no lasting effect of climate change on cuttlefish populations has been found to date (Giansante et al., 2014, Keller et al., 2014). Xavier et al. (2016) discussed possible long-term effects of climate change on *S. officinalis*, noting temperature rises to 9.5º C in the north Atlantic could lead to an expansion of the range of *S. officinalis* to reach the eastern American coast, with potentially high impacts on coastal marine ecosystems.

### A11.4.4. Stock assessment

Probably the most significant progress was made in the field of stock assessment, where a two-stage biomass model was developed (Gras et al., 2014) and improved (Alemany et al., 2015, 2017) for assessment of English Channel cuttlefish stocks. The model developed allows estimating biomass, not only of the exploited part of stock, but also an unexploited winter biomass, and provides a potentially useful tool to allow detection of excessive stock depletion.

The distribution of the fleet and fishing pressure in the recreational fishery for cuttlefish were studied in the Ría of Vigo area (Palas et al., 2017). This fleet exploits an area of approximately 30 km² and contributes up to 11% catches of this species in the area. The authors proposed that marine recreational fisheries should be considered in fishery regulations.

The protective potential of marine protective areas (MPA) for cuttlefish was assessed by Abecasis et al. (2013), who concluded that MPAs are not effective in long-term protection of highly migratory cephalopods such as cuttlefish and thus do not benefit the stocks. Note however, that the most likely value of MPAs would be to protect spawning habitat.

Two more studies should be noted in relation to fishery management and regulation. A study on the Adriatic Sea stock of cuttlefish (Mion et al., 2014) revealed that extension of a summer ban for a trawling fishery could allow a higher portion of stock to reach a commercial size. From our point of view, the results of this research closely relate to the study on cuttlefish survival rate in the English Channel (Revill et al., 2015). According to that study, only 31% of captured non-commercial size cuttlefish remain alive by the time they reach the sorting table. This reveals the necessity of developing methods to reduce the capture of small cuttlefish. It is possible that the solution recommended for the Adriatic Sea stock could benefit English Channel fisheries as well.

*A11.4.5. Other studies*

There are a number of studies on general cuttlefish biology which should be highlighted in this review. The study on effects on artificial incubation on cuttlefish (O'Brien et al., 2017) showed that this type of incubation is no different from natural incubation in relation to hatchling size, defence and predation behaviour. These results show that eggs which would otherwise be lost as bycatch could be reared artificially. The study on reproductive biology in the Aegean Sea (Lampri et al., 2016) showed that spawning and recruitment occurs throughout the whole year, with the peak in the spring-summer period. A study on invertebrate predation revealed that ten species feed on cuttlefish egg masses (Martins et al., 2018). The most important finding was that cuttlefish egg masses could be eaten by the invasive blue crab *Callinectes sapidus*, which should be considered as a new threat for cuttlefish in North Eastern Atlantic waters. A study on the impact of maternal and embryonic stress showed that both natural and artificial stressors affect juvenile cuttlefish hunting behaviour (O'Brien et al., 2017). Weight-length relationships were studied on common cuttlefish from southern Portugal (Vasconcelos et al., 2018). It was shown that, in this part of range, cuttlefish growth follows a hypoallometric growth pattern, which is typical for the species in the other parts of range as well. The main factors affecting the growth pattern are discussed. A study on seasonal changes in locomotor activity showed that cuttlefish show dualistic behaviour, being more active at night during summer and autumn and more active during the day in winter (Oliveira et al., 2017). These findings could be applied to the improvement of the culture protocols. Protocols for small-scale cuttlefish culture were described by Panetta et al. (2017) who report on methodology for maintaining of a small cuttlefish colony for research purposes.

The increasing need for methods of tracking cuttlefish migratory activities has been met by the development of long-term electronic tagging methods (Wearmouth et al., 2013). Tests showed that the electronic tags don't significantly affect cuttlefish natural behaviour and can be used to monitor their migrations. Methods of cuttlefish biology research in the laboratory studies changed significantly after adopting the Directive 2010/63/EU. Methods of sex and maturity determination, tagging and DNA sample collecting were tested, regarding pain, suffering, distress and lasting, harmful effects (Sykes et al., 2017). Tests revealed that the use of an endoscope, visual implant elastomer and swabbing could provide all necessary information without causing said effects. Safi et al. (2018) used digestive enzyme ratios as an indicator of digestive gland maturation in cuttlefish early life stages. According to the study, enzyme ratios precisely reflect both yolk content and digestive gland development. Moreover, this approach could serve as the tool for determination of cuttlefish growth performance supporting culture management.

*A11.5.* **Sepia elegans** and *S. orbignyana*

*Sepia elegans* and *S. orbignyana* are small cuttlefish species distributed across relatively deep waters (up to 580 m) of North-Eastern Atlantic and Mediterranean (Jereb et al., 2015). Both cuttlefishes attain small size (DML of 9 cm and 12 cm respectively in *S. elegans* and *S. orbignyana*) and are of relatively low interest for fisheries, despite their high abundance in some parts of the range.

Both species have been much less studied than *S. officinalis*. Of three studies on *S. elegans* published during 2013 to 2018, a large-scale study of its reproductive biology in the eastern Mediterranean revealed a number of differences from the western Mediterranean and Atlantic Ocean (Salman, 2015). Dance et al. (2014) confirmed differences in the spawning and nursery ground locations of the three Mediterranean cuttlefish species (*S. officinalis*, *S. elegans* and *S. orbignyana*) based on stable isotope analysis of cuttlebone. A study on the composition of trawling fleet catches in the southeastern Mediterranean in 2014-2015 (Rizkalla et al., 2016), showed that *S. elegans* is the sole representative of the family occurring in the catches.

The systematic position of *S. elegans* remains unclear and studies on stocks status are needed in order to avoid potential overexploitation.

In relation to *S. orbignyana*, two recent articles were devoted exclusively to the species and a number mention it as a part of the cephalopod community. The impact of the Eastern Mediterranean environmental

conditions as well as some aspects of reproductive biology of the species in this area were examined by Dursun et al. (2013). Their study showed that *S. orbignyana* experience a phenomenon known as Mediterranean nanism, i.e. animals attain maturity at smaller sizes. Examination of gonads showed that pink cuttlefish in this area spawn all year round and are more r-strategic than in the rest of the range, which may be the consequence of the impact of environmental factors. In the central Mediterranean, cuttlefish represent less pronounced r-strategic traits, reaching maturity at the greater size and having a much lower fecundity (Šifner et al., 2018). Parameters of the length-weight relationship of *S. orbignyana* were estimated in this study as well. It was found that both sexes grow following a negative allometry pattern (b = 2,46 in males and b = 2,62 in females), which corresponds to the growth pattern of cuttlefish in the Gulf of Cadiz are, where scaling exponent b reaches only 2,38 (Torres et al., 2017).

Thus, as in the case of *S. elegans*, lack of studies on stock identification and development of tools for easy identification of landings remain a limitation for the comprehensive understanding of species biology and sustainable fishery management.


### A11.6. Sepietta oweniana

According to Jereb et al. (2015), common bobtail squid, *Sepietta oweniana* is a relatively small sepiolid species widely distributed across ICES area and adjacent waters. Among sepiolids, S. *oweniana* have the greatest commercial value and is exploited as bycatch across its range. On the other hand, common bobtail squid plays an important role in demersal ecosystems feeding on the wide spectrum of small-sized crustaceans as well as serving as the prey for medium and large-sized fish, cetaceans and crustaceans.

Jereb et al. (2015) indicated two fields as the essential for an understanding of species biology: (1) separation of stocks and cohorts and (2) development of easier tools for identification allowing the separation of fishery landings. However, none of 10 articles on *S. oweniana*, published since 2013 targeted these fields. All performed studies could be attributed to one (or more) of three fields: trophic relations, distribution and the life history traits of bobtail squid.

Study on food contents of *S. oweniana* in the northern part of the range showed that individuals caught in the Barents Sea show unusual prey preferences (Golikov, 2014; Golikov et al., 2014). Unlike other parts of the range, fish becomes major prey for bobtail squid in this area. In turn, Lopez et al. (2016) and Kousteni et al. (2017) studied the role of *S. oweniana* as the prey of demersal fish (black and white anglerfishes and two elasmobranchs, the small-spotted catshark and the longnose spurdog, respectively). These studies showed that bobtail squid contributes to the relatively bigger share of black anglerfish diet than to the rest of studied fishes diet.

Another group of studies is devoted to distribution and abundance of the common bobtail squid in the different parts of its range. Golikov et al. (2014) and Xavier et al. (2018) report the first catches of bobtail squid in the Barents Sea driven by ongoing Arctic warming, however, the occurrence of this species in Arctic waters remain infrequent. The opposite situation is observed in western and central Mediterranean (Quetglas et al., 2014; Šifner et al., 2015; DeLaHoz et al., 2018), where *S. oweniana* represents the most abundant sepiolid species (and one of the most abundant cephalopod species) widely distributed across areas and depths. Study of Keller et al. (2017) confirms that S. oweniana is one of the most common cephalopod species in the Mediterranean and describes its depth and temperature preferences. It was shown that bobtail squid abundance is positively correlated with the winter SST, as well as that the bobtail squid follows the dome-shaped depth preference pattern (when abundance achieves maximum at average depth (400 m), lowering at the greater and lower depths).

Finally, the third group is represented by only one study aiming the life history traits (in particular length-weight relationship) of the bobtail squid inhabiting the Gulf of Cadiz area (Torres et al., 2017). It was shown, that among cephalopods inhabiting studied area *S. oweniana* has the lowest scaling exponent (b = 2,07), indicating the most pronounced negative growth allometry.

Summing up, a significant number of studies published in the reviewed period were devoted to S. oweniana, however, essential fields of study, indicated by Jereb et al. (2015) remain being relatively poorly studied.


### A11.7. *Loligo vulgaris*

#### A11.7.1. Introduction and overview

The list of research fields on *Loligo vulgaris*, marked in the previous report as having a significant importance includes three major topics: (1) impacts of climate change, (2) trophic relationships and (3) the development of simple and reliable tools for identification of caught individuals. At present, *L. vulgaris* remains the most studied of European squids. An Internet search in July 2018 implied 9 pieces of research have *directly* (for clarity, this search only included research articles with the species name within the title) studied *L. vulgaris* since 2017, whereas *Loligo forbesii* only produced one item of research, which was, notably, carried out in comparison with *L. vulgaris.* The 9 pieces of research could be split into 4 fields: climate change (n=2), biomolecular (n=4), age determination (n=1), and fishing gear selectivity (n=2). The development of identification methods for Loliginid species remains a priority yet is apparently poorly studied, to ensure that data are made available at species level. Combining morphological and molecular methods may help deliver a rapid, cost-effective and reliable tool for identification at species level.

The further development of fishery management methods incorporating data on spatiotemporal structures of squid populations is needed due to the risk of overexploitation. Finally, further development of methods for rearing in captivity appears to be highly desirable.


#### A11.7.2. Climate change effects

A study on impact of ocean warming and acidification (Rosa et al., 2014) revealed that ocean warming led to a significant decrease of embryo survival rate. According to the study, 2°C warming and 0.5 decrease of pH caused a decrease of survival rate in summer hatching embryos from approximately 94% to 47%. Additionally, higher ambient temperature and hypercapnia cause shortening of the embryonic development period, a higher percentage of abnormalities and a decrease in growth rate. Moreno et al. (2014b) suggested that temperature effects may be responsible for high inter-annual variation in juvenile abundance on the southern shelf of Portugal.

More recently, a study by Engelhard et al., (2018) predicted that around the UK, *L. vulgaris* and *L. forbesii* habitat suitability has increased since 1985 and will continue to do so until at least 2050 (median estimates of habitat suitability increase by 31% for *L. vulgaris* and 7% for *L. forbesii*). As their model implies squid habitat suitability is increasing much more than for finfish, they anticipate that more vessels will target squid, ultimately making the species more common to the diets of UK citizens.


#### A11.7.3. Trophic relationships

A stable isotope study on trophic relationships of pelagic fish and squid in the Mediterranean (Albo-Puigserver et al., 2016) suggested that *L. vulgaris* predated primarily on sardine and anchovy. Furthermore, the study showed significantly less overlap in the diet of two squids (*L. vulgaris* and *I. coindetti*) than there was between *L. vulgaris* and both Atlantic bonito *Sarda sarda* and horse mackerel *Trachurus mediterraneus*. *Loligo vulgaris* did not show clear seasonal differences in $\delta^{15}$N and $\delta^{13}$C values, implying that feeding habits are not changing significantly during the year.

As *L. vulgaris* are an important prey and predator item to many other commercially important species, a better understanding of knock-on effects of their population fluctuations are important for reducing uncertainty in predictions of fisheries. The FAO (Food and Agriculture Organization) workshop on "effects of climate variability and change on the population dynamics of short-lived species predictive models and forecast products to inform fisheries management" (2017) worked to identify mechanisms to predict such

population dynamics, with the hope of developing predictive models to support squid fishery forecasting and fisheries management decisions.

*A11.7.4. Fishery and other studies*

Three recent studies are of significant interest for fishery management. A study on the recreational cephalopod fishery in Galicia (Palas & Pita, 2015) revealed that *Loligo vulgaris* is one of the two most exploited cephalopod species (along with *S. officinalis*). Recreational fishery catches account for approximately 30% of total squid catch in the Ría de Vigo and these data should be included in resported catches so as to be available for future stock assessment and management.

According to Malhomme et al. (2015), squid mortality due to recreational fishing in the English Channel could be sufficient to result in overexploitation the stocks. However, the authors also note that the current status of the *L. vulgaris* stock is close to the long-term optimum. Pilar-Fonseca et al. (2014) showed how integration of geo-referenced fisheries data and data on population structure for *L. vulgaris* in Portuguese waters can allow detailed description of exploited squid stocks distribution. It was found that the main fishing season coincides with the period when squid migration into inshore waters to breed. Thus, higher direct fishing effort on squid at this time could lead to depletion of the stock due to reduction of population reproduction potential.

Finally, Vidal & Boletzky (2014) reviewed the culture potential of the species and Feyjoo et al. (2016) presented a new scale for description of embryonic development stages.

## A11.8. Loligo forbesii

Despite its significant commercial value, *Loligo forbesii* was studied much less than the European squid over the last few years (since 2017, an Internet search reveals only one piece of research directly studying *L. forbesii*, albeit this research also directly studied *L. vulgaris*, to determine whether eye-lens are a suitable tool for ageing either species. However, fields of research which were marked as 'of importance' in the previous report of the Working Group were well covered by these studies. Life history, distribution, trophic relationships and stock assessment were all described in Pierce et al. (2013). A study on post-recruit life stages (Smith et al., 2013) revealed habitat preferences of squids at different maturity stages. It was shown that in winter, squid prefer lower salinity, while in spring and summer, higher salinity. Also, summer and autumn are characterized by higher abundance of squid at shallower depths. As for substrate preferences, it was found that squid aggregations are associated more with gravel substrate, than with mud.

The status of the English Channel stock was assessed by Malhomme et al. (2015). As well as in case of *L. vulgaris*, it was shown that the squid stock is overexploited, but nevertheless currently close to long-term optimum. The potentially important role of squid in the ecosystem of the Channel was highlighted, and recommendations provided on methods to evaluate. Most recently (Engelhard et al., 2018), modelling has predicted that UK habitat suitability for *L. forbesii* will have increased by 7% between 1985 and 2050 (see *L. vulgaris* section for further detail).

There is still a need for tools to permit rapid routine separation of *L. forbesii* and *L. vulgaris* in commercial and survey catches, to permit separate assessment of stocks of these species. To date, a recent ID guide by Laptikhovsky & Ouréns (2017) has allowed for shelf cephalopods of UK waters to be more easily identified by scientists onboard fish surveys. Additional studies on the trophic role and the impact of environmental factors would also be useful.

## A11.9. Alloteuthis spp.

Two species of *Alloteuthis* (*A. subulata*, *A. media*) have the widest distribution among European Myopsid squids. However, perhaps due to a lack of direct commercial interest, they are much less studied than *Loligo vulgaris* (an Internet search implied only two pieces of research had been carried on *A. media* since 2017, whilst no research had directly studied (for clarity, the species name did not appear in the work's title) *A.*

*subulata*. The two items on *A. media* were on its diet, and distribution and biological characteristics. Although at least two different morphotypes can be identified and are often assumed to characterise the two species, in practice, identification of *Alloteuthis* by traditional morphological methods is nearly impossible (Jereb et al., 2015). It seems that different morphotypes may occur in both species; one possibility is that a consistent relationship between species and morphotype is only found in areas where both species coexist. The issue of lack of consistent correspondence between genotype and morphotype in *Alloteuthis* still needs to be resolved and reliable identification methods developed, not least to ensure that stocks can be assessed and sustainable exploitation assured.

A study on *Alloteuthis* in the English Channel indicated the possibility of separating the two species using PCR-RFLP (McKeown et al., 2015). Gebhartd et al. (2015) found three morphotypes of *Alloteuthis* in the North and Baltic seas, but the analysis of COI and rDNA did not confirm any differences between them. Identification methods based on analysis of shape and colour also appear to be quite promising for squids (Fang et al., 2016 a, Green et al., 2015, Lishchenko et al., 2017, Jin et al., 2017).

Analysis of a 35-year series of data on squid catches during trawling surveys in the North Sea showed that *Alloteuthis* dominated in catches from shallow areas (depths <50 m) of the southern North Sea during August and September, and that *Alloteuthis* had expanded its range northwards and increased in abundance over the study period. Barrett & Laptikhovsky (2017) also found that *Alloteuthis* were the most common Myopsid squids in this area. Quetglas et al. (2014) reported that *A. media* as among the three most numerous cephalopods in the Western Mediterranean, observed only in the bottom layer and showing high seasonal variability in occurrence.

Studies on trophic relations of *A. media* have shown that the paralarvae consume prey from 10 orders, the most frequently detected families being Campanulariidae (order Leptothecata), Paracalanidae and Clausocalanidae (order Calanoida) (Olmos-Perez et al., 2017). In the adults, teleost fishes make up 84% of the diet, followed by crustaceans (8%), and molluscs (3%) (Rosas-Luis & Sanchez, 2015).


### A11.10. Illex coindetii

*A11.10.1. Introduction and overview*

*Illex coindetii* is a widespread Ommastrephid squid, of increasing commercial value, the distribution of which covers both sides of the Atlantic and the Mediterranean Sea from surface waters to approximately 1000 m depth. Previous studies did not reveal significant genetic differences among populations. Further research is needed on the systematic and ecological status of *I. coindetii* morphotypes, as well as studies on stock structure (both spatial and temporal), climate change effects and trophic role are required to ensure sustainable exploitation (Jereb et al., 2015). Information on squid populations dynamics in relation to environmental and community variability can be used in fishery management within the ecosystem approach.


*A11.10.2. Distribution, abundance and stock structure*

Studies on distribution of squids in the North Sea showed that Ommastrephidae are distributed throughout most parts of the northern and central North Sea, but aggregations of *I. coindetii* were observed only in the central part of the sea in winter (Oesterwind et al., 2015). Despite the relatively low abundance and apparently limited distribution in the North Sea, *I. coindetii* could be an important species for the ecosystem of this region (Oesterwind et al., 2015).

Studies on the eastern Iberian coast population revealed a negative correlation of local abundance with depth, probably because of recruitment at shallow depths (Puerta et al., 2014). These authors note that squid responses to environmental drivers are difficult to recognize due to the high mobility of individuals and the constant mixing of subpopulations in neighboring areas.

Recent studies suggest the existence of 4-8 separate stock units are recognised in the Mediterranean Sea (Fiorentino et al., 2014; see also Keller et al., 2017). In this area, *I. coindetii* is distributed across a wide range

of depths. The greatest abundance is reached at depths less than 200 m and more than 600 m, with the minimum at approximately 400 m. The densest concentrations of squid are observed in the most highly productive zones, related to the Atlantic Ionian Stream (Lauria et al., 2016).

### A11.10.3. Life history and trophic ecology

Observations on on squid from the Adriatic and Aegean Seas provided evidence that *I. coindetii* has a multiple-spawning reproductive strategy (Ceriola et al., 2017, Salman et al., 2017). The smallest mature indivuals in Greek seas were recorded in this area (Pattoura, et al., 2016). This is likely a result of the gradual rise in temperature both in the surface and the deepest layers of the sea which leads to the faster maturation rates of individuals.

A recent study of trophic ecology of the squid in the northwestern part of the Mediterranean Sea showed the presence of 35 species in the squid's diet, mainly crustaceans, squid and mesopelagic fish. Food preferences depend on ontogenetic stages. The juveniles' diet mainly consisted of crustaceans, especially in winter, while adults preyed mainly on fish and crustaceans, with no apparent seasonal differences. It was hypothesized that diet composition is dependent on the development of the beak. as well as availability of prey (Martinez-Baena et al., 2016).

Another ongoing study is focusing on aging of North Sea *Illex coindetii* (Oesterwind et al. 2018). The statoliths of a total of 46 individuals were analyzed so far. The sample consists of specimens with a dorsal mantle length of 45 mm to 130 mm (mean 69 mm ±18 mm). Assuming each ring representing one day, the analyzed individuals are between 132 and 202 days (mean 174 days ±16 days) old. The preliminary results show no correlation between DML and age for *I. coindetii* if all individuals were combined. Two different life cycles are known for the species and spawning takes place throughout the whole year with seasonal peaks (Jereb et al. 2015), assuming that different cohorts exist in the North Sea. However, further investigations are needed.

### A11.11. Ommastrephes bartramii

*Ommastrephes bartramii* is a widely distributed species, with high commercial importance outside the ICES area. In North Atlantic waters the species is less common and its commercial value markedly lower. Consequently, the species is much less studied in the North Atlantic than in the Pacific counterpart. This problem was noted in the previous report of the Working Group; it was stated that additional studies are needed in all fields of research, with emphasis on the basic biology of species, and this continues to be the case. As with several of the other species mentioned, further studies are needed on on stock identity and trophic relationships of this species in the North Atlantic. While lessons can be learned from studies in the Pacific, especially in relation to methodological developments, such tools for age determination, in general caution is necessary in applying results to the species in the North Atlantic since we may be dealing with different subspecies (Jereb et al., 2015). There is a need to review on Russian studies on this species and other oceanic ommastrephids, and for studies on the systematic status of North Atlantic and Pacific populations.

Only two articles were published on this species in the North Atlantic and adjacent waters during the reviewed period. Both studies concerned distribution across the Mediterranean Sea (Lefkaditou et al., 2013; Franjevic et al., 2015). According to the second study, frequency of observations of young specimens increased significantly from the beginning of 1990's (Lefkaditou et al., 2013), which probably reflects spawning in this, or adjacent, area(s). Recent records of large females in this area support this hypothesis. The second study represents a modern report on capture of the mature female in the Adriatic Sea (Franjevic et al., 2015). Outputs of both studies reflect the possible connection of the climate change and *O. bartramii* range expansion.

Among studies on *O. bartramii* in other regions, some are potentially relevant to the North Atlantic population. Several studies on hard structures of the squid provide reliable tools for age determination

(Fang et al., 2016 (a), Liu et al., 2015), while others concern tools for stock identification (Fang et al., 2014 a, Fang et al., 2014 b, Fang et al., 2017) or for monitoring of migrations (Fang et al., 2016 (c), Kato et al., 2016). In general, it could be concluded that hard structures of squids (not only of *O. bartramii*) could be used in a wide variety of studies.

Another relevant topic is the assessment of the impact of abiotic factors on distribution and abundance (Alabia et al., 2015, Feng et al., 2016, Xu et al., 2016, Wang et al., 2017, Yu et al., 2015, Yu et al., 2016, Feng et al., 2016). It has been shown that warming has a positive effect on abundance and allows it to expand its range into high-latitude waters. These results are consistent with studies in Mediterranean (Lefkaditou et al., 2013).

### A11.12. *Todaropsis eblanae* and *Todarodes sagittatus*

A study on the squid distribution and abundance in the North Sea (Oesterwind et al., 2015) showed that *Todaropsis eblanae* is the most widespread ommastrephid species in this area while *Todarodes sagittatus* was found to be the least common squid in the area, possibly because it passes through the area only when migrating between feeding areas and the spawning areas on the mid-Atlantic ridge and western continental slope of Europe. More recent surveys performed by Cefas (C. Barrett, pers. comm.) found that *T. eblanae* was abundant only in the western part of the sea. Previous studies suggest that high abundance of both species in the northeast Atlantic may be sporadic and that large shifts in distribution can be seen.

Lauria et al. (2016) showed that spatial distribution of *T. eblanae* in the Mediterranean was related to the temperature regime, salinity and chlorophyll-a concentration. It was concluded that squid prefers highly productive areas associated with the Adventure Bank Vortex.

Fernandez-Alvarez et al. (2017) developed an identification key for paralarvae of ommastrephids (*I. coindetti*, *T. eblanae*, *T. sagittatus*) based on morphological differences. Among the most useful characters were the relative size and the arrangement of pegs on the lateral and medial proboscis suckers and the presence of photophores. This key provides a cost-effective and reliable tool for studies on the life-cycles and population dynamics of ommastrephid squids in the North Atlantic.

A study on feeding habits of *Todarodes sagittatus* in the NW Mediterranean (Rosas-Luis et al., 2014) showed that the species has a wide prey spectrum: 49 types of prey were identified, most being mesopelagic fish, decapod crustaceans and amphipods. It was concluded that *T. sagittatus* feeds opportunistically on the most accessible prey, adjusting its vertical distribution in the water column according to the availability of prey resources. Choice of prey also depends on the size of squid: small squid primarily consume small crustaceans, squids of medium size include medium-sized fish in the diet, and large individuals feed on larger fish, crustaceans and molluscs.

Additional studies on *T. sagittatus* are needed in the fields of reproductive biology, age estimation and stock identification. For *T. eblanae*, important fields of future research include studies on stock separation, distribution and life history traits of populations.

### A11.13. *Gonatus fabricii*

#### A11.13.1. Introduction and overview

*Gonatus fabricii* is a boreoatlantic oceanic ommastrephid. It is the most abundant squid of the Arctic and Subarctic waters of the North Atlantic and might have some fishery potential (Jereb et al., 2015). The species has been assessed by the IUCN as Least Concern (Barratt & Allcock, 2014). Confusion with *Gonatus streenstrupi* may happen in the North Atlantic where ranges of both species overlap (Jereb et al., 2015).

#### A11.13.2. Distribution, abundance and stock structure

In addition to the comprehensive information about the species' distribution in Jereb et al (2015), some additional information on the biomass and abundance of *G. fabricii* in the Barents Sea and adjacent waters

has been published (Golikov, 2014; Golikov et al., 2017). Golikov et al. (2017) reported a maximum biomass of *G. fabricii* of approx. 25000 tonnes and an abundance of 1.7 billion specimens with higher concentrations in deep water troughs in the marginal parts of the Barents Sea and adjacent deep-water areas. They further reveal that the importance of cephalopods or at least the quantitative distribution in the Artic ecosystem is lower compared to the Antarctic and Tropics due to the lower biomass. The findings of Golikov et al. (2017) are also mentioned in the review by Xavier et al. (2018). They compare the biodiversity, distribution and trophic role of cephalopods in the Arctic and in the Antarctic and describe that there is no correlation between climatic conditions in 2009 - 2012 and the abundance and biomass of *G. fabricii*. Another publication describes the cephalopod biodiversity at Bear Seamount (BSM) which is the most inshore seamount in the New England Seamount chain and report the presence of *G. fabricii* in their fishing hauls (Shea et al., 2017).

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# Annex 12. ToR D. Report on social and economic importance of cephalopod fisheries

Cristina Pita, Fábio L. Matos, Sílvia Monteiro, Sónia Seixas, Marina Santurtun, Sebastián Villasante

## 1. Large-scale cephalopod fisheries at European level

In Europe, according to EUROSTAT, cephalopod products represent on average (for the period 2013-2017) 1.5% of the weight and 6.1% of the value of total landings of marine fish products (Table 1). The quantity and value of landings are highest in Southern European countries (Figures 1, 2).

Spain, Italy, France, Portugal, Greece and the United Kingdom together account for more than 98% of the total catches and revenue generated by cephalopods fisheries in Europe (Table 1). These countries together landed on average 97.8 thousand tonnes and generated a revenue of 465.4 million euros per year for the period 2013-2017. Other countries also land cephalopods, although in lesser quantities (Figure 1 and Figure 2).

The landings of squids, cuttlefishes, and octopuses varied between 2.4% (UK) and 14.1% (Italy) of total weight landed, and 5.4% (UK) and 28.6% (Italy) of total revenue. The average price at auction ranged between €3.42 and €7.61, around double the values of other marine fishery products (€1.5 to €3.65). These differences were most notable in Italy and Portugal, reflecting the high value squid, cuttlefish and octopus achieve in first auction when compared to other species landed. Revenue from cephalopod landings in Italy and Portugal represented on average, respectively, 28.6% and 22.2% of the total value of landings of marine fisheries (Table 1).

Further illustration of these data is provided in the Annex to this document.

**Table 1. Landings (total and cephalopods) in quantity and value of fishery products in Spain, the United Kingdom (UK), France, Italy, Portugal, and Greece. The values are an average per year for the period between 2013 and 2017, except for Greece (2013-2015) (Data source: EUROSTAT statistics).**

| | Europe | Spain | UK | France | Italy | Portugal | Greece | % of six countries in Europe |
|---|---|---|---|---|---|---|---|---|
| **Landings of marine fish (mean last five years)** | | | | | | | | |
| Quantity (thousand tonnes) | 6665.9 | 819.6 | 320.4 | 222.7 | 125.7 | 117.0 | 52.4 | 24.9 |
| Value (€ million) | 7758.3 | 1780.7 | 491.1 | 602.5 | 473.2 | 175.2 | 191.2 | 47.9 |
| Average price (€/kg) | - | 2.17 | 1.53 | 2.71 | 3.77 | 1.50 | 3.65 | - |
| **Total landings cephalopods (squids, cuttlefishes, and octopuses)** | | | | | | | | |
| Quantity (thousand tonnes) | 99.6 | 41.2 | 7.8 | 17.0 | 17.8 | 8.7 | 5.4 | 98.2 |
| Value (€ million) | 471.8 | 166.3 | 26.7 | 74.5 | 135.2 | 38.9 | 23.9 | 98.7 |
| Average price (€/kg) | - | 4.04 | 3.42 | 4.39 | 7.61 | 4.47 | 4.40 | - |
| **% cephalopods / total landings (quantity)** | 1.5 | 5.0 | 2.4 | 7.6 | 14.1 | 7.4 | 10.4 | - |
| **% cephalopods / total landings (value)** | 6.1 | 9.3 | 5.4 | 12.4 | 28.6 | 22.2 | 12.5 | - |
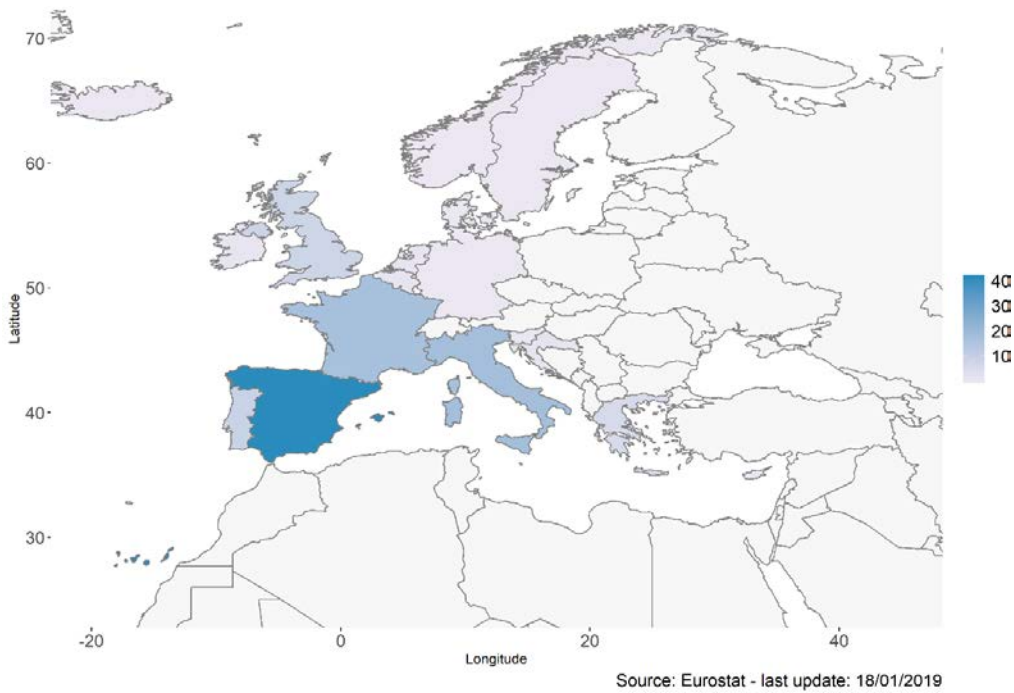
**Figure 1. Total landings of squids, cuttlefishes and octopuses products for the EU Member States, Iceland, and Norway (average product weight in thousand tonnes for the period between 2013 and 2017, except for Greece: 2013 – 2015, and Iceland and Denmark: 2013 – 2016) (Data source: EUROSTAT statistics).**
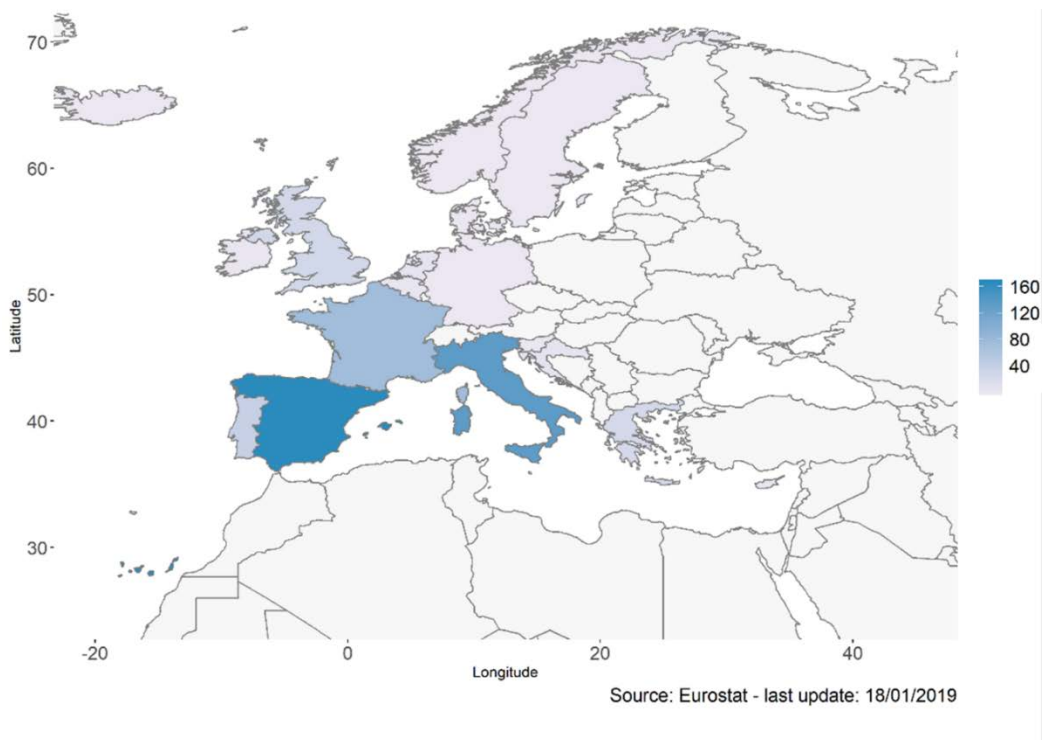


**Figure 2. Total landings of squids, cuttlefishes and octopuses in the EU Member States, Iceland, and Norway (average value in million Euros for the period between 2013 and 2017, except for Greece: 2013 – 2015, and Iceland and Denmark: 2013 – 2016) (Data source: EUROSTAT statistics).**

**2. The most important groups of cephalopod species landed in the top 6 countries**

Species belonging to Loliginidae and Ommastrephidae families were the most popular cephalopod groups landed in European ports, particularly in Spain, followed by Sepiidae (e.g., *Sepia officinalis*) and Octopodidae (e.g., *Octopus vulgaris*) (Figure 3).

