# WORKING GROUP ON CEPHALOPOD FISHERIES AND LIFE HISTORY (WGCEPH; outputs from 2019 meeting)

VOLUME 2 | ISSUE 46

ICES SCIENTIFIC REPORTS

RAPPORTS SCIENTIFIQUES DU CIEM

**ICES** INTERNATIONAL COUNCIL FOR THE EXPLORATION OF THE SEA

**CIEM** CONSEIL INTERNATIONAL POUR L'EXPLORATION DE LA MER

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

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



ISSN number: 2618–1371 I 

# ICES Scientific Reports

Volume 2 | Issue 46


## WORKING GROUP ON CEPHALOPOD FISHERIES AND LIFE HISTORY (WGCEPH; outputs from 2019 meeting)


## Recommended format for purpose of citation:

ICES. 2020. Working Group on Cephalopod Fisheries and Life History (WGCEPH; outputs from 2019 meeting).
ICES Scientific Reports. 2:46. 121 pp. http://doi.org/10.17895/ices.pub.6032



## Editors

Graham J. Pierce • Jean-Paul Robin • Ana Moreno • Daniel Oesterwind

## Authors

Esther Abad • Nicholas Badouvas • Nikolaos Fotiadis • Ángel F. González • Ane Iriondo • Ana Juarez • Alexandra Karatza • Vladimir Laptikhovsky • Angela Larivain • Evgenia Lefkaditou • Fedor Lishchenko • Fábio L. Matos • Ana Moreno • Silvia Monteiro • Daniel Oesterwind • Catalina Perales-Raya • Michael Petroni • Uwe Piatkowski • Graham J. Pierce • Cristina Pita • Anne Marie Power • Jean-Paul Robin • Alberto Rocha • Elina Samara • Marina Santurtun • Sónia Seixas • Luis Silva • Jennifer Smith • Ignacio Sobrino • Julio Valeiras • Sebastian Villasante



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

# Contents

# i Executive summary

The Working Group on Cephalopod Fisheries and Life History (WGCEPH) improves knowledge about and the assessment of cephalopods as an exploited resource

WGCEPH report provides information on status and trends in cephalopod stocks; preliminary assessments of selected stocks update information on life history parameters; social and economic profile of the cephalopod fisheries; recommended tools for identification cephalopod species; updated best practices for data collection.

Cuttlefish landings from the main fishing grounds (English Channel and Bay of Biscay) have decreased in recent years, although landings by UK vessels in the English Channel have increased. Squid landings are still mainly reported at family level, making it harder to infer stock status and trends. Loliginid squid landings have increased in northern areas and decreased in southern areas. Survey data suggest a decrease in abundance of *L. forbesii* and an increase in *L vulgaris*. Abundance of ommastrephid squid fluctuates widely with occasional peaks, the timing and size of which varies between species and areas. Octopus are mainly landed in southern Europe and comprise mainly of *Octopus vulgaris*. Abundance varies widely from year to year with no clear trends. Commercial LPUE and survey CPUE follow similar trends in some areas.

An update is provided on progress with stock assessment. An assessment exercise using production models gave satisfactory results for loliginid squid and cuttlefish in several areas. A forecasting model for *Octopus vulgaris*, driven by environmental variables and a recruitment index, is also presented. WGCEPH members organised a theme session (H, on non-quota and data-poor species) at the ICES Annual Science Conference (ASC) 2019. Several presentations during this session, linked to WGCEPH work, are summarised.

New review and synthesis work carried out on cephalopod life history, management of octopus fisheries and markets for cephalopods is summarised and is expected to be submitted for publication shortly. Relevant work was also presented at the ICES ASC 2019.

Progress with North Sea identification guide is described and the list of identification guides and keys has been updated. Current fishery data collection for cephalopods in the EU is described and proposals for improved data collection are presented. Fundamentally, this requires full identification of cephalopod landings to species. Increased frequency of sampling would facilitate in-season stock assessment.

# ii Expert group information

| | |
|---|---|
| **Expert group name** | Working Group on Cephalopod Fisheries and Life History (WGCEPH) |
| **Expert group cycle** | multiannual |
| **Year cycle started** | 2017 |
| **Reporting year in cycle** | 3/3 |
| **Chairs** | Graham Pierce, Spain |
| | Jean-Paul Robin, France |
| **Meeting venues and dates** | 6–9 June 2017, Funchal, Madeira, Portugal (19 participants) |
| | 5–8 June 2018, Pasaia, San Sebastian, Spain (11 participants) |
| | 4–7 June 2019, Athens, Greece (18 participants) |

# 1 ToR A: Cephalopod stock status and trends

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.

## 1.1 Introduction

Updated data on Northeast Atlantic fishery statistics and survey catches for cephalopods was obtained via the "Fisheries Data call 2019" call issued by ICES for all working groups. The call was launched on 30 January 2019. A correction related to discards data for cephalopod species was sent on 5 February. The cephalopod section of the call was similar to that in 2018 and included three different components. Commercial catch data and discard observations were provided via InterCatch, while survey data and detailed commercial catch and effort of the main trawler fleets were sent to data.call@ices.dk.

There were some issues with the data received and it may ultimately be necessary to request re-extractions of data from this and previous years to correct some errors. Although the 2019 Cephalopod data call was similar to the 2018 call it seemed that some of the main fishing countries were not able to repeat the same extractions from their databases. This happened with some commercial catch and effort data and some survey indices (which cannot always be computed from DATRAS extractions, especially when surveys are carried out with a stratified sampling scheme).

As was the case for previous data calls, the WGCEPH component of the "Fisheries Data call 2019" requested effort by metier and not by species. This means that the effort values should be the same for all cephalopod categories/species, for a given stratum, which is justified on the basis that cephalopods are rarely targeted but are usually landed even if taken as a bycatch (although the validity of this assumption should also be regularly re-evaluated). However, in several cases, the data received indicated different effort values by metier (and by month) for each category, suggesting that effort was reported only when non-zero catches of a particular category were obtained.

Some general limitations of the data series should be noted. Cephalopods are not assessed on a regular basis and there is no TAC for any cephalopod stock in EU waters. Biological data are collected only for certain species in certain countries under the DCF. This creates the potential risk that low priority is given to collection of fishery and fishery-independent data on cephalopod stocks. Landings and discards of cephalopods are most often recorded by family or order rather than by species. For example, long-finned (loliginid) squid landings are still reported mainly at the family (Loliginidae) level by most countries. In 2017 and 2018, only 2.2% of landings were reported at species level (oul.27.nea and sqr.27.nea). A noticeable improvement was achieved in 2017 with 48% of landings being reported at species or genus level compared to 16% in 2016 (oul.27.nea, ouw.27.nea, sqc.27.nea and sqr.27.nea), but this percentage dropped to 36% in 2018. Nevertheless, landings reported as sqz.27.nea are expected to be composed mostly of *Loligo* spp. Denmark, Portugal and Spain are the countries reporting data at species level.

Surveys are usually not targeted at cephalopods and not all species will be taken in proportion to their abundance in all gears. To state the obvious, small squid and sepiolids (e.g. *Alloteuthis*, *Sepiola*) and juveniles of larger species may usually pass through nets while benthic species like octopus may be poorly sampled by trawling. In addition, cephalopods show a clear seasonal cycle of size and abundance so surveys at different times of year will give different results.

Changes in research vessels used for surveys may lead to some inconsistencies in time series of abundance indices.

Among other data analysis (which varies from year to year according to the ToRs), WGCEPH produces annual updates of landings per family, per ICES division (or group of divisions) and per country named "ToR A tables". At present, family is generally the lowest taxonomic level available for all datasets. However, for some survey series, catches are nowadays identified to species. It should be noted that in some countries (e.g. Spain) recreational fishing may take a significant amount of cephalopods - and it would also be useful to re-examine reported landings from small-scale cephalopod fisheries, an exercise last undertaken around 20 years ago, involving application of the interview-based Gomez-Muñoz model to estimate landings and compare those with official landings.

A copy of these "ToR A tables" is annexed to the report (Annex 3) and an Excel workbook version is available on request. These annual landings data were also integrated in an ArcGIS project to prepare maps. The project file, related shapefiles and joint tables are available on request.

The locations of the main cephalopod fishing grounds and countries involved in their exploitation are presented, based on 2014–2018 averages (Figure 1). This highlights the importance of Octopodidae landings for southern countries like Spain and Portugal. In comparison, Sepiidae (technically [order] Sepiida since some Sepiolidae may also be landed) are fished in colder waters of the English Channel and squid are the main resources in the most northern areas.

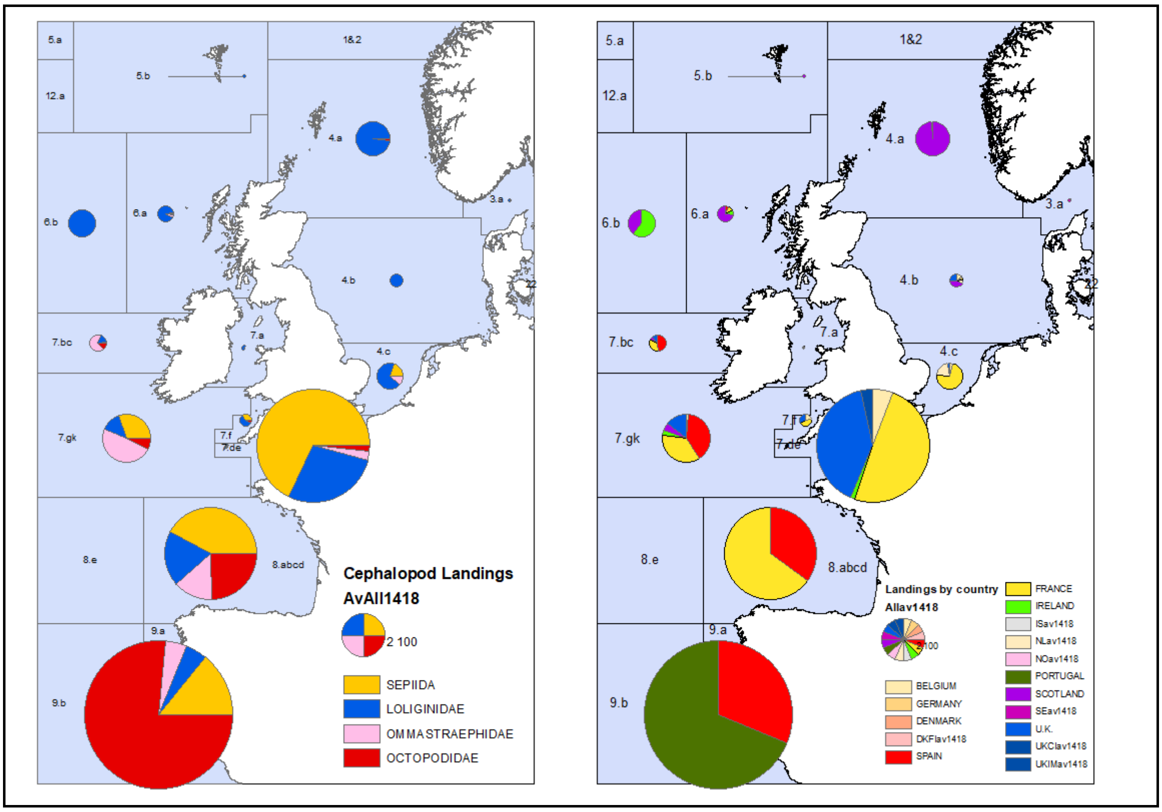



**Figure 1. Maps showing the origin of Cephalopod landings (average annual landings for the period 2014–2018) per groups of species (left) and per country (right).**

During the period 2000–2018, cuttlefish was the most important cephalopod resource in northeast Atlantic waters (41% of average annual landings versus 31% for Octopodidae, 21% for Loliginidae and 7% for Ommastrephidae). This ranking has not changed in 2018 in spite of lower landings (Figure 2).

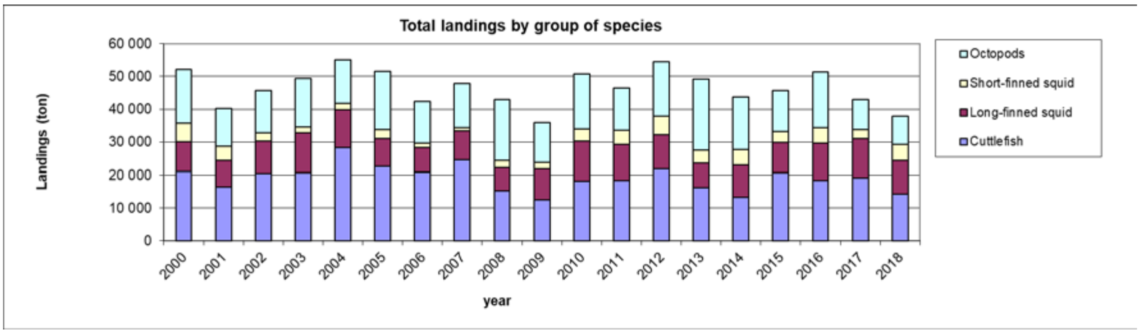



**Figure 2. Total landings from northeast Atlantic waters by groups of species (in tons)**

Year-to-year trends in fisheries landings from the different areas are displayed in Figure 3. These maps do not reveal consistent trends across ICES areas or across groups of species. The main points that can be noted are the recent increase of Ommastrephid squid landings from the Celtic sea and a slight downward trend in recent years in yields from main fishing areas (for instance: octopuses in area 27.9.a, cuttlefish in the English Channel).