Species from the family Sepiidae were important in French and Italian landings, while those from the Octopodidae family were important in Spanish and Portuguese landings (Figure 4 and Figure 5). Regarding Sepiidae, the quantities landed followed a slightly increasing trend over the past years and a considerable increase on the values reached in auction. On the other hand, the quantities landed of Octopodidae decreased substantially over the years while the values at auction were stable over time (Figures 6 to 11).

Squid (mainly species of the families Loliginidae and Ommastrephidae) represent economically important cephalopod fisheries in Spain, and to a lesser extent Italy and France (Figure 7 and 10). Spanish squid landings include two species captured outside European waters, the Patagonian squid (*Doryteuthis* (formerly *Loligo*) *gahi*) and Argentine short fin squid (*Illex argentinus*), both in the Argentine EEZ and the Malvinas/Falkland Islands Conservation Zone of the Southwest Atlantic Ocean (FAO Area 41)[1]. These species were captured in large quantities and reached considerable values in the market.
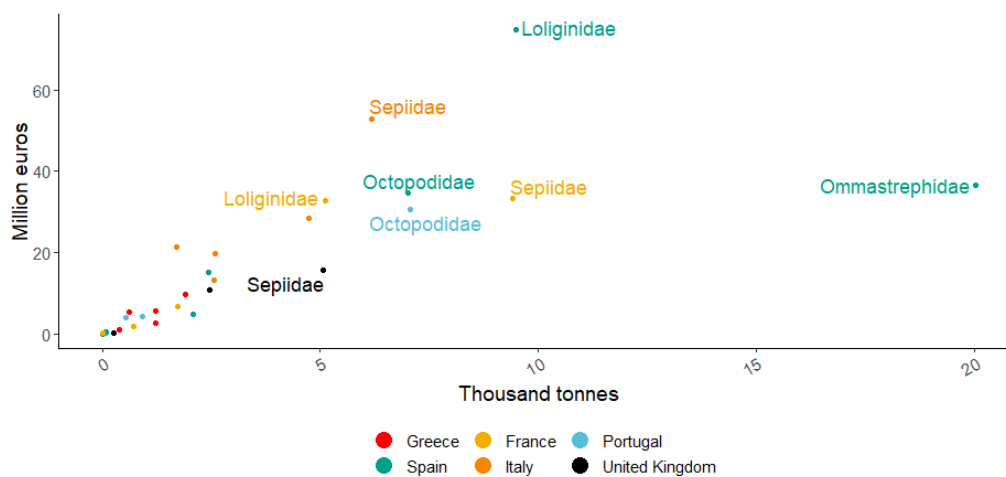


Source: Eurostat - last update: 18/01/2019

**Figure 3. Total weight of products based on squids, cuttlefishes, and octopuses landed in the ports of the top-6 producing countries versus their economic value (data corresponds to average values for the period 2013-2017) (Data source: EUROSTAT statistics).**

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[1] There are also Spanish fishing vessels operating in both zones but flagged in Argentina and the Malvinas/Falkland Islands, which are not included here.
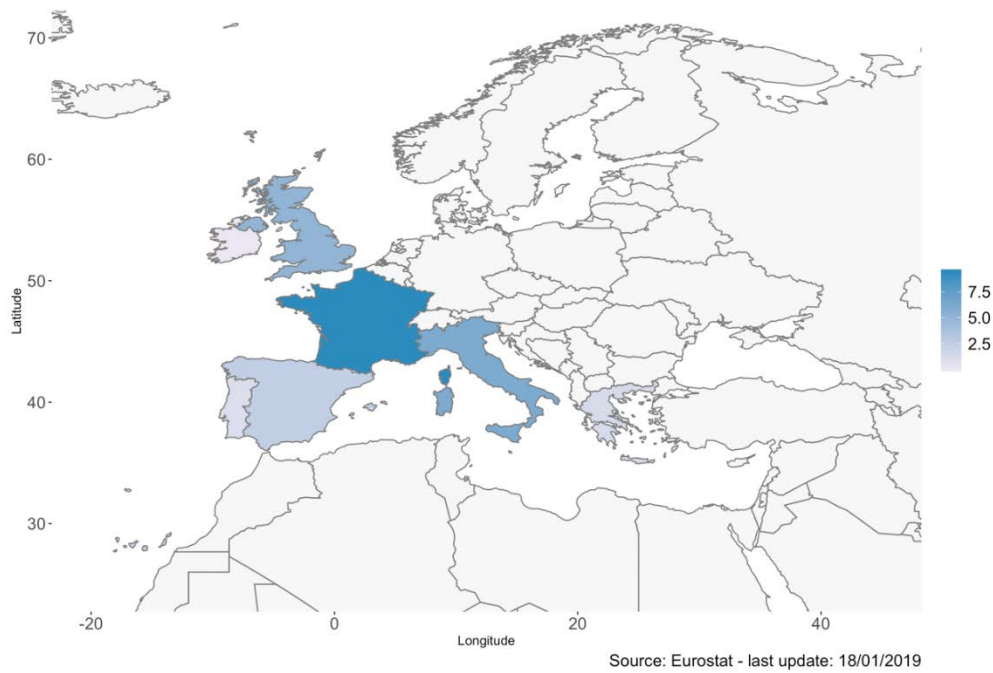
**Figure 4. Total landings of Sepiidae for the top-6 European countries (thousands of tonnes) (Data source: EUROSTAT statistics).**
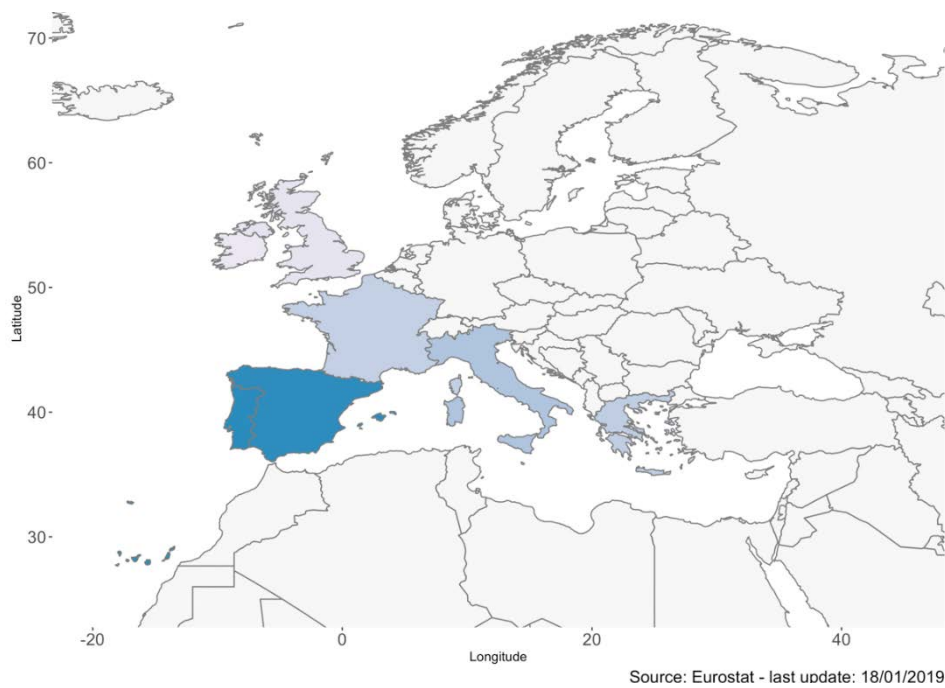


**Figure 5. Total landings of Octopodidae in the top-6 European countries (thousand tonnes) (Data source: EUROSTAT statistics).**
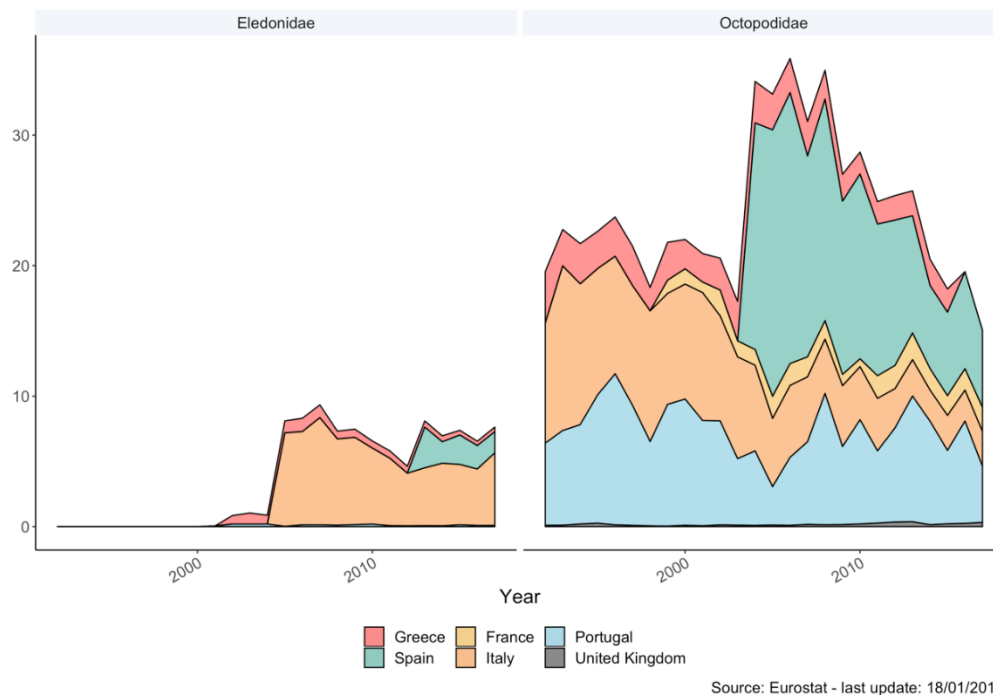
**Figure 6. Time series of landings (thousand tonnes) in the top 6 countries for octopus species of the families Eledonidae and Octopodidae. (Data source: EUROSTAT statistics).**
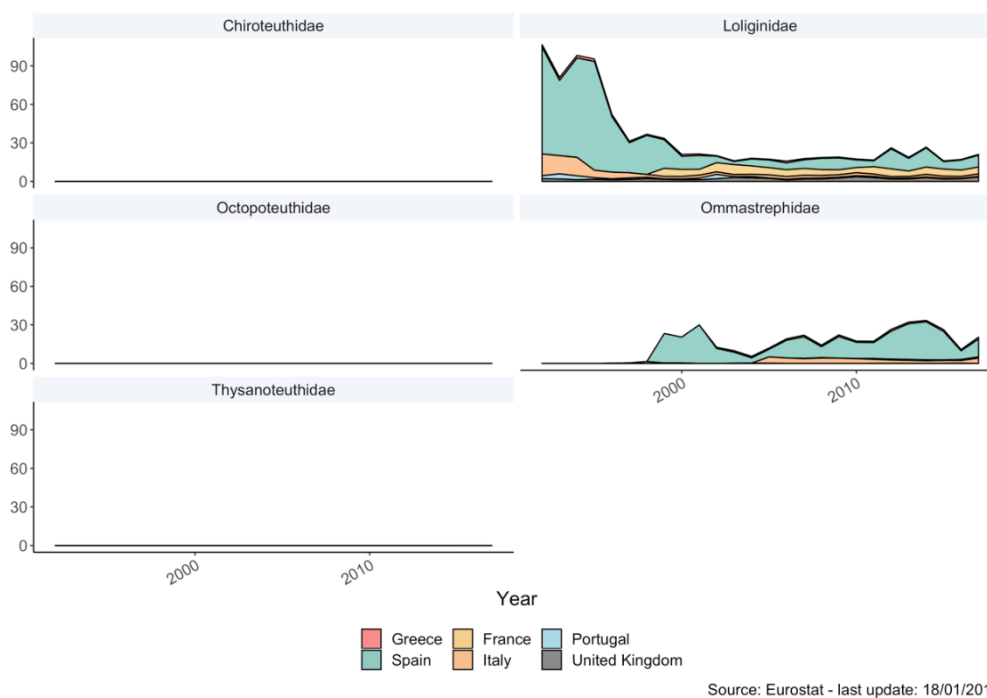


**Figure 7. Time series of squid species landings (thousands of tonnes) in the top 6 countries. (Data source: EUROSTAT statistics).**
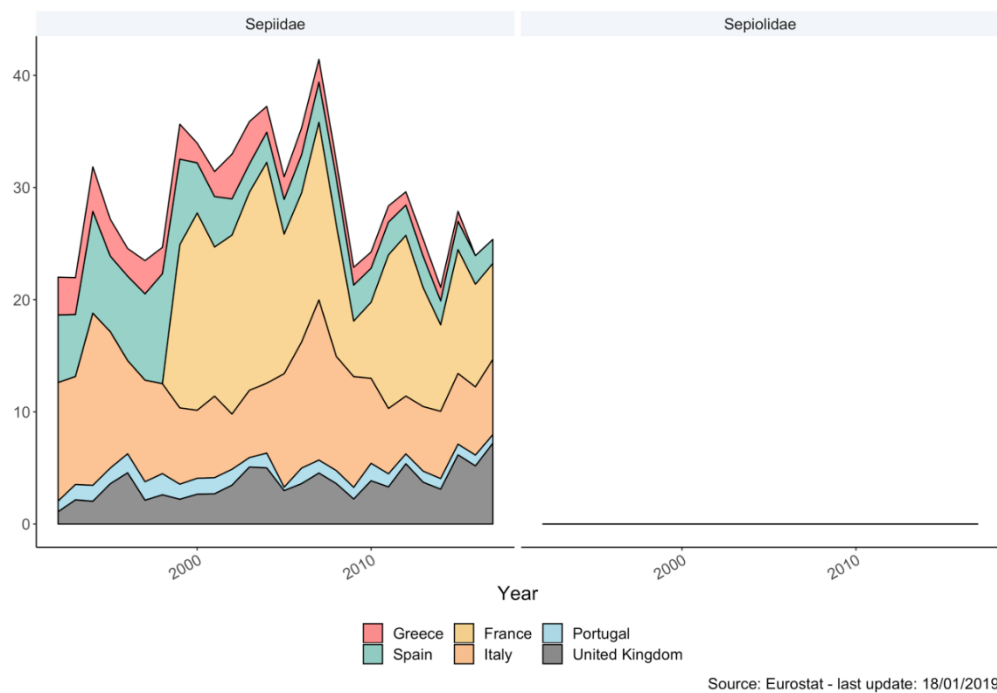
**Figure 8. Time series of cuttlefish species landings (thousand tonnes) in the top 6 countries. (Data source: EUROSTAT statistics).**
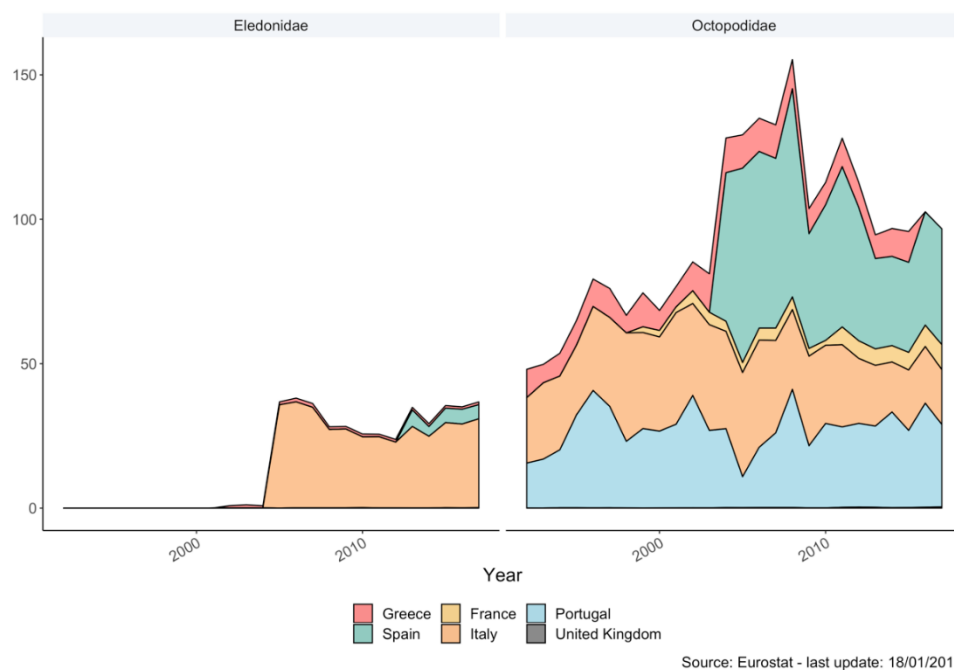


**Figure 9. Time series of octopus species landings, in million euros, in the top 6 countries at the European level. (Data source: EUROSTAT statistics).**

**Figure 10. Time series of squid species landings, in million euros, for the top 6 countries. (Data source: EUROSTAT statistics).**



**Figure 11. Time series of cuttlefish species landings, million euros, for the top 6 countries. (Data source: EUROSTAT statistics).**

**3. First sale prices for large-scale European cephalopod fisheries (*Loligo* sp.) and metiers**

An analysis of the first sale prices (value) of the catch of *Loligo* spp., was attempted for some countries and fishing area. Two reference years were used for this first analysis, the most recent years with price data available to the WG. The United Kingdom, Ireland and France provided data on cephalopod prices by species groups, sea area and metier.

Loliginids landings from vessels in the **United Kingdom** come, mainly, from ICES Subarea 4, 5, 6 and 7. For this analysis the reference years were 2014 and 2015. In 2014, the highest landings of *Loligo* spp. were obtained in Subarea 4, reaching 1,400 t. Followed by landings in Subarea 6, reaching 780 t. The value of the catch was 4,160 thousand euros and 3,410 thousand euros respectively. In 2015, the largest catches were obtained in Subarea 7, reaching 857 t which corresponded to 5,240 thousand euros. Squid prices in Subarea 7, squid prices increased from 4.87 €/kg to 6.12 €/kg between 2014 and 2015. An increase in price was also recorded for loliginids landings coming from Subarea 4. In this area the average value increased from 3.05 €/kg to 4.90 €/kg. In Subarea 4 and 6, the metiers contributing most to landings were otter trawls targeting mollusc and otter trawls targeting cephalopods. In Subarea 7, Scottish Seines targeting demersal species were the metiers which caught the highest quantity of Loliginids spp., being the metier generating the highest revenue from this species.

Loliginids landings from **Ireland** come, mainly, from catches in ICES Subarea 6 and 7. For this analysis reference years were 2013 and 2014. In 2013, the highest landings of Loligo spp. were obtained in Subarea 7, reaching 193 t. Followed by landings in Subarea 6, reaching 28 t. The catch accounted for 835 000 euros and 115 000 euros, respectively. In 2014, the largest catches were obtained in Subarea 7, reaching 153 t which corresponded to 734 000 euros. Loliginids prices increased from 4.33€/kg to 4.82 €/kg between 2013 and 2014 for Subarea 7. For Subarea 6, however, a decrease in price was recorded. In this case the price per kg decreased from 4.00 €/kg to 3.64 €/kg. In 2013, in Subarea 7, the metiers contributing most to landings and value of landings were otter trawls of various mesh sizes targeting demersal species. In 2014 and for the same are, otter trawls and Scotish Seines targeting demersal species were the metiers catching the highest number of Loliginids spp. and contributed with the highest value to the catch.

**French** vessels catch loliginids mainly in Subarea 7 and 8. For this analysis the reference years were 2014 and 2015. In 2014, the highest landings of *Loligo* spp. were obtained in Subarea 7, reaching 2 543 t. Followed by landings in Subarea 8, reaching 1 566 t. The value of the catch was 12.625 million € and 8.340 million €, respectively. In 2015, landings dropped to levels of 86 t and 14 t in these subareas, respectively. There are some concerns about the quality of the data. Focusing on year 2014, when most landings were available, loliginid prices were 4.96 €/kg for Subarea 7 and 5.33 €/kg for Subarea 8. In 2014, in both areas, the metiers contributing most to landings (in terms of weight and value) were otter trawls of different mesh sizes targeting demersal species.

The lack of data from some fleets and countries contributing to the different fisheries (e.g. prices, catch composition, etc) limits our ability to provide a comprehensive picture of the importance of revenue from cephalopod catches to the various fleets. In addition, where large fluctuations in annual landings and value are seen, it is not clear to what extent these are driven by fluctuations in cephalopod abundance (although this is plausible, especially for ommastrphid squid) and to what extent they reflect fisher behaviour, e.g. in response to variation in abundance of (and quota for) the fishery target species.

An analysis of Spanish catches (volume and value) is also presented in this section. It is important to highlight that Spain does not report data for cephalopods (squids, cuttlefish and octopus) by

ICES fishing areas. Rather, Spain provides information on cephalopod catches by FAO areas for the period 2006-2017. Compared to the previously mentioned EU countries, Spain presents the particularity that its fishing vessels are operating not only in European waters but also elsewhere, namely in the Southwest Atlantic Ocean and in Western Africa (Villasante et al. 2014).

According to the national statistics published by the MAGRAMA (2019), the volume of catches of cephalopods harvested in all FAO areas by the Spanish fishing vessels decreased from 43 300 t in 2006 to 35 700 t in 2017 (Figure 12). FAO fishing area 27 (Northeast Atlantic) represented a low percentage of total catches of cephalopods during the period 2006-2017, decreasing from 12 200 t (28.3% of catches in all FAO areas) to 8 000 t (22.5%).
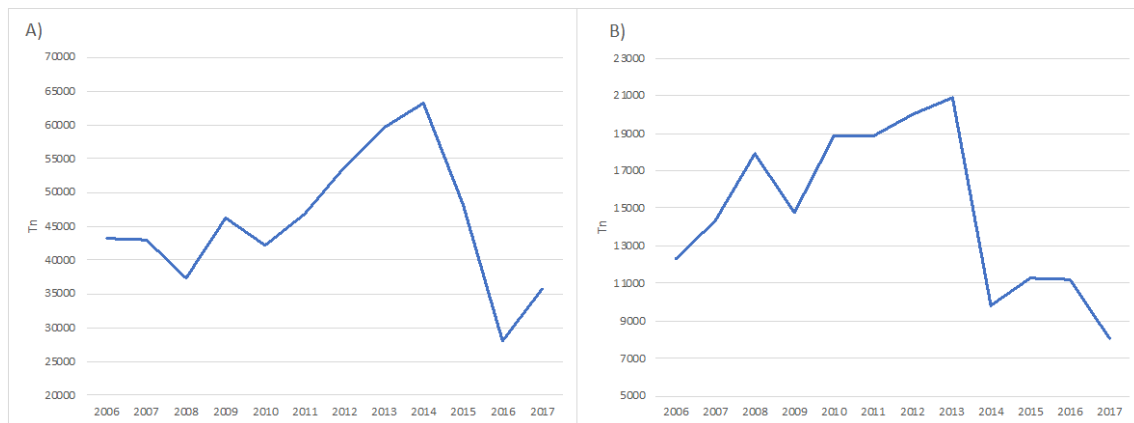


**Figure 12. Time series of Cephalopods landings, in tonnes, for A) Spain in all FAO fishing areas and B) FAO Fishing Area 27 (Atlantic Northeast) (Data source: MAGRAMA statistics).**

The times series of value of landings, in euros, shows an increase of the economic value during the period 2006-2017, ranging from 125 million euros in 2006 to 135.8 million euros in 2017. The highest landings value was reached in 2014, at more than 288.8 million euros, while the lowest value, 110.6 million euros, was reported in 2015 (Figure 13a). Regarding FAO Area 27, the contribution of cephalopod catches increased from 35.4 million euros to 42 million euros, which represents 28.3% and 31.4% of the total economic value of catches from the area respectively (Figure 13b).
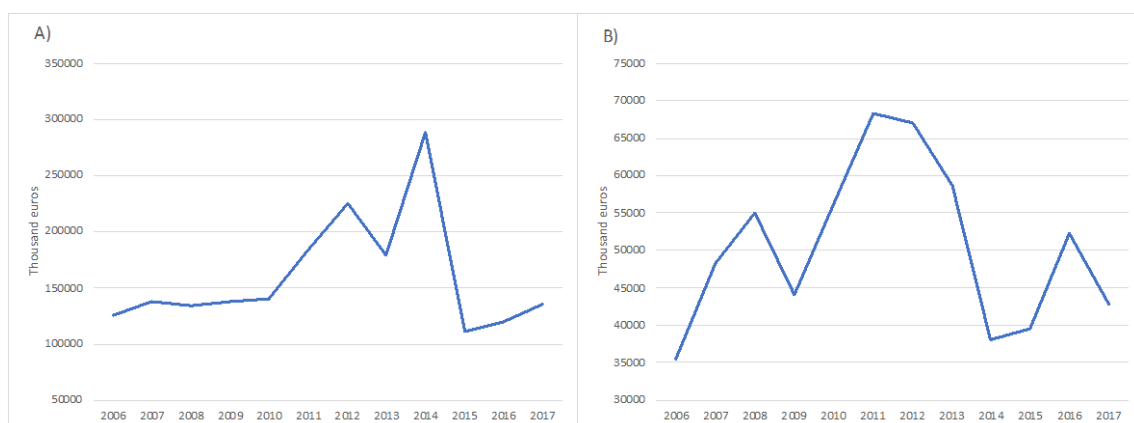


**Figure 13. Time series of value of cephalopods landings, in thousands of euros, for A) Spain in all FAO fishing areas and B) FAO Fishing Area 27 (Northeast Atlantic) (Data source: MAGRAMA statistics).**

The prices at first sale of cephalopods caught by the Spanish fishing fleet in all FAO fishing areas increased from 2.88 €/kg in 2006 to 3.79 €/kg in 2017, which represents an overall growth of 31%

during this decade, although prices also fluctuated markedly during the intervening years(Figure 14).
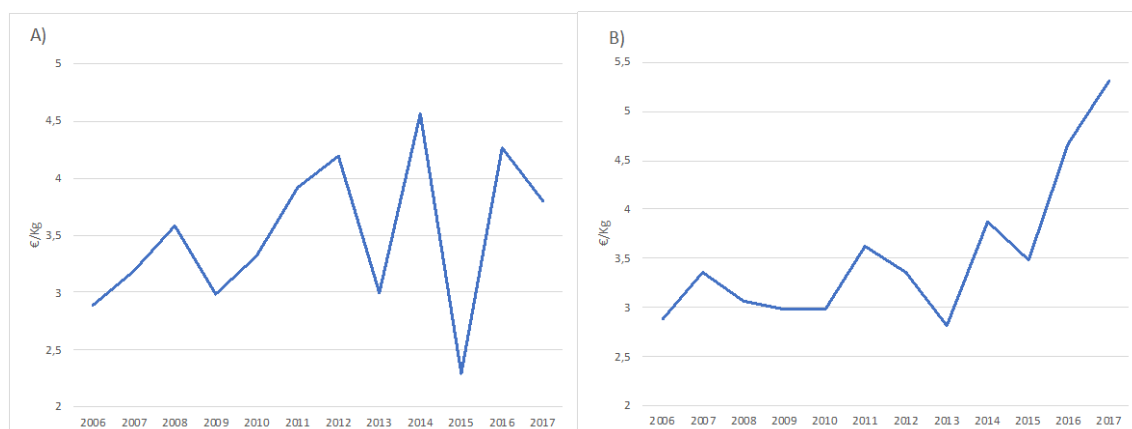


**Figure 14. Time series of prices at first sale of cephalopods, €/Kg., for A) Spain in all FAO fishing areas and B) FAO Fishing Area 27 (Atlantic Northeast) (Data source: MAGRAMA statistics).**

The growth of prices has been substantially higher (85%), and more consistent, in the case of the FAO fishing area 27 (Northeast Atlantic), where the price of catches at first sale increased from 2.88 €/kg to 5.13 €/kg in the same period (Figure 14).

## 4. The Portuguese octopus fishery

The landings of Octopodidae species in Portugal are characterized by fluctuations over the years, in the range 5 000 -10 000 t (Figure 15). The number of licensed boats authorized to fish these species followed a slightly decreasing trend over time, except for the year 2005.
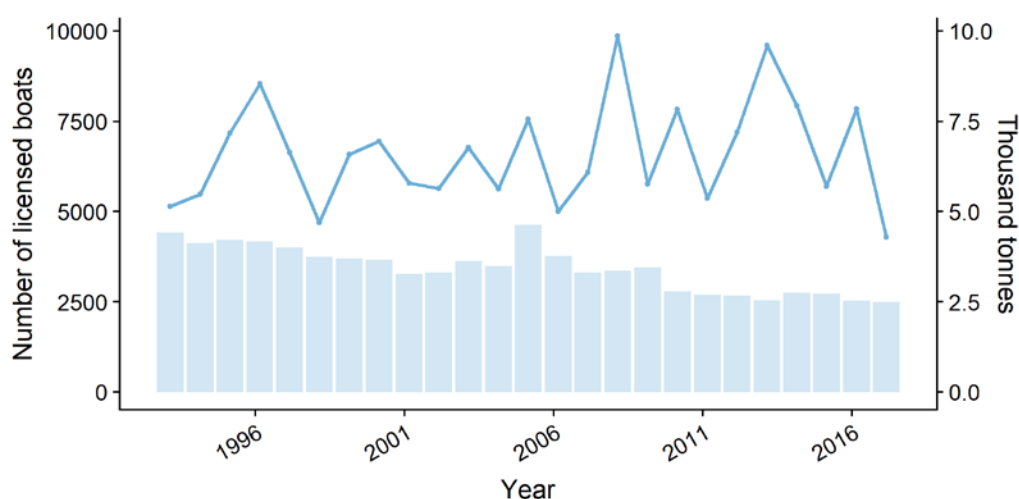


Source: DGRM 2018

**Figure 12. Time series of total landings (lines) of Octopodidae species in Portuguese ports and the total number of licensed fishing boats (bars). (Data source: DGRM statistics).**

Regarding the local importance of Octopodidae species, the ports of Castelo do Neiva, and Viana do Castelo (in the North of Portugal), Peniche and Sesimbra (centre), and Portimão and Santa Luzia (in the Algarve, South of Portugal), where the ports with the highest quantity of landings in 2017, going from 220 up to 464 tonnes (Figure 16). The revenue by port was higher in Southern ports: Sesimbra (over 3.505 million euros), followed by Portimão, Peniche, Santa Luzia, Olhão, and in the North, Castelo do Neiva (ca. 1.412 million euros) (Figure 17).