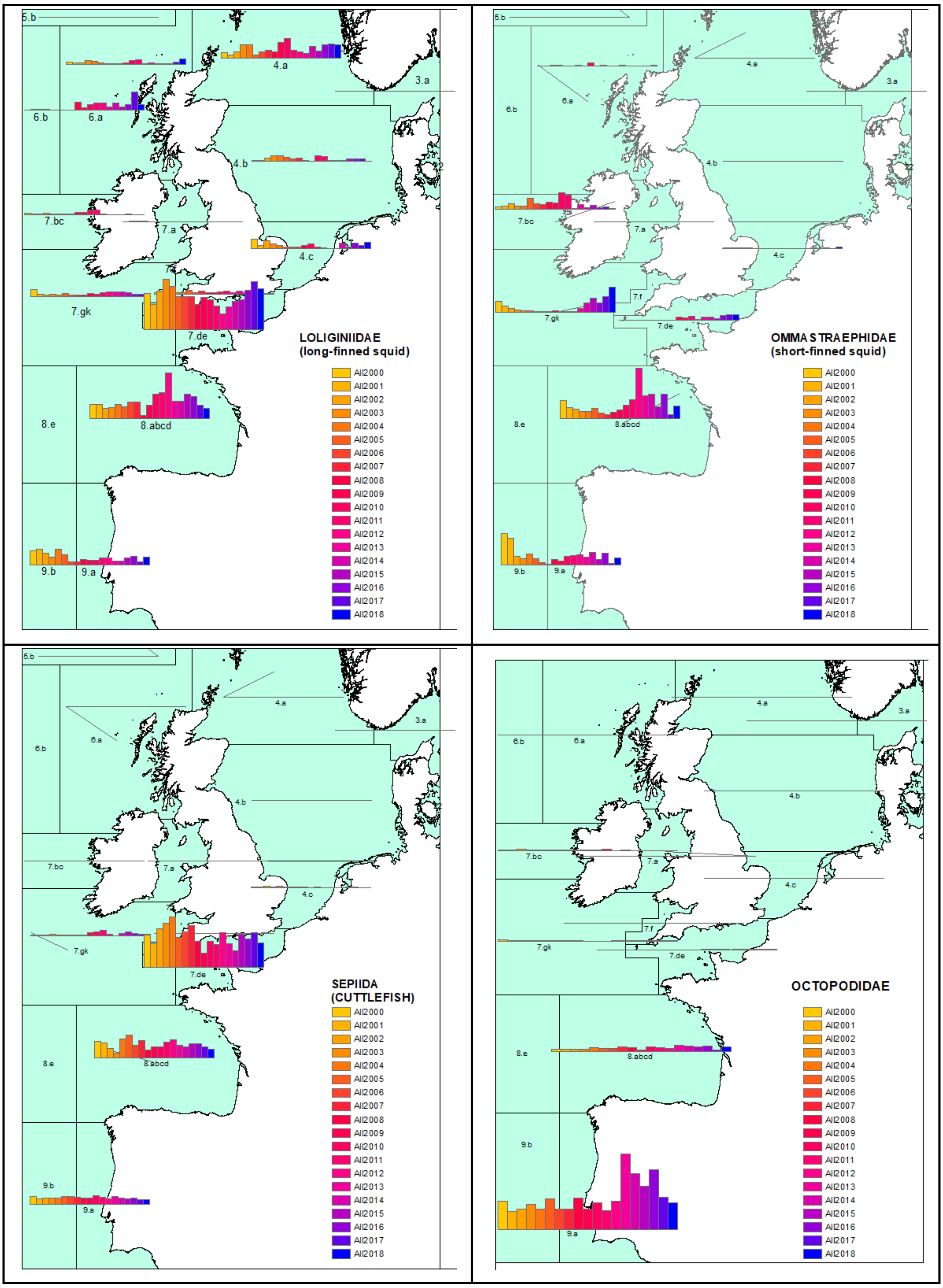



**Figure 3. Trends in Cephalopod landings during 2000–2018 (upper left Loliginidae, upper right Ommastrephidae, lower left Sepiida, lower right Octopodidae).**

## 1.2 Trends in landings, discards and survey indices

### 1.2.1 Cuttlefish and bobtail squids (*Sepiida*)

Cuttlefish landings, discards and survey data are presented here for the main areas where the species occurs (in decreasing order of importance these are: English Channel, Bay of Biscay and Iberian Peninsula); (see above in Figure 2).

#### Fisheries

The main countries exploiting Sepiida are France, the UK, Spain and Portugal (Figure 4). InterCatch 2018 extractions show that some countries record landings of *Sepia officinalis* (Belgium, France, Portugal) whereas other countries report landings of Sepiidae (Spain, UK). A minor proportion of the French landings is reported to comprise *Sepia orbignyana*. In all countries, a high proportion of landings of Sepiida is likely to be *Sepia officinalis* but we cannot currently say with any certainty what proportion comprises *S. orbignyana* or indeed other Sepiidae or Sepiolidae species. Small amounts of bobtail squids (Sepiolidae), specifically *Rossia macrosoma* (ROA), are reported among discards by Spain (7 kg in 2018) and Sweden (80 kg in 2018).

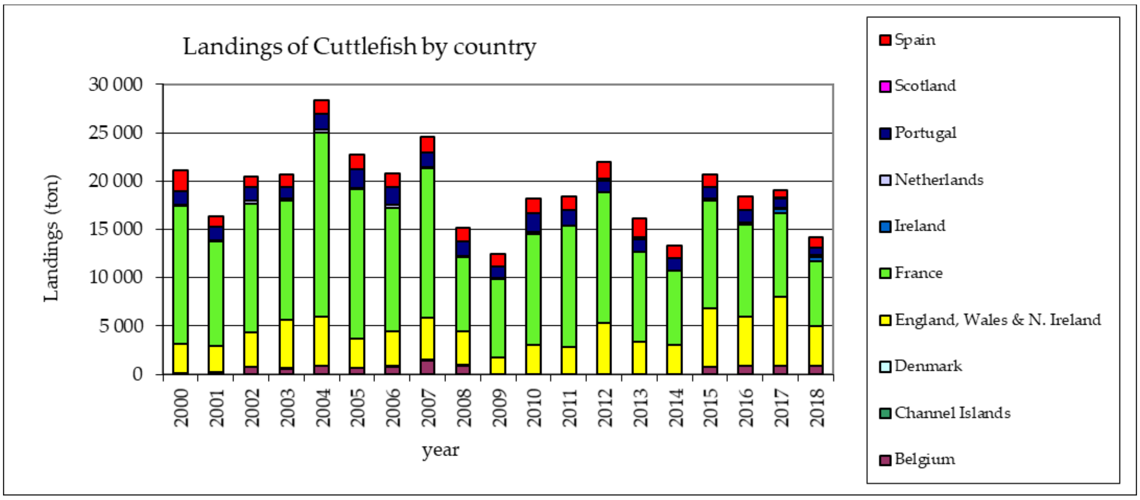



**Figure 4. Annual landings of cuttlefish (Sepiida) by country from 2000 until 2018.**

#### English Channel fishery (ICES Divisions 27.7.d-e)

The English Channel is the most important fishing ground for cuttlefish in the northeast Atlantic. Landings in 2018 were below the average (8900 t versus 10500 t). However, the most striking feature of the data over the last 15 years has been the decline in French landings, alongside a less marked increase in English landings (Figure 5). Since 2016 has been UK the most important country for cuttlefish landings in the area. While this requires further investigation, it is likely that these trends reflect a northward shift in cuttlefish distribution within the English Channel. In 2018, the most important gear for catching cuttlefish was bottom beam trawl (44%), as used in the UK, followed by otter bottom trawl (34%) and trap fishing (11%).

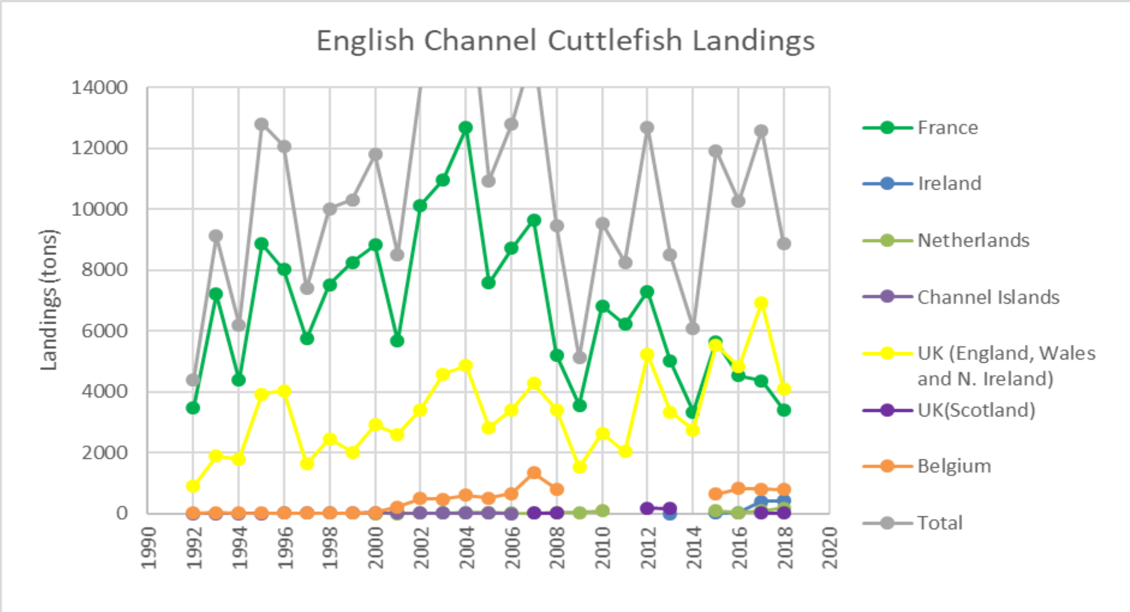



**Figure 5. English Channel Landings of cuttlefish, by country from 1992 until 2018.**

### Bay of Biscay Fishery (ICES Divisions 27.8.abd)

In the Bay of Biscay, cuttlefish is almost exclusively exploited by the French fishing fleet (Figure 6). Landings have decreased since 2015 and the total landings in 2018 were the third lowest between 1992 and 2018. Cuttlefish landed in 2018 were mainly fished by otter bottom trawl (55%), followed by twin bottom trawl (15%), trammel nets (11%) and trap fishing (2%).