Octopus is clearly an important fishing resource in the South of Portugal. The relative importance of octopuses was highest in the small ports of the south of Portugal (Figures 18 and 19), in some ports representing more than 80% of the total quantity and value of landings. This is a clear indication of these communities' economic dependence on this fishing resource.
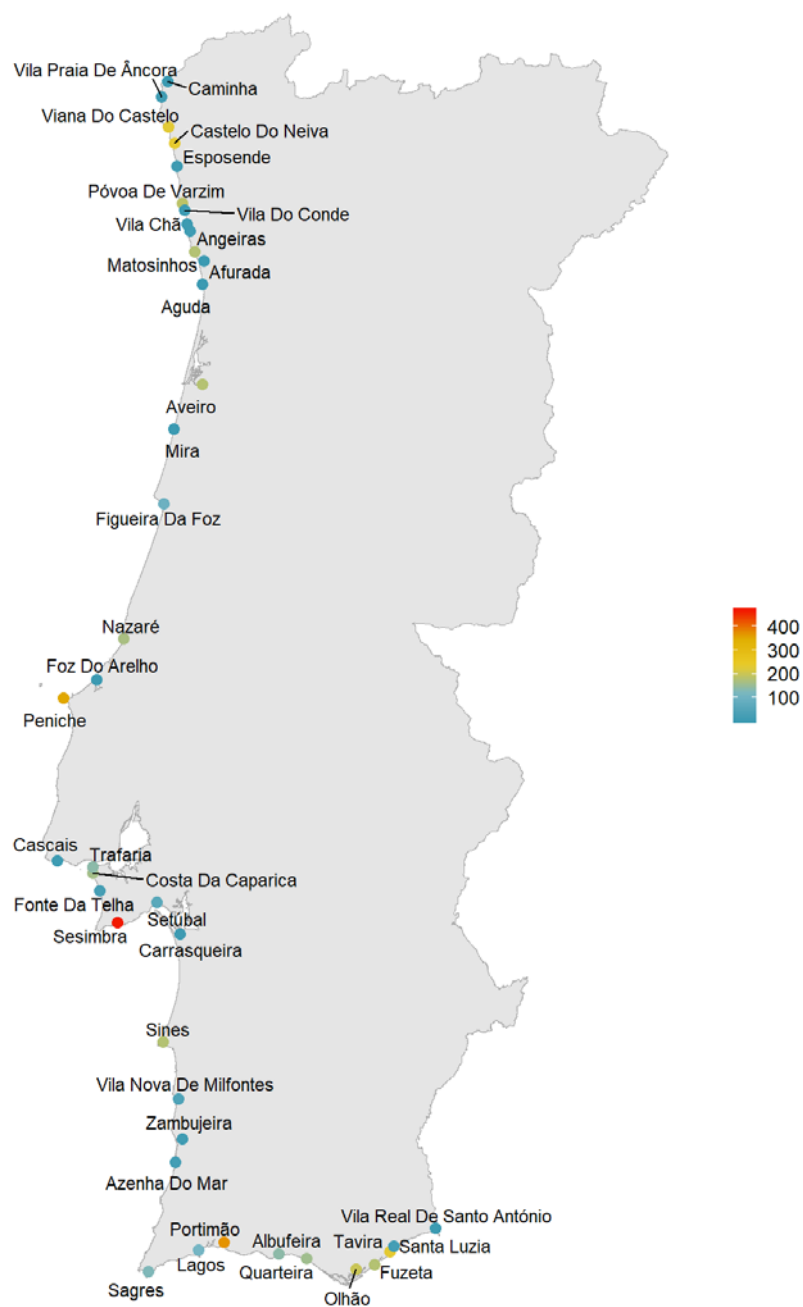
**Figure 13. Landing values in quantity (in tonnes) of Octopodidae species across Portuguese ports in 2017. (Data source: DGRM statistics).**
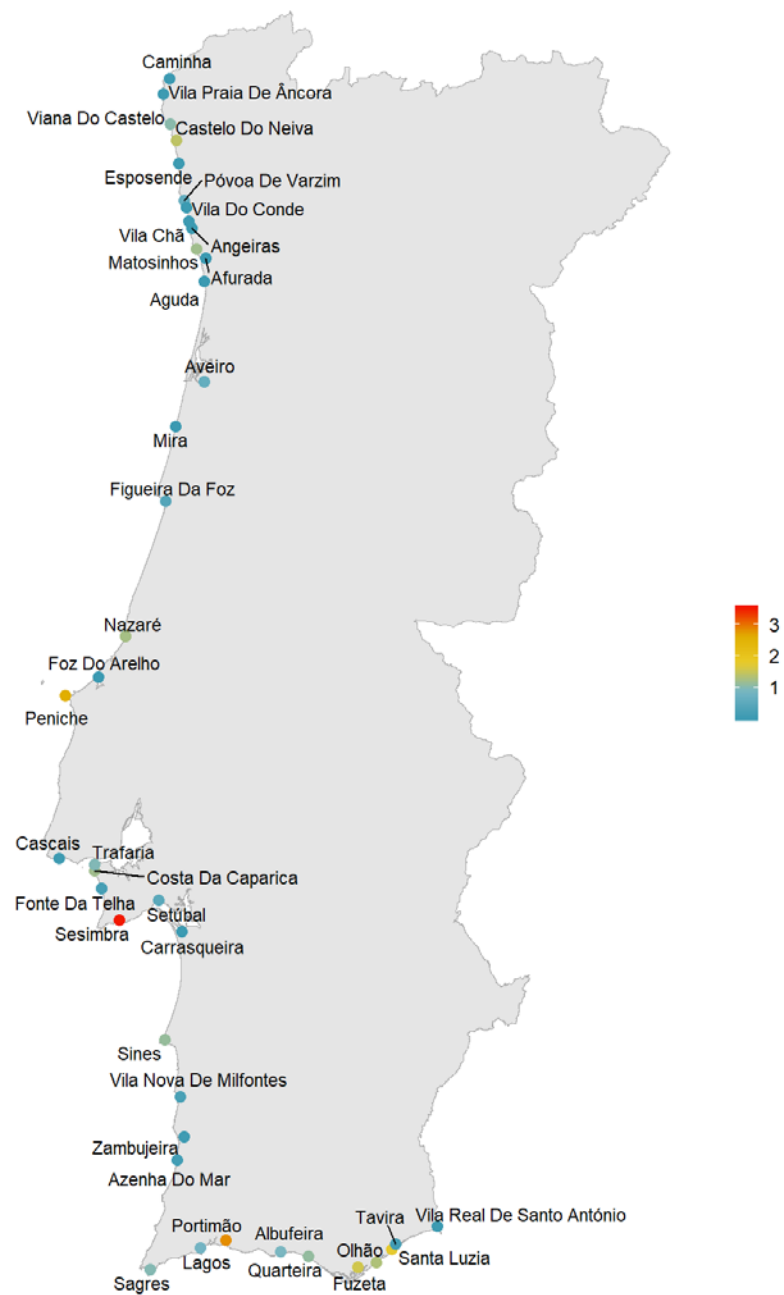
**Figure 14. Landing values of Octopodidae species in millions of euros across Portuguese ports in 2017. (Data source: DGRM statistics).**
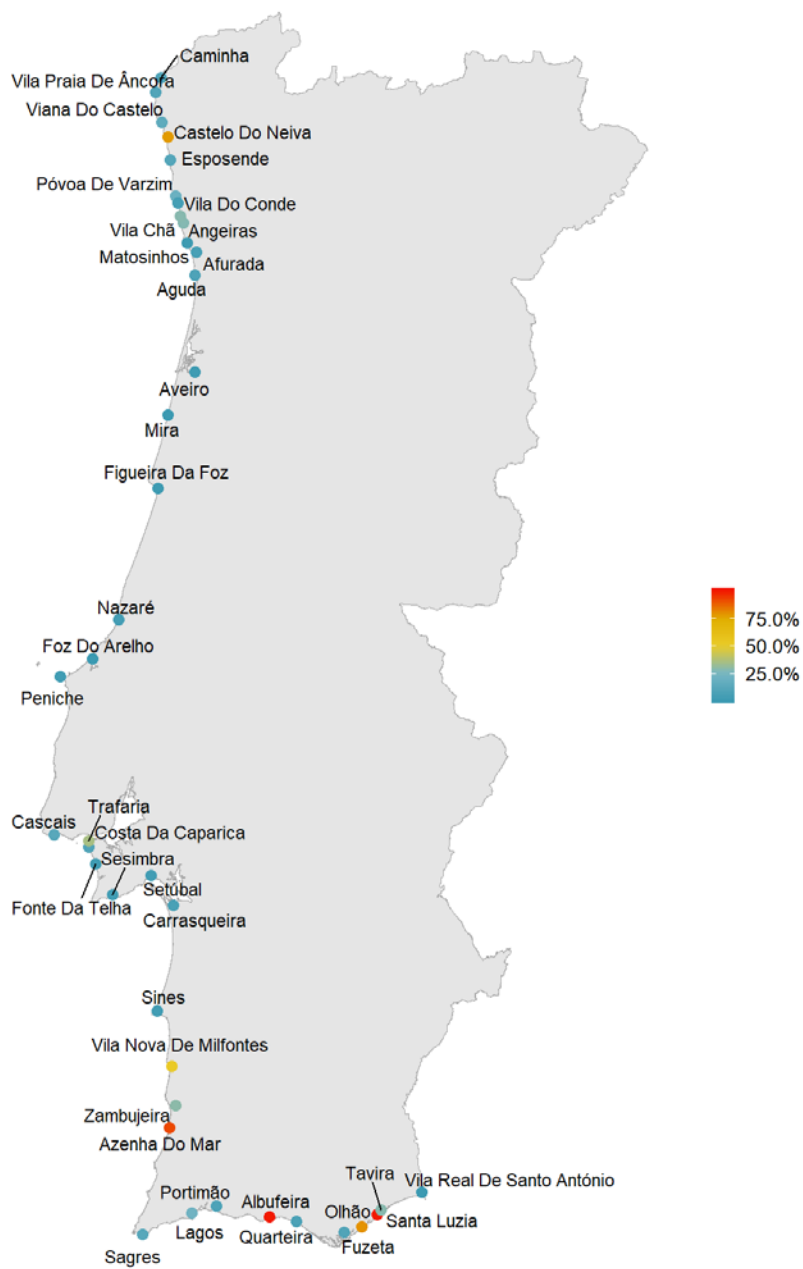
**Figure 15. Relative importance of Octopodidae landings (in weight) compared to the total landings across Portuguese ports in 2017. (Data source: DGRM statistics).**
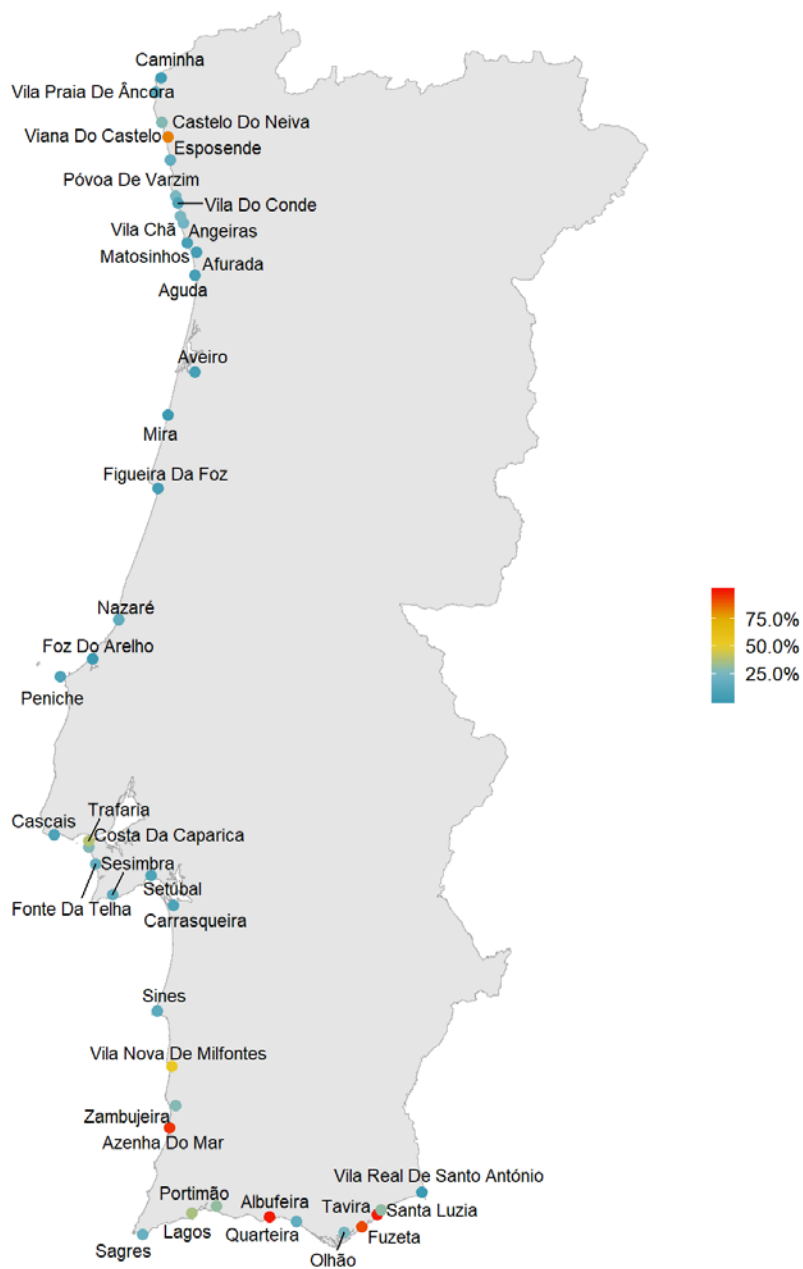
**Figure 16. Relative economic importance of Octopodidae landings (in value) compared to the total landings across Portuguese ports in 2017. (Data source: DGRM statistics).**

## 5. The Galician octopus fishery

Spain has been traditionally one of the main contributors to European landings of cephalopods caught in territorial and international waters reaching 35 785 t in 2017 (MAGRAMA, 2019). Within Spain, Galicia (NW Iberian Peninsula) is the most important Autonomous Community in terms of the Octopus (*Octopus vulgaris*) fishery. In spite of the enormous importance of the Octopus fishery in Galicia, there are several biological, socioeconomic and institutional aspects that remain largely unknown.

The Octopus fishery in Galicia has been exploited at least since Roman times using multiple methods and fishing gears. It represents the most important small-scale fishery in Galicia, deeply rooted in the coastal communities and the cultural gastronomy of the region (Bañón et al. 2018). Most of cephalopod species has a short life-span of about two years. The variations in distribution and abundance are conditioned by the life cycle, spawning season and reproductive migrations, which determine geographic and seasonal variations on effort. The dominant gear for the Octopus fishery is a small trap that begun to generalize in the 1970s, creating one of the few specialized fisheries (one gear, one target) in the region (Freire and Garcia-Allut 2000).

Octopus has been fished in all the Galician coast, even that the area of Rias Baixas, in the South of the region, traditionally had larger catches, and in the last years more than 90% of the catches correspond to small-scale fleet (Bañón et al. 2018). The Octopus fishery in Galicia is managed under management plans arranged by the regional government[2] that includes closed seasons (from May to July), minimum size of catches (currently 1 kg), maximum daily captures taking into account the number of crew members, limited number of traps of working hours at sea, etc. Legal catch limits are regulated according to the season and the number of fishers per boat, which is 30 kg/per vessel/day between July-August until a maximum of 210 kg/vessel/day, and 50 kg/per vessel/day up to a maximum of 350 kg per vessel and day in the rest of the season.

A total of 1224 vessels had permission to deploy traps in 2017, though effective license usage was considerably lower and has steadily decreased since 2004 (Bañón et al. 2018). Bueu and Ribeira are the auctions markets that concentrated more than 90% of total catches of Octopus during the period 2007-2017 (Xunta de Galicia, 2018). The volume of landings slightly increased decreased from 1 800 t in 2006 to 19 000 t in 2018, with the highest record in 2010 of 4 100 t (Figure 20). The evolution of Galician landings is due to interactions between diverse factors such as natural environmental variation in the Galician rias, contamination from land-based industries, overfishing, and low effectiveness of control and monitoring of the activity. Reconstructed total removals of *Octopus vulgaris* from Galician rias have been higher than official catches (Villasante et al. 2015; Bañón et al. 2018).

The Illegal, Unreported and Unregulated (IUU) catches of *Octopus vulgaris* have been estimated to range between 20%-50% of total reported catches in 2010, while the volume of recreational fishers harvesting Octopus and selling to restaurants is important (Villasante et al. 2015). Nevertheless, better control and monitoring programs with more sustainable fishers' practices have contributed to a substantial reduction of IUU practices in recent years.

[2] Resolution of May 8, 2018 approving the pilot plan for the management of octopus (Octopus vulgaris) with pots for the campaign 2018-2019.
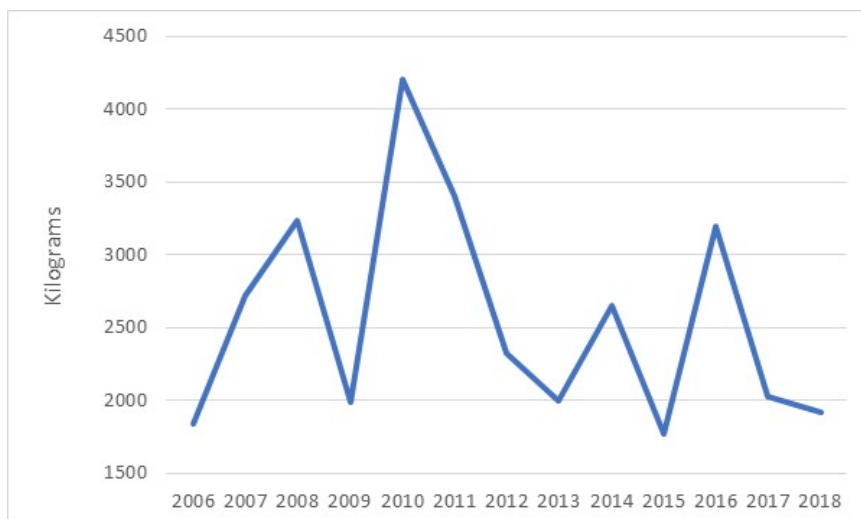
**Figure 20. Time series of total landings (volume) of *Octopus vulgaris* in Galician ports (Data source: PescadeGalicia.gal).**

As a result of the declining supply of *Octopus vulgaris* from Galician rias, the average price at first sale per kilo significantly increased from 5.1 €/kg from 2006 to 9.7 in 2018 €/kg, while the lowest price at first sale has been recorded in 2010 with 1.5 €/kg.[3] (Figure 21, Xunta de Galicia, 2018).
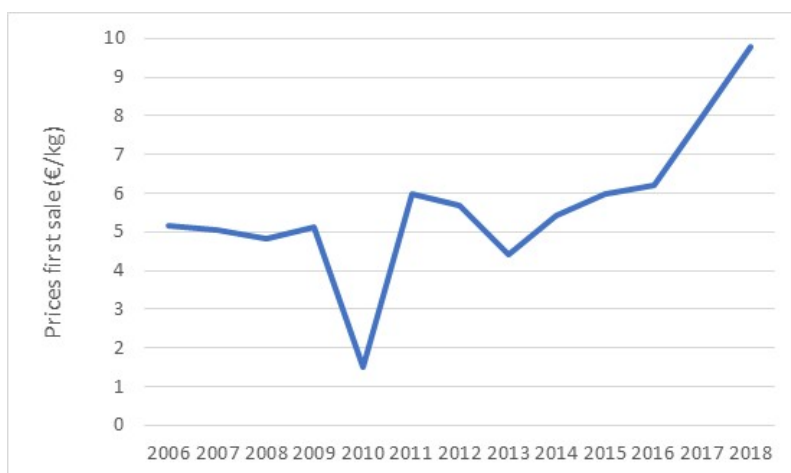


**Figure 21. Time series of prices at first sales (€/kg.) of *Octopus vulgaris* in Galician ports (Data source: PescadeGalicia.gal).**

The analysis of the landings value (euros) show that Galician *Octopus vulgaris* has doubled from 9.3 million euros in 2006 to 28.6 million euros in 2018 (Figure 22). However, the time series of landings value also show, as expected, a high variability the landings value each year due to both the volume of catches sold in Galician ports from Galician rias and the changes of the seafood market demands and the capacity of other fishing grounds (e.g., Africa). The octopus vulgaris fishery constitutes a key fishery for many artisanal boats. However, the increasing demand of Octopus vulgaris from international markets (until 23 countries demanded this highly valued species from Galicia in 2017) forced the Galician small-scale fishers to multiply by 10 the imports

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[3] Xunta de Galicia (2018) Anuario de Pesca 2017 Available online at https://www.pescadegalicia.gal/Publicaciones/AnuarioPesca2017/indice.html [Accessed February 15th, 2019].

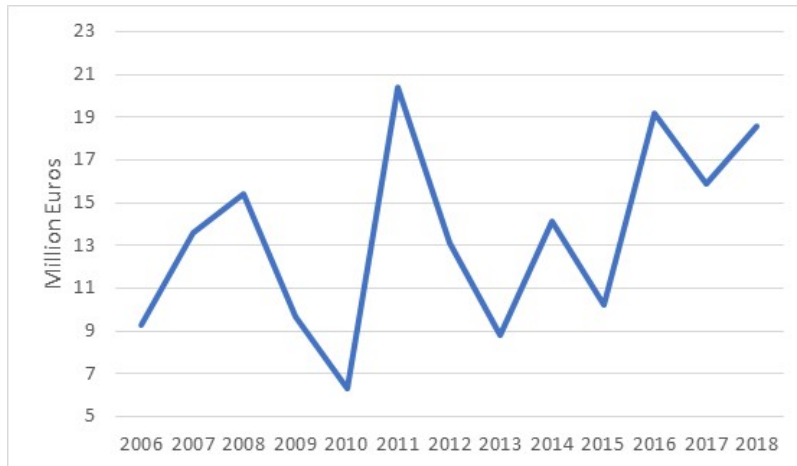(namely from Morocco and Portugal) of cephalopods compared to the local catches during the last decade[4].



**Figure 22. Time series of landings value (in million euros) at first sales of *Octopus vulgaris* in Galician ports (Data source: PescadeGalicia.gal).**

## 6. The Basque country cephalopod fishery

In this section the Basque Country landings will be analysed in detail. Cephalopod proportion in the landings increased from around 8% in 1997 to almost twice in 2001 in "Baka" otter trawls operating in Div. 8a,b,d (Santurtun et al., 2005 (ICES WGCEPH WD)). In the last five years, the cephalopod proportion in landings is around 15% with a peak of 28% in year 2007.

In the early 2000s, cephalopods appeared to be an important accessory species for the "baka" otter trawlers in division 8a,b,d due to the 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 from 2009-2012, effort of the mixed cephalopod metier (OTB_MCF) increased on a yearly basis and landings from the metier also increased. But in 2013 and 2014, effort has decreased significantly. This appears to reflect a change in fishing exploitation pattern, with 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 a quota system for them (Figure 23).

The analysis of prices shows that in the last twelve years there has been hardly an increase in prices of cephalopods at first auction, as has also occurred for the main demersal commercial species. Squids remain the cephalopod with the highest price in auction with an increasing trend in the last two years, and the short-finned squid and octopus are the ones with lowest values in auction (Figure 24).

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[4] Villasante S, Garcia-Rodrigues J, Pita P, Monteiro S, Matos F, Power AM, Pita C. (2019) Repository on supply and demand of Galician Octopus vulgaris, Cephs and Chefs Project [Accessed February 15th, 2019).
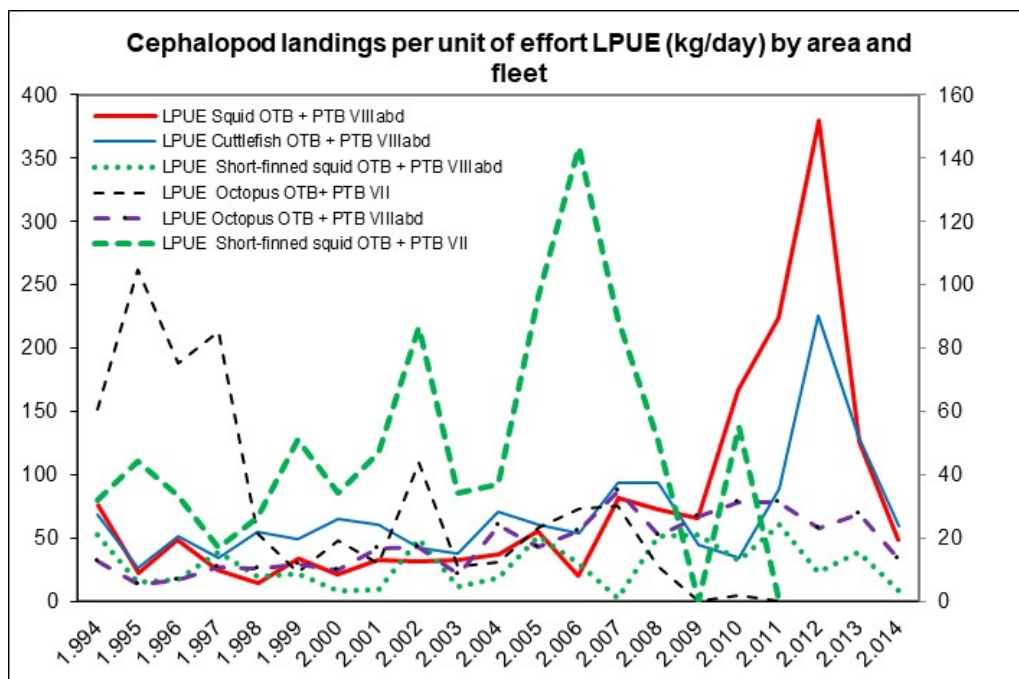
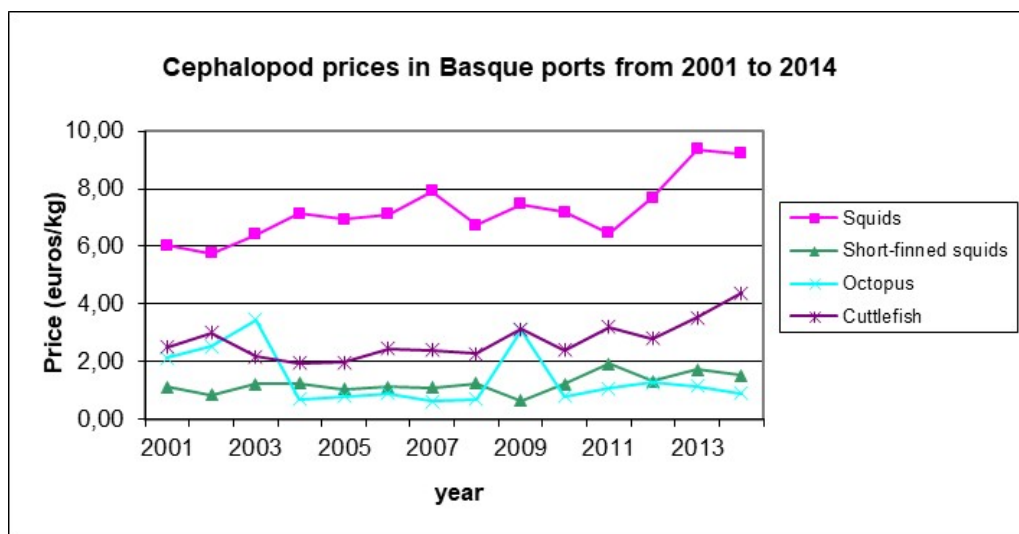**Figure 23. Cephalopod landings per unit of effort (kg/day) of the basque fleet from 1994 to 2014.**



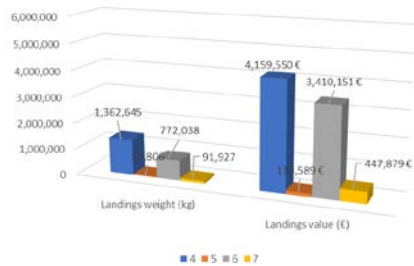**Figure 24. Cephalopod prices in Basque ports from 2001 to 2014.**

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Xunta de Galicia (2018) Anuario de Pesca 2017 Available online at https://www.pescadegalicia.gal/Publicaciones/AnuarioPesca2017/indice.html [Accessed February 15th, 2019).
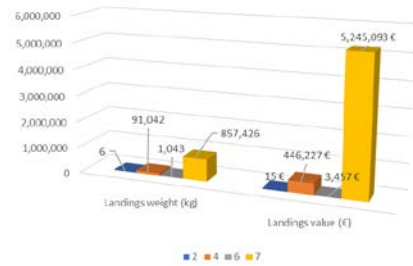
Annex: further information on cephalopod landings in the UK, Ireland and France

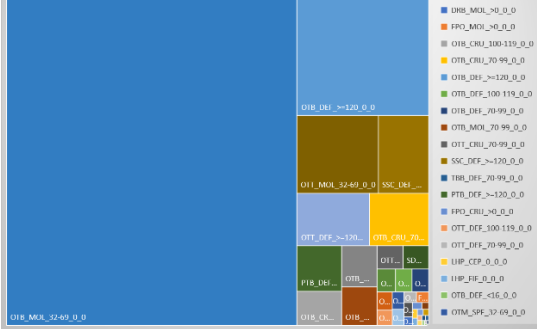## United Kingdom: 2014-2015, *Loligo* spp. All fisheries and sea areas

# Ireland: 2013-2014, Loligo spp. All fisheries and sea areas


Ireland *Loligo spp.* landings and value in 2013


Ireland *Loligo spp.* landings and value 2014


Ireland: 2013 ICES Subarea 7, metiers contributing most to landings
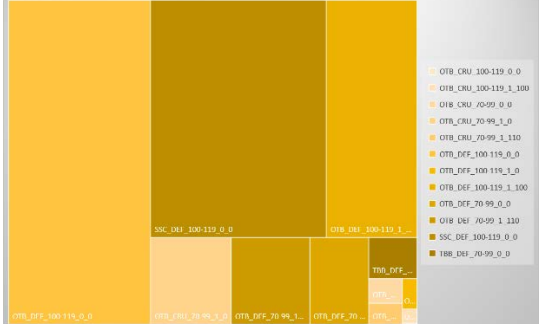

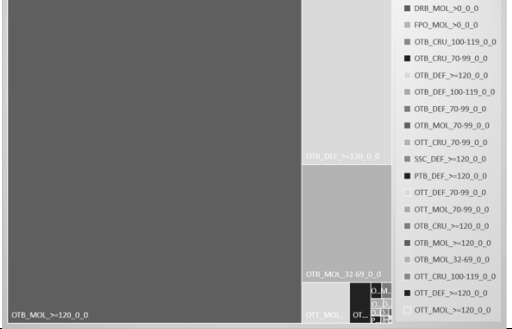Ireland: 2014 ICES Subarea 7, metiers contributing most to value
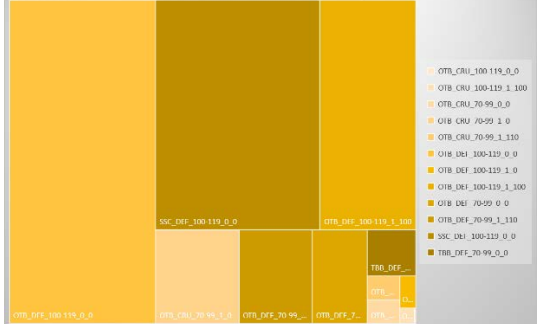

Ireland: 2014 ICES Subarea 7, metiers contributing most to landings


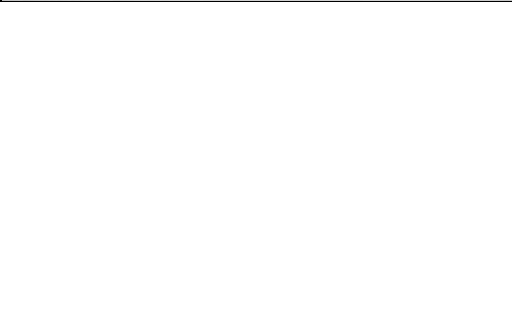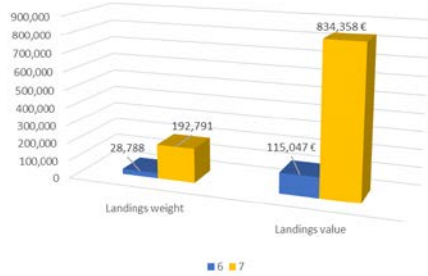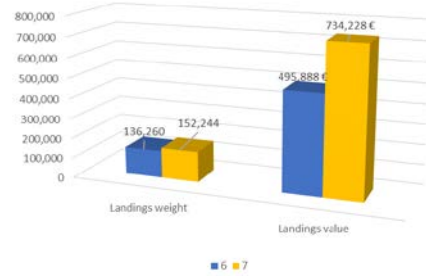Ireland: 2014 ICES Subarea 7, metiers contributing most to value

# France: 2014-2015 Loligo spp. All fisheries and sea areas



France *Loligo spp.* landings and value in 2014



France *Loligo spp.* landings and value in 2015



France: 2014 ICES Subarea 7, metiers contributing most to landings
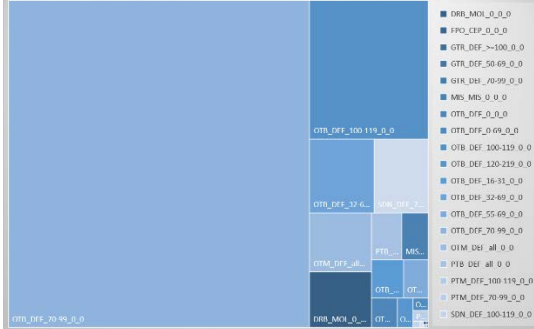


France: 2014 ICES Subarea 7, metiers contributing most to value
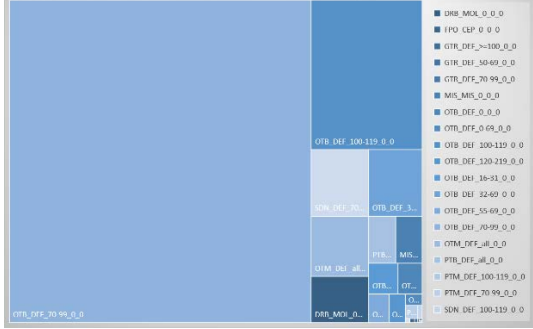


France: 2014 ICES Subarea 8, metiers contributing most to landings



France: 2014 ICES Subarea 8, metiers contributing most to value



France: 2015 ICES Subarea 7, metiers contributing most to landings
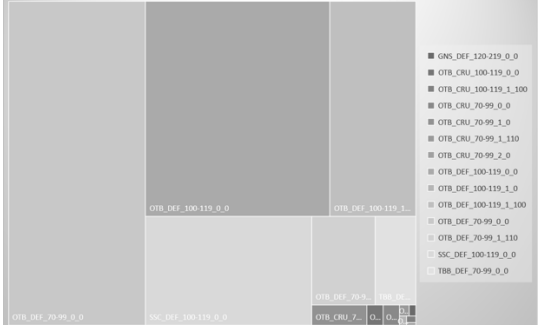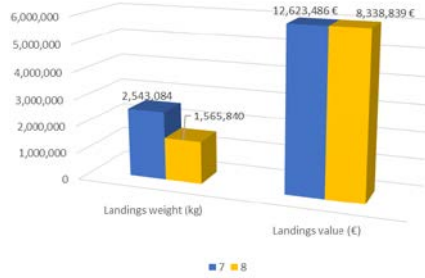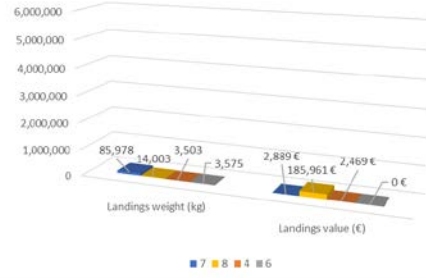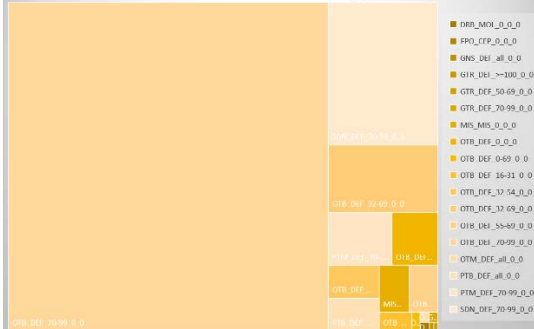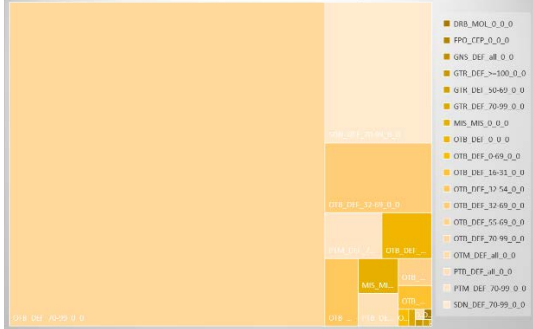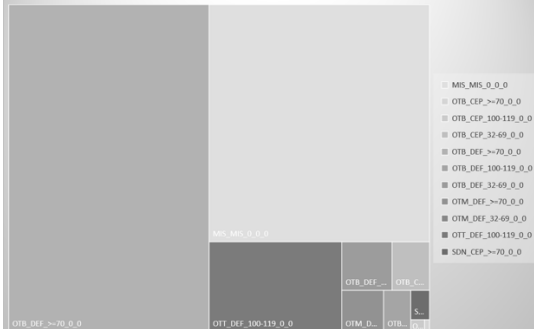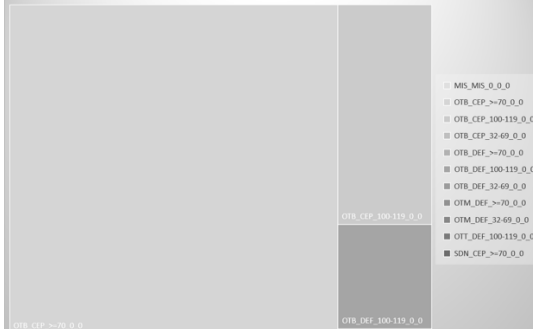


France: 2015 ICES Subarea 7, metiers contributing most to value

# Results on main cephalopods species captured
# in the bottom trawl surveys in the Porcupine Bank (Division 7c and 7k)

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**Citation of the material is subject to approval by the authors**

## Abstract

*This working document presents the results of the significant cephalopods in the Spanish Ground Fish Survey on the Porcupine bank (SPPGFS) from 2001 to 2017. The species more abundant in biomass terms in these surveys are curled octopus (Eledone cirrhosa), European flying squid (Todarodes sagittatus), Northern European squid (Loligo forbesi) and lesser flying squid (Todaropsis eblanae). Other scarce cephalopods are stout bobtail squid (Rossia macrosoma), seven-arm octopus (Haliphron atlanticus), globose octopus (Bathypolypus sponsalis), and reverse jewell squid (Histioteuthis reversa). Biomass, distribution and length ranges were analysed. Most of the species occur in the shallower range of the grounds covered by the survey (180-800 m), except T. sagittatus, H. atlanticus and B. sponsalis that were mainly found in the deeper strata (450-800).*

## Introduction

The Porcupine Bank bottom trawl survey has been carried out annually since 2001 to provide data and information for the assessment of the commercial fish species in the area (ICES divisions 7c and 7k) (ICES, 2017). During these 17 years of surveys, the cephalopods have occurred frequently but they have been little reported and assessed.