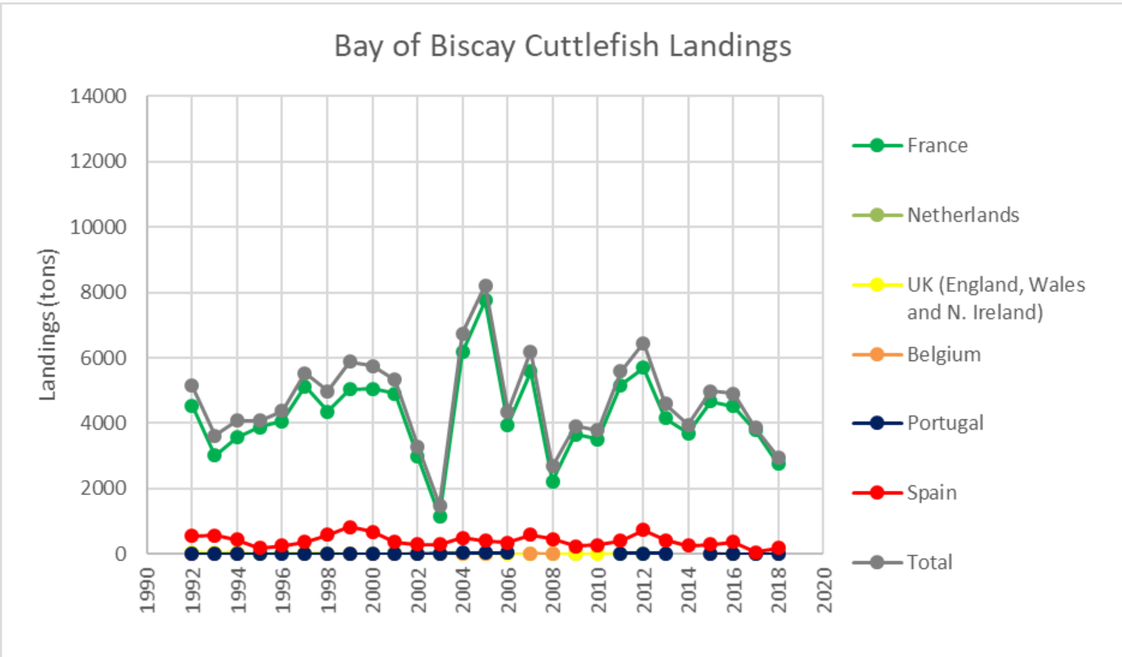



**Figure 6. Bay of Biscay Landings of cuttlefish by country from 1992 until 2018.**

**Iberian Peninsula Fishery (ICES Divisions 27.9.a)**

In the ICES Division 27.9.a cuttlefish is the second most important cephalopod resource (after Octopodidae). Landings are rather stable although a decreasing trend is apparent in Portuguese landings since 2010 and in Spanish landings since the 2013 (Figure 7). InterCatch extractions show that the most important gear type in 2018 landings was "miscellaneous" gears (MIS = 45%), which suggests that artisanal fleets are responsible for a substantial proportion of cuttlefish landings in this area.

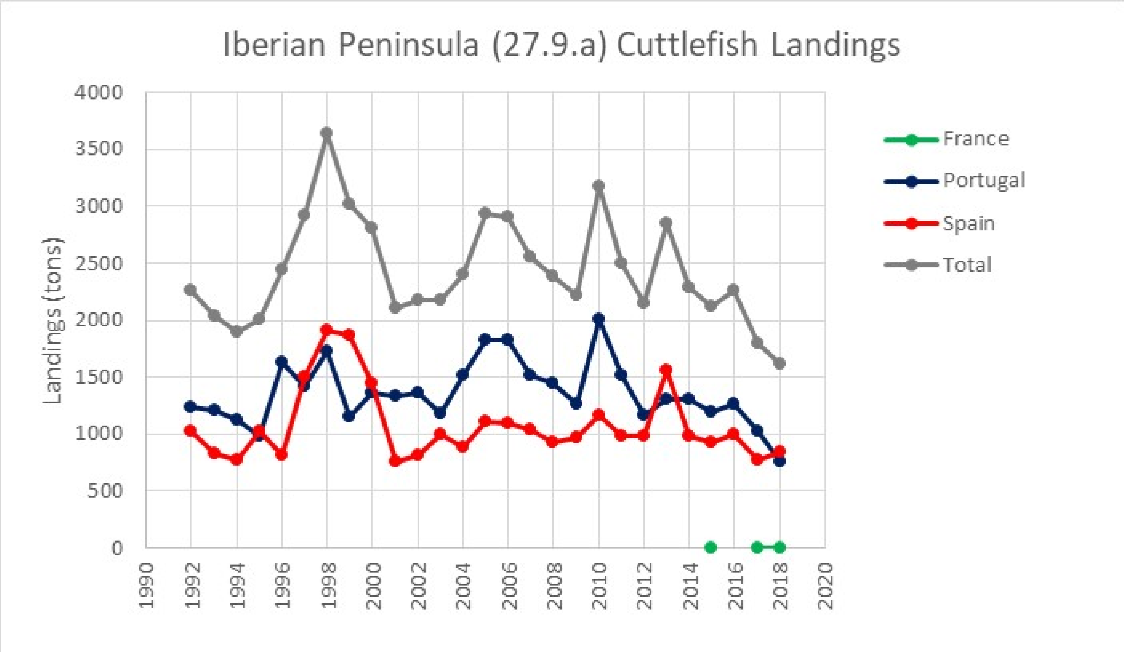



**Figure 7. Iberian Peninsula (Div. 27.9.a) Landings of cuttlefish by country from 1992 until 2018.**

## Discards

In general, low discarding rates were seen in areas where landings are highest (Table 1). In areas where more than 5% of the total cuttlefish catch was taken, the discard rate was usually less than 5%. The exceptions were area 27.8a (northern part of French Biscay coast) in 2017 (5%) and 27.8b (southern part of French Biscay coast) in 2018 (7%). The InterCatch extractions suggest that 98% of discards are due to trawlers (48% by otter trawlers and 50% by beam trawlers).

However, a more detailed analysis of discard data is needed to obtain a better understanding of the reasons for discarding cuttlefish. In particular, it would be interesting to know the size of discarded individuals and the season when animals are most often discarded. The survival rate of discarded specimen is still uncertain but could be low. However, in the lack of mesh size regulations preventing the catch of juvenile specimen the option to put them back into the sea could be considered.

## Survey

Cuttlefish data from the French Channel Groundfish Survey illustrate a decreasing trend in catch per unit effort in the Eastern English Channel since around 2006 (Figure 8).

**Table 1. Percentage of cuttlefish discards in relation to total catches in each sub-area (% Discards) and the percentage of total catches (across all subareas) that take place in each subarea (% Catches), in 2017 and 2018.**

| | 2017 | 2017 | 2018 | 2018 |
|---|---|---|---|---|
| Area | % Discards | % Catches | % Discards | % Catches |
| 27.3.a | 100% | 0.0% | NA | 0% |
| 27.4.a | 100% | 0.0% | 0% | 0% |
| 27.4.b | 0% | 0.0% | 0% | 0% |
| 27.4.c | 0% | 0.6% | 0% | 1% |
| 27.5.b | NA | 0.0% | NA | 0% |
| 27.6.a | 0% | 0.0% | 0% | 0% |
| 27.6.b | NA | 0.0% | NA | 0% |
| 27.7.a | 0% | 0.0% | 0% | 0% |
| 27.7.b | 0% | 0.0% | 0% | 0% |
| 27.7.c | 0% | 0.0% | 0% | 0% |
| 27.7.d | 1% | 16.0% | 2% | 15% |
| 27.7.e | 1% | 50.0% | 3% | 48% |
| 27.7.f | 0% | 0.7% | 22% | 0% |
| 27.7.g | 1% | 0.4% | 2% | 0% |
| 27.7.h | 4% | 2.6% | 1% | 4% |
| 27.7.j | 2% | 0.0% | 0% | 0% |
| 27.7.k | NA | 0.0% | 0% | 0% |
| 27.8.a | 5% | 14.7% | 3% | 13% |
| 27.8.b | 1% | 5.5% | 7% | 6% |
| 27.8.c | 0% | 0.0% | 0% | 1% |
| 27.8.d | 0% | 0.0% | 0% | 0% |
| 27.9.a | 0% | 5.4% | 0% | 5% |
| 27.9.a.c | NA | 0.0% | 0% | 0% |
| 27.9.a.n | 0% | 1.8% | 0% | 3% |
| 27.9.a.s | 0% | 2.2% | 0% | 3% |
| | | 100% | | 100% |

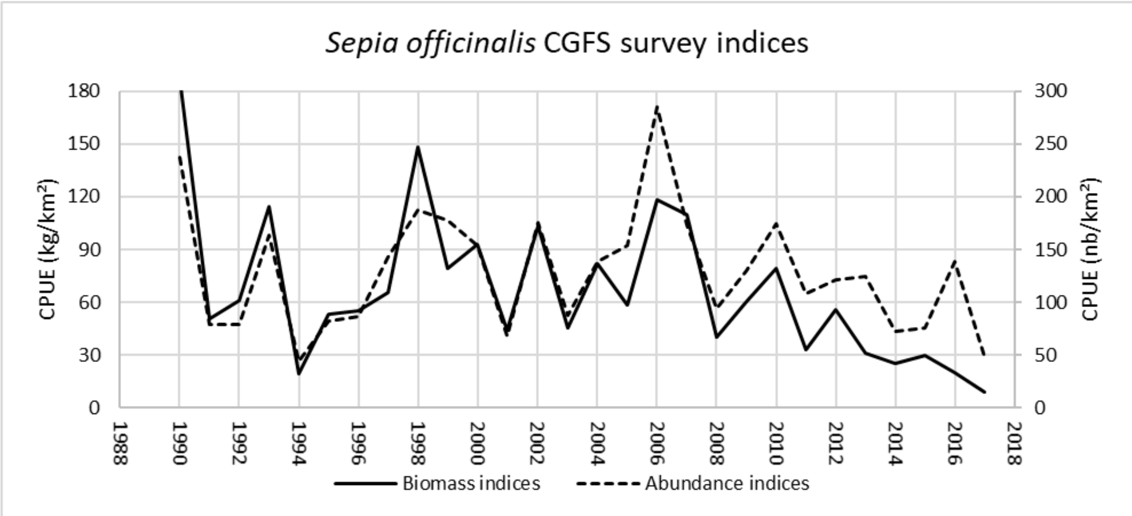



**Figure 8. *Sepia officinalis* abundance and biomass indices in the eastern part of the English Channel (Division 27.7.d) as described by the IFREMER CGFS surveys.**

### Summary

Cuttlefish landings and population indices show decreasing trends in recent years in the main fishing grounds (English Channel and Bay of Biscay/Iberian Peninsula). Discard data suggest that only a small proportion of the catch is discarded, at least in areas with significant catches. The main observed change in the exploitation of this resource in recent years is the decreasing importance of French landings, and an increase in UK landings, in the English Channel. While landings in the English Channel show no clear trends over time (Figure 5), IFREMER surveys suggest a decreasing trend in cuttlefish abundance in the eastern part of the English Channel since 2006 (Figure 6). The consequences, for the stock and the fisheries, of apparently decreasing cuttlefish abundance combined with possible redistribution of the species and the increasing prevalence of an annual (rather than biennial) life-cycle (Gras *et al.* 2016), alongside possible changes in fisher behaviour, need to be analysed.

## 1.2.2 Loliginid squids (Loliginidae or long-finned squid)

Loliginid commercial landings and discards, abundance/biomass derived from surveys and fishery LPUEs in the period 2016–2018 are presented by area and Member State. Trends in landings and abundance/biomass between 2000 and 2018 are presented for the five most important fishing areas.

### Loliginid fisheries

Amounts of loliginids landed between 2000 and 2018, by ICES Division/Sub-Area and country are presented in Supplementary Information, Table 2. Catches of Loliginidae may include *L. forbesii*, *L. vulgaris*, *A. media* and *A. subulata*. In the ICES area, *Alloteuthis* sp. are probably only of fishery interest in Spain and Portugal (Moreno, 1995; Tasende *et al.*, 2005; Jereb *et al.*, 2015).

Around 99% of north-eastern Atlantic Loliginid catches (landings + discards) are taken in 6 fishing areas. In the period 2016–2018 the proportion of catches in these 6 areas varied between 18–23% in the North Sea (Div. 27.4), 7–22% in the Celtic Seas (Div. 27.6a, b plus 27.7.a-c, f-k), 42–44% in the English Channel (Div. 27.7.d, e), 10–22% in the Bay of Biscay (Sub-area 27.8) and 3–9% in Western Iberia and the Gulf of Cadiz (Sub-area 27.9.a) and 1–5% in the Azores (Sub-area 27.10.a) (Figures 9, 10).

Discards are reported mainly at the family level (Loliginidae) by most countries. Some countries report zero loliginid discards. In the case of Portugal, discards are not estimated due to low frequency of loliginids in samples from the discard sampling program.

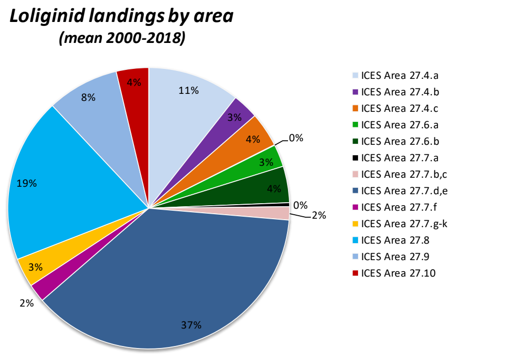



**Figure 9. Percentage of landings of Loliginids by ICES areas between 2000 and 2018.**

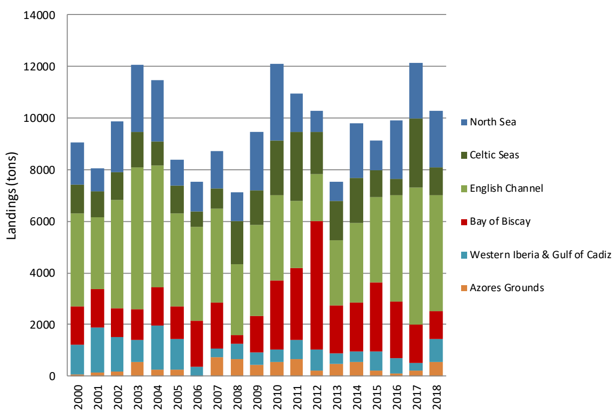



**Figure 10. Landings of Loliginids by the main 6 fishing areas between 2000 and 2018.**

There has been a weak upward trend in loliginid landings since the year 2000, with three important peaks, in 2003, 2010 and 2017 (Figure 10 and A11 left, see also Supplementary Information, Table 2). In 2016–2018, Loliginid landings were above the mean (2000–2018) in 27.4.a, 27.4.c, 27.6.b and 27.7.d, e and below the mean in the remaining subareas/divisions. Comparing the recent mean landings (2016–2018) with the previous 3-year period (2013–2015), a recovery in squid production is also observed in 27.6.a and 27.9.a. (Figure 11 right). In the NE Atlantic Loliginids are exploited mainly by the trawl fleet (92%, in 2016–2018 period), with the exception of Belgium, Denmark and the Netherlands (Figure 12).

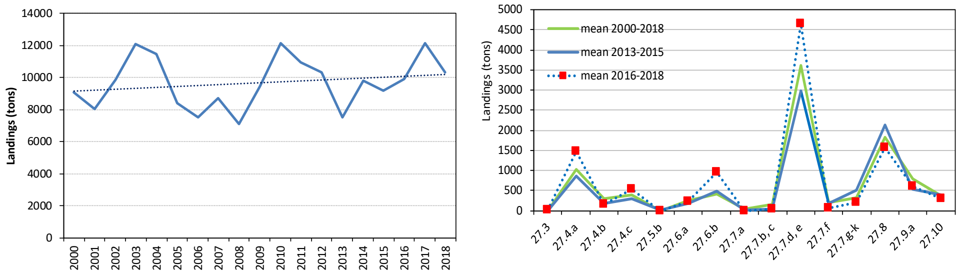



**Figure 11. Trends in total Loliginid landings in the ICES area for the years 2000 to 2018 (left) and recent mean landings (2016–2018) and the previous 3 years (2013–2015) by sub-area/Division compared with 2010–2018 mean (right).**

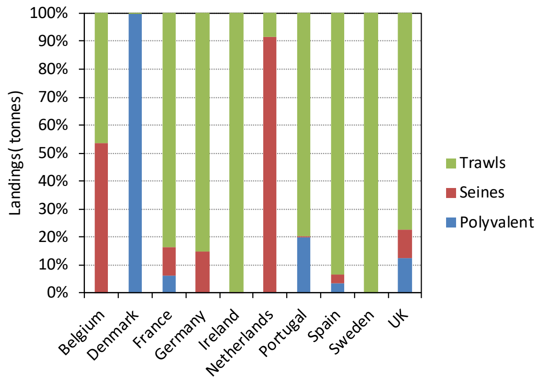



**Figure 12. Loliginid landing proportions by fleet for each country for the years 2016 to 2018.**

Loliginid discards are generally negligible. In 2018, discards represented only 1% of total catches. Although in some subareas, may exist 100% of discards by a given country, it is a general rule that areas with higher discards have small catches and the areas with higher catches have small discards (Table 2). Loliginids are mainly discarded by the trawl fleet. There are no records of discards from the polyvalent fleet (MIS).

## Fisheries in the North Sea

Fisheries statistics for the North Sea (27.4) indicate that landings in 2018 summed 2190 tons, a stable amount since 2016 (Figure 13). A slight decrease occurred in areas 27.4.a and 27.4.b. in 2018 and an increase in area 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, 2017 and 2018, the Netherlands fleet reported a significant amount of landings of Loliginids from the southern North Sea and some from the Central area (Figure 13).

In the North Sea, discards are generally very low. In 2018, 24.2 tons of *L. vulgaris*, 0.8 tons of *Loligo* sp. and 3.5 tons of unspecified Loliginids were discarded by England, France and Germany. In the North Sea Loliginid squids are mainly exploited by the trawl fleet (ca. 92%).

## Fisheries in the Celtic Seas

Landings from the Celtic Seas (27.6.a, b and 27.7.a-c, f-k) increased substantially in 2017, in particular in Rockall (27.6.b), reaching a peak similar to that seen in 2011, but squid production dropped to 1077 tons in 2018 (Figure 14). The main fleets fishing in this area belong to Scotland, in the northern part, and France, as well as England and Ireland in the southern part. Reported discards from area 27.6 are generally very low (<1 ton annually). Loliginid discards from 27.7.a-c, f-k amounted 62.4 tons in 2016, 27.2 tons in 2017 and 64.7 tons in 2018, and were mostly reported as *Loligo* sp. Discards are reported by France, England and Spain. In the Celtic Seas, loliginid squids are mainly exploited by the trawl fleet (ca. 97% of landings).

**Table 2. Percentage of Loliginid discards in relation to total catches (% Discards) and relative percentage of catches by subarea (% Catches) in the period 2016 to 2018.**

| **Loliginids** | 2016 | | 2017 | | 2018 | |
|---|---|---|---|---|---|---|
| | % Discards | % Catches | % Discards | % Catches | % Discards | % Catches |
| 27.3.a | **45** | 0 | **26** | 0 | **21** | 0 |
| 27.4.a | 1 | **13** | 1 | **13** | 0 | **14** |
| 27.4.b | 0 | 2 | 0 | 2 | 1 | 1 |
| 27.4.c | 0 | **6** | 0 | 3 | 0 | **7** |
| 27.5.b | 0 | 0 | 0 | 0 | 0 | 0 |
| 27.6.a | 3 | 1 | 0 | 2 | 0 | 6 |
| 27.6.b | 0 | **5** | 0 | **17** | 0 | **5** |
| 27.7.a | 0 | 0 | 0 | 0 | 0 | 0 |
| 27.7.b | 1 | 0 | 1 | 0 | 0 | 0 |
| 27.7.c | **8** | 0 | 2 | 0 | 4 | 0 |
| 27.7.d | 0 | **29** | 0 | **36** | 0 | **34** |
| 27.7.e | 3 | **9** | 2 | **9** | 5 | **9** |
| 27.7.f | 3 | 1 | 0 | 0 | 0 | 1 |
| 27.7.g | **7** | 0 | **16** | 0 | 4 | 0 |
| 27.7.h | **12** | 1 | 1 | 1 | **10** | 1 |
| 27.7.j | 7 | 1 | 2 | 1 | 1 | 1 |
| 27.7.k | 0 | 0 | 0 | 0 | 0 | 0 |
| 27.8.a | 4 | **14** | 3 | **8** | 2 | **8** |
| 27.8.b | 3 | 7 | 2 | 4 | 1 | 3 |
| 27.8.c | 6 | 0 | 0 | 0 | 0 | 0 |
| 27.8.d | **8** | 0 | 0 | 0 | 1 | 0 |
| 27.9.a | 2 | **8** | 4 | **3** | 0 | **9** |

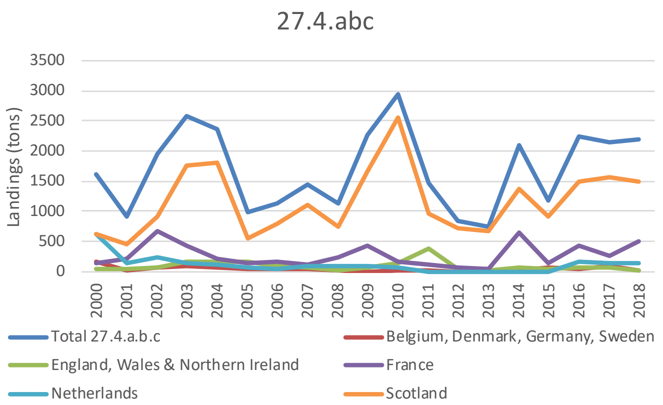



**Figure 13. Trends in Loliginid landings in the North Sea (27.4a, b, c) for the years 2000 to 2018, by national fleet.**

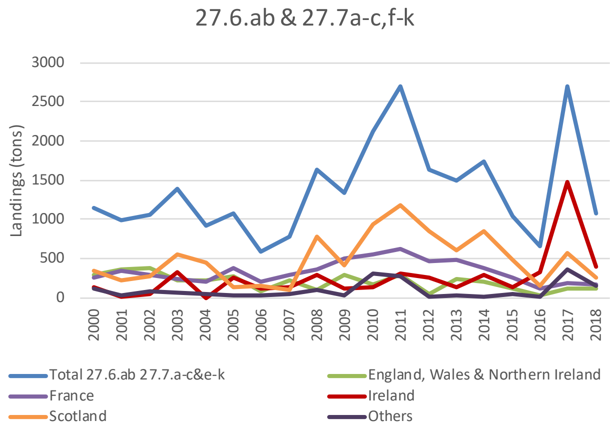



**Figure 14. Trends in Loliginid landings in the Celtic Seas (27.6.a, b & 27.7.a-c, f-k) for the years 2000 to 2018 by national fleet.**

## Fisheries in the English Channel

Squid production of 5700 tons in 2017 in the English Channel (27.7.d, e) continued the consistent increasing trend which observed since 2012 (Figure 15). In 2018 landings decreased to 4518 tons, still well above the mean of the last two decades and indeed higher than in every year except 2003, 2004 and 2017. The fishing fleets exploiting include those of the UK, Netherlands and Belgium but France dominates landings.

In total, 51.2 tons of loliginids were discarded in this area in 2018, mainly by England. France discarded 28.2 tons in 2016 and 21.0 tons in 2017. Most of these discards were reported as *L vulgaris* and *Loligo* spp. Similar to the northern areas, loliginids are mainly exploited by the trawl fishery in the English Channel, although the seine fleet also makes an important contribution, generating 33% of landings.

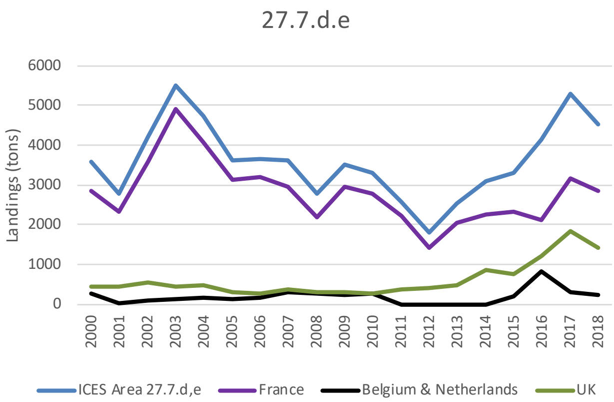



**Figure 15. Trends in Loliginid landings in the English Channel (27.7.d, e) for the years 2000 to 2018 by national fleet.**

## Fisheries in the Bay of Biscay

Loliginid landings in the Bay of Biscay (area 27.8.a, b, c, d) in 2017 summed 1077 tons, following the decreasing trend observed since 2012. 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) in this area are generally negligible (Figure 16). Loliginid discards in this area decreased from 91.2 tons in 2016 to 19.5 tons in 2018.

Most discards in 2016–2018 period for this area were reported by France, from 27.8.a and 27.8.b. Loliginids are mainly exploited by the trawl fishery in the Bay of Biscay (89%). The seine fleet landed 13% of loliginids from this area in 2016–2018.

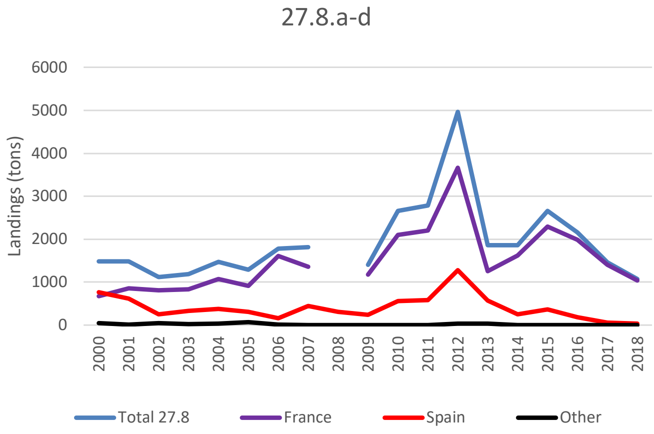



**Figure 16. Trends in Loliginid landings in the Bay of Biscay (27.8.a, b, c, d) area for the years 2000 to 2018 by national fleet. Note that there are no French data for 2008, hence no total.**

## Fisheries in Western Iberia and Gulf of Cadiz

Loliginid landings from Western Iberia and Gulf of Cadiz (Subarea 27.9.a), increased substantially in 2018 to 878 tons, which is the highest landing amount since 2005, albeit only around half of the amount landed in 2001 and 2004. Of these landings, 184 tons are reported as *Alloteuthis* sp. Loliginid catches in this area are taken equally by Spain and Portugal and the year-to-year variation in landings by both countries generally appears to be similar (Figure 17).