This working document presents the results on abundance indices, geographic distributions and length frequency of the most significant cephalopods caught on the Porcupine Spanish ground fish survey in 2017, *Eledone cirrhosa* and *Bathypolypus sponsalis* (fam. Octopodidae), *Haliphron atlanticus* (fam. Alloposidae), *Todarodes sagittatus*, *Todaropsis eblanae* and *Illex coindetii* (fam. Ommastrephidae), *Loligo forbesi* (fam. Loliginidae), *Histioteuthis reversa* (fam. Histtioteuthidae) and *Rossia macrosoma* (fam. Sepiolidae), as well as it updates the previous document presented with the information on the first twelve years (2001-2012) of the time series on the Porcupine Bank (Ruiz-Pico *et al.* 2012).

## Material and methods

The area covered in the Spanish Ground Fish Survey on the Porcupine bank (SP-PORC-Q3) extends from longitude 12° W to 15° W and from latitude 51° N to 54° N, following the standard IBTS methodology for the western and southern areas (ICES

2017). The R/V "Vizconde de Eza" a stern trawler of 53 m and 1800 Kw has been used throughout the historical series to carry out the SP-PORC-Q3. The sampling design was random stratified to the area (Velasco and Serrano, 2003) with two geographical sectors (Northern and Southern) and three depth strata (> 300 m, 300-450 m and 450-800 m). Hauls allocation is proportional to the strata area following a buffered random sampling procedure (as proposed by Kingsley *et al*. 2004) to avoid the selection of adjacent 5×5 nm rectangles (Figure 1). More details on the survey design and methodology are available in the Manual of the IBTS North Eastern Atlantic Surveys (ICES 2017).

The reduction in the tow duration (20 instead of 30 minutes) applied in the last two surveys worked successfully. Now the catches are reduced and more manageable for people who sort it, but keep on being abundant enough to provide representative samples. The biomass indices of the whole time series are not affected by this reduction because the results of these last surveys were extrapolated to 30 minutes of trawling time to keep the comparability of the time series.

Trying to know the catches when the net contacts ground and before it starts to trawl, some "zero minute hauls" were carried out this 2017 survey within the frame of an IBTSWG experiment.

Cephalopods species are identified and sorted at the end of each haul, and since 2008, following IBTS protocols, length distributions are collected for the most common cephalopod species.

Two different methods were used to estimate abundance variability: (i) the parametric standard error derived from the random stratified sampling (Grosslein and Laurec, 1982), and (ii) a non parametric bootstrap procedure implemented in R (R Development Core Team, 2008) re-sampling randomly with replacement stations within each stratum and maintaining the sampling intensity, and using 80% bootstrap confidence intervals from the 0.1 and 0.9 quantiles of the resultant distribution of bootstrap replicates (Efron and Tibshirani, 1993). Geographical and bathymetric distributions of the most common species are analysed in biomass and number terms for the seventeen years of the overall time series. Length distributions data just were collected from 2008 to 2017 and results are presented only for these years.

## Results

In 2017, 80 standard hauls, 4 additional hauls and 10 zero-minute hauls were carried out (Figure 1).
Cephalopods represent a relatively small percentage of the invertebrates mean stratified biomass caught (5%) and of the mean stratified abundance (1%), but about 85% and 64% of the molluscs mean stratified biomass and abundance caught respectively.
The species with the largest stratified biomass were curled octopus *(Eledone cirrhosa)*, then European flying squid (*Todarodes sagittatus*), lastly lesser flying squid (*Todaropsis eblanae*) and long finned squid (*Loligo forbesi)*. Other scarce cephalopods were seven-arm octopus (*Haliphron atlanticus)*, globose octopus (*Bathypolypus sponsalis)*, reverse jewell squid (*Histioteuthis reversa*) and stout bobtail squid (*Rossia macrosoma*). However, there are differences in numeric abundance terms. *L. forbesi* and *T. eblanae* showed more abundance than *T sagittatus* while *H. atlanticus* showed marked lower abundances than *B. sponsalis* and *H. reversa*. *Illex coindetti* was not found this last year.
Some patterns of geographical distribution were observed in *E. cirrhosa* and *T. eblanae* which are mainly found in the North sector and close around the central mound of the Bank. Therefore, most of the species showed a higher percentage of occurrences in the

shallower depth strata, below 300 m, although *T. sagittatus* also occurred frequently deeper than 450 m while the octopus *H. atlanticus* and *B. sponsalis* showed a narrower and deeper bathymetric range.

Length size data have been collected for the last decade, some trends have been observed. *T. eblanae* showed lower sizes and *T. sagittatus* showed wider length size range than the other Ommastrephids. Finally, modes were observed in all species, although could not be followed during the whole time series.

**Curled octopus (*Eledone cirrhosa*)**

This species represented about 51% of the cephalopods caught in 2017, both in mean stratified biomass and abundance. The biomass and abundance of *E. cirrhosa* dropped this last survey, changing the increasing trend of the previous five years (Figure 2).

The distribution of *E. cirrhosa* was reduced to the shallower strata around the bank this last survey. The species was hardly found in the south sector from 300 m to 450 m and was absent in the Irish shelf in contrast to the previous years (Figure 3a and Figure 3b).

The length size of the last survey ranged from 1 to 15 cm with a mode around 5 cm as usual. Smaller specimens than 5 cm were scarce in the time series, but from 2014 they were found more and more until reaching the highest values in 2016. However, in 2017, the small specimens were scarce again (Figure 4).

**European flying squid (*Todarodes sagittatus*)**

*T. sagittatus* represented about 22% of the cephalopods mean stratified biomass caught while it just showed about 4% of the stratified abundance caught. The stratified biomass slightly decreased this last survey but remained similar to the values of the last seven years. However, the abundance decreased markedly after the peak of 2016. Other three peaks were showed in 2003, 2008/2009 (Figure 5).

*T. sagittatus* extended throughout the Porcupine area from 189 to 764 m. In 2017 the specimens were mainly found in the western deepest part of the study area (Figure 6a and Figure 6b).

The minimum length size of *T. sagittatus* in the last ten years, were 10 cm in 2011 and 2016 and the maximum 48 cm in 2008. A very clear mode around 21 cm and 23 cm was found in 2008 less marked but also clear around in 2009, and also a slightly marked mode around 16 and 17 cm can be appreciated in 2016 and quite smaller in around 17 and 18 cm in 2017. A clear length mode is absent among the low values of the rest of the time series (Figure 7).

**Lesser flying squid (*Todaropsis eblanae*)**

This species represented a small percentage of the cephalopods mean stratified abundance caught (5%) and of the stratified biomass caught (6%). The stratified biomass showed a smoother trend than stratified abundance trend. The abundance peaks in 2005, 2009, 2012 and 2016 represented little increases in biomass (Figure 8).

*T. eblanae* was mainly found in the North sector, close to the southern part of the central mound of the Bank and in the eastern area close to the Irish shelf. It extended from 189 to 719 m and occurred in about 30% of the hauls shallower than 300 m in the overall time series (Figure 9a and Figure 9b).

Most of the specimens of this species showed little sizes up to 10 cm, even a marked mode in 6 cm was found in 2009 and 2012, but some larger specimens about 20 cm were also observed in 2009 (Figure 10).

**Broadtail shortfin squid (*Illex coindetii*)**

This species was absent in the last survey. The stratified biomass and abundance were low in the overall time series, although two marked peaks were found in 2007 and 2009, being the former year quite lower in the stratified biomass trend (Figure 11).

No clear pattern was found in the geographical distribution of *I. coindetti*. The bathymetric distribution showed the majority of biomass in the shallowest depth strata, below 300 m, although this species was found from 200 to 724 m (Figure 13).

There were few size measurements to analyse the length size trend in that species, even so the specimens ranged from 4 to 21 in the time series and 2009 sizes showed a clear mode around 16 cm (Figure 12).

**Long finned squid (*Loligo forbesi*)**

*L. forbesi* represented about 11% of the cephalopods mean stratified biomass caught and 6% of the stratified abundance caught in the overall time series. The stratified biomass and abundance trend were similar and showed an increase from 2008, after seven years of very low values, showing a peak in 2009 (Figure 14).

This species was mainly found in the Northern sector, close around the Bank and in the shallower eastern area. It dwelled between 189 and 507 m, although higher biomass was found below 300 m (Figure 15a and Figure 15b).

*L. forbesi* showed a wide length size range, like that of *T. sagittatus*. It ranged from 8 to 47 cm in the time series. A mode around 16 was found in 2009 and 2017and one around 13 cm was found in 2009 (Figure 16).

The two species of *Loligo* have been reported in the area (Lordan *et al*, 2011). *L. forbesi* is the most numerous species in catches of the cephalopods, while *L. vulgaris* have been occasionally caught, following these authors, who also recognize that the identification of the both *Loligo* species is especially difficult in smaller specimens, this fact may have also affected our results. Even a special effort has been made to distinguish between both species in the last years no presence of *L. vulgaris* has been reported.

**Other species**

Although *Haliphron atlanticus*, *Bathypolypus sponsalis*, *Histiotheuthis reversa* and *Rossia macrosoma* also represented a small percentage of the cephalopods mean stratified biomass caught (5%, 2%, 0.6%, 0.4% respectively) and abundance (0.24, 1%, 2% and 0.4% respectively), some trends have been observed. An important decrease was found in the stratified biomass trend of *H. atlanticus* since 2008, while a slight decreasing trend in abundance was observed in *B. sponsalis* in the last four years (Figure 17 and Figure 19).

*H. atlanticus* and *B. sponsalis* were not found in the shallower depth strata, except for one haul at 253 m in 2014 with two individuals of *H. atlanticus*. They dwelled respectively from 315 (253) to 763 m and from 309 to 764 m. High biomass of *H. atlanticus* and *B. sponsalis* were found some years in the deepest South and occasionally in North sector. (Figure 18a, Figure 18b, Figure 20a and Figure 20b).

*R. macrosoma* showed a decreasing trend of the stratified biomass after the peak in 2013, returning to average values of the time series in the last surveys (Figure 21). In abundance terms, a peak was found in 2014 and the specimens extended in the North sector from 192 to 760 m in the overall time series, although the higher abundances were found shallower than 450 m (Figure 22a and Figure 22b).

*H. reversa*, despite being scarce, increased its abundance this last survey, reaching the highest value of the time series (Figure 23).

## Acknowledgements

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# Figures
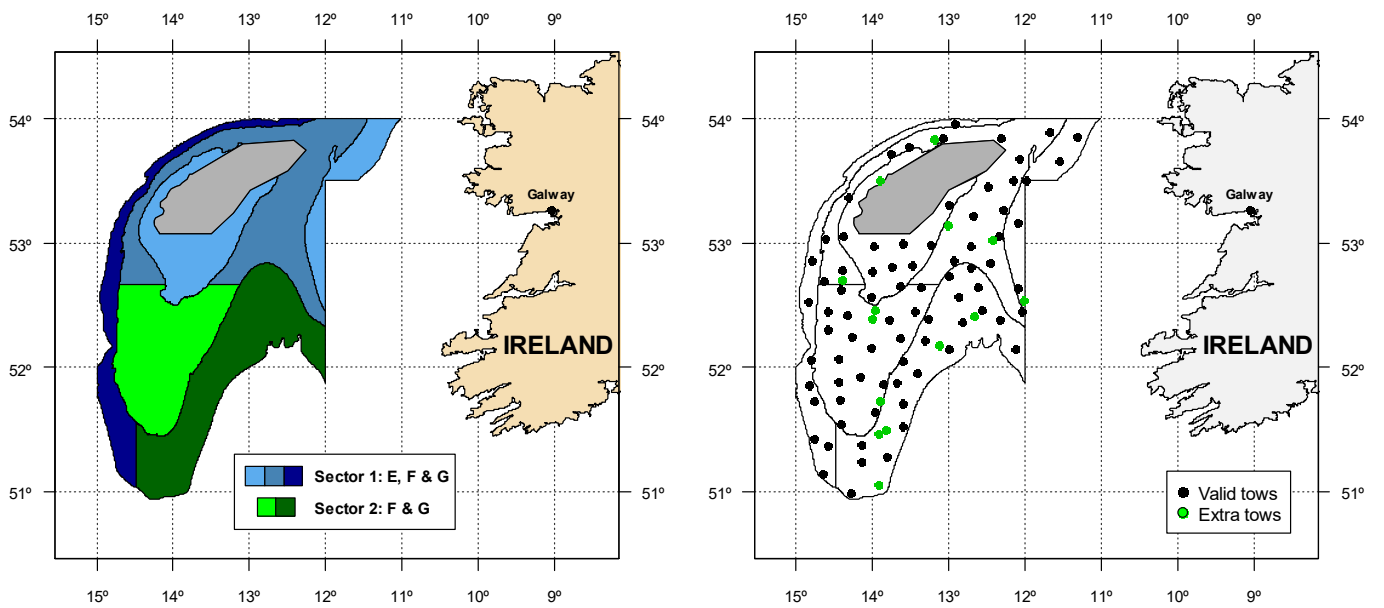


Figure 1 Left: Stratification design used in Porcupine surveys from 2003, previous data were re-stratified. Depth strata are: E) shallower than 300 m, F) 301 – 450 m and G) 451 – 800 m. Grey area in the middle of Porcupine bank corresponds to a large non-trawlable area, not considered for area measurements and stratification. Right: distribution of hauls performed in 2017



Figure 2 Evolution of *Eledone cirrhosa* biomass index and abundance during the Porcupine bank bottom trawl survey time series (2001-2017). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000)

Figure 3 a) Geographic distribution of *Eledone cirrhosa* catches (kg/30 min haul) in Porcupine bank bottom trawl surveys between 2006 and 2017.



Figure 3 b) Bathymetric biomass profile of *E. cirrhosa* in the Porcupine bank bottom trawl surveys (2001-2017)

Figure 4 Mean stratified length distributions of *Eledone cirrhosa* in the Porcupine bank bottom trawl surveys (2008-2017)

Figure 5 Evolution of *Todarodes sagitattus* biomass index and abundance during the Porcupine bank bottom trawl survey time series (2001-2017). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000)

Figure 6 a) Geographic distribution of *Todarodes sagittatus* catches (kg/30 min haul) in Porcupine bank bottom trawl surveys between 2006 and 2017.



Figure 6 b) Bathymetric biomass profile of *T. sagitattus* in the Porcupine bank bottom trawl surveys (2001-2017)

Figure 7 Mean stratified length distributions of *Todarodes sagitattus* in the Porcupine bank bottom trawl surveys (2008-2017)

Figure 8 Evolution of *Todaropsis eblanae* biomass index and abundance during the Porcupine bank bottom trawl survey time series (2001-2017). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000)
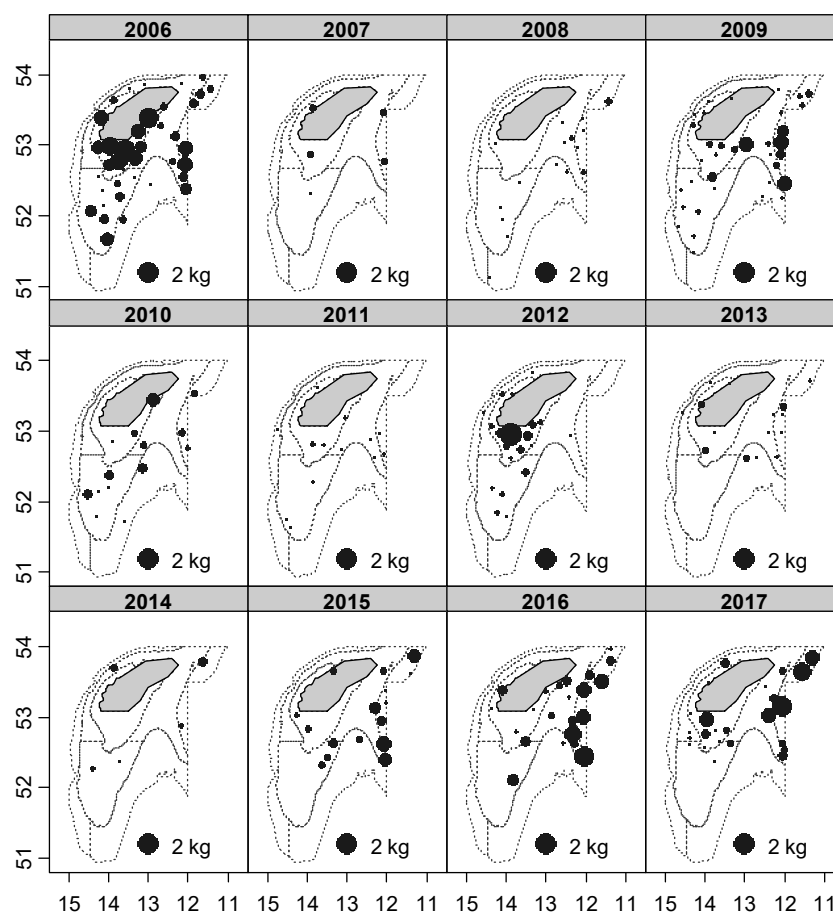


Figure 9 a) Geographic distribution of *Todaropsis eblanae* catches (kg/30 min haul) in Porcupine bank bottom trawl surveys between 2006 and 2017.

1
2
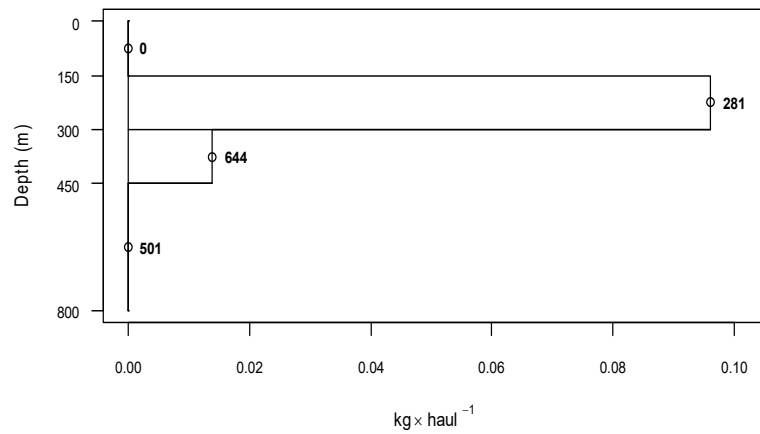
Figure 9 b) Bathymetric biomass profile of *T. eblanae* in the Porcupine bank bottom trawl surveys (2001-2017)
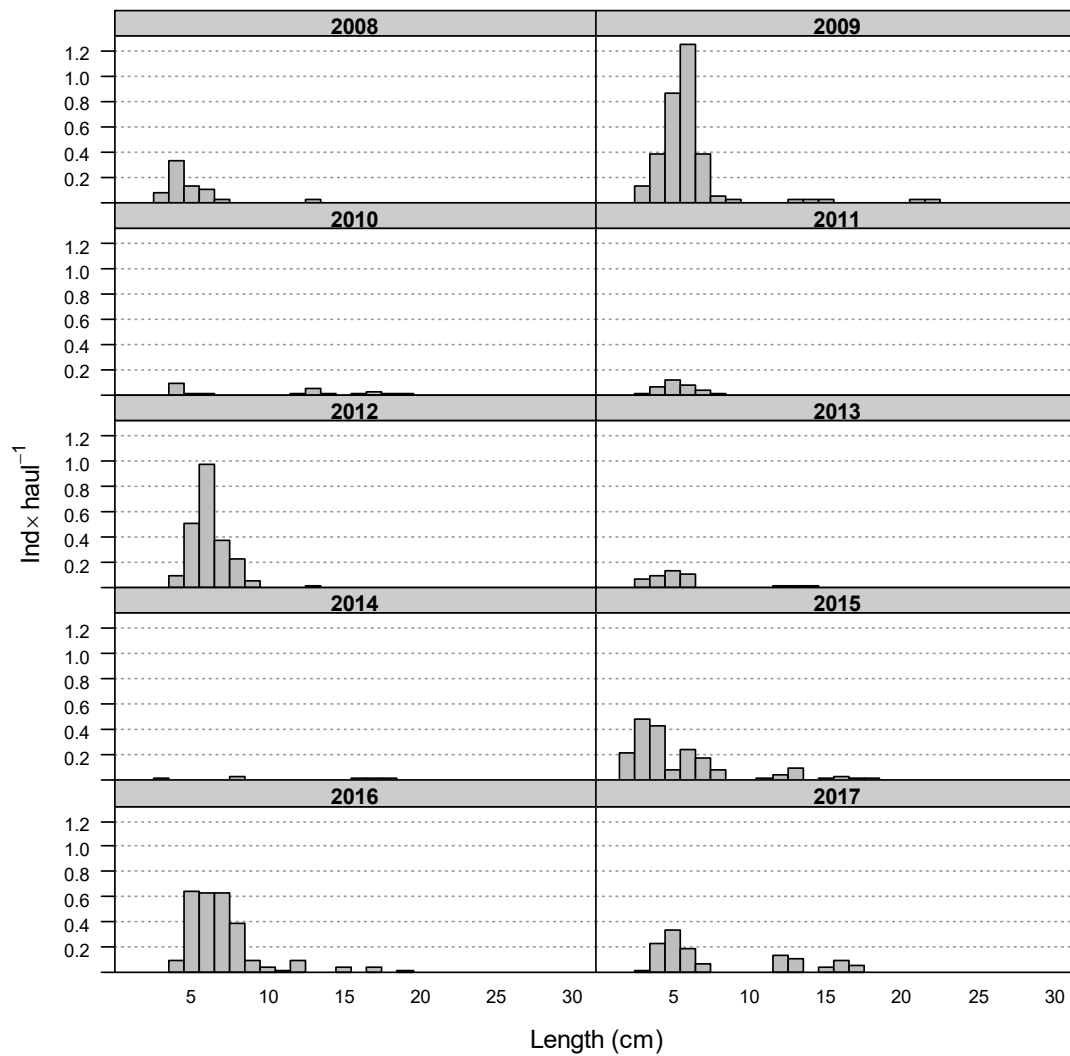


Figure 10 Mean stratified length distributions of *Todaropsis eblanae* in the Porcupine bank bottom trawl surveys (2008-2017)
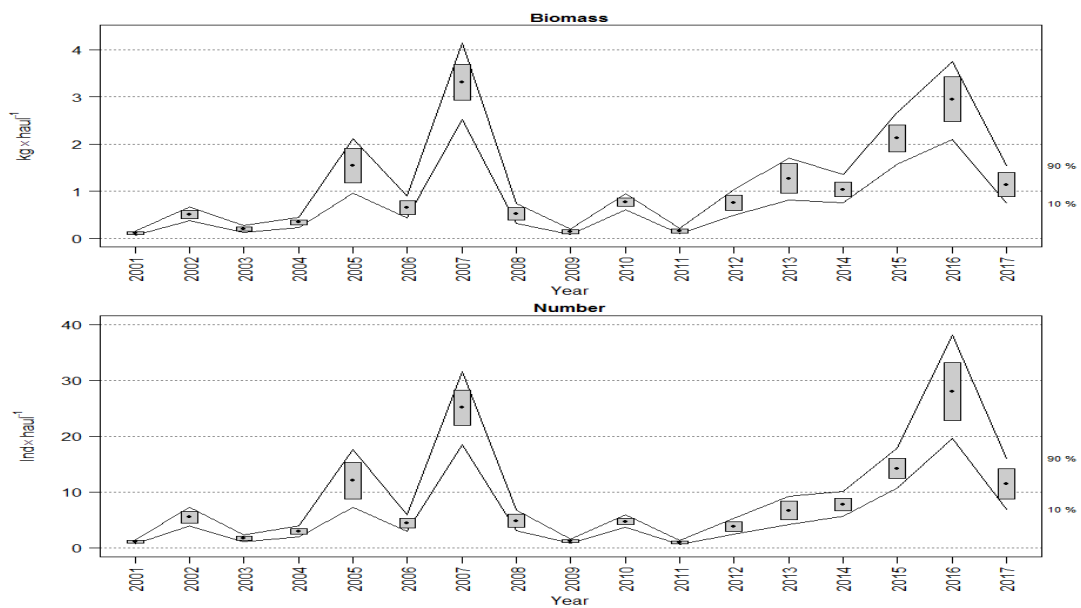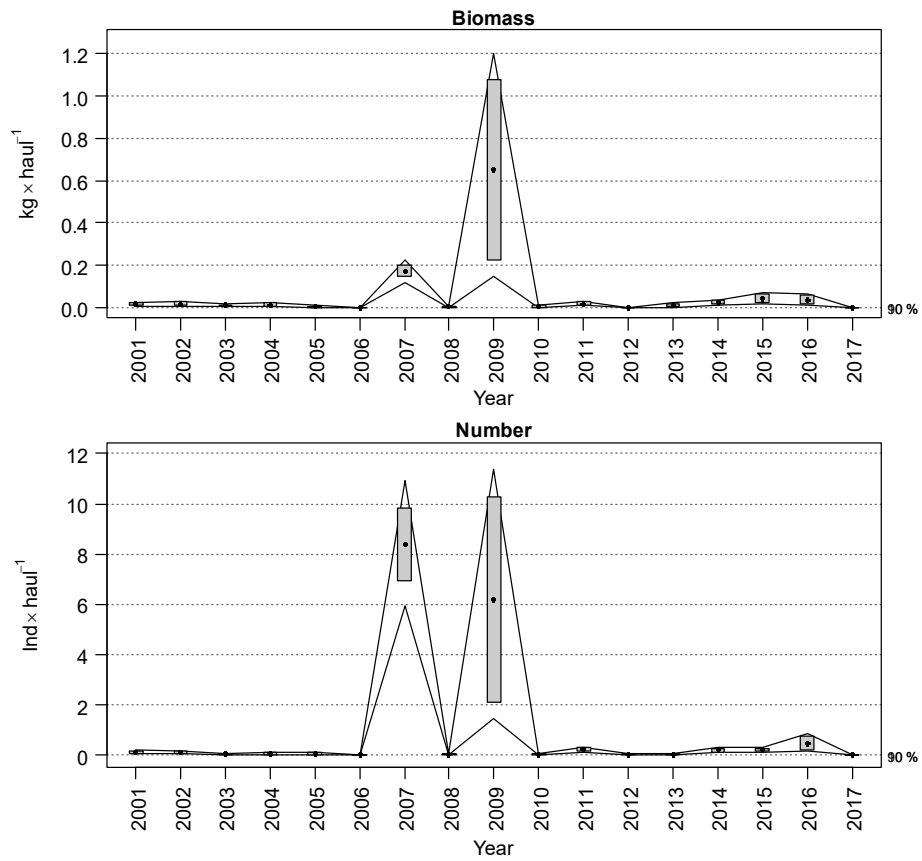
Figure 11 Evolution of *Illex coindetti* biomass index and abundance during the Porcupine bank bottom trawl survey time series (2001-2017). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000)
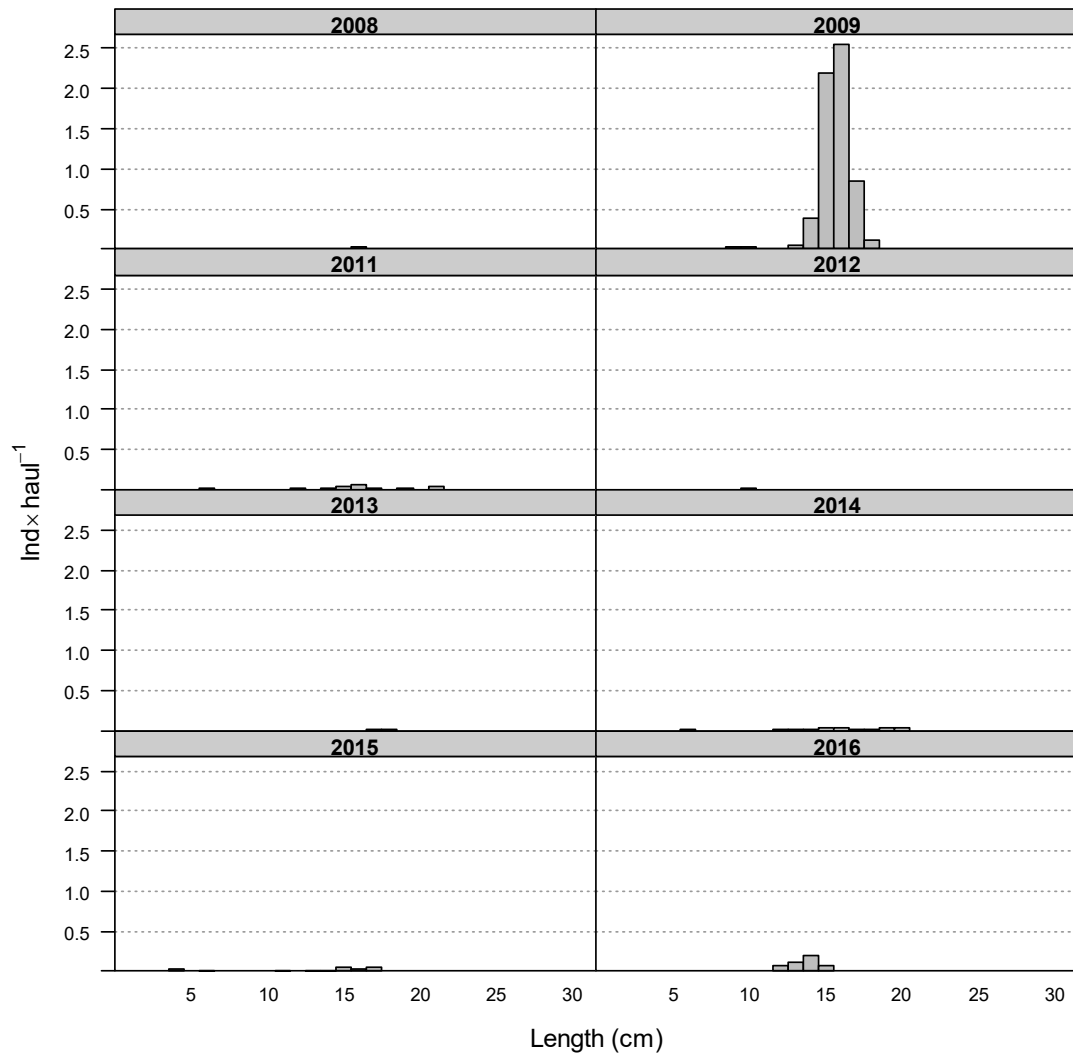
Figure 12 Mean stratified length distributions of *Illex coindetti* in the Porcupine bank bottom trawl surveys when captured (2008-2017)