In 2018, Spain reported a total of 10.8 tons of *A. media*, 9.0 tons of *Alloteuthis* spp. and 6.1 tons of *L. vulgaris* discarded in sub-area 27.9.a.s.c and 13.3 tons of unspecified loliginids discarded in sub-area 27.9.a.n. Portugal did not estimate discards of loliginids due to their low frequency of occurrence during sampling, which potentially hinders the estimations of total discards. Results from previous years indicate that the percentage of discards of loliginids in Portuguese trawl fleets may vary from 2 to 25% in the OTB-CRU and 7 to 48% in the OTB-DEF. The percentage of loliginids discarded in the Spanish OTB fleet in 27.9.a.s.c is generally low (0–3%). As in the whole ICES area, loliginids are mainly exploited by the trawl fishery in Western Iberia and Gulf of Cadiz (87%). The polyvalent artisanal fleet landed 10% of Loliginids from this area in 2016–2018.

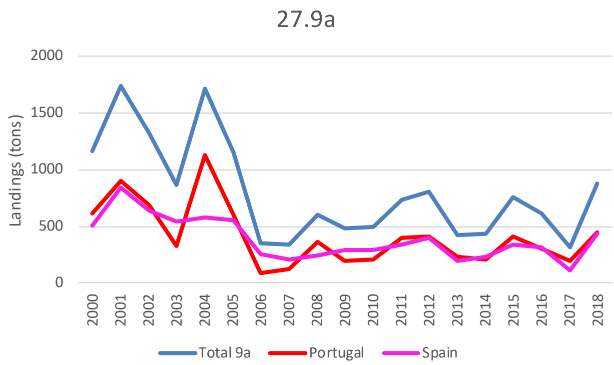



**Figure 17. Trends in Loliginid landings in Western Iberia and Gulf of Cadiz (ICES Subarea 27.9.a) for the years 2000 to 2018, by national fleet.**

## Relative biomass indices for loliginids

Regional fishery CPUEs datasets by species or groups of species need further improvement to be used as a proxy of biomass. This will be postponed to the WGCEPH 2020 meeting. The following bottom trawl research cruises, including those with data submitted in DATRAS, were analysed 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.

## Research Surveys in the North Sea

Survey trends in the North Sea indicate a general decrease in loliginid biomass in 2018. There was an increase in mean biomass of *L. forbesii* in 2016–2018 compared to 2013–2015 period, which relates well with the trend in landings. On the other hand, there was a decrease in mean biomass of *Alloteuthis* sp. when comparing the two periods (Figure 18). Both species present similar biomass indices and both have higher biomass in winter than in summer. The German 1st quarter IBTS indicates the entrance of *L. vulgaris* into the North Sea in some years. There is still a considerable proportion of non-identified loliginids in North Sea surveys, stressing the need for the presence (and use) of good identification guides for cephalopods on-board (see section 5 in this report for more details).

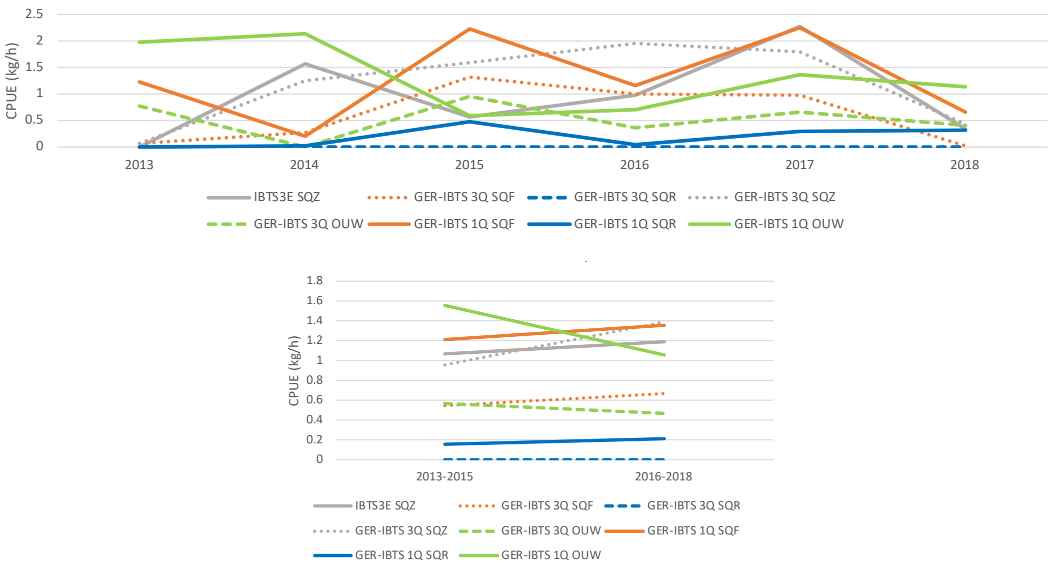
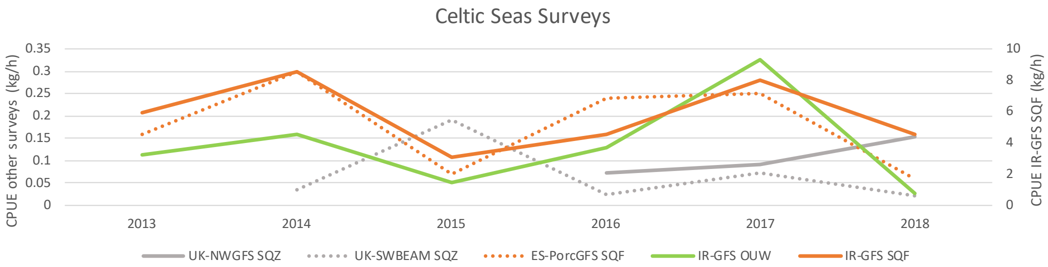



**Figure 18. Recent trends in Loliginid biomass survey indices in the North Sea (ICES Subareas 27.4.a, b, c); (SQF = *Loligo forbesii*, SQR = *Loligo vulgaris*, OUW = *Alloteuthis* sp., SQZ = Loliginidae).**

## Research Surveys in the Celtic Seas

All the different surveys in the Celtic Seas indicate an increase in biomass of *L. forbesii* and *Alloteuthis* sp. in 2017 and a drop in 2018 (Figure 19). There was a decrease in mean biomass of *L. forbesii* in 2016–2018 compared to 2013–2015 period, except on the Porcupine Bank. On the other hand, there was an increase in mean biomass of *Alloteuthis* sp. when comparing the two periods. Similar to North Sea surveys, there is still a considerable proportion of non-identified loliginids in the Celtic Seas surveys.



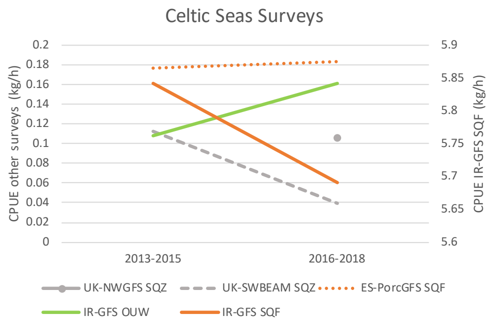




**Figure 19. Trends in Loliginid biomass survey indices in the Celtic Seas (ICES Subareas 27.6.a, b & 27.7.a-c, e-k); (SQF = *Loligo forbesii*, SQR = *Loligo vulgaris*, OUW = *Alloteuthis* sp., SQZ = Loliginidae).**

## 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. Nevertheless, in recent years the trends in biomass derived from the EVHOE and CGFS surveys were comparable (Figure 20). *L. forbesii* is still at very low CPUE compared to the historical mean and still shows a decreasing trend (lower biomass in 2016–2018 than in 2013–2015). The trend of *Alloteuthis* sp. CPUE in the English Channel is also downwards. *L. vulgaris* is presently the most abundant loliginid in the English Channel, and its mean biomass in 2016–2018 increased compared to 2013–2015 period. The increase in *L. vulgaris* biomass supported the recent increase in squid production in the English Channel.

## Research Surveys in the Bay of Biscay

*L. forbesii* has generally low biomass indices in the Bay of Biscay and recent values (2016–2018) were lower than the mean CPUE for the years 2013–2015 (Figure 21). On the contrary, *L. vulgaris* CPUE increased until 2016 and dropped sharply in 2018 (2017 data missing). *Alloteuthis* sp. biomass indices showed an increase in 2018.

## Research Surveys in the Western Iberia (27.8.c & 27.9.a west)

*L. forbesii* biomass indices in subareas 27.8.c and 27.9.a. west are comparable to those in the Bay of Biscay and trends are similar in Spanish (ES-IBTS survey) and the Portuguese waters (PT-IBTS survey); (Figure 22). Recent values (2016–2018) were lower compared to the mean CPUE for the years 2013–2015. The recent trend of *Alloteuthis* sp. biomass is also decreasing. On the contrary, the biomass of *L. vulgaris* shows an increasing trend, in particular in Portuguese waters. The highest biomass indices were recorded in 2018 in both Spanish and Portuguese waters.

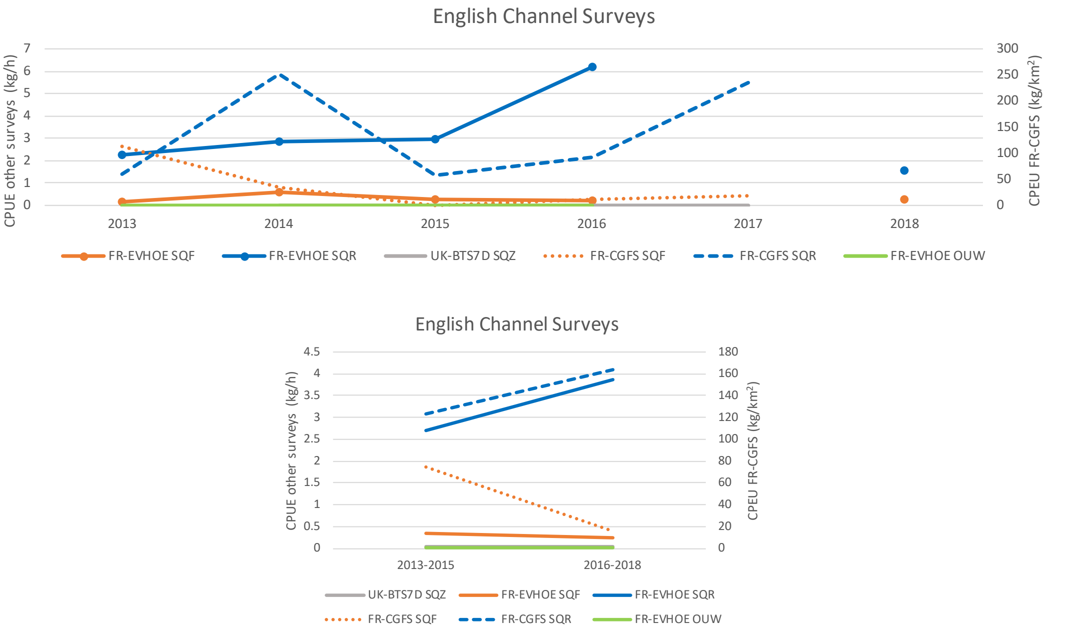



**Figure 20. Trends in Loliginid biomass survey indices in the English Channel (ICES Subareas 27.7.d, e). FR-CGFS in kg/km² and others in Kg/h. (SQF = *Loligo forbesii*, SQR = *Loligo vulgaris*, OUW = *Alloteuthis* sp., SQZ = Loliginidae)**

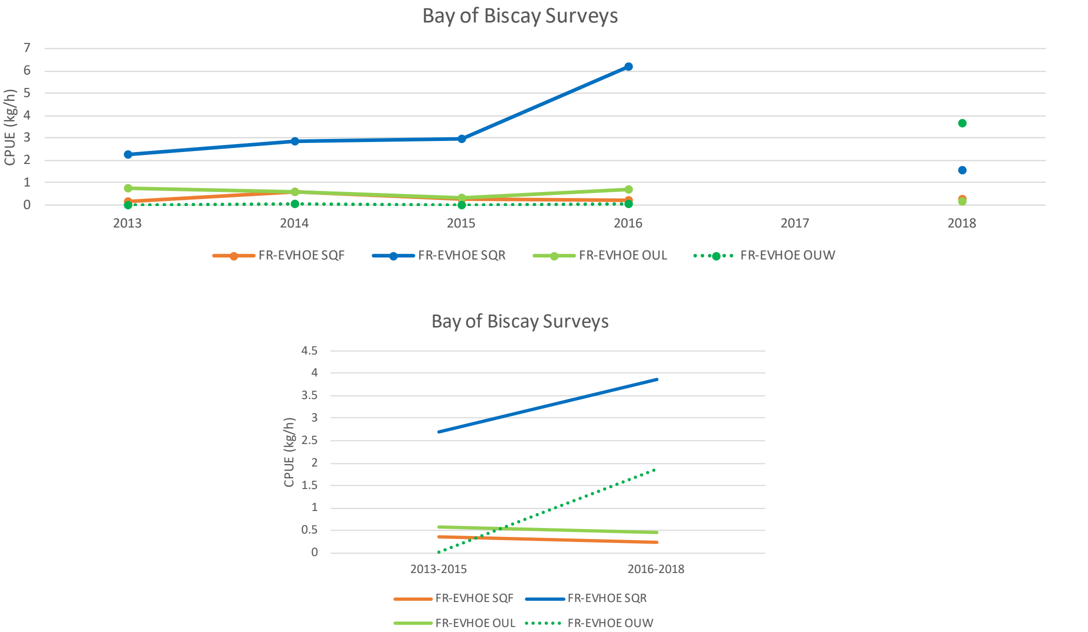



**Figure 21. Trends in Loliginid biomass survey indices in the Northern Bay of Biscay (ICES Subareas 27.8.a, b, d); (SQF = *Loligo forbesii*, SQR = *Loligo vulgaris*, OUW = *Alloteuthis* sp., SQZ = Loliginidae).**

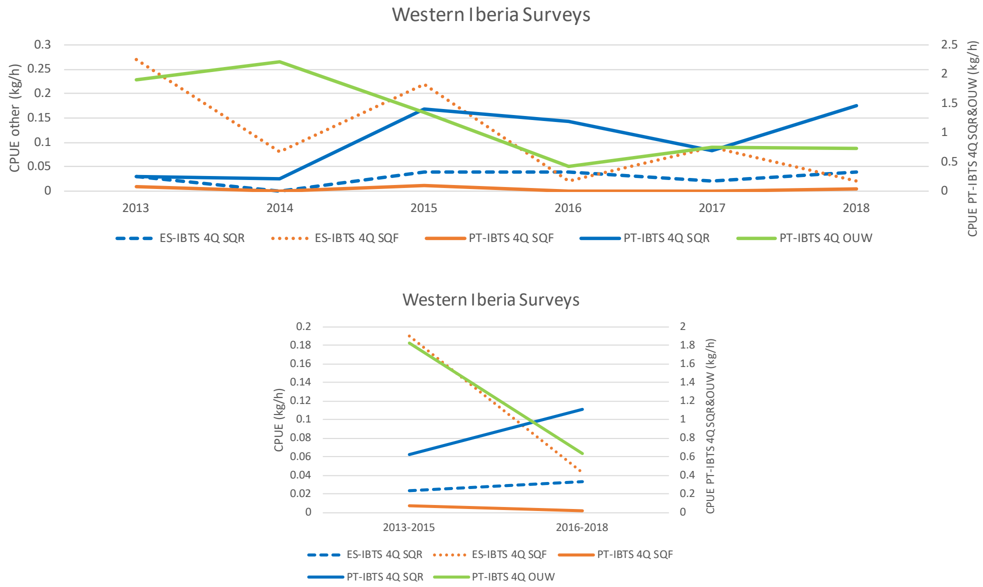



**Figure 22. Trends in Loliginid biomass survey indices in the Western Iberia (ICES Subareas 27.8.c & 27.9.a west); (SQF = *Loligo forbesii*, SQR = *Loligo vulgaris*, OUW = *Alloteuthis* sp., SQZ = Loliginidae).**

## Research Surveys in the Gulf of Cadiz

*L. vulgaris* is the most abundant species, in both the western and the Eastern areas of the Gulf of Cadiz (Figure 23). Higher biomass indices of this species were recorded in 2015 in the Eastern area and in 2016 in the Western area. Changes in biomass from 2013–2015 to 2016–2018 differ between the eastern and western areas, but the changes were not large. *L. forbesii* was recorded only in the Eastern part of the Gulf of Cadiz, with higher biomass in the most recent 3 years. *Alloteuthis* sp. decreased from 2013–2015 period to 2016–2018 period.

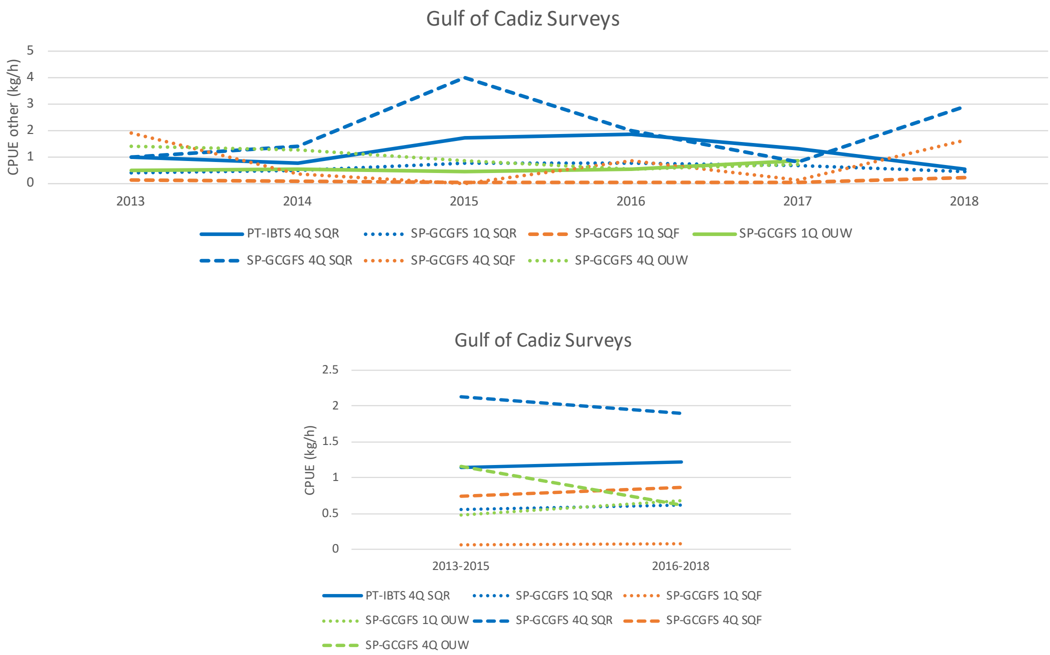



**Figure 23. Trends in Loliginid biomass survey indices in the Gulf of Cadiz (ICES Subarea 27.9.a south). (SQF = *Loligo forbesii*, SQR = *Loligo vulgaris*, OUW = *Alloteuthis* sp., SQZ = Loliginidae)**

### Summary of trends and status

Landings are still reported mainly at the family level (Loliginidae) by most countries. In southern countries, where cephalopods are traditionally consumed, an improvement is observed in reporting at species level. In 2016–2018, 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, 27.9.a and 27.10.a. Loliginid discards are generally negligible and in 2016–2018 represented around 1% of total catches. Based on landings we could conclude that the status of loliginid populations may not be good south of the English Channel and on the Azores grounds. However, CPUE data from several research surveys suggest that the recent decrease in loliginid landings in these areas may, at least in part, reflect a decrease in *L. forbesii* biomass in all areas except in the North Sea. Landings in the English Channel increased despite this lower biomass of *L. forbesii*, apparently reflecting an increase of *L. vulgaris* biomass. *Alloteuthis* spp., which started recently to be valued and are landed mainly in Spain and Portugal, present a decreasing trend in biomass in most areas.

## 1.2.3 Ommastrephid squids (Ommastrephidae)

Landings of Ommastrephidae from all countries combined are presented by ICES divisions. Catches of this species group averaged around 3200 t annually along the data series. There was a peak in 2012, mainly due to the Spanish catches in Subarea 8 and landings have subsequently been variable. In year 2018, an increase of landings was observed. This increase was mainly due to Spanish catches from division 7f-k, 8 and 9.

Commercial catches of Ommastrephidae are thought to be composed mainly of *Illex coindetii, Todaropsis eblanae* and *Todarodes sagittatus*. Since the data call requests data by species, some countries provide data by species but most data refer to Ommastrephidae. Survey data for several areas was provided by species and its main feature seems to be considerable variation in abundance. Note: historical FAO data suggest that *Illex illecebrosus* is also found in European waters, although this probably reflects the fact that, at least until the mid-1980s, some authors argued that *I. coindetii* was a subspecies of *I. illecebrosus* (see Rodhouse *et al.*, 1998).

### Fisheries

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 caroli*[1]) 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.

In Figure 24, 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 2018, an increase of landings was observed in division 7.f-k and 8 mainly comprising Spanish catches.

---

[1] *Ommastrephes bartramii* has recently been recognised as a species complex. European specimens are now designated as *O. caroli* (Fernandez-Alvarez *et al.*, 2020).

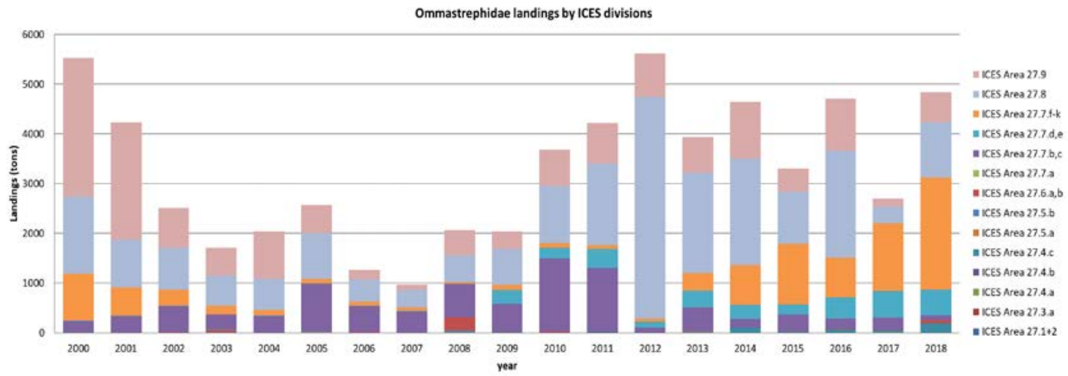



**Figure 24. Ommastrephidae landings from year 2000 to 2017 for all countries and ICES divisions.**

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 landed by trawlers in multispecies and mixed fisheries.

Although some countries provide data by species, generally these catches are not identified to species. WGCEPH reported on the species composition of ommastrephid squid in Galicia (NW Spain) in 2009 and 2010 (ICES 2009, 2010), based on market sampling at Galician ports; 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 2018. The percentage of the catch discarded in relation to total catch is estimated to be around 5%. Analysing data by ICES division, the discard percentage is higher for areas with small catches and areas with higher catches have smaller discards (Table 3).

## Fisheries in ICES Division 7abcdegk

Available commercial landings data indicate that between 300 and 1400 t are landed per year in Subarea 7. Most of these landings were reported by Spain in Divisions 7f-k and by France in 7d-e and 7f-k.

## Fisheries in ICES Division 8abd

The countries contributing to ommastrephid catches in Division 8abd were France and Spain. In 2018, France landed 219 t of ommastrephids (67% of catches) from Div. 8abd, while Spanish landings amounted for 109 t (33%).

## Fisheries in ICES Division 8c & 9a

Overall, landings of ommastrephids amounted to 1389 t caught by Spain and Portugal, 57% from ICES Div. 8c and around 43% from Div. 9a. The total amount in division 8c and 9a have increased significantly, from 17 t to 791 t and from 166 t to 598 t in 9.a.