**Illex coindetii**
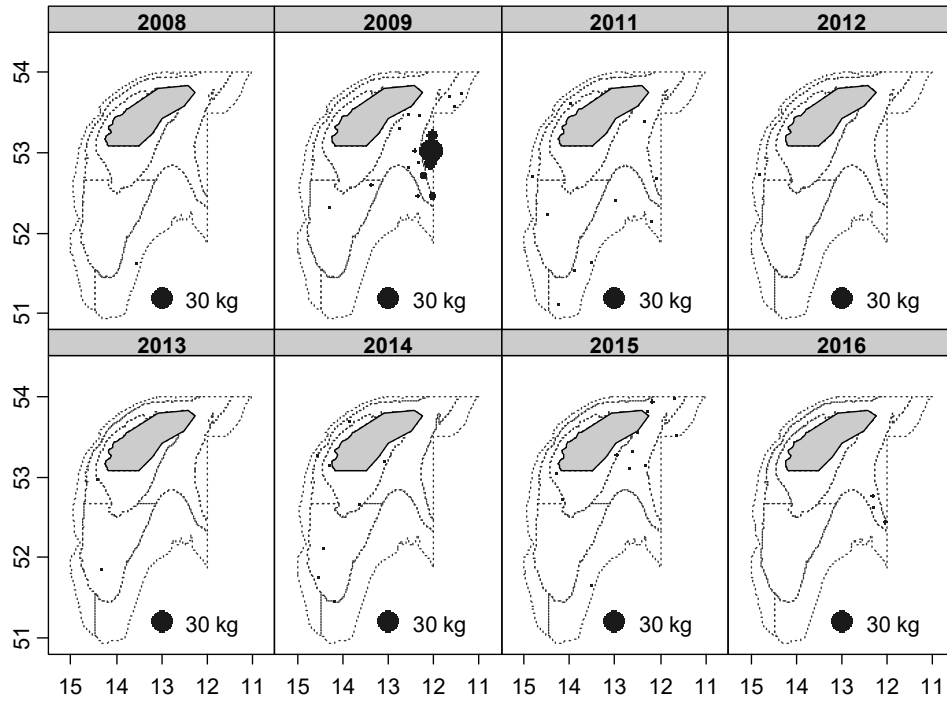


Figure 13 Geographic distribution of *Illex coindettii* catches (kg/30 min haul) in Porcupine bank bottom trawl surveys when it appeared
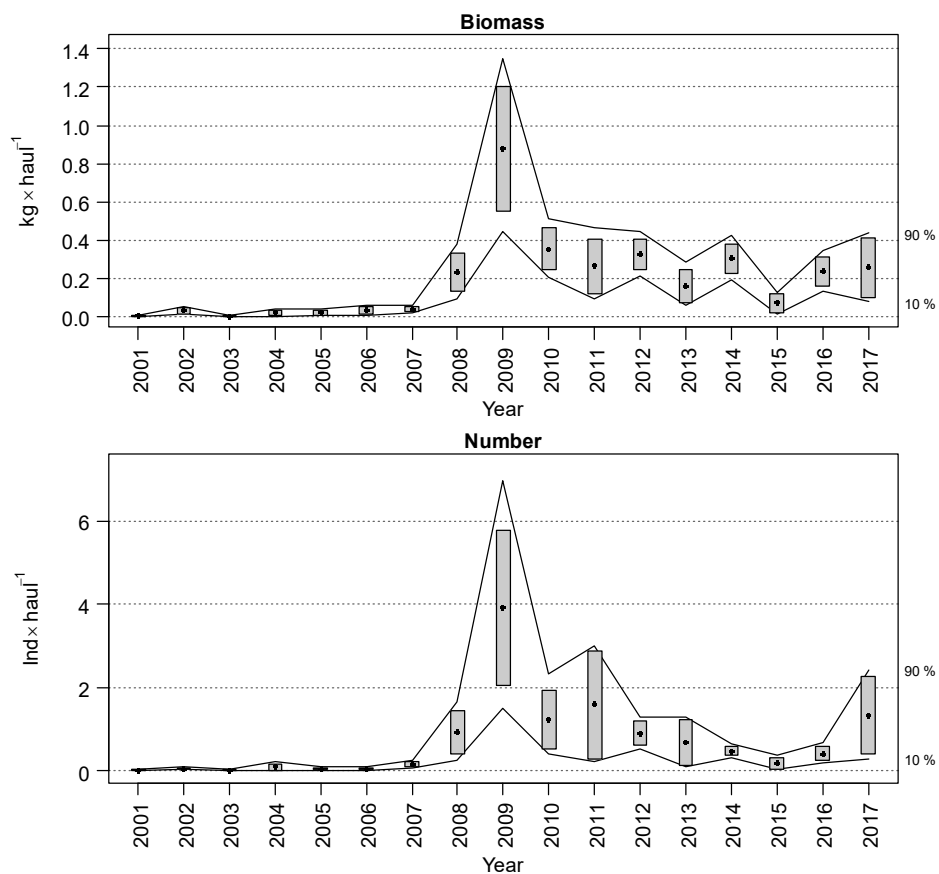
Figure 14 Evolution of *Loligo forbesi* biomass index and abundance during the Porcupine bank bottom trawl survey time series (2001-2017). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000)
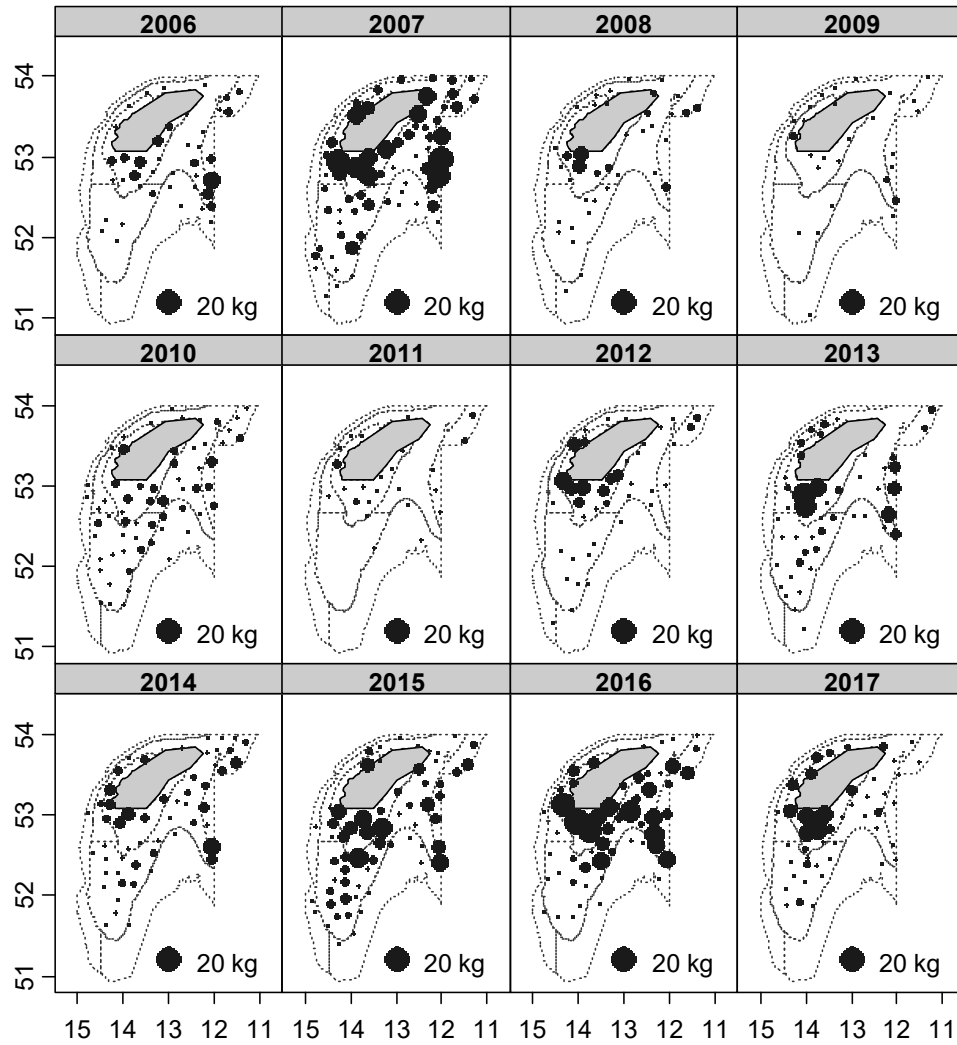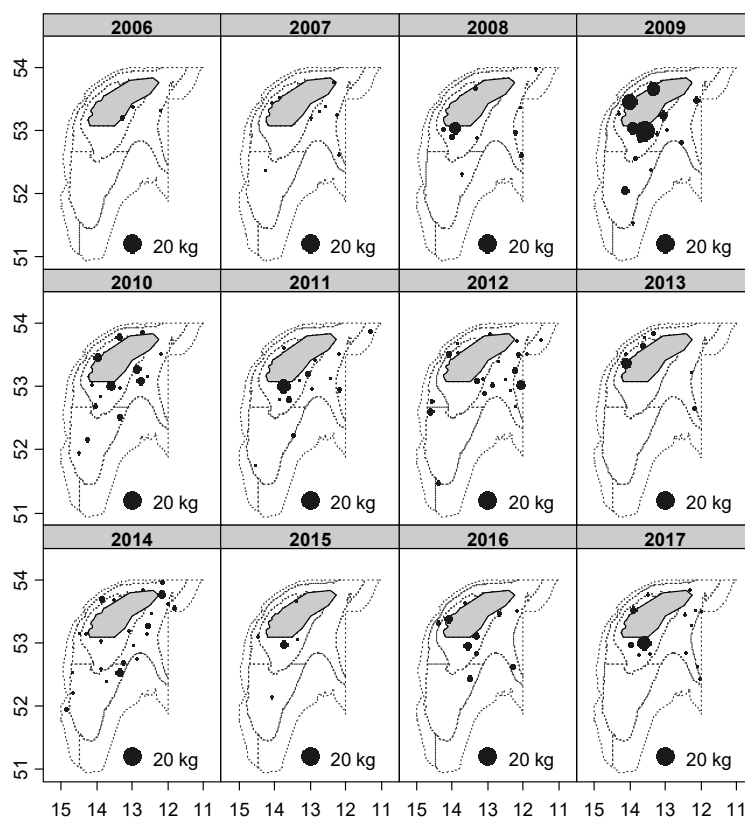
Figure 15 a) Geographic distribution of *Loligo forbesi* catches (kg/30 min haul) in Porcupine bank bottom trawl surveys between 2006 and 2017
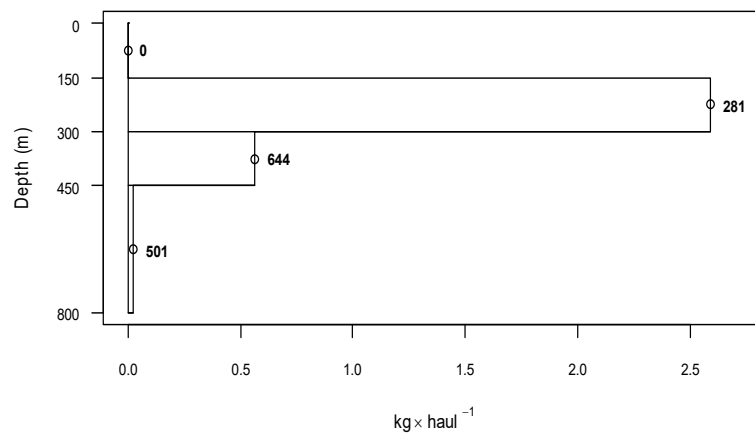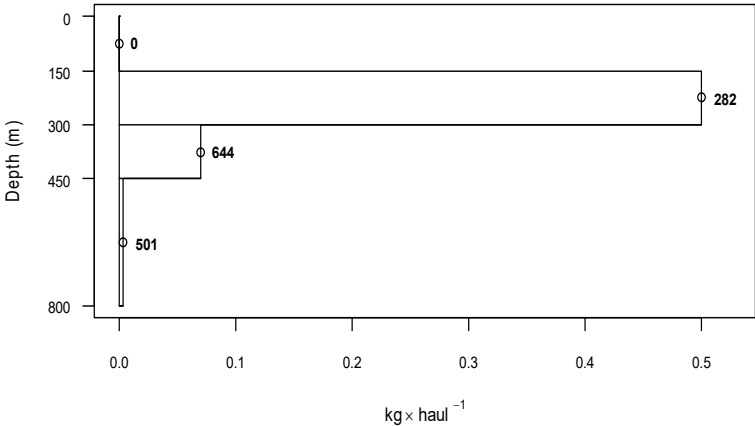


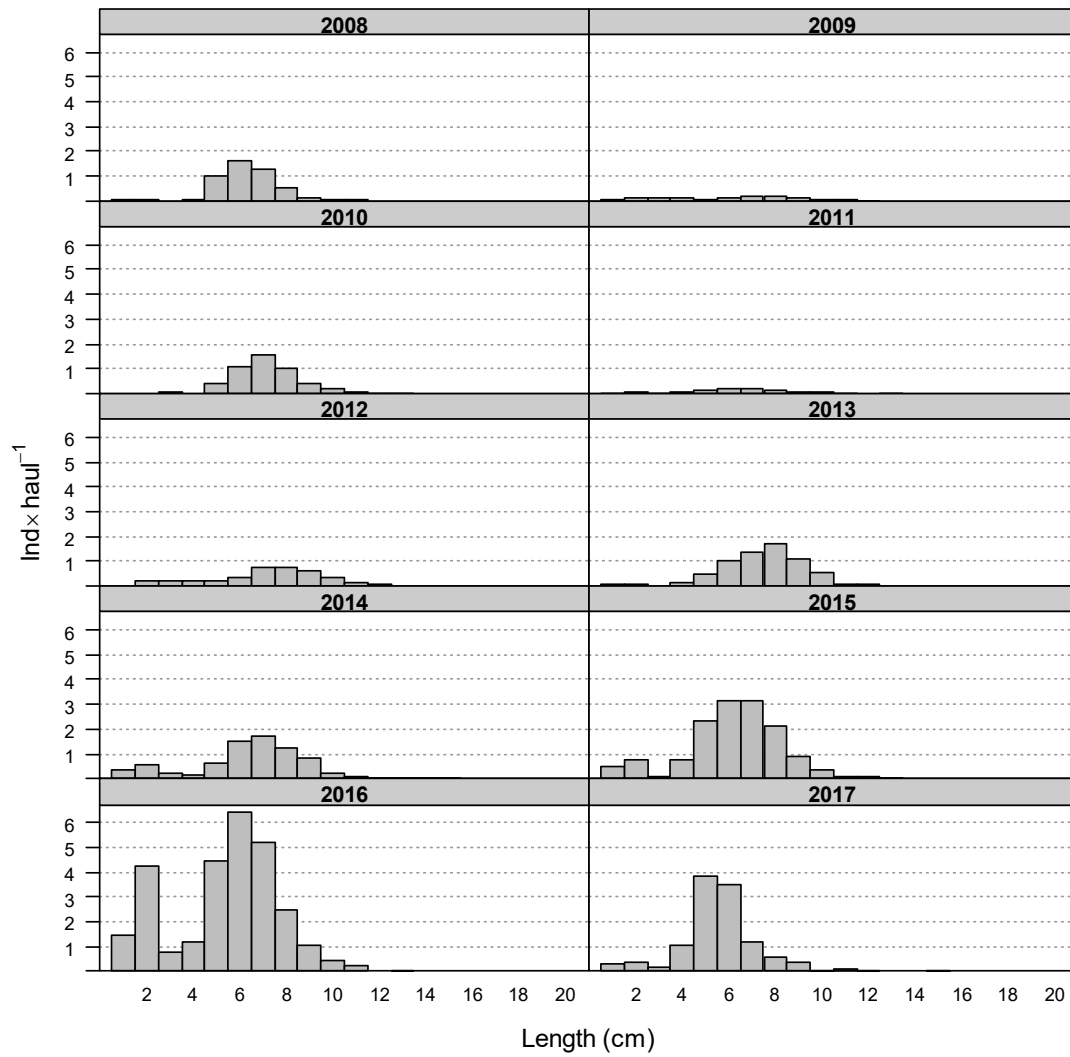Figure 15 b) Bathymetric biomass profile of *L. forbesi* in the Porcupine bank bottom trawl surveys (2001-2017)
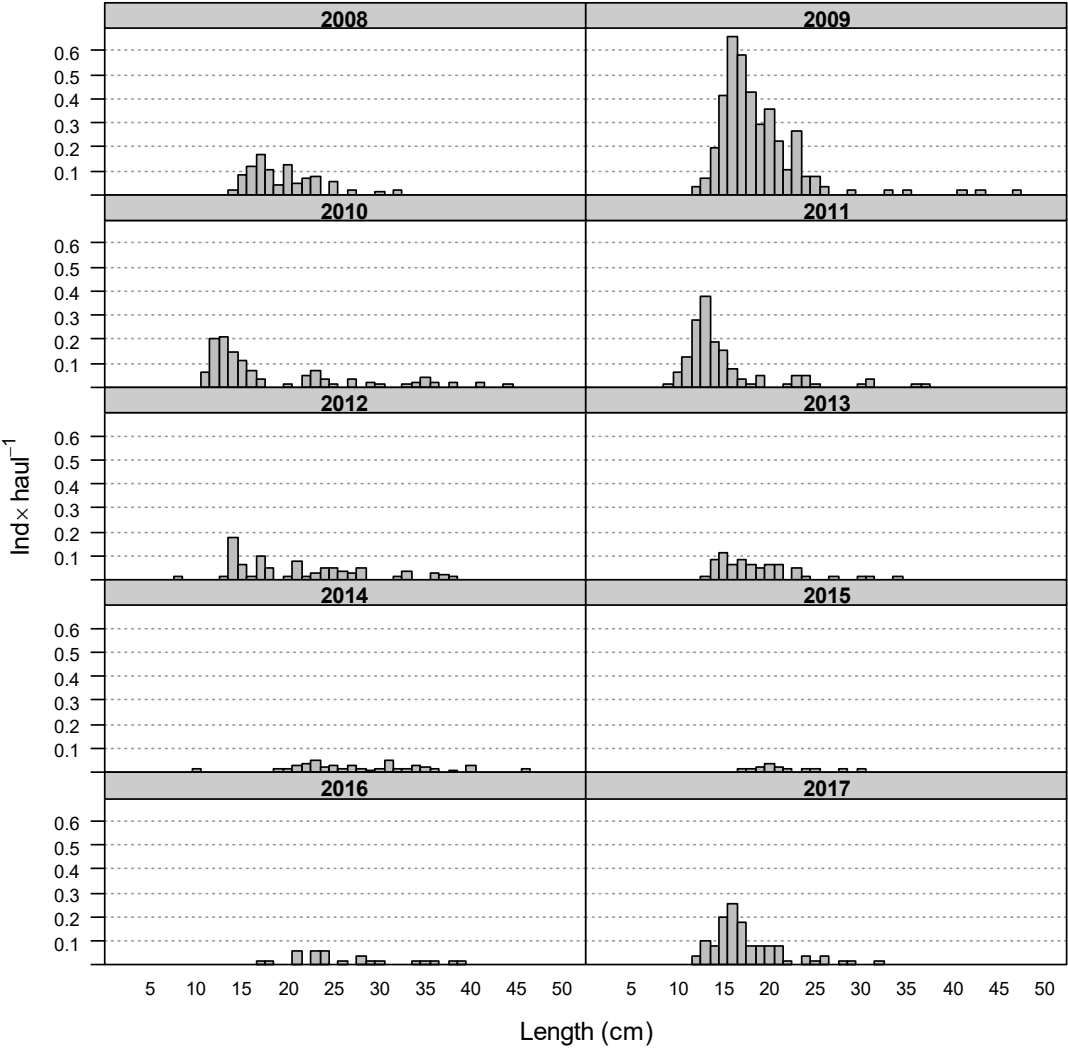


Figure 16 Mean stratified length distributions of *Loligo forbesi* in the Porcupine bank bottom trawl surveys (2008-2017)
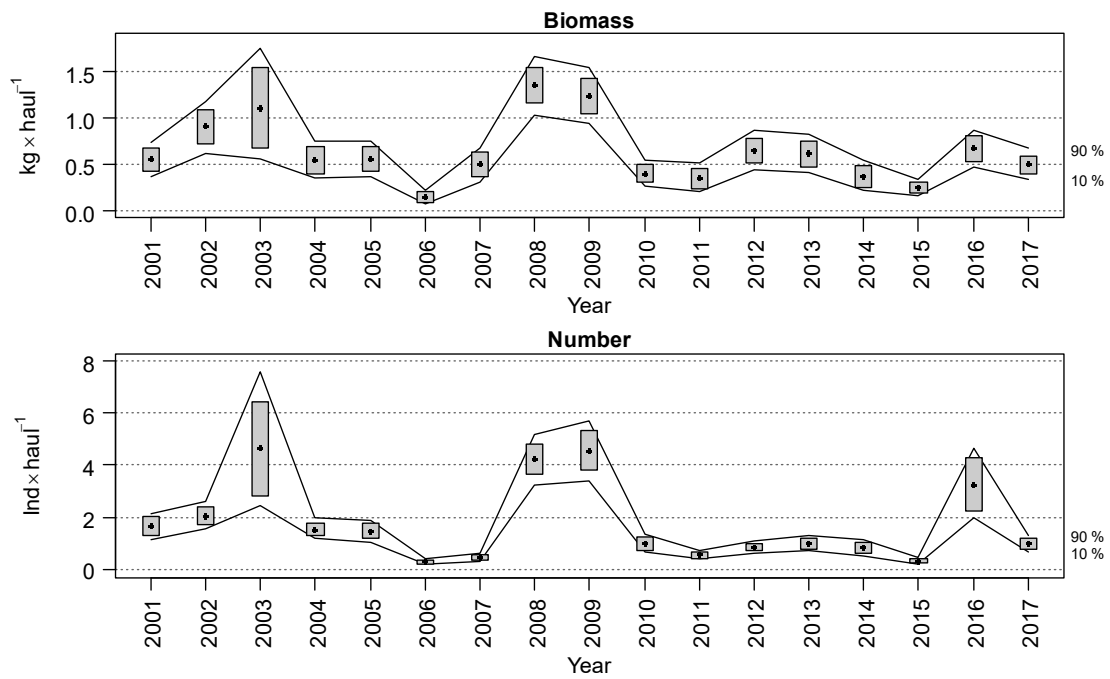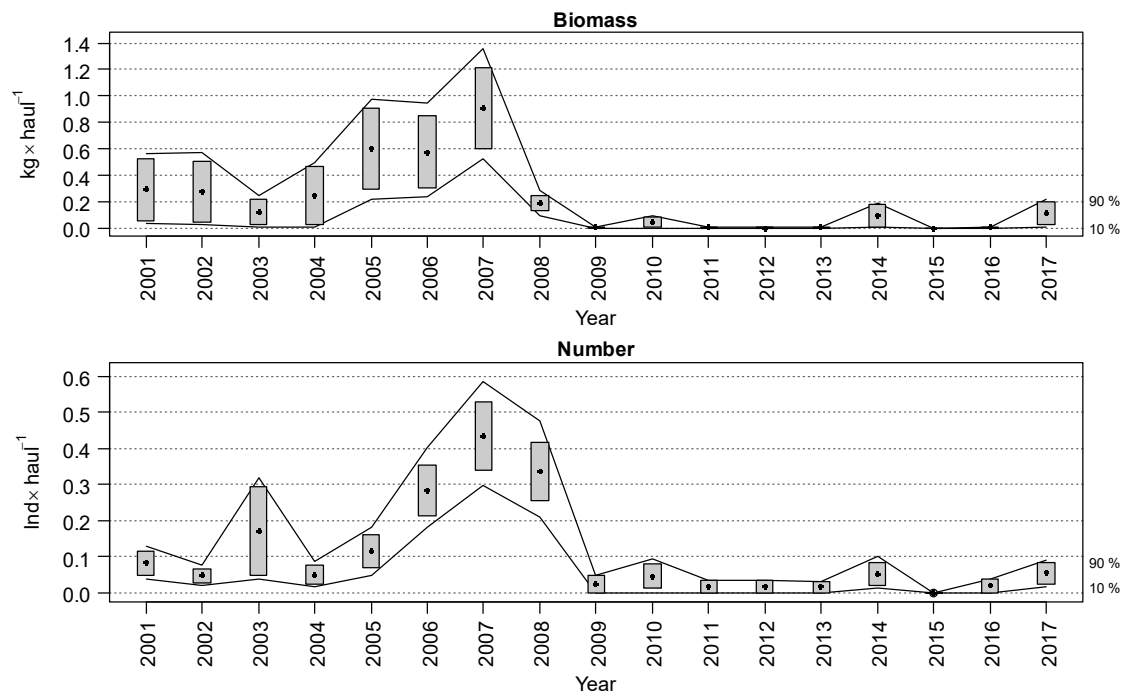
Figure 17 Evolution of *Haliprhon atlanticus* biomass index and abundance during the Porcupine bank bottom trawl survey time series (2001-2017). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000)
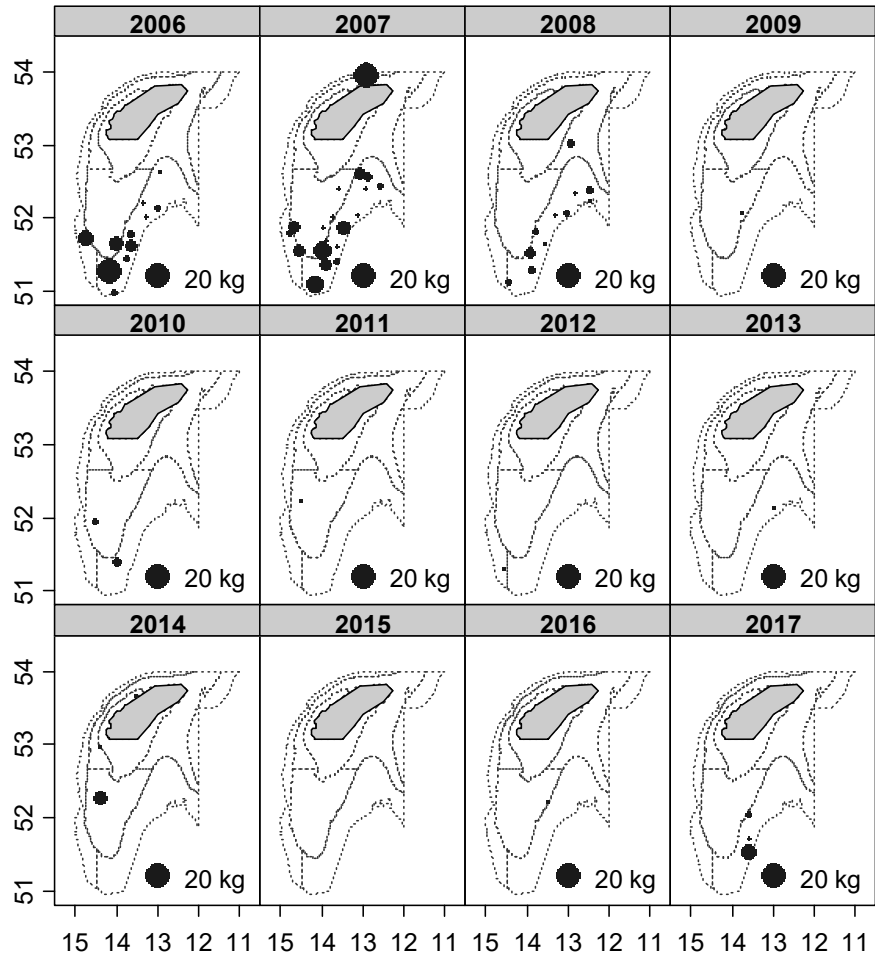
Figure 18 a) Geographic distribution of *Haliprhon atlanticus* catches (kg/30 min haul) in Porcupine bank bottom trawl surveys between 2006 and 2017.
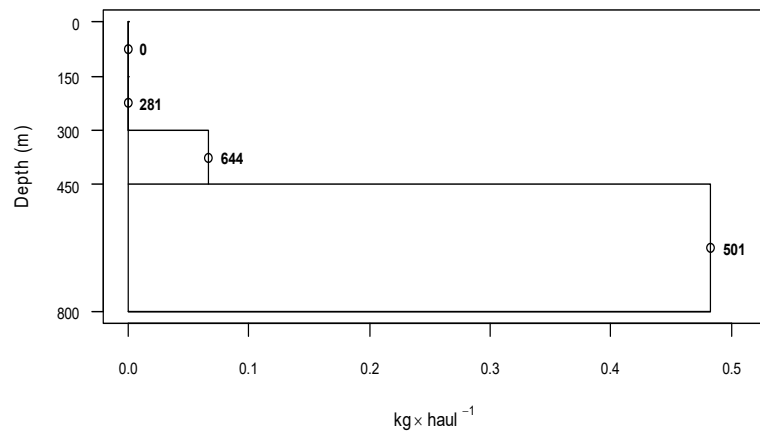


Figure 18 b) Bathymetric biomass profile of *H. atlanticus* in the Porcupine bank bottom trawl surveys (2001-2017)
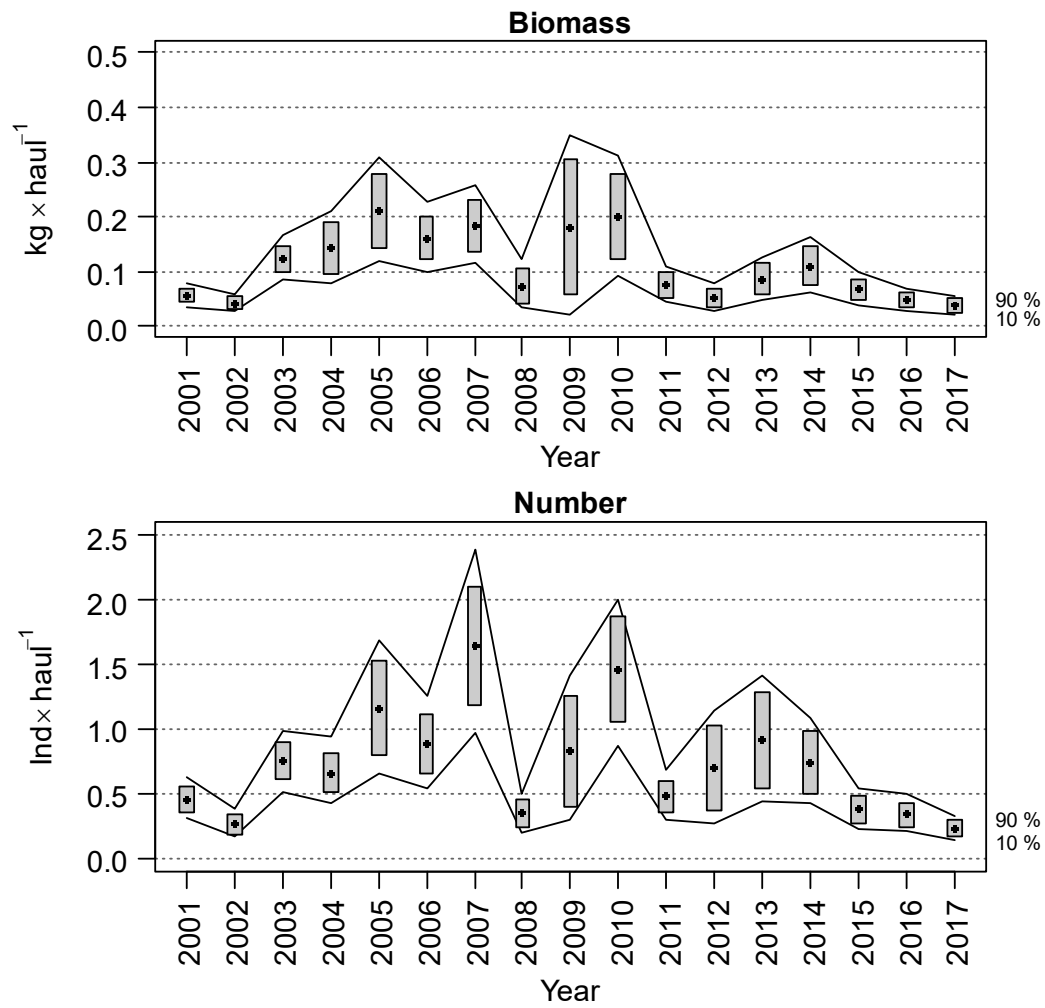
Figure 19 Evolution of *Bathypolypus sponsalis* biomass index and abundance during the Porcupine bank bottom trawl survey time series (2001-2017). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000)
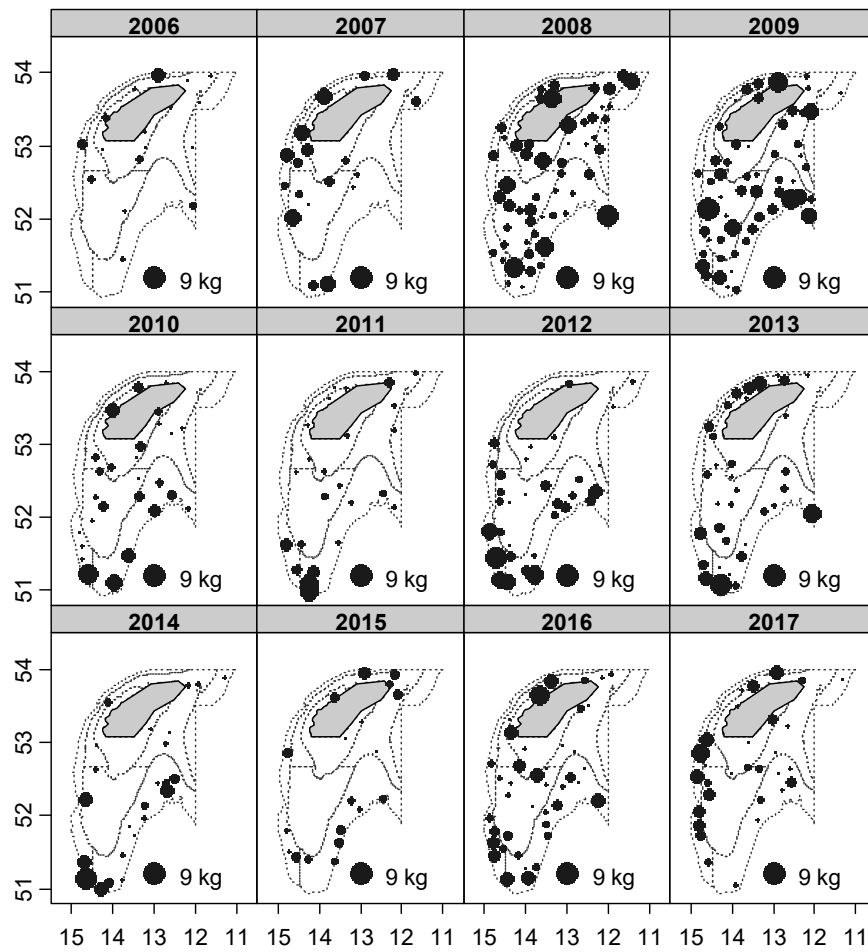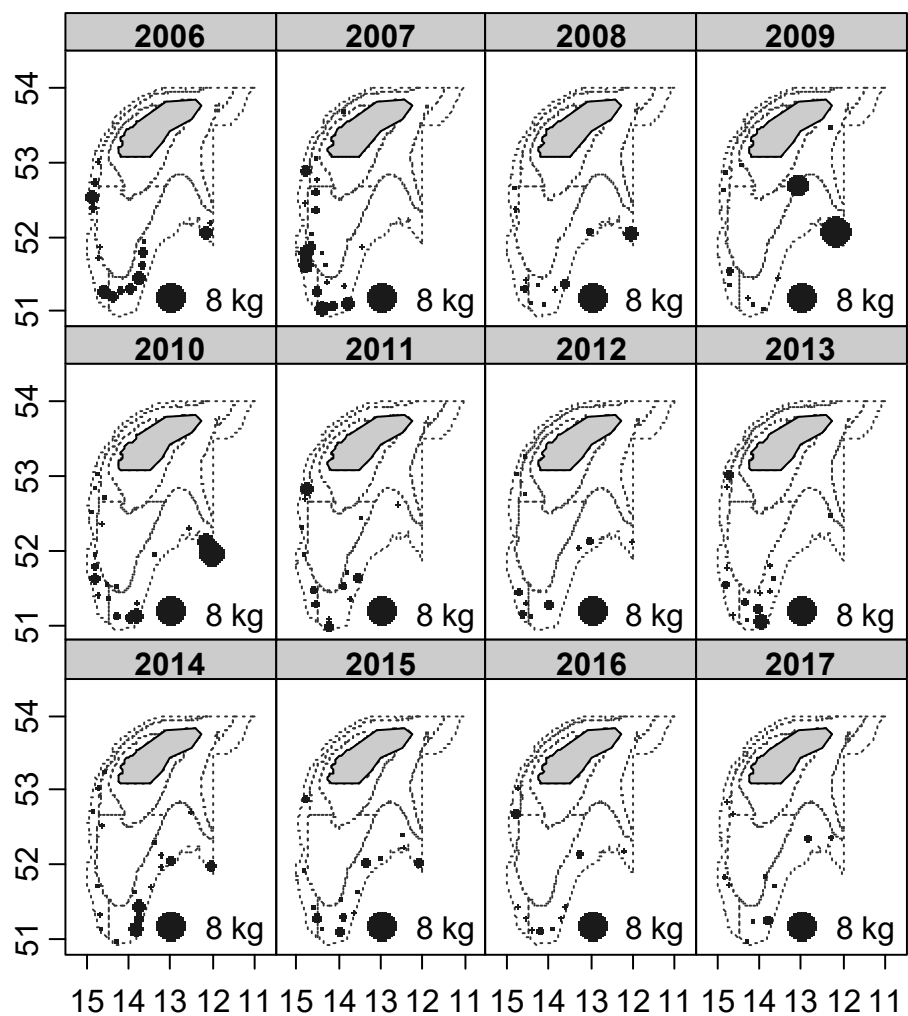
Figure 20 a) Geographic distribution of *B. sponsalis* catches (kg/30 min haul) in Porcupine bank bottom trawl surveys between 2006 and 2017
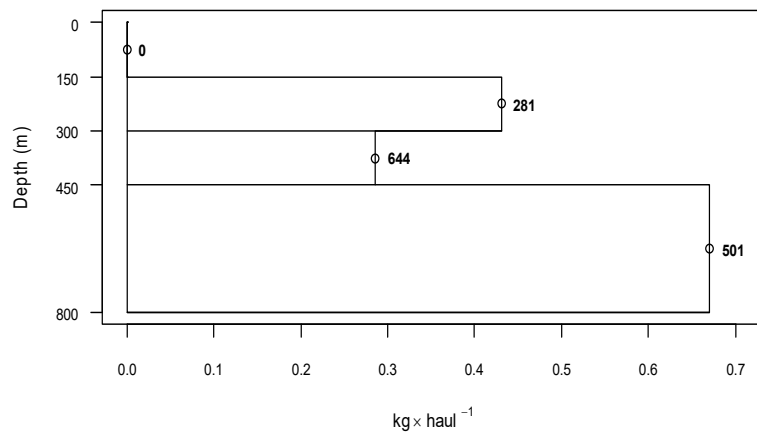
b)
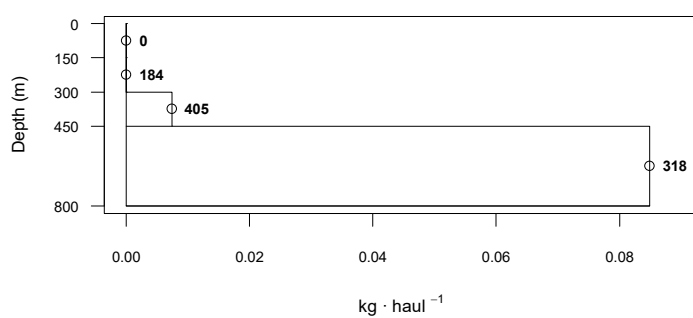