**Table 3. Percentage of Ommastrephidae discards (as a percentage of catches) and catches (as a percentage of total catches across all areas) by subarea in 2018.**

| | | |
|---|---|---|
| **Ommastrephids** | | **2018** |
| | | |
| **ICES Division** | **% Discards** | **% Catches by area** |
| 27.3.a | 100% | 0% |
| 27.4.a | 46% | 0% |
| 27.4.b | 0% | 0% |
| 27.4.c | 0% | 4% |
| 27.5.b | 0% | 0% |
| 27.6.a | 94% | 1% |
| 27.6.b | 2% | 1% |
| 27.7.b | 0% | 0% |
| 27.7.c | 7% | 1% |
| 27.7.d | 0% | 10% |
| 27.7.e | 0% | 1% |
| 27.7.f | 0% | 0% |
| 27.7.g | 10% | 0% |
| 27.7.h | 46% | 0% |
| 27.7.j | 3% | 45% |
| 27.7.k | 2% | 1% |
| 27.8.a | 29% | 3% |
| 27.8.b | 22% | 5% |
| 27.8.c | 3% | 16% |
| 27.8.d | 21% | 0% |
| 27.9.a | 0% | 1% |
| 27.9.a.c | 0% | 2% |
| 27.9.a.n | 2% | 9% |
| 27.9.a.s | 14% | 0% |
| **Total general** | **5%** | **100%** |

## Survey catch rates

## Surveys, ICES Division 4

Data on catch in numbers per hour of hauling (CPUE), per length class and per area, from the IBTS quarter 1 and quarter 3 surveys were downloaded from ICES DATRAS (17th of June 2019). Data were provided by DEN, ENG, FRA, GFR, NED, NOR, SCO and SWE and filtered for ommastrephids (incl. the following classifications: *Illex*, *Illex coindetii*, *Illex illecebrosus*, Ommastrephidae, *Todarodes*, *Todarodes sagittatus*, *Todaropsis eblanae*). Afterwards the CPUE per length class per area were summed for each area. As mentioned in previous WGCEPH reports, the quality of the data seems to be insufficient at least for 2011 and 2012 because some species were listed as 'teuthida', i.e. squids (and hence not included in the data presenting here), showing that problems with species identification occurred.

Quarter 1 surveys

The data show a strong increase of CPUE values since 2014 (Figure 25). The strongest CPUE increase was in RFA 1 and RFA 2 in the north. The maximum CPUE is observable in RFA 1 (54.5 individuals per hour in 2019). However, increasing CPUE is also seen for RFA 3, 4 and 7. In RFA

5 and RFA 6 in the south ommastrephids seems to be very rare. A more detailed analysis illustrates that the increase in CPUE of ommastrephids squids is linked to a strong increase in CPUE of *I. coindetii* in the last few years (not illustrated).

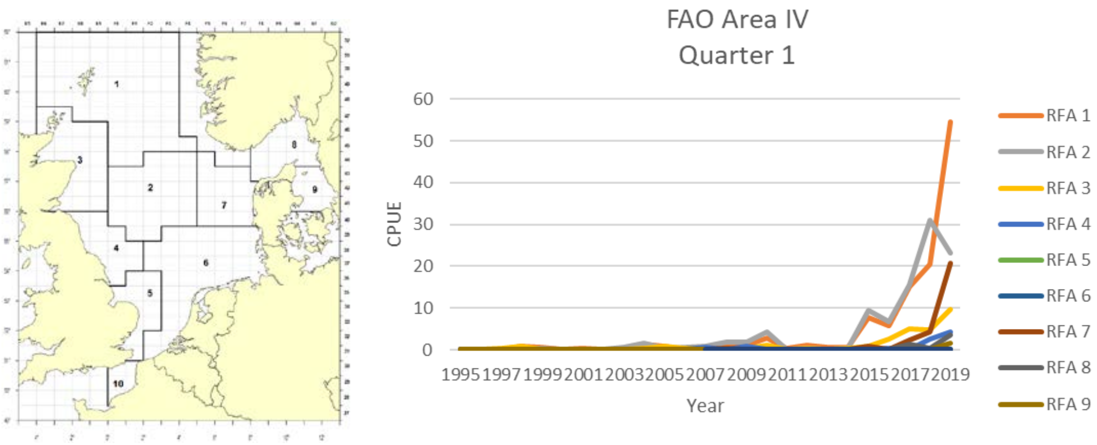



**Figure 25. Summed ommastrephid catch rate (number per hour of hauling (CPUE), summed across length classes) per Roundfish Area (RFA 1–9) based on the ICES IBTS Quarter 1 Datras dataset, 1998–2019.**

<u>Quarter 3</u>

In general, the CPUE for ommastrephids is smaller compared to quarter 1, with a maximum value of ~ 7 individuals per hour. Aside from isolated peaks seen in 2005) and 2008 (RFA3), there was a general upward trend since 2014 as also seen in the quarter 1 surveys, but in most areas catch fell in 2018 (Figure 26).

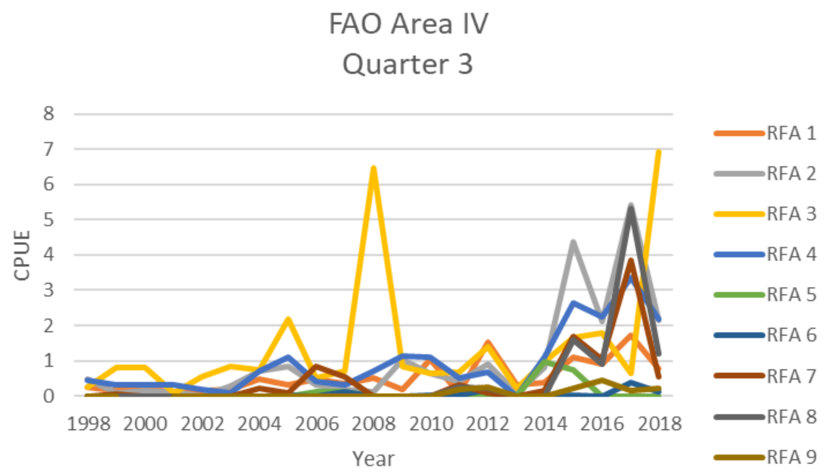
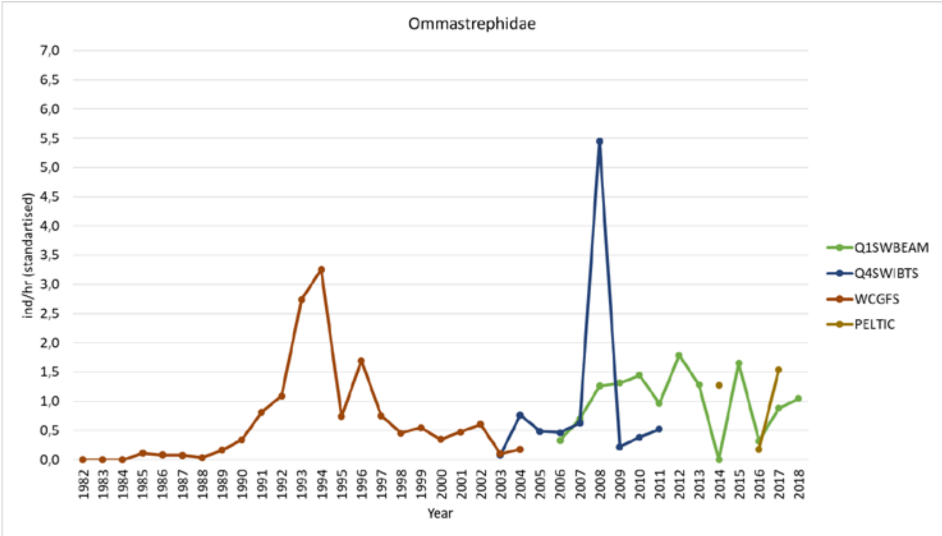


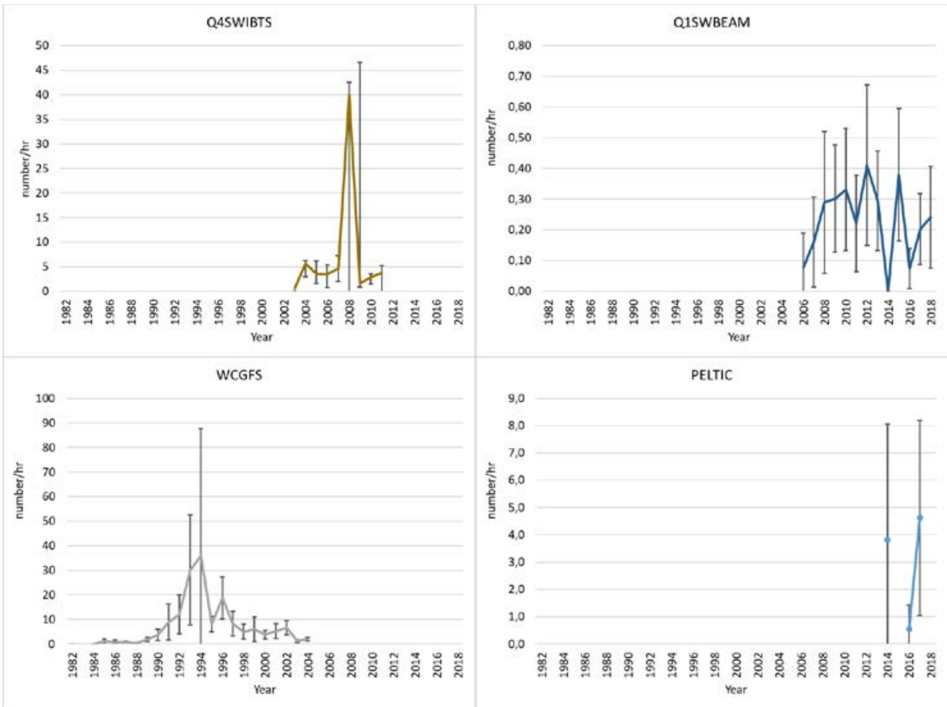

**Figure 26. Summed ommastrephid catch rate (number per hour of hauling (CPUE), summed across length classes) per Roundfish Area (RFA 1 – 9) based on the ICES IBTS Quarter 3 Datras dataset.**

## Surveys, ICES Division 7abcdegk

Cefas survey data for subarea 7 are shown in the Figure 27a. The 7d beam trawl survey (BTS7D) and the northwest groundfish survey NWGFS caught too few ommastrephids to examine trends in CPUE. Trends extracted from other survey programmes look rather different and in all cases confidence limits are wide (Figure 27b). 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.




*a*




*b*

**Figure 27. 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 onwards the taxonomic resolution in the data does not cause any concerns, although the suitability of some of the trawl gears used (like beam trawls) is questionable.

## Surveys, ICES Division 7c and 7k (Porcupine bank)

Results on CPUE for the main ommastrephid species captured in the bottom trawl surveys in the Porcupine Bank (Division 7c and 7k), 2001–2018 are summarised below.

European flying squid (*Todarodes sagittatus*)

In the 2018, survey the biomass and abundance of *T. sagittatus* decreased slightly since 2017, remaining among the lowest values of the time series (Figure 28). Nevertheless, biomass of this species was 32% of the mean stratified biomass of cephalopods, more than in the previous year. The percentage of numerical abundance remained low, 5% of the stratified abundance caught.

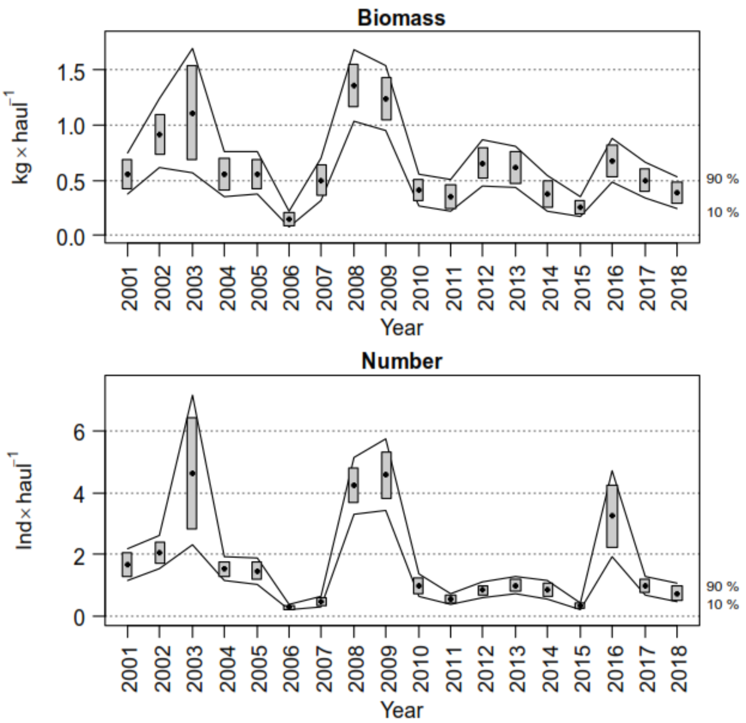



**Figure 28. Evolution of the biomass index and numerical abundance *Todarodes sagittatus* during the Porcupine bank bottom trawl survey time series (2001–2018). Boxes mark the parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a= 0.80, bootstrap iterations = 1000).**

Lesser flying squid (*Todaropsis eblanae*)

The biomass of *T. eblanae* increased slightly in 2018 but remained well below the series peak in 2005. However, numerical abundance increased more substantially, equalling the previous highest value (2005) in the time series (Figure 29). The biomass of *T. eblanae* was only 11% of the cephalopod mean stratified biomass caught in the 2018 survey while *T. eblanae* made up 32% of the cephalopod mean stratified abundance, higher than *T. sagittatus*.