Figure 20 b) Bathymetric biomass profile of *B. sponsalis* in the Porcupine bank bottom trawl surveys (2001-2017)
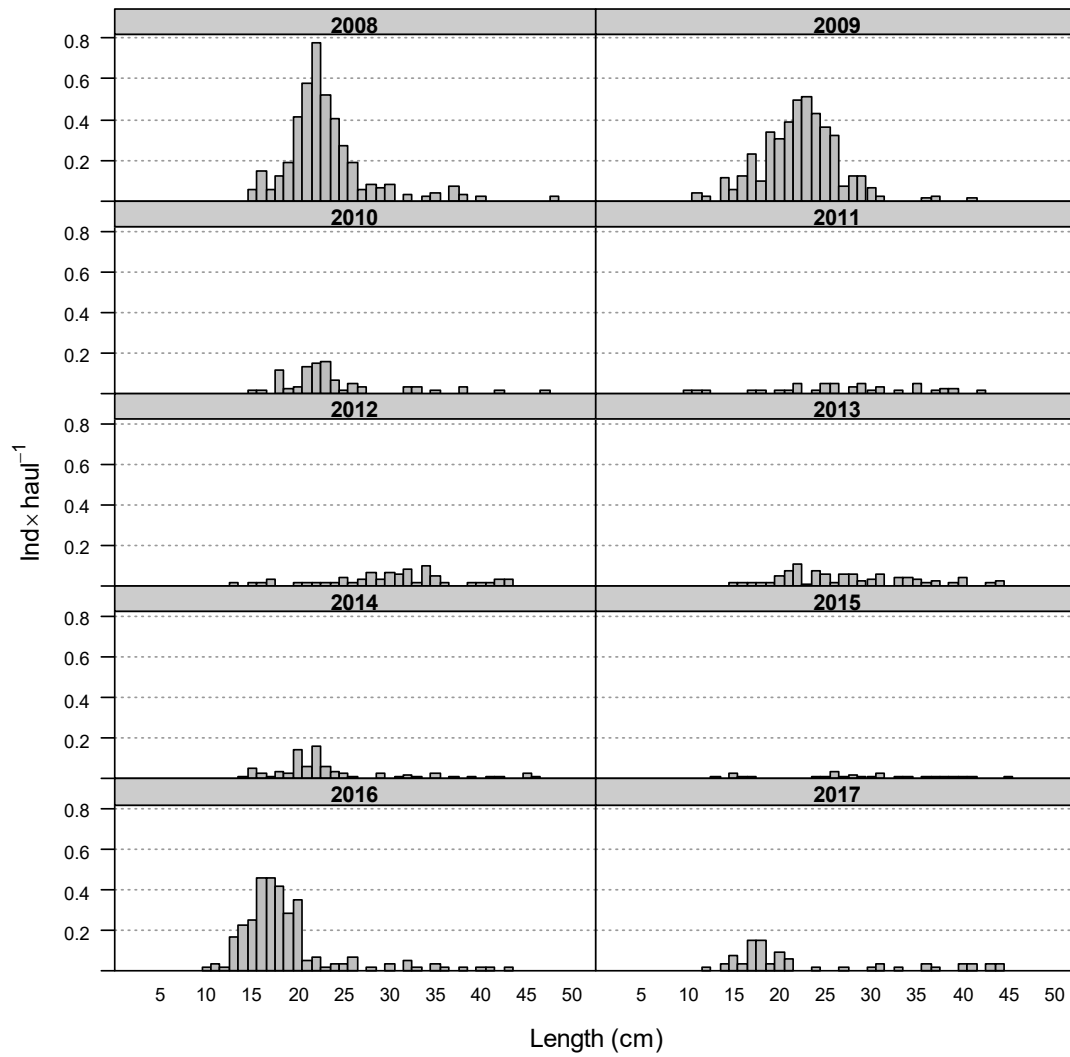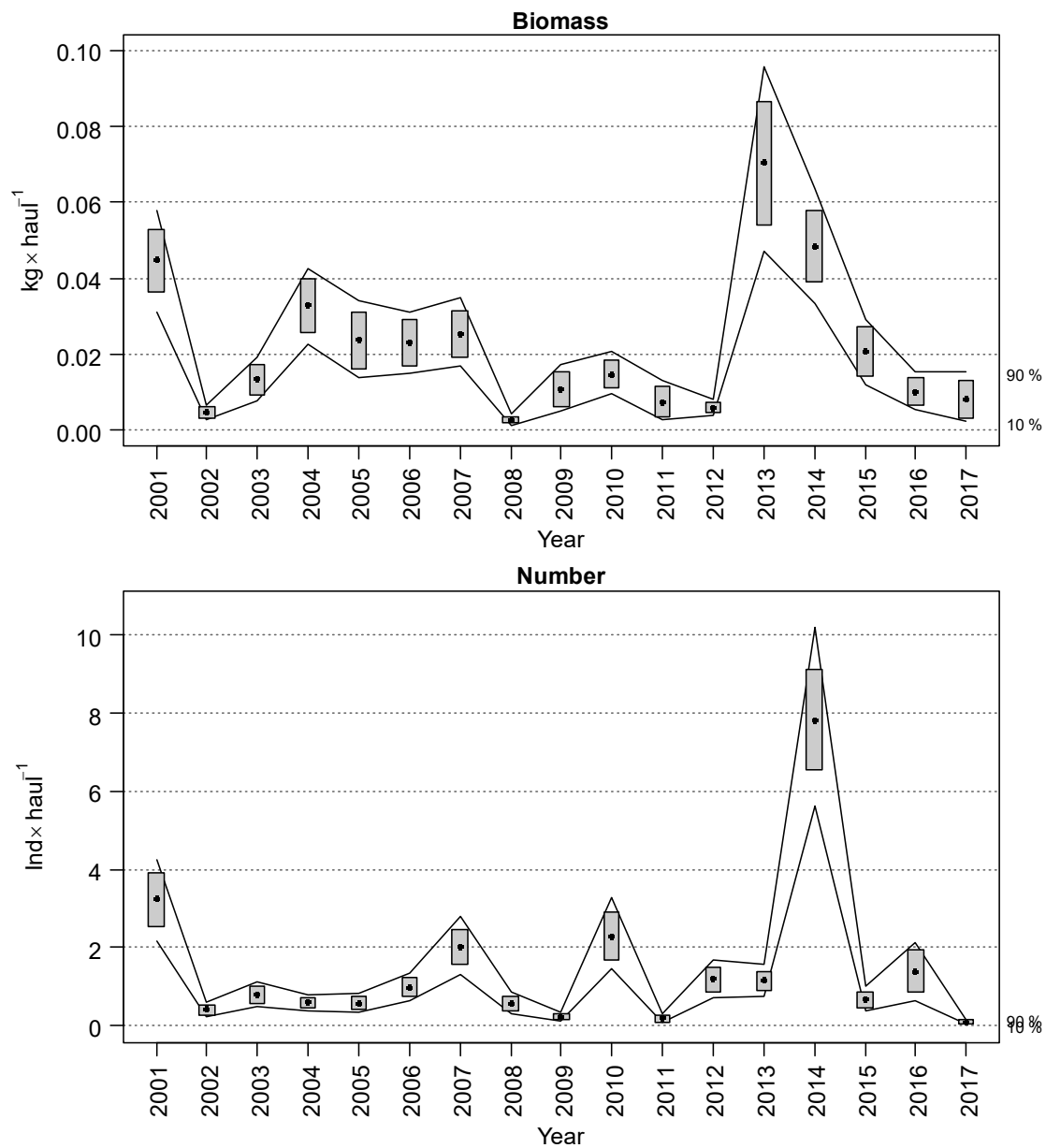
Figure 21 Evolution of *Rossia macrosoma* biomass index and abundance during the Porcupine bank bottom trawl survey time series (2001-2017). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000)
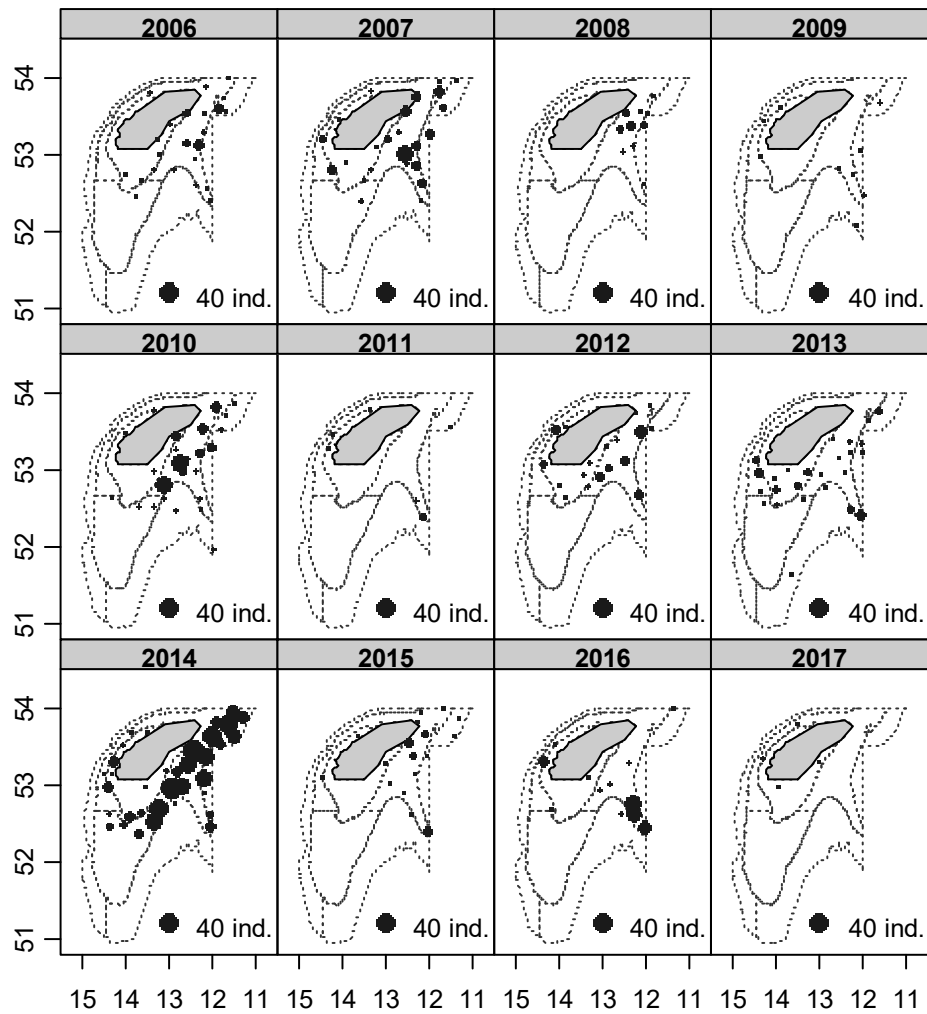
Figure 22 a) Geographic distribution of *Rossia macrosoma* catches (ind/30 min haul) in Porcupine bank bottom trawl surveys between 2006 and 2017.
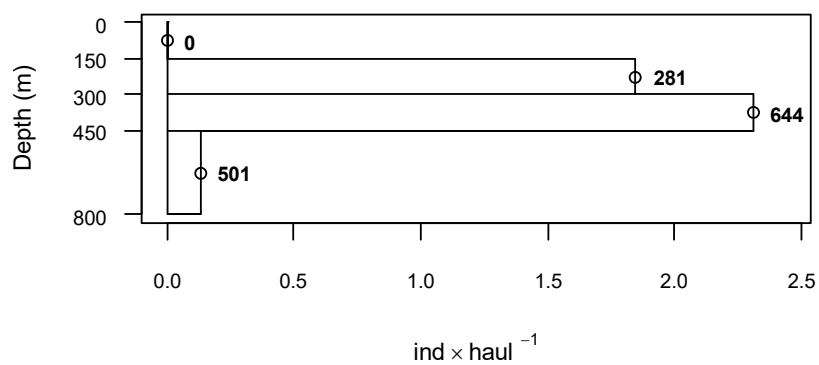


Figure 22 b) Bathymetric abundance profile of *R. macrosoma* in the Porcupine bank bottom trawl surveys (2001-2017)
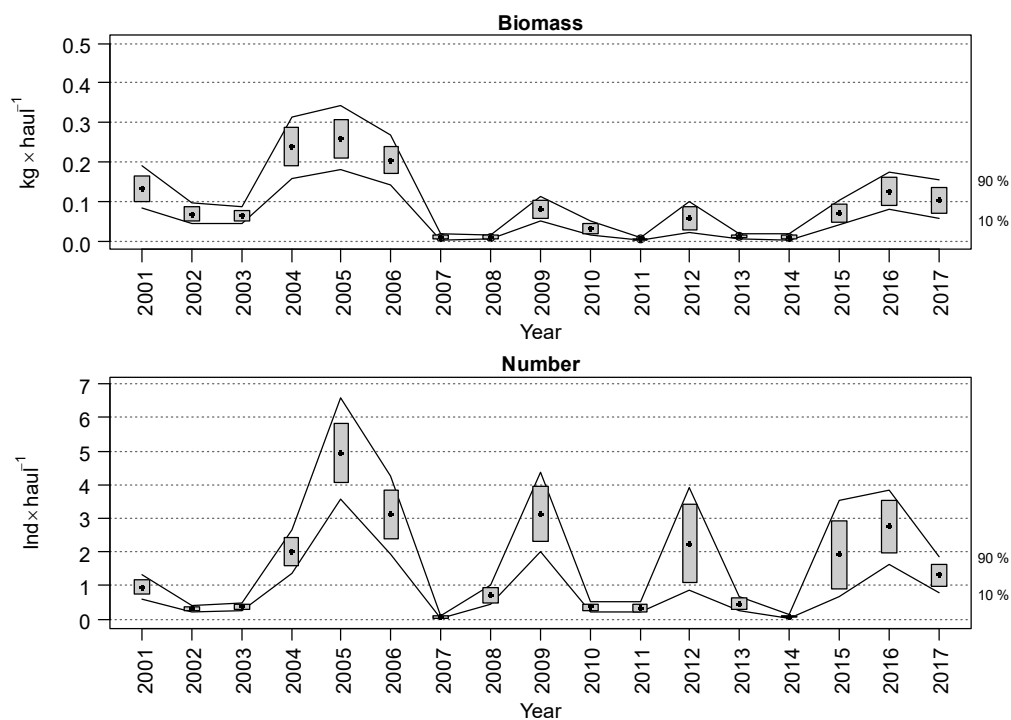
**Biomass**

**Number**
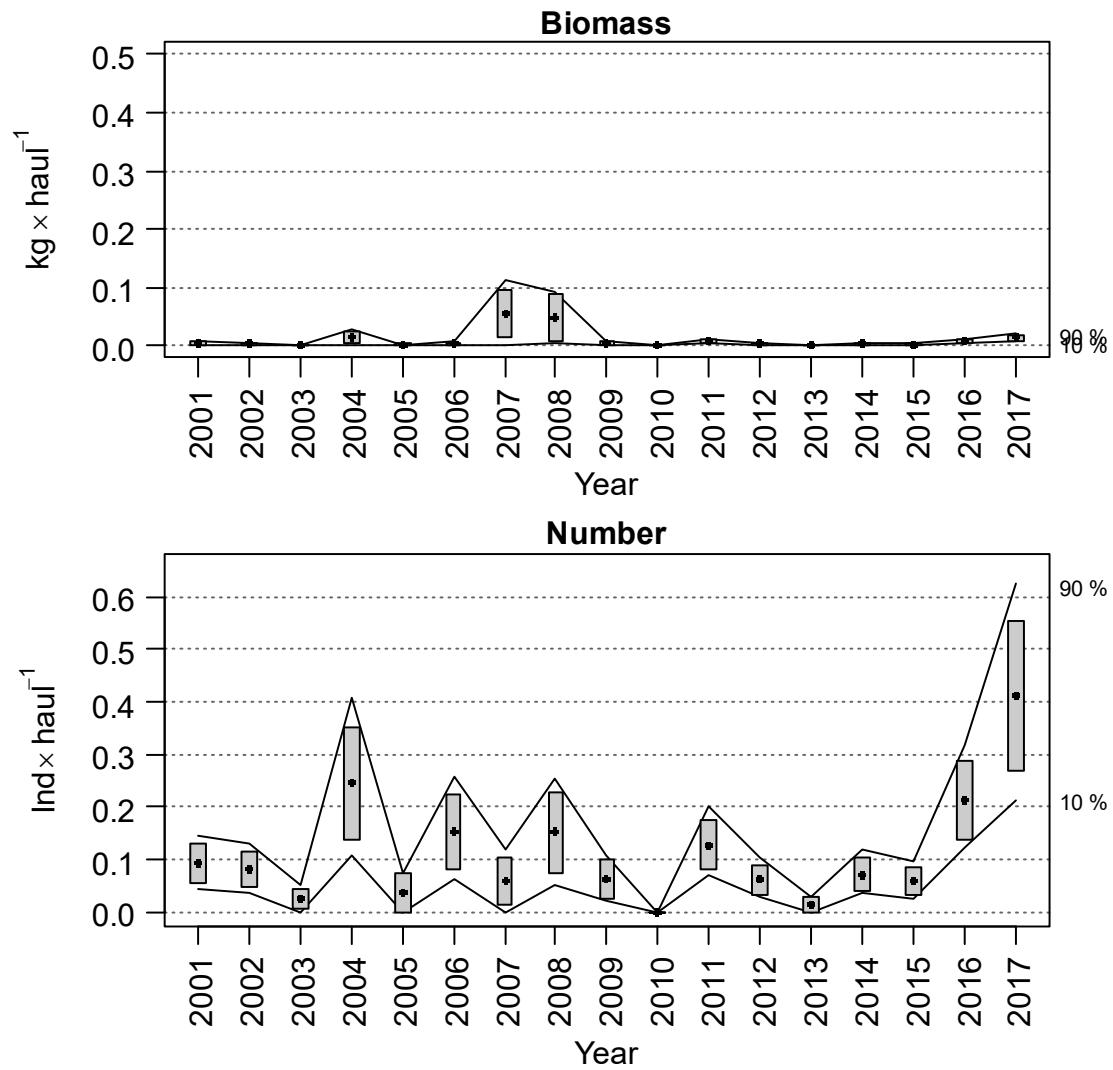
Figure 23 Evolution of *Histioteuthis reversa* biomass index and abundance during the Porcupine bank bottom trawl survey time series (2001-2017). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (α= 0.80, bootstrap iterations = 1000)

# AN UPDATE OF CEPHALOPOD LANDINGS-DISCARD DATA OF THE SPANISH FISHING FLEET OPERATING IN ICES AREA FOR 2000-2016 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. It has been used both the information from logbooks and sales sheets which have been provided by the Fishing General Secretary of the Spanish Government. Table A8.1 shows the Spanish annual landings (in tons) by species group (Octopodidae, Loliginidae, Ommastrephidae and Sepiidae) and the total annual for the 2000-2017 period.

Table A8.1. Spanish cephalopod annual landings (in tons) caught in the ICES Area by species group and total annual during the 2000-2017 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 |
| 2015 | 453 | 4484 | 2209 | 1058 | 8203 |
| 2016 | 495 | 5654 | 3042 | 1382 | 10573 |
| 2017 | 179 | 2606 | 1555 | 840 | 5179 |

Figure A8.1 shows the trend of total annual landings through the analyzed time period (2000-2017). Mean annual landings along the time series were around 9439 tons, with a minimum of 5179 t in 2017 and a maximum of 14504 tons in 2012. The highest landings belonged to the Octopodidae group which accounted for 55 % of the averaged landings for the analyzed period, followed by Ommastrephidae (22%), Sepioidea (15%) and Loliginidae (8%). The trend presents a drop of landings from 2000 to 2001, followed by a slight increase until it reaches a peak in

2005 of 10500 t. Afterwards, a new decrease appears until 2009, with a great increase in 2010 of about 63% in comparison to 2009. In 2011, the landings showed similar values to previous years, with a new increase in 2012 reaching the highest value of the time series. In 2013, the landings decreased 16% with regard to the previous year due to the reduction of Ommastrephidae. This decrease continued in 2014, with an 18% reduction compared to 2013, which coincided with a decrease in abundance of Octopodidae. By the year 2015, there was a general reduction in catch which affected all taxonomic groups and was similar to that reported in 2014 (17.5%). However, an increase was detected in 2016 for all group, mainly in Octopodidae. In 2017, there was a general decrease in the landings.
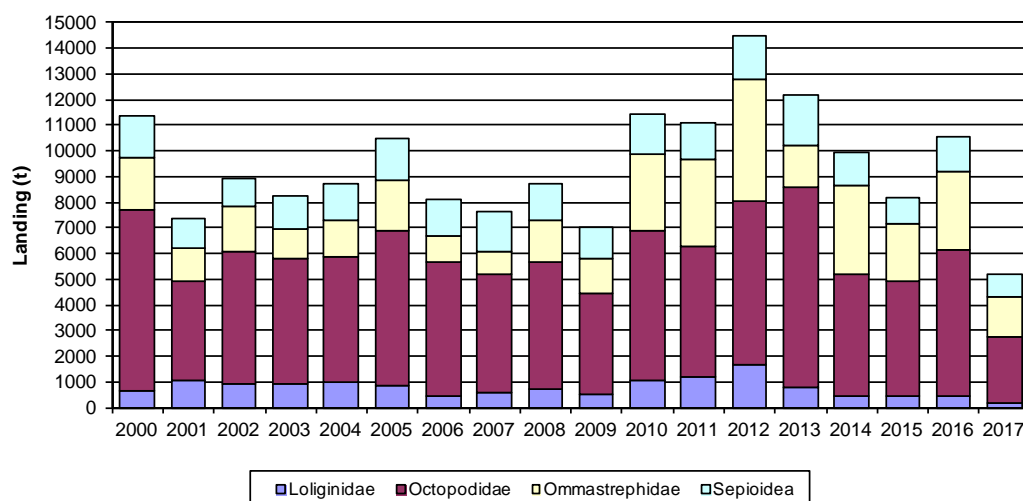


Figure A8.1. Spanish cephalopod annual landings (in tons) caught in the ICES area by species group for the 2000-2017 period.

## 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 A8.2 shows the total octopods landings trend by Subarea/Division in the last fourteen years. Total annual catch ranged between 3896 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 6040 t can be observed. Afterwards, a new decreasing trend appears until 2009 with 3935 t, followed by a great increase in 2010 of about 46% with regard to 2009, maintaining a similar value in 2011. In 2012, a sharp increase can be observed until it reached the highest value of the time series with 7798 t in 2013. In 2015 was reported 4480 t, with an increasing in 2016 to 5654 t. In 2017 was reported 5654 t(Figure A8.3).

**F. Octopodidae**



| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ▢Total | 7032 | 3896 | 5150 | 4888 | 4882 | 6040 | 5238 | 4643 | 4920 | 3935 | 5776 | 5122 | 6391 | 7798 | 4689 | 4480 | 5654 | 2606 |
| ♦ VI | 0 | 0 | 0 | 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 | 108 | 103 | 120 |
| ▲ VIIIabd | 247 | 182 | 197 | 112 | 257 | 161 | 216 | 282 | 308 | 164 | 181 | 191 | 153 | 130 | 92 | 15 | 113 | 202 |
| ● VIIIc | 1193 | 1209 | 1165 | 1498 | 1466 | 1421 | 1433 | 1933 | 1476 | 961 | 2075 | 1743 | 1387 | 1133 | 1172 | 1075 | 980 | 11 |
| ✳ IXa | 5205 | 2179 | 2936 | 2804 | 2787 | 4010 | 3164 | 2027 | 2737 | 2421 | 3056 | 2355 | 4847 | 5905 | 3276 | 3283 | 4458 | 2274 |

Figure A8.2. Spanish landings (in tons) of octopus species (Fam. Octopodidae) by ICES Subarea/Division for the 2000-2017 period

More than 90% of octopodidae were caught along the Spanish coast (Divisions IXa and VIIIc), where common octopus *O. vulgaris* is the main species caught (Figure A8.3). In Division VIIIc and Subdivision IXa-north most of the *O. vulgaris* were caught by the artisanal fleet using traps (Figure A8.4). The rest of landings are 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 51% of the total catch on average, and the remaining 49% by the artisanal fleet using mainly clay pots and hand-jigs (Figure A8.4), along the time series. In the last five years, the artisanal landings have exceeded significantly the trawl landings, providing around 70%-80% of the total catch. This may be due to a progressive increase in the declaration of artisanal landings at the octopus market as a consequence of greater pressure by the fishing control. 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 A8.4, 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. Possibly, such oscillations in Subdivision IXa-south may be related with environmental changes such as rainfall and discharges of rivers (Sobrino *et al.*, 2002).

Most of the horned octopus *Eledone cirrhosa* is caught by the bottom-trawl fleet, which landings account for the bulk of the octopod landings in Subarea VII and Subdivisions VIIIabd. In the last two years, the trend tended to decrease. Horned octopus landings in Division VIIIc account for 257 t(Figure A8.4), on average, of total octopods landings along the time series. In Subdivision 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.

**Octopus vulgaris**

**Subdivision IXa- South**

Landing (t)

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Trawler fleet | 1915 | 498 | 645 | 496 | 342 | 1490 | 855 | 497 | 663 | 434 | 396 | 146 | 927 | 1317 | 187 | 359 | 321 | 97 |
| Artisanal fleet | 1101 | 139 | 234 | 182 | 112 | 1381 | 1077 | 149 | 402 | 595 | 403 | 139 | 2315 | 2468 | 803 | 974 | 1181 | 553 |

**Subdivision IXa- North**

Landing (t)

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Trawler fleet | 0 | 7 | 5 | 10 | 37 | 4 | 4 | 18 | 54 | 29 | 50 | 42 | 12 | 18 | 9 | 3 | 1 | 2 |
| Artisanal fleet | 1201 | 1097 | 1337 | 1518 | 1798 | 701 | 837 | 977 | 1342 | 958 | 1741 | 1463 | 1078 | 1416 | 1633 | 1133 | 2360 | 1218 |

**Division VIIIc**

Landing (t)

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Trawler fleet | 6 | 7 | 4 | 5 | 51 | 4 | 23 | 15 | 16 | 3 | 80 | 55 | 37 | 76 | 20 | 17 | 7 | 0 |
| Artisanal fleet | 843 | 1126 | 914 | 881 | 1195 | 1168 | 802 | 1648 | 1412 | 860 | 1659 | 1502 | 1075 | 639 | 942 | 795 | 869 | 0 |

Figure A8.3. *O. vulgaris* landings (in tons) by fleet in Sub-division IXa south, Sub-division IXa-north and Division VIIIc, for the 2000-2017 period.

**Subdivision IXa south**

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Eledone spp | 88 | 88 | 144 | 99 | 118 | 70 | 51 | 74 | 136 | 235 | 132 | 184 | 320 | 296 | 466 | 587 | 356 | 182,2 |
| O. vulgaris | 3016 | 638 | 879 | 677 | 454 | 2871 | 1932 | 646 | 1065 | 1029 | 799 | 285 | 3243 | 3785 | 990 | 1333 | 1503 | 650,6 |



**Subdivision IXa north**

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Eledone spp | 901 | 350 | 486 | 501 | 380 | 364 | 301 | 311 | 141 | 170 | 335 | 380 | 194 | 286 | 175 | 154 | 144 | 176,8 |
| O. vulgaris | 1201 | 1104 | 1342 | 1528 | 1835 | 705 | 840 | 996 | 1395 | 987 | 1791 | 1505 | 1090 | 1435 | 1642 | 1136 | 2396 | 1256 |



**Division VIIIc**

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Eledone spp | 344 | 308 | 247 | 612 | 220 | 249 | 326 | 264 | 184 | 99 | 337 | 177 | 300 | 396 | 203 | 263 | 100 | 2,03 |
| O. vulgaris | 849 | 1133 | 918 | 886 | 1246 | 1172 | 825 | 1663 | 1428 | 863 | 1739 | 1559 | 1112 | 715 | 962 | 812 | 883 | 8,51 |

Figure A8.4. Octopodidae landings by species in Division VIIIc and IXa (north and south) for the 2000-2017 period.

The contribution of *Eledone* spp in the total cephalopod landings from Division IXa is higher in Subdivision IXa north, with 25.24 % (700 t) of total landings in 2017, than in Subdivision IXa south, which contributed with only 182,2 t in 2017 (Figure A8.4). In this last Subdivision, IXa south, the main landed species is the musky octopus *Eledone moschata* instead of *E. cirrhosa*, which is caught in the Gulf of Cadiz by the trawl fleet as a by-catch due to its scarce commercial value (Silva *et al.*, 2004). In IX south, there was a increase of *Eledone sp.* landings from 2006 reaching a maximum in 2015, with almost 600 tonnes. These landings decrease to 356 tonnes in 2016 and to 182 t in 2017.

## Sepiidae

The cuttlefish annual landings trends by Subarea/Division is shown in Figure A8.5. Total landings ranged between 1985 t in 2013 and 1066 t in 2015. Since 2001, landings had been increasing until 2005 and 2007, when they reached the two new maximum values similar to those reached in 2000. Afterwards, landings decreased slightly up to 1224 t in 2009, reaching the highest values of the time series in 2013, 1985 t, with an important decreasing trend in 2014 of 36% reduction in relation to the previous year, continuing the decline in 2015 and increasing in 2016. In 2017, there was an decrease in landings. Division IXa contributed with 75% of total cuttlefish landings by the Spanish fleet, with the 51% of landings on average corresponding to the Subdivision IXa-South (Gulf of Cadiz). Landings in Division VIIIc increased at the end of the analysed period, reaching 117 t in 2015 and 210 in 2016, whereas in Division VIIIabd they showed a mean value of 216 t, with a marked drop in the last years of the time series, from 548 t in 2012 to 59 t in 2017, and only 8 t in 2015. Landings in Subarea VII were below 20 t, and very scarce in the last years, except in 2000 and 2010 with 110 t and 73 t, respectively, and they were almost absent in the Subarea VI. In 2017, the landings showed a slight decrease to the previous years in all Division.

**O. Sepioidea**

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 1719 | 1129 | 1133 | 1193 | 1394 | 1635 | 1456 | 1563 | 1412 | 1224 | 1535 | 1423 | 1714 | 1985 | 1257 | 1066 | 1382 | 840 |
| VI | 0 | 0 | 0 | 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 | 18 | 13 | 4 |
| VIIIabd | 418 | 247 | 187 | 200 | 318 | 226 | 208 | 272 | 221 | 114 | 83 | 227 | 548 | 228 | 167 | 7,91 | 162 | 59 |
| VIIIc | 154 | 99 | 123 | 88 | 176 | 182 | 149 | 246 | 237 | 134 | 216 | 176 | 187 | 194 | 102 | 117 | 210 | 1 |
| IXa | 1037 | 765 | 820 | 899 | 889 | 1215 | 1090 | 1036 | 935 | 965 | 1164 | 991 | 978 | 1555 | 984 | 922 | 997 | 775 |

Figure A8.5. Spanish landings (in tons) of cuttlefish species (O. Sepioidea) by ICES Subarea/Division for the 2000-2017 period.