Broadtail shortfin squid (*Illex coindetii*)

*Illex coindetii* was not found in 2017, but in 2018, two specimens were found in two hauls in the north of the Irish shelf. The stratified biomass and abundance were low in the whole time series, although two marked peaks in numerical abundance were seen in 2007 and 2009, the latter also representing a peak in biomass (Figure 30).

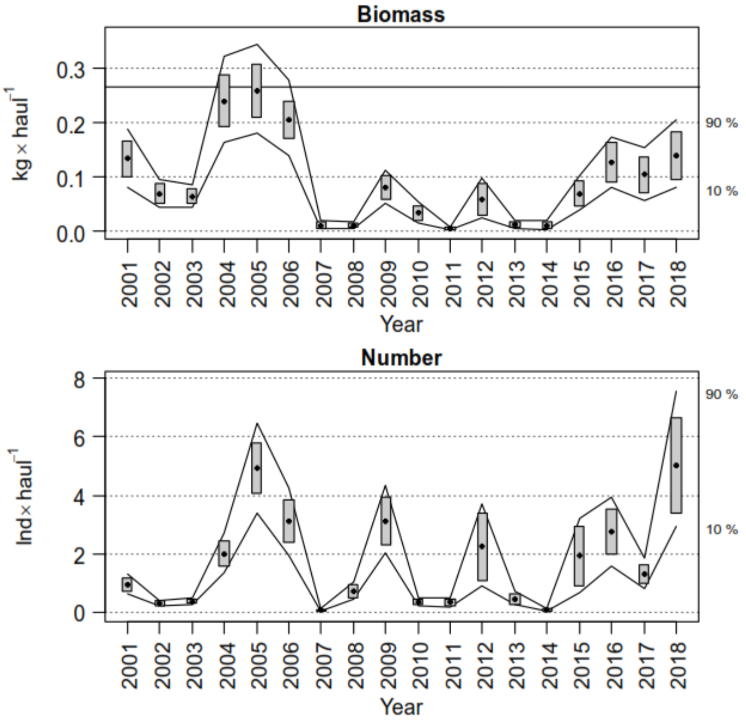



**Figure 29. Evolution of *Todaropsis eblanae* biomass index and abundance during the Porcupine bank bottom trawl survey time series (2001–2018). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a= 0.80, bootstrap iterations = 1000).**

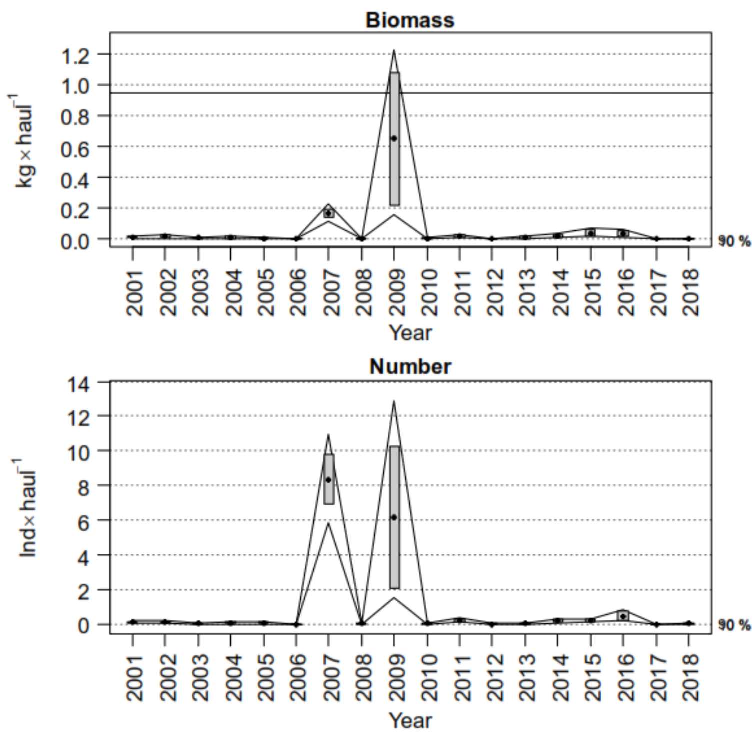



**Figure 30. Evolution of *Illex coindetii* biomass index and abundance during the Porcupine bank bottom trawl survey time series (2001–2018). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a= 0.80, bootstrap iterations = 1000).**

## Surveys, ICES Divisions 8ab

From the French EVHOE survey, abundance indices for three species of Ommastrephids (*Illex coindetii, Todaropsis eblanae* and *Todarodes sagittatus*) have been extracted. The time series extends from 1992 to 2018 (data from 2017 are missing) and the area covered comprises Divisions 8ab. The abundance of *Illex coindetii* showed a peak in 2008 and was also high in 2018. Amounts of *Todaropsis eblanae* and *Todarodes sagittatus* recorded were small in all years (Figure 31).

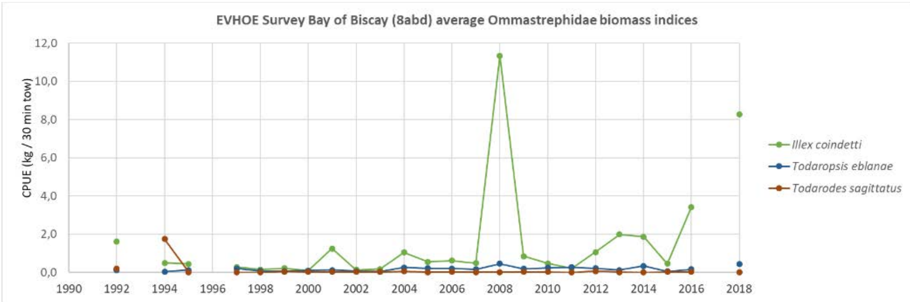



**Figure 31. EVHOE survey CPUE for Ommastrephids in Divisions 8ab. (Standardized values for a swept area per tow of 0.02 mi² (= 0.0686 km²)).**

## Surveys, Division 8c and 9a. North

The SPNSGFS (Spanish Northern Shelf ground fish survey) covers ICES Div. 8c and the Northern part of 9a corresponding to the Cantabrian Sea and Galician waters. The main ommastrephid species caught in the survey are *Illex coindetii, Todarodes sagittatus* and *Todaropsis eblanae*. Abundances of Ommastrephids in this survey are low and variable, although *Todarodes sagittatus* is generally least abundant (Figure 32). In the year 2016 both *Illex coindetii* and *Todaropsis eblanae* showed peaks in abundance (Figures 33, 34).

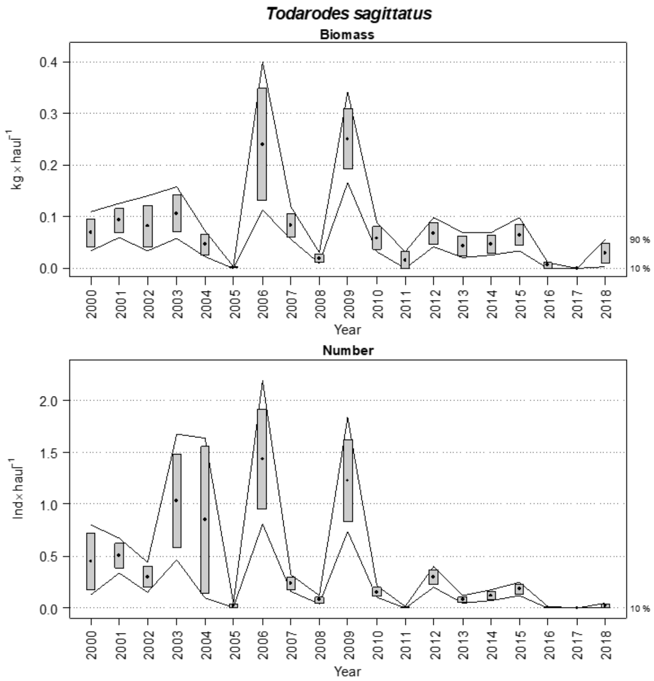



**Figure 32. Evolution of *Todarodes sagittatus* biomass index and numerical abundance during the Spanish Northern Shelf ground fish survey time series (2000–2018). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a= 0.80, bootstrap iterations = 1000).**

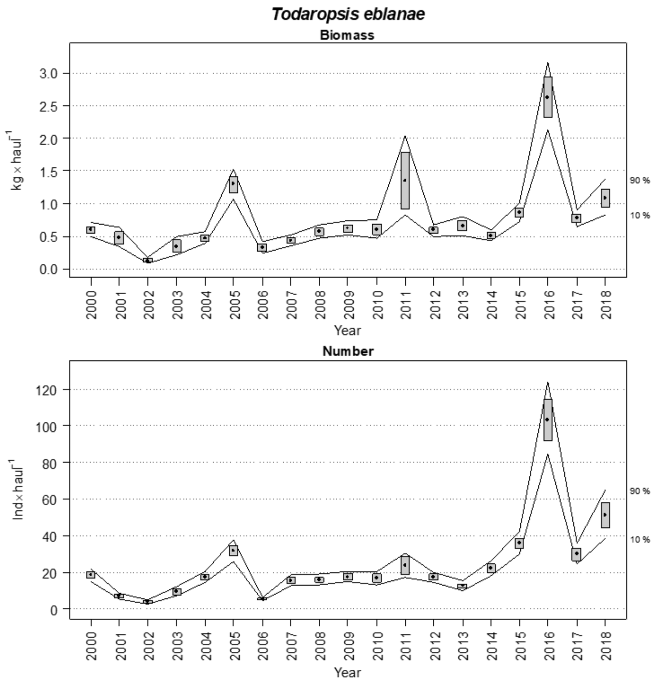



**Figure 33. Evolution of *Todaropsis eblanae* biomass index and numerical abundance during the Spanish Northern Shelf ground fish survey time series (2000–2018). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a= 0.80, bootstrap iterations = 1000).**

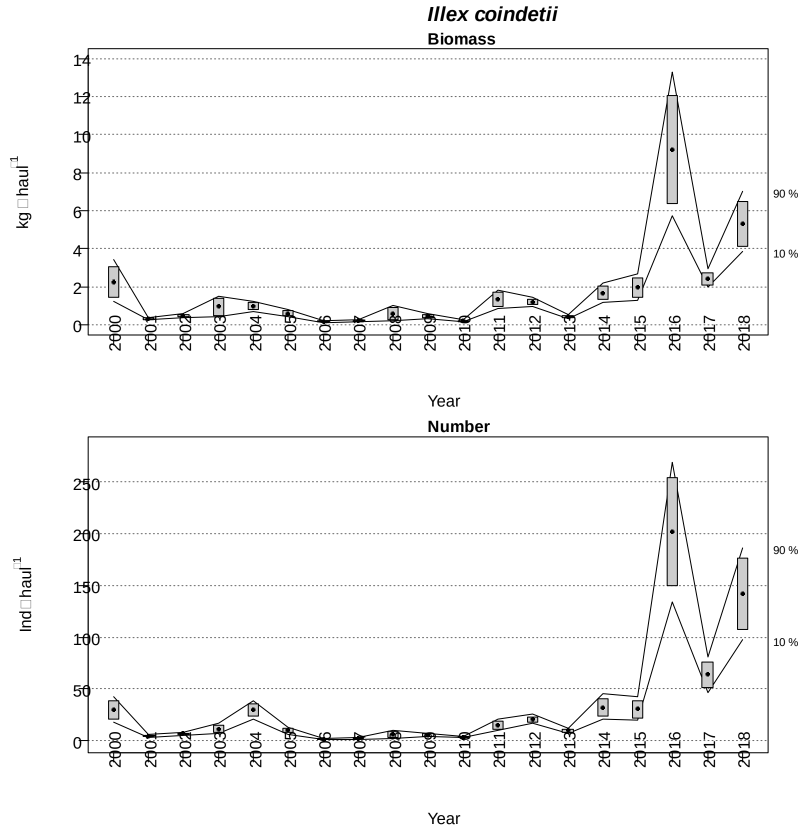



**Figure 34. Evolution of *Illex coindetii* biomass index and numerical abundance during the Spanish Northern Shelf ground fish survey time series (2000–2018). Boxes mark parametric standard error of the stratified biomass index. Lines mark bootstrap confidence intervals (a= 0.80, bootstrap iterations = 1000).**

## Surveys, 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 carried out in November and March each year. Some species of ommastrephids are recorded, including *Illex coindetii* and *Todaropsis eblanae*. For *Illex coindetii* abundance there was a peak of abundance in 2001 (10 kg per hour in March survey) and abundance was higher in 2018 than in any year since 2001. For *Todaropsis eblanae*, catch rates were lower, with peaks in abundance seen in 2001, 2005 and 2010 in the November survey. Catch rates were very low in 2018 (Figure