Cuttlefish (O. Sepioidea) landings from Subarea VII and Divisions VIIIabd mainly comprise common cuttlefish *Sepia officinalis* and, in a smaller amount, also elegant cuttlefish *Sepia elegans* and pink cuttlefish *Sepia orbignyana*. Bobtail squid *Sepiola* spp. hasn't been identified in most of the landings. Only *Sepia officinalis* and *Sepia elegans* are present in landings from Divisions IXa and VIIIc. Data on the proportion of each species is only available for Subdivision IXa-south, where *Sepia officinalis* makes up to 95% of cuttlefish landed (Figure A8.6). In this area, *Sepia elegans* and *Sepia orbignyana* appeared mixed in the landings, although the last specie is quite scarce. The commercial value of *Sepia elegans* is high, and for this reason is separated in the catch. During the 2014-2017 periods, the landings of *Sepia elegans* in Subdivision IXa-South showed an important drop.
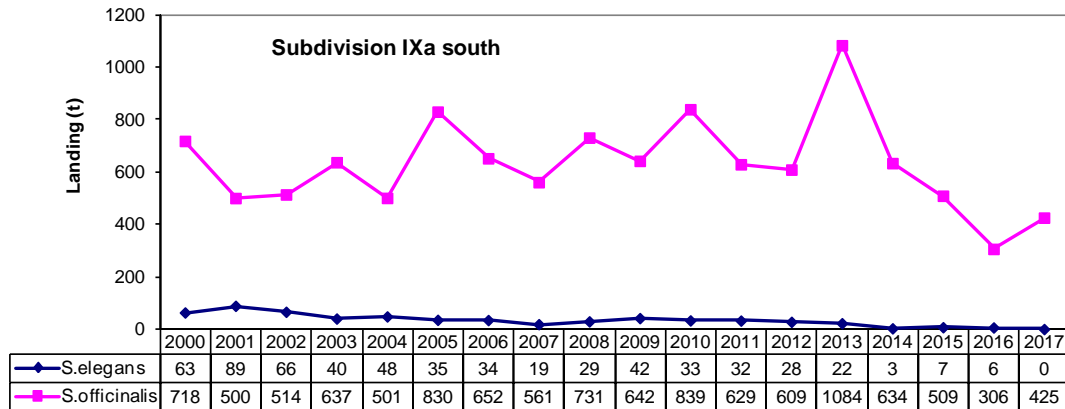
Figure A8.6. Sepiidae landings by species in Subdivision IXa south for the 2000-2017 period.

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S.elegans | 63 | 89 | 66 | 40 | 48 | 35 | 34 | 19 | 29 | 42 | 33 | 32 | 28 | 22 | 3 | 7 | 6 | 0 |
| S.officinalis | 718 | 500 | 514 | 637 | 501 | 830 | 652 | 561 | 731 | 642 | 839 | 629 | 609 | 1084 | 634 | 509 | 306 | 425 |

## *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 sagitattus* also appears in catches, but it is very scarce. Figure A8.7 illustrates the trends of both total landings of short-finned squids and by Subarea/Division. Total landings presented a mean value of 2081 t, with low values in the first half of the time interval. Afterwards, landings quickly dropped reaching a minimum of 834 t in 2007. In 2008, this value doubled in relation to the previous year, with a new decrease in 2009. From 2014 to 2016 a strong increase occurs, reaching the maximum values of 4718 tonnes in 2012, as in the rest of cephalopod groups. However, a sharp decrease is observed in 2013, with a decline of 3000 t in comparison to the previous year. It is possible that this decrease in landings is due to a change in the fisheries information source and the correct name assignment to each species landed. In 2014, an increase of 2000 t is observed in Figure A8.7, reaching the second maximum value in the time series, followed by a drop of 1400 t in 2015, and a new increase of about 900 t in 2016. However, in 2017, only were landed 1555 t.

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 maximums in 2005 and 2008 of 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 maximum 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, a value 300% greater than in 2011 (3651 t) was reached in 2012. Subdivision IXa–South accounts for the lowest values of the time series with landings below 1% of the total short-finned squid species landings. In 2013, the landings decreased in all Divisions, except in Division VII, which showed a significant recovery. The decrease was most important in Division VIIIc, with a reduction 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. However, only the Division VII showed an increase in 2015, with the rest of them showing an overall drop as it has been mentioned before. This oscillating trend of the last five years continued in 2016 with increases in all Division. In 2017, there was a general decrease in the total landing and in Subdivisions VIIIc and IXa. On the other hand, subdivisions VIIIabd and VII showed an increase of 2017 landings of this family.
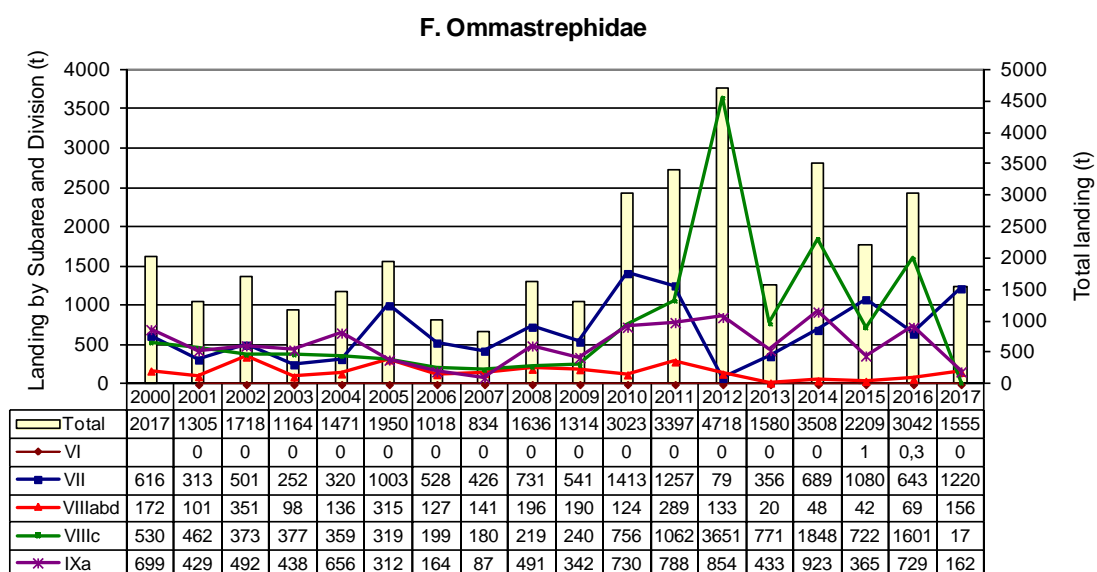
**F. Ommastrephidae**

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 2017 | 1305 | 1718 | 1164 | 1471 | 1950 | 1018 | 834 | 1636 | 1314 | 3023 | 3397 | 4718 | 1580 | 3508 | 2209 | 3042 | 1555 |
| VI | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0,3 | 0 |
| VII | 616 | 313 | 501 | 252 | 320 | 1003 | 528 | 426 | 731 | 541 | 1413 | 1257 | 79 | 356 | 689 | 1080 | 643 | 1220 |
| VIIIabd | 172 | 101 | 351 | 98 | 136 | 315 | 127 | 141 | 196 | 190 | 124 | 289 | 133 | 20 | 48 | 42 | 69 | 156 |
| VIIIc | 530 | 462 | 373 | 377 | 359 | 319 | 199 | 180 | 219 | 240 | 756 | 1062 | 3651 | 771 | 1848 | 722 | 1601 | 17 |
| IXa | 699 | 429 | 492 | 438 | 656 | 312 | 164 | 87 | 491 | 342 | 730 | 788 | 854 | 433 | 923 | 365 | 729 | 162 |

Figure A8.7. Spanish landings (in tons) of short-finned squid species (Fam. Ommastrephidae) by ICES Subarea/Division for the 2000-2017 period.

## Loliginidae

Long-finned squid landings (F. Loliginidae) consists 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 A8.8 shows the trend of total long-finned squid landings and by Subarea/Division. Total landings presented a maximum value of 1052 t in 2001, afterwards 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 of 441 t. An increasing trend is observed from this year up to 2012, reaching the maximum value in this year of 1683 t, indicating a considerable recovery of landings. However, the landings decreased in all Divisions in 2013, with only a slight recovery in Division VII. This trend to decrease kept going in 2014. The reason could be the same as in the case of ommastrephidae. In 2015-2016, global landings remained stable although there was a strong drop in the subarea VIIIabd and an appreciable increase in the IXa. 2017 showed a decrease of total landings in general and in every area.

The analysis by Subarea/Division showed 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 when the maximum value is reached (401 t). In 2013, the landings decreased by 50% in relation to the previous year, with a slightly recover in 2014 that continued throughout the 2015-216, when more than 310 t were reached. Landings in Division VIIIabd and VIIIc were lower than in IXa, except 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. In 2015, the lowest value of the time series which was only 15 t, was registered in the Division VIIIabd, recovering 130 t in 2016 but decreasing again in 2017. Landings in Subarea VII were also very low as compared with other

areas, with a mean value of the annual landings of only 30 t, but they showed a significant increase in 2010 and 2011, as also happened in Division VIIIc and VIIIabd. 2017, with 8 t, is the lowest value of landings in Subarea 7. The Subarea VI showed very scarce landings, below 10 t, as it was also mentioned above for the other analysed groups of cephalopod species, without landings in the last years. Only 2 t were registered in 2015 and almost zero en 2016 and 2017.

### F. Loliginidae



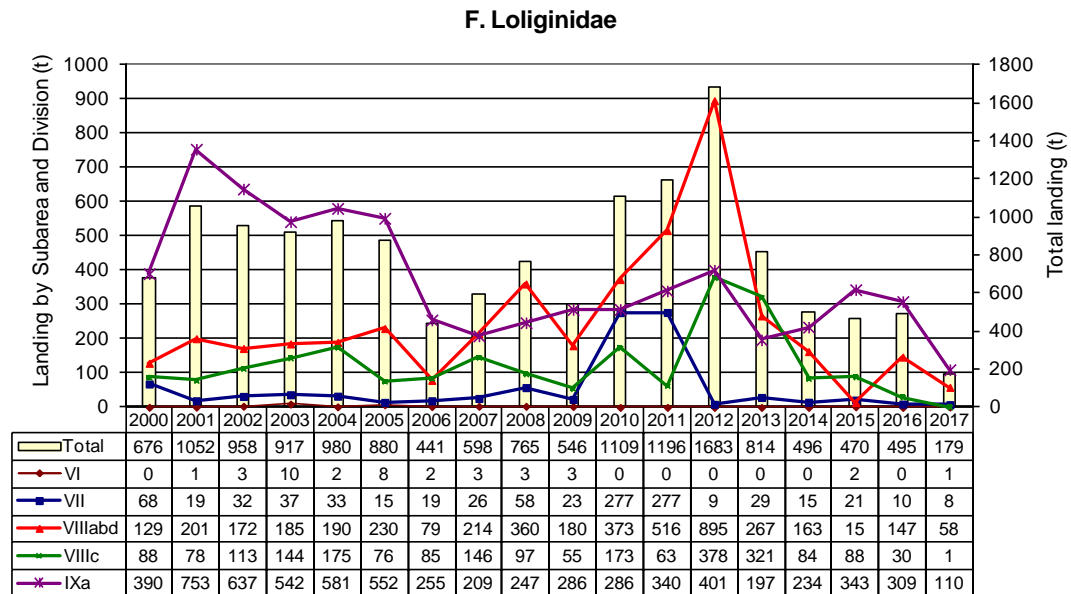| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 676 | 1052 | 958 | 917 | 980 | 880 | 441 | 598 | 765 | 546 | 1109 | 1196 | 1683 | 814 | 496 | 470 | 495 | 179 |
| VI | 0 | 1 | 3 | 10 | 2 | 8 | 2 | 3 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 1 |
| VII | 68 | 19 | 32 | 37 | 33 | 15 | 19 | 26 | 58 | 23 | 277 | 277 | 9 | 29 | 15 | 21 | 10 | 8 |
| VIIIabd | 129 | 201 | 172 | 185 | 190 | 230 | 79 | 214 | 360 | 180 | 373 | 516 | 895 | 267 | 163 | 15 | 147 | 58 |
| VIIIc | 88 | 78 | 113 | 144 | 175 | 76 | 85 | 146 | 97 | 55 | 173 | 63 | 378 | 321 | 84 | 88 | 30 | 1 |
| IXa | 390 | 753 | 637 | 542 | 581 | 552 | 255 | 209 | 247 | 286 | 286 | 340 | 401 | 197 | 234 | 343 | 309 | 110 |

Figure A8.8. Spanish landings (in tons) of long-finned squid species (Fam. Loliginidae) by ICES Subarea/Division for the 2000-2017 period.

Both in Sub-divisions IXa south and north, *Loligo spp* and *Alloteuthis* spp landings appear separated due to their high commercial importance. Figure A8.9 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 important increase in 2011-2012 in Subdivision IXa-north, with landings of around 45 t. In 2013, the landings of these species decreased significantly in Subdivison IXa-north, while in IXa south there was a 100% increase in relation to the previous year. Lower values were recorded in 2014, followed by a 22% increase in 2015. 2016 account for the lowest value of the times series for Alloteuthis in both subdivión, con 14 t in IXa-south and almost zero in IXa-north. However, Loligo sp showed a slight increase in IXa-south and remained stable in IXa-north. In 2017, Loligo sp. Is still lower than in 2016 although Loligo sp. Showed a little increase. Finally, it is worth mentioning that in the last few 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).
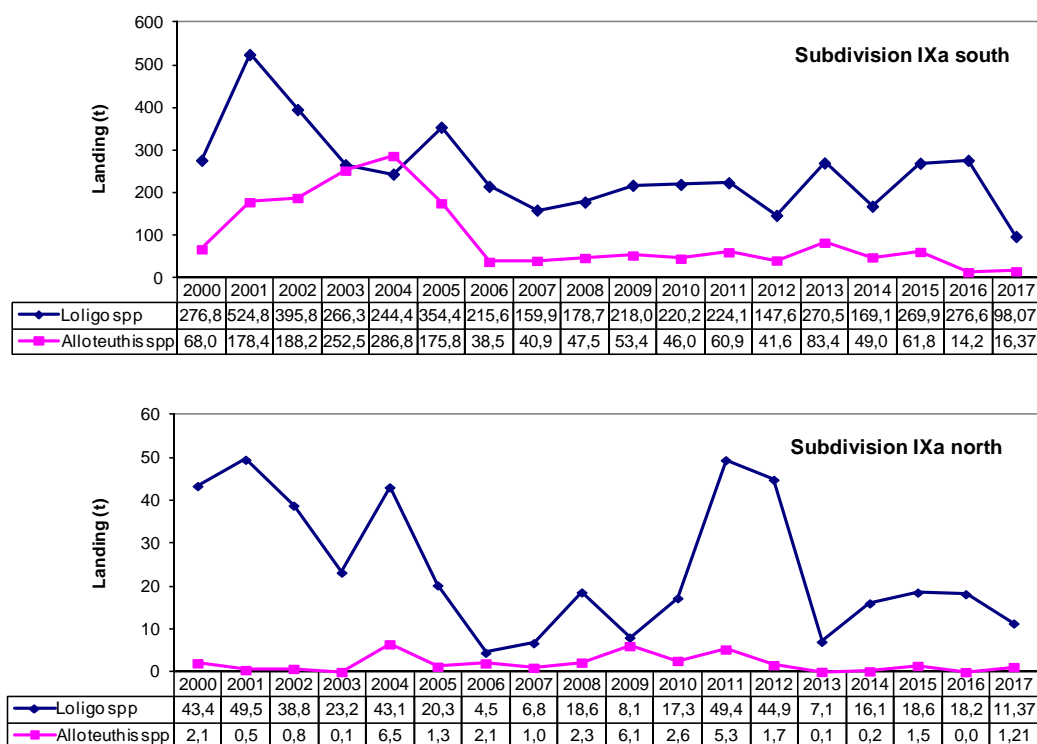
| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Loligo spp | 276,8 | 524,8 | 395,8 | 266,3 | 244,4 | 354,4 | 215,6 | 159,9 | 178,7 | 218,0 | 220,2 | 224,1 | 147,6 | 270,5 | 169,1 | 269,9 | 276,6 | 98,07 |
| 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 | 61,8 | 14,2 | 16,37 |

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Loligo spp | 43,4 | 49,5 | 38,8 | 23,2 | 43,1 | 20,3 | 4,5 | 6,8 | 18,6 | 8,1 | 17,3 | 49,4 | 44,9 | 7,1 | 16,1 | 18,6 | 18,2 | 11,37 |
| Alloteuthis spp | 2,1 | 0,5 | 0,8 | 0,1 | 6,5 | 1,3 | 2,1 | 1,0 | 2,3 | 6,1 | 2,6 | 5,3 | 1,7 | 0,1 | 0,2 | 1,5 | 0,0 | 1,21 |

Figure A8.9. Long finned squid landings by species in Sub-Division IXa south and north for the 2000-2017 period.

**Discard ratio**

The discarded fraction has been estimated with the information got form the sampling programs carried out by the observers aboard the fishing vessels in the several bottom trawl fleets. Table A8.2 shows the discarded fraction in relation to the total amount of landings by species or group of species, for the different trawling métiers, by Sub-area/Division. The Sub-areas VI-VII exhibits the higher estimates of discards, while the smaller values were registered in the Sub-Division IXa south. The most discarded species for the time period 2003-2017 were *Eledone cirrossa,* with mean values around 48% of the total catch in subareas VI-VII and 51% in VIIIc-IXa.north. The Ommastrephidae group accounted for 48% in the Sub-areas VI-VII. It's likely that this low commercial value is related to the high discarding rate.

The lowest discard estimates proceed from the bottom trawl metier of the Sub-Division IXa south (Table II). The estimates mentioned before have mean values for the period 2005-2017 which oscillated between 6.3-5.2 %, respectively, for *Eledone sp* and *Octopus vulgaris* and less than 1% registered for *Loligo sp*, Ommastrephides and *Sepia oficinalis.* The highly multispecific nature of the OTB_MCD metier in the Sub-Division IXa, and that they take advantage of everything that is fished by the fleet makes the discards estimates to be low. The highest peaks observed for *O. vulgaris* between 2009-2011 occurred because of a high recruitment and also a tougher control by the fishing control. The last mentioned caused an increase in the discarding of octopus with less than 1 kg (Minimum capture weight: 1 kg; BOE nº 290, Orden de 22 de noviembre de 1996). (Santos *et al.*, 2012)

Table A8.2. Estimated discarded fraction of the total catch for the main species/groups of species by Sub-area/Division. 2003-2017 period.

| Gear | Area | Spain Species | % discard from total catches | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
| OTB | VI-VII | Eledone cirrhosa | 59,0 | 34,2 | 50,8 | 46,0 | 66,5 | 59,9 | 72,3 | 38,7 | 71,2 | 96,6 | 12,7 | 52,8 | 23,8 | 27,8 | 14,1 |
| | | Loligo spp. | 52,0 | 24,0 | 73,0 | 80,0 | 92,0 | 65,0 | 26,0 | 12,0 | 4,4 | 35,4 | 0,7 | 1,1 | 10,8 | 32,7 | 24,5 |
| | | Octopus vulgaris | 0,0 | 100,0 | 100,0 | 91,0 | 0,0 | 0,0 | 0,0 | 37,0 | 0,0 | 0,0 | 10,3 | 0,0 | 0,0 | 0,0 | 0,0 |
| | | Ommastrephidae | 90,1 | 79,2 | 68,7 | 71,4 | 79,5 | 74,3 | 77,3 | 29,4 | 10,7 | 74,4 | 32,7 | 18,0 | 12,4 | 8,1 | 2,3 |
| | | Sepia officinalis | 77,4 | 8,7 | 5,9 | 76,6 | 4,6 | 21,7 | 2,4 | 0,0 | 0,5 | 94,6 | 21,8 | 0,7 | 0,0 | 0,0 | 0,0 |
| OTB_MIX OTB_HOM OTB_MAC | VIIIc + IXa north | Eledone cirrhosa | 8,0 | 26,0 | 8,2 | 23,0 | 18,6 | 5,9 | 36,7 | 5,2 | 24,2 | 14,0 | 35,7 | 22,4 | 11,7 | 12,2 | 16,0 |
| | | Loligo spp. | 2,0 | 1,0 | 12,0 | 1,0 | 1,0 | 2,0 | 7,0 | 2,0 | 61,0 | 0,3 | 43,3 | 0,7 | 0,0 | 2,5 | 0,0 |
| | | Octopus vulgaris | 6,0 | 4,4 | 34,0 | 7,0 | 39,0 | 0,8 | 12,0 | 3,1 | 25,3 | 1,3 | 0,0 | 0,0 | 0,9 | 24,8 | 20,8 |
| | | Ommastrephidae | 10,8 | 26,7 | 18,7 | 11,4 | 20,6 | 19,4 | 13,9 | 6,5 | 27,0 | 6,1 | 73,0 | 3,8 | 6,5 | 0,9 | 21,9 |
| | | Sepia officinalis | 60,8 | 0,9 | 13,1 | 60,5 | 1,2 | 1,2 | 17,7 | 5,9 | 33,6 | 11,4 | 0,0 | 3,3 | 0,0 | 7,1 | 0,0 |
| PTB | VIIIc + IXa north | Eledone cirrhosa | 0,0 | 0,0 | 64,0 | 63,0 | 94,0 | 31,6 | 90,3 | 95,5 | 36,8 | 0,6 | 0,0 | 94,6 | 100,0 | 98,3 | 0,0 |
| | | Loligo spp. | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 4,4 | 0,0 | 0,0 | 0,0 | 0,0 |
| | | Octopus vulgaris | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 |
| | | Ommastrephidae | 2,1 | 1,5 | 10,5 | 3,7 | 2,7 | 2,6 | 8,9 | 0,5 | 1,1 | 0,1 | 2,0 | 0,8 | 2,4 | 0,0 | 0,0 |
| | | Sepia officinalis | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 100,0 | 0,0 | 100,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 |
| OTB | IXa - south | Alloteuthis spp | - | - | 0,0 | 0,0 | 0,0 | 0,0 | 3,2 | 4,5 | 7,1 | 0,0 | 2,6 | 0,7 | 0,0 | 0,0 | 37,4 |
| | | Eledone spp | - | - | 0,0 | 0,0 | 1,1 | 4,5 | 16,8 | 19,0 | 11,4 | 0,0 | 4,3 | 1,6 | 2,1 | 5,1 | 15,5 |
| | | Loligo vulgaris | - | - | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 3,0 | 0,0 | 0,0 | 0,0 | 0,1 | 0,5 | 3,9 |
| | | Octopus vulgaris | - | - | 0,0 | 3,1 | 0,0 | 18,8 | 35,1 | 0,0 | 1,6 | 1,9 | 0,0 | 0,0 | 0,0 | 1,6 | 5,9 |
| | | Ommastrephidae | - | - | 0,0 | 0,0 | 0,0 | 0,0 | 2,0 | 5,8 | 0,0 | 0,0 | 1,2 | 0,0 | 0,0 | 0,0 | 0,0 |
| | | Sepia elegans | - | - | 0,0 | 0,0 | 0,0 | 2,1 | 9,0 | 2,7 | 1,2 | 0,0 | 21,1 | 5,1 | 0,0 | 9,9 | 0,0 |
| | | Sepia officinalis | - | - | 0,2 | 4,0 | 0,0 | 0,0 | 0,0 | 0,5 | 0,0 | 3,2 | 0,7 | 0,0 | 0,0 | 1,0 | 0,0 |

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# The multispecies small-scale fishery of the Canary Islands: Analysis of Cephalopod landings

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**Citation of the material is subject to approval by the authors**

## Summary

The study analyses the landings of cephalopods by the small-scale fisheries (SSF) of Canary Islands for the last ten years (2007-2017). Environmental data for this period are also used to compare with landing data. Results show that *Octopus vulgaris* is the most landed species and its annual trend is determinant in the temporal evolution of all cephalopods, mostly due to the exceptional values observed in 2009 and 2012, which were mostly landed in one port of Gran Canaria Island (Mogán). Further analysis with local scale analysis of environmental data from Gran Canaria could help to contrast with the regional data addressed in the present study for a better understanding of octopus landings in Canary Islands. Cuttlefish landings showed similar pattern to those of common octopus, with seasonal peaks of landings in spring (cold season) and to a lesser extend in autumn (hot season). Squids have a strong seasonality: summer months in Ommastrephid squids, May-December in *Loligo vulgaris* and October-January in *Loligo forbesii*.

## Introduction

The Canary Archipelago is a Spanish-EU outermost region located at around 100 km off the African coast (Central-East Atlantic waters). The Canaries are composed of seven main islands with narrow insular shelf surrounded by oceanic waters transported by the Canary Current and influenced by African upwelling. This influence creates a soft east-west gradient of increasing temperature and salinity (Barton *et al.*, 1998). These waters have a high variety of marine resources (warm, subtropical and tropical species): tuna, small pelagics, demersal fish and invertebrates. The marine ecosystem is very vulnerable due to the low abundance of the high number of species, and the complex relationships between them (Falcón *et al.*, 2017).

Canary Islands SSF is highly dependent on pelagic species (small pelagic resources in terms of landing volume and tuna fish in both landing volume and value terms). Demersal landings greatly increase their value, but have declined over the years as a consequence of overexploitation, since many consecutive years of low tuna fish availability have produced a high level of fishing effort redirection to demersal resources (Martín-Sosa *et al.*, 2018). At present, three Canary artisanal métiers are monitored under the EU-Data Collection Framework: purse seiners targeting small pelagics, baitboats targeting tuna and a polyvalent fleet of small boats using minor gears (traditional traps, hooks, nets) and targeting demersal species. One of the important traits of the SSF in the Canaries is that most of fishing days several gears are combined and catch is mixed

before landing. Fishing time is also information with many reluctances to be given, as well as specific fishing zone (Martín-Sosa, 2012). The fleet capturing cephalopods in Canary Islands is mostly composed by small boats (<10m length) targeting demersal species, although there is a polyvalence and opportunistic alternation with tuna fishing. Approximately 200 target species and 30 different gears have been identified in the small-scale fishing operations (Santamaría *et al.*, 2013; Castro *et al.*, 2015).

**Material and methods**

As in other EU-outermost regions, there is a high number of landing sites in the Canary Islands. The official system of first sale notes were established in the Canaries in 2004, although several years elapsed until a good coverage and reliability were achieved. Official statistics from sale notes were used from 2007 to 2017, when the coverage and reliability increased and reached an adequate level for data analysis. Daily fishing landings in the Canary Islands of the cephalopods were analyzed and monthly aggregated according to the official Spanish sales notes, for the same period.

Regional environmental data were used to compare with the landing trends of cephalopod species along the period analyzed. Monthly mean values from January 2007 to December 2017 of environmental data were downloaded for the geographical area comprising the Canary Islands (27-30°N, 13-18.5°W): chlorophyll *a* concentration (Chl-*a*, mg·m$^{-3}$) from GIOVANNI (Acker and Leptoukh, 2007), Sea Surface Temperature (SST, °C) and Sea Surface Temperature Anomalies [SSTA, °C; derived from monthly Optimum Interpolation (OIv2) SST analyses, with an adjusted base period of 1971-2000 to compute the SST anomaly using a weighted monthly mean climatology and the current observed Reynolds SST values from the database IGOSS-IRI (Reynolds *et al.*, 2002)].

**Results and discussion**

Cephalopods are mostly accessory species in the SSF of Canary Islands and not relevant in terms of landing volume, although they have a high economic value and the seasonal fishing of squids provide an alternative to reduce the pressure on fish resources. In 2017, cephalopod landings from official first sale notes counted about 0.5% of the total 14045 tons landings in the archipelago (**Figure AX.1a**). Tuna is the most important resource in landings (68%), followed by small pelagics (18%) and demersal species of fish and invertebrates (13%).
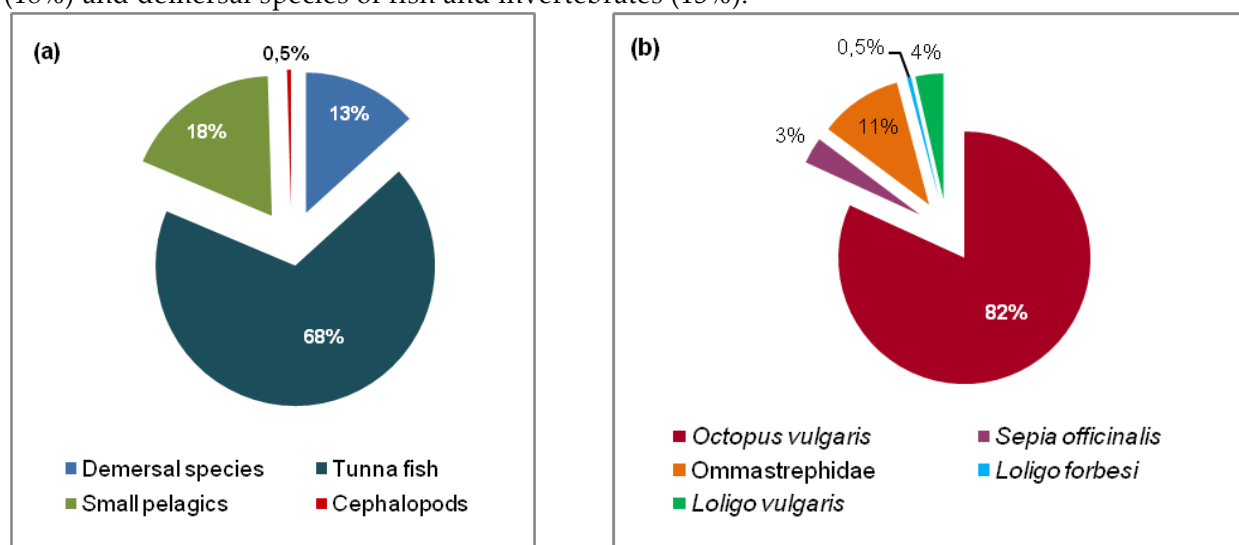


**Figure AX.1.** Landing composition by groups in SSF of Canary Islands from official sale notes of 2017 (a). Mean values of cephalopod landing composition in the period 2007-2017 (b)

In the period 2007-2017 the mean value of cephalopod landings was 36.9 tons/year, with an associated effort of 4493 fishing days/year. As shown in **Figure AX.1b**, most landed species are common octopus (*Octopus vulgaris*) with a mean value of 82%, ommastrephid squids (*Sthenoteuthis pteropus, Ommastrephes bartramii, Todarodes sagittatus, Illex coindetii, Todaropsis eblanae*) with 11% of landings, loliginid squids (*Loligo vulgaris, Loligo forbesi*) with 4.5% and cuttlefish (*Sepia officinalis*) that only accounted for 3%. Traps (both for fish and shrimps) are the most common gears used for capturing octopus and cuttlefish, which are part of the retained by-catch and therefore no directed fishing effort is carried out to these species. Ommastrephids and loliginids are seasonal resources caught mostly by handle jigging with directed fishing effort to these species. Temporal distribution of cephalopod landings showed a high annual variability (**Figure AX.2**).
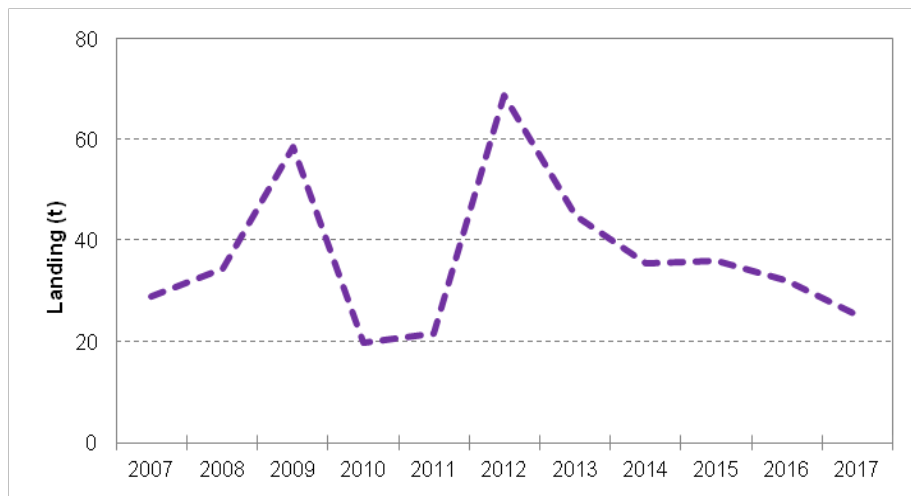


**Figure AX.2.** Trend of cephalopod landings (t=tons) in the period 2007-2017

## Octopus vulgaris

When analyzing the behaviour of octopus landings, it is clear that they were determinants in the temporal evolution of all cephalopods, mostly due to the exceptional values observed mainly in 2008-2009 and 2012-2013 (**Figure AX.3**). Preliminary analysis of this pattern, compared with the trend of environmental data (SST, SSTA, Chl *a*), indicated that these high values could be associated with cold SST and high values of SSTA and Chl *a*. Nevertheless it was not a homogeneous pattern since there are similar values (even colder SST and higher Chl *a*) in later years, e.g. 2014-2015, with low landing records. Other variables, including those related to global environmental processes (such as the North Atlantic Oscillation or NAO), should be analysed for a better knowledge of their effects on octopus landings.
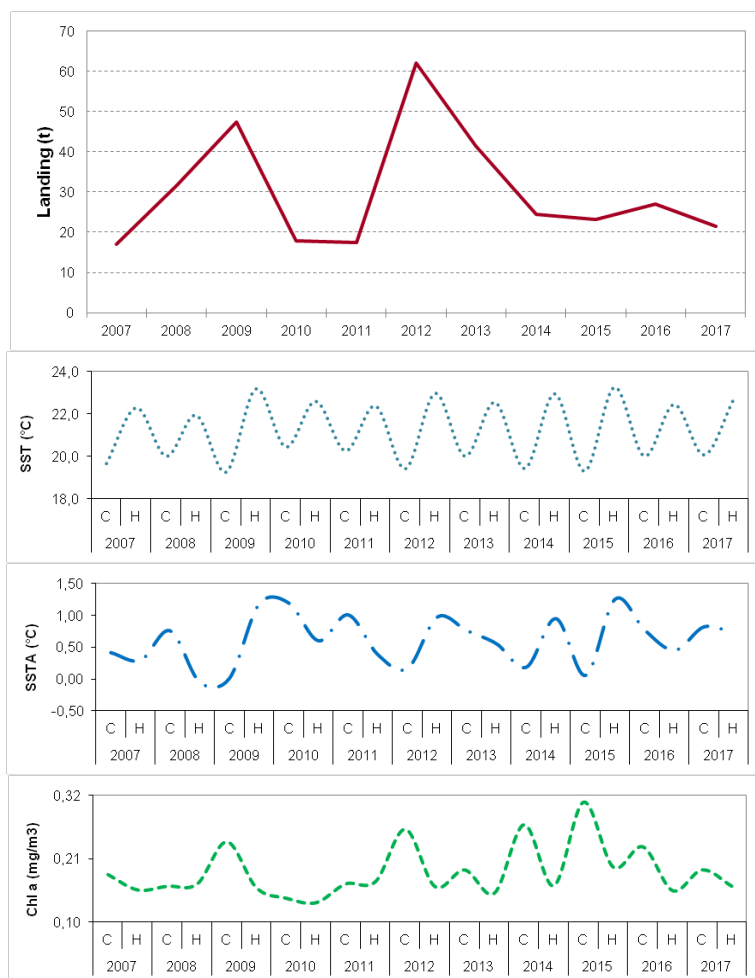


**Figure AX.3.** Landings (t=tons) of *Octopus vulgaris* from 2007 to 2017 and environmental parameters analyzed: Sea Surface Temperature (SST, ºC), SST anomaly (SSTA, ºC) and chlorophyll *a* concentration (Chl-*a*, mg/m³)

After analysing octopus data by island (**Figure AX.4**), similar pattern with two exceptional values in the same periods are observed only in Gran Canaria Island (located in the central region of the archipelago), driving the trend of the species landings. Hernández-García *et al.* (1998) analysed the octopus landings from 1980 to 1996 in the port of Mogán (Gran Canaria) and reported two high annual values between 21 and 25 tons in the octopus landings. Data from the same period were analysed by Caballero-Alfonso *et al.* (2010) including environmental variables (NAO, SST) and resulting in significant effects on octopus landings of this port. This scenario based on global factors and the SST does not seem to explain the pattern of octopus landings because NAO would affect the entire archipelago, not only the port of Mogán. Furthermore the regional environmental gradient marked by east-west gradient of increasing SST should influence the octopus landings of other islands, particularly in eastern and coldest islands (Fuerteventura and Lanzarote).
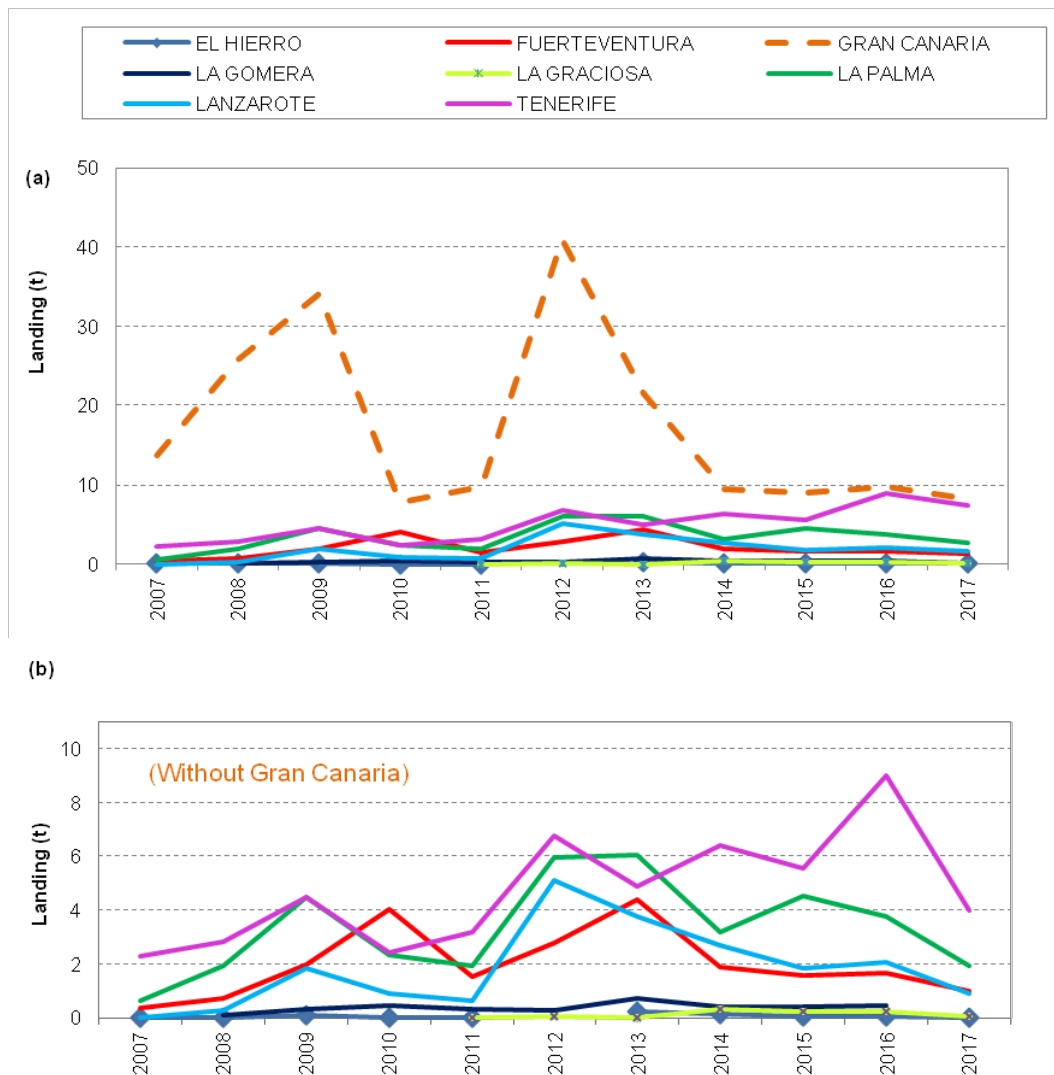


**Figure AX.4.** Landings of *Octopus vulgaris* (2007-2017). Data disaggregated by island in the whole Archipelago (a) and without Gran Canaria (b).

It seems advisable examine deeply in the environmental data of Gran Canaria, which implies a local scale analysis in contrast with the regional data addressed in the present study. The interaction of other descriptive factors of the fishery, including those of a socioeconomic nature, should be addressed, without neglecting the status of by-catches that octopus catches represent in the SSF of Canary Islands. The seasonal pattern registered maximum annual values in April-May, with a less important peak in September-October (**Figure AX.5**). Similar trend were reported by Hernández-García *et al.* (1998) who associated to the reproductive cycle of the species. In addition, **Figure AX.5** highlights the exceptional volume of landings of years 2009 and 2012. In this latest year, the annual peak occurred in the hot season, being in turn the maximum of the series, while 2009 remained the general pattern.
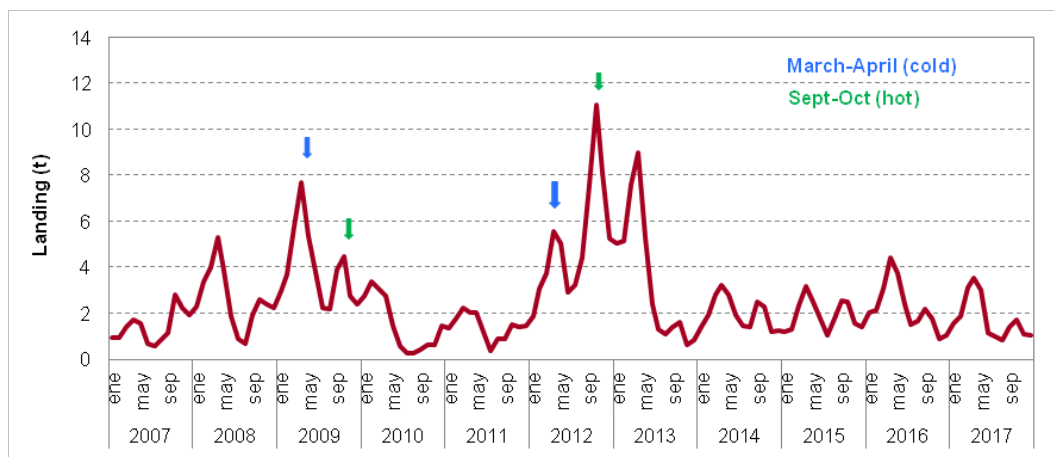


**Figure AX.5.** Monthly distribution of *Octopus vulgaris* landings (t=tons) by the SSF in Canaries, period 2007-2017.

### *Sepia officinalis*

Landings of this species (**Figure AX.6**) showed similar trend that observed for the common octopus, with differences in scale relative to the lower volume of cuttlefish (3% of total landings). This species, like common octopus, is by-catch in the fleet of demersal species using traps for fish and traps for pandalid shrimp. In the monthly distribution it was observed some concentration of the landings in the months with colder water temperatures, but this pattern presented important annual oscillations. As observed in seasonal distribution of the common octopus (**Figure AX.5**), the trends of cuttlefish showed inverse seasonality for the years of extreme values of landings: 2009 with higher value during cold season (same trend as the studied period) and 2012 with higher value during the hot season.
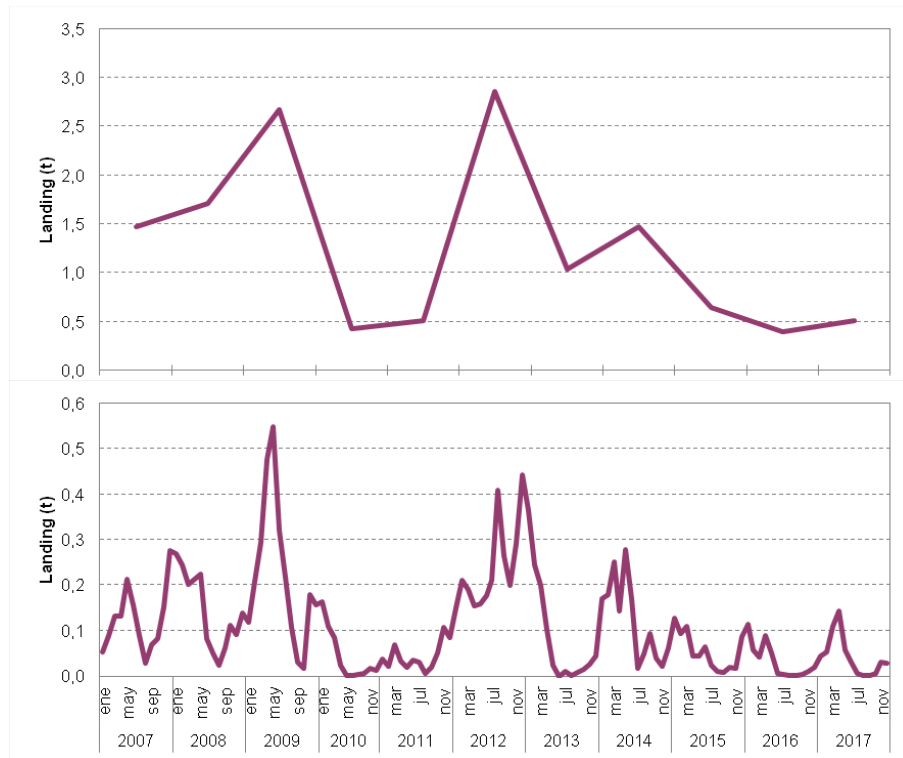
**Figure A<span style="color:red">X</span>.6.** Landings of *Sepia officinalis* (t=tons) by the SSF in Canaries, period 2007-2017. Annual (up) and monthly (down) distributions

**Ommastrephidae**

Landings of the five species of ommastrephid squids (*Sthenoteuthis pteropus, Ommastrephes bartramii, Todarodes sagittatus, Illex coindetii, Todaropsis eblanae*) were analysed aggregated due to the clear evidence of mistakes in their landing labelling at first sale sites. Fishermen identify correctly the species but when labelling the scientific name in the first sale note, the confusion is very common in the ommastrephids, probably due to the similarity of their common names. Thus, for example, some species are missing in the sale notes but we know for sure that they are being caught, whereas others uncommon species are overestimated in landings. **Figure A<span style="color:red">X</span>.7** shows irregular trend (peaks and troughs) with maximum values usually followed by minimum ones. Fishermen have reported that annual variability of ommastrephid catches (and abundance) is normal, which entails a loss interest in the fishery due to the low economic profitability of "bad years". Recreational fishermen, however, keep capturing ommastrephids those years. On the contrary, there is a clear seasonality with most of ommastrephid landings in the summer months (July-September), coincident with seasonality reported for the squid *Todarodes sagittatus* in the neighbouring archipelagos of Madeira (Lourenço and Hermida 2017).

In view of these results, it is a priority to solve the labelling problem of landings before any further analysis of the ommastrephid seasonality. The importance of these resources is relatively low, but their concentration in a particular season makes them to fulfil a role in the annual sustainability of vessels capturing them, contributing also to the diversification of the artisanal fishing activity.
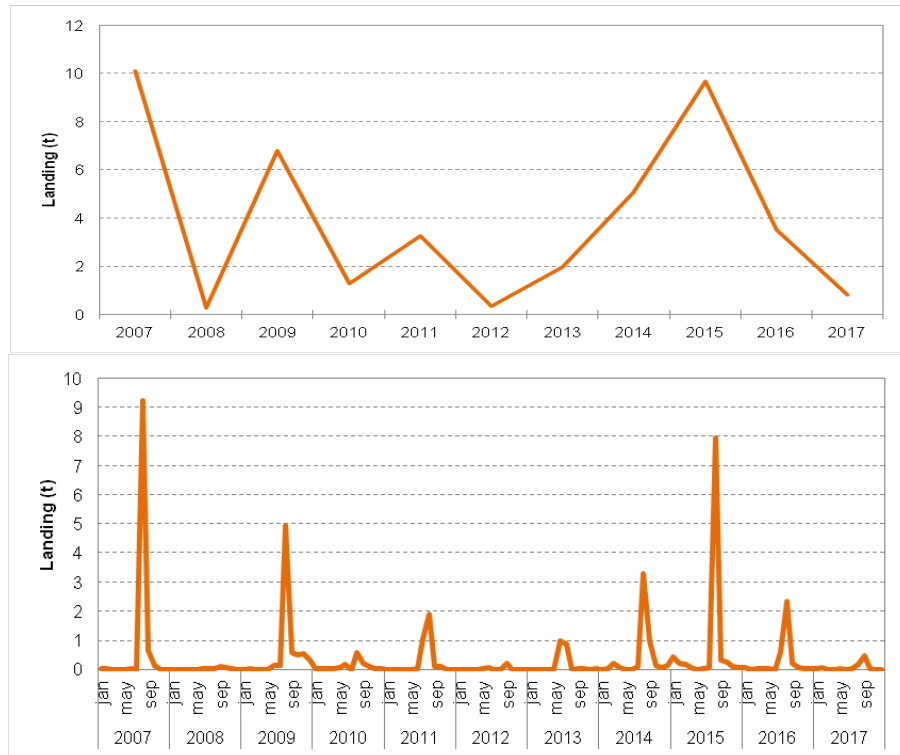
**Figure A**X**.7.** Landings (all species grouped) of Ommastrephid squids (t=tons) by the SSF in Canaries, period 2007-2017. Annual (up) and monthly (down) distributions

## *Loligo vulgaris*

Two differentiated periods are observed in the annual trend of landings (**Figure A**X**.8**): before 2012 with low values and stable trend, and after 2012 when variability and volume of landings increased. Seasonal distribution also shows these differences, as well as more concentration of landings during months of May-December. Additionally, this species is used by fishermen as live bait for fishing large demersal fish of high economic value. This could influence in the reported and commercialized captures of the species.
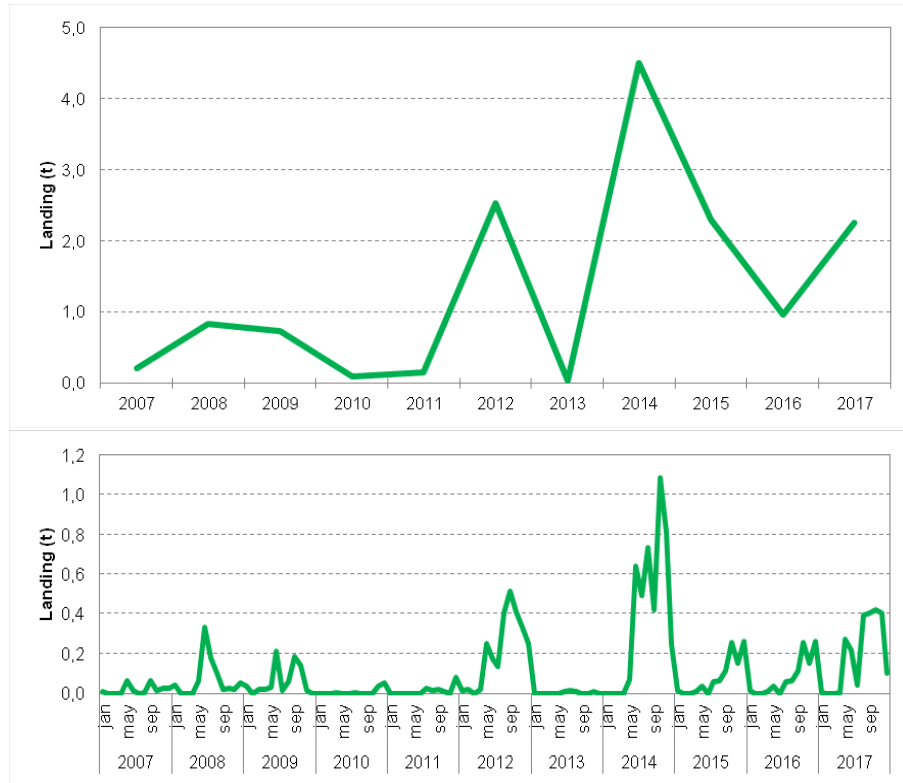
**Figure AX.8.** Landings of *Loligo vulgaris* (t=tons) by the SSF in Canaries, period 2007-2017. Annual (up) and monthly (down) distributions

## *Loligo forbesii*

This is the specie with fewer catches of all cephalopods analyzed in this study. During the period 2007-2017, the landings of *L. forbesii* only presented relevant values in 2012 (**Figure AX.9**), with a marked seasonality from October to January. This seasonality could be related to the behaviour pattern of the species, which aggregates in the spawning season (Jereb and Roper, 2010), and supported by the dominance of adult specimens (usually over 5 kg of weight). In the Canary Islands the highest annual value of landing is about two months later than in Madeira, where *L. forbesii* was the most landed species during the period 2006-2016 (Lourenço and Hermida, 2017). This suggests greater differences than expected between both close archipelagos.
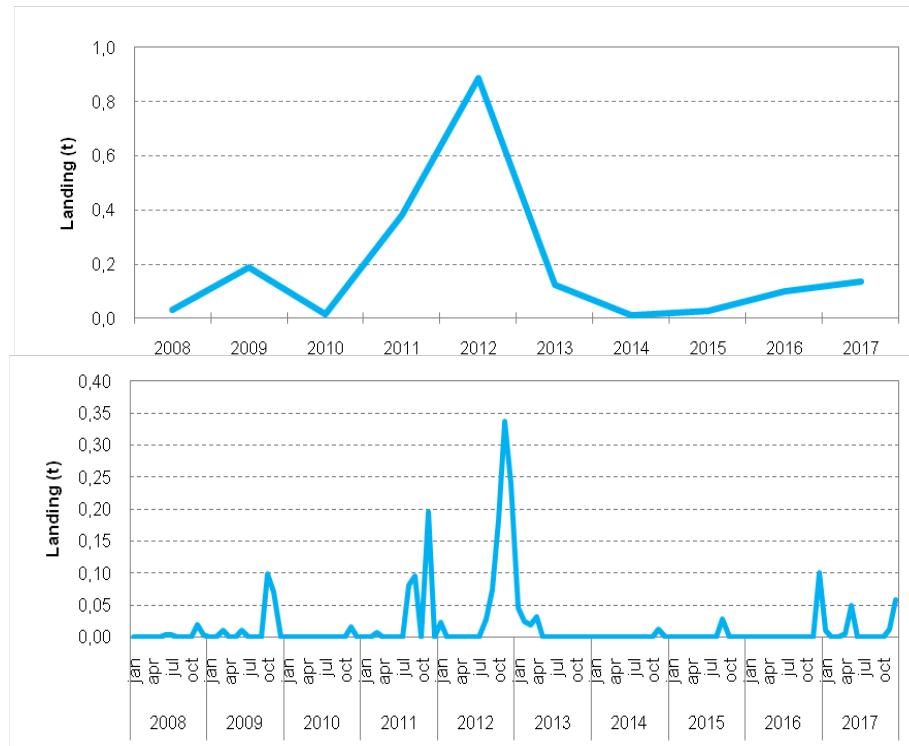
**Figure AX.9.** Landings of *Loligo forbesi* (t=tons) by the SSF in Canaries, period 2007-2017. Annual (up) and monthly (down) distributions

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# Trial study about age reading of North Sea squids

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## I Introduction

In order to asses population characteristics like life span, age at maturity and growth rate, the age reading is a necessary and important tool (Florin et al 2018). The growth rates of cephalopods are highly variable with season, year and population, and spawning of commercial Loliginidae and Ommastrephidae is usually extended, sometimes with several peaks (Jereb et al., 2010). The co-existence of several "microcohorts" with different spawning behaviour is discussed for *L. forbesii* and *A. subulata* in the North Sea (Pierce et al., 1994a, Oesterwind et al. 2010). Status of these micro-cohorts is unclear, and determining the age of *L. forbesii* and other squids from the North Sea might give some new insight about population dynamics and changes over time. The working document presents preliminary age reading results, of *L. forbesii*, *A. subulata* and *Illex coindetii* fished in the North Sea.

## II Material & Method

### *L. forbesii*

Specimens were caught during the ICES coordinated NS - IBTS (North Sea -International Bottom Trawl Survey) quarter 1 with FRV Walther Herwig III. Fishing methods are standardized and described in the IBTS Manual (ICES 2012).

Only the smallest and largest specimens were selected for this trial study. The wet weight was taken within 1 g, dorsal mantle length was measured to the nearest mm, the sex and maturity stage (Table. 1) were identified for each individual.

Table 1. Simplified key to determine the maturation stage.

| Marturity stage | male | female |
|---|---|---|
| 0 | indistinguishable | |
| 1 | Spermatophoric organ visible under microscope | Nidamental gland visible under microscope |
| 2 | Spermatophoric organ visible with naked eyes | Nidamental glant visible with naked eyes |
| 3 | Spermatophoric organ with white structure | First eggs in ovary visible |

| 4 | Spermatophores in spermatophoric sac or in penis visible | Oviduct filled with ripe eggs |
|---|---|---|
| 5 | Spent | Spent |

Statoliths were fixed with Crystal Bond™ on a slide and grinded with different grit grates (Micro Mesh TM P1500 – P4000) on each side. Afterwards the statoliths were polished with Micro Mesh grit grates between P6000 and P12000 on both sides and rings were counted under a transmitted light microscope. We started to count the rings at the natal ring and ended the counting at the edge of the lateral dome. In addition, total width and length of the statoliths were measured.
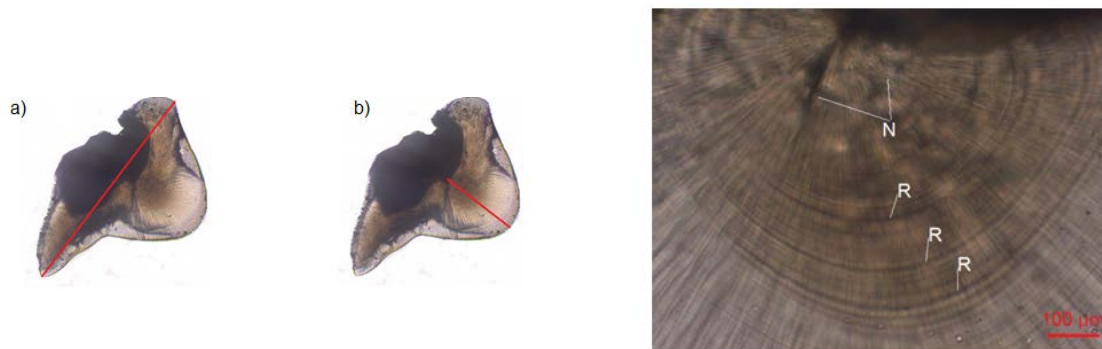


**Figure 1: Left figure: a) length and b) width of the statolith; right figure: labels indicate natal ring (N) and significant rings.**

If possible we read and measured both statoliths of an individual and estimated the mean number of rings. Statoliths from 35 *L. forbesii* with a DML of 48 – 158 mm and 17 *L. forbesii* with a DML of 312 – 584 mm from the North Sea RFA 1, 2 3, 7 were read and measured.

### *A. subulata*

Individuals were fished during standardized NS-IBTS in quarter 3 with CEFAS Endeavour. For detailed standard description see ICES IBTS Manual (ICES 2012). Squids were identified to species level and a random subsample of *A. subulata* individuals was taken for aging.

### *Illex coindetii*

Specimens were collected during the ICES standardized IBTS Q1 2018 (ICES 2012) and individuals were prepared similar to the preparation of *L. forbesi*.


## III Preliminary Results

### *L. forbesii*

The statoliths' length and width of 51 out of 52 *L. forbesii* could be measured. The best description of the relation between length and width is a logarithmic equation (Fig. 2).
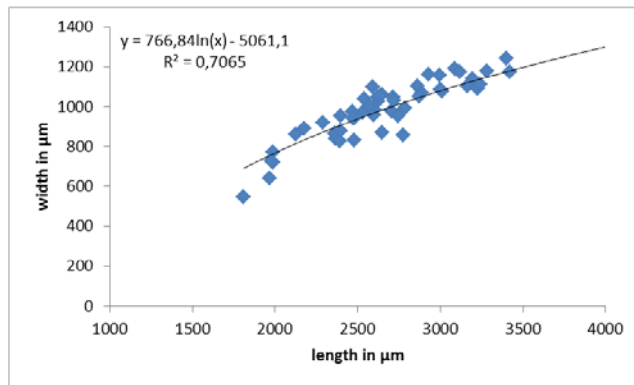
**Figure 2: Length-width relation of *L. forbesii* statoliths (N=51).**

The correlation between dorsal mantle length and statoliths' length as well dorsal mantle length and statoliths' width could be described by a potential or log function (Fig. 3).
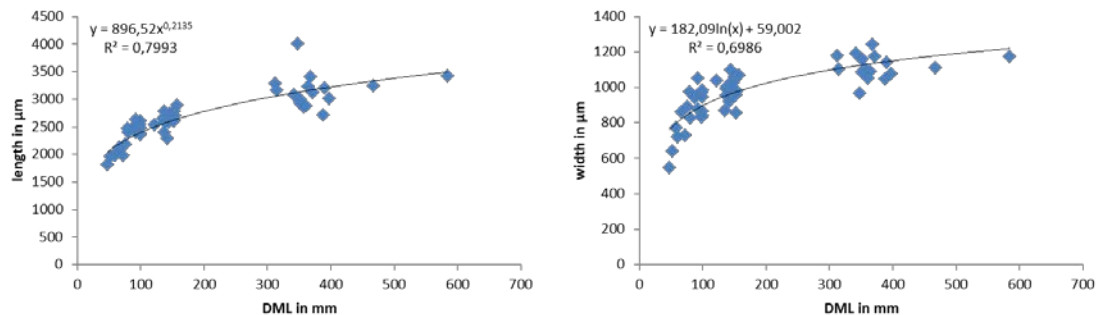


**Figure 3. Correlation between dorsal mantle length (DML) and statolith length (left panel) and dorsal mantle length (DML) and statolith width (right panel) of *L. forbesii* (N=51).**

In addition, it was possible to count the rings on the statoliths of 43 out of 52 of the prepared individuals. The standard deviation between the numbers of counted rings on both statoliths from the same individual was between 0.71 and 30.4 rings with a mean standard deviation of 17.2 rings. Assuming that each ring represents one day, the examined individuals were between 193 and 480 days old.
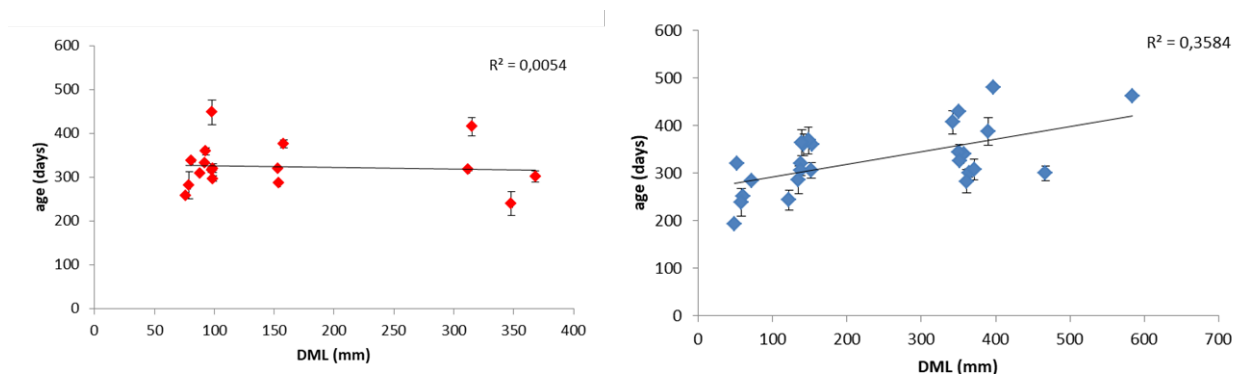


**Figure 4: Correlation between dorsal mantle length (in mm) and age (in days) for *L. forbesii*. Left panel: females (n=17); right panel: males (n=26).**

It seems that the relation between length and age is very weak for females, while the correlation between length and age is a bit stronger for males (Fig. 4). The possible reason of this is that all animals, immature, maturing, and mature, were sampled during a short period of time so represent different seasonal cohort. Most likely, it could be a sampling bias as the German research vessel does not cover main winter reproductive area off Scotland (ICES, 2012 – Fig. 2.2.4), where adult squid spawn during this period. The species is known to mature over two different size ranges although apparently at similar ages (ICES, 2015), the phenomenon requiring further investigation.
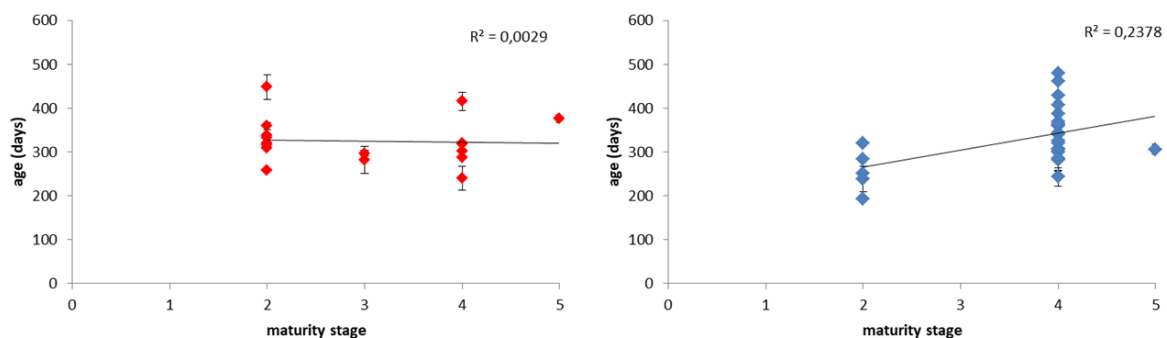


**Figure 5: Correlation between maturity stage and age (in days) of** *L. forbesii*. **Left panel: females (n=17); right panel: males (n=26).**

There is no relation between maturity stage and age of females observable, while males show an increase of maturity stage with increasing age, even if there is a strong overlap between age and different maturity stages (Fig. 5).

*A. subulata*

Statoliths of a total of 39 *A. subulata* individuals were examined. The preliminary results show that there is no correlation between dorsal mantle length and age for *A. subulata* because of the same reason as in *L. forbesii*: all animals, immature, maturing, and mature, were sampled during a short period of time so represent different seasonal cohort. Analyzed species were between 114 (± 5) days and 370 (±50) days old (Fig. 6). As the hatching was found to occur all year round, mostly from spring to autumn, it does not exclude a possibility of existence of two life cycles with different duration, as in *Sepia officinalis* in which both annual and bi-annual cycles coexist. In respect to Alloteuthis, squid hatched in spring possibly might exhibit semi-annual life span as in subtropical waters (Arkhipkin, Nekludova, 1993), whereas autumn born offspring's potentially could be annual. The problem needs further investigation.
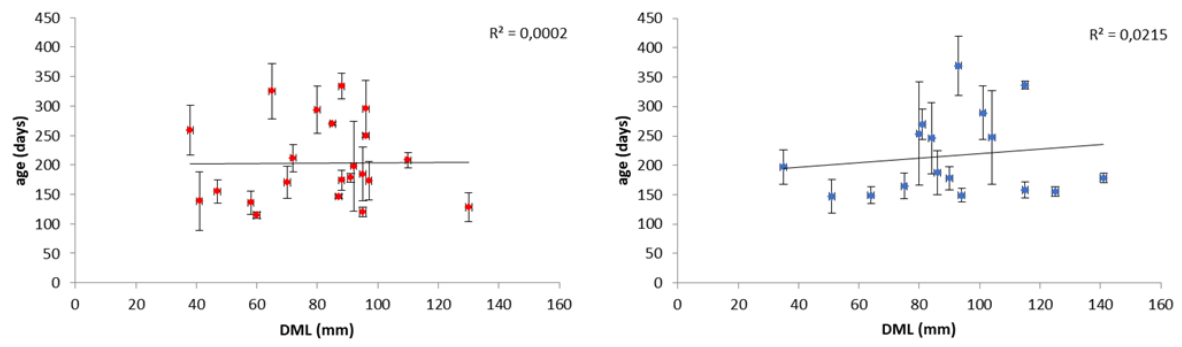
**Figure 4: Correlation between dorsal mantle length (in mm) and age (in days) for *A. subulata*. Left panel: females (n=17); right panel: males (n=26).**

_Illex coindetii_

The statoliths of a total of 46 individuals were analyzed. The sample consists of specimens with a dorsal mantle length of 45 mm to 130 mm (mean 69 mm ±18 mm). Assuming each ring representing one day, the analyzed individuals are between 132 and 202 days (mean 174 days ±16 days) old.
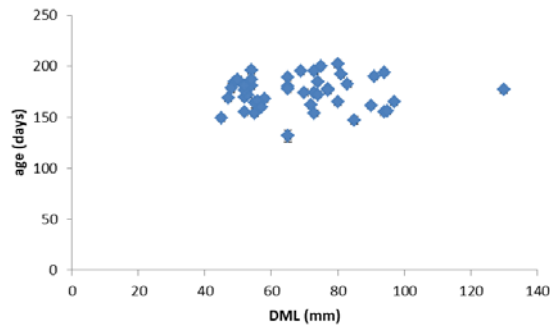


**Figure 5. Relationship between dorsal mantle length (in mm) and age (in days) for _I. coindetii_ (n = 46).**

Similar to the long-finned squids, there is no correlation observable between DML and age for _I. coindetii_ if all individuals were combined (Fig. 5). Two different life cycles are known for the species and spawning takes place throughout the whole year with seasonal peaks, assuming that different cohorts exist in the North Sea as well (Fig. 5).

## IV Conclusion & Outlook

The trial illustrates the enormous potential of statoliths age reading and shows the high potential to reveal information about the population and stock dynamic of the species occurring in the North Sea.

The preliminary results show that there is no clear relationship between age and dorsal mantle length, nor a correlation between age and maturity for _L. forbesii_, _A. subulata_ and _Illex coindetii_ if all monthly cohorts are mixed together.

Therefore we will continue our collaboration on age reading to increase the sample size, and reading statoliths collected during different months of the year to get a better insight of the population dynamics of the North Sea cephalopods and hopefully reconstruct growth of the most abundant monthly cohorts. In 2019 it is planned to perform some genetically analysis to figure out if different growth rates could be explained by the occurrence of different populations within the North Sea or whether other factors like habitat and food availability drive the different growth and maturation rates.

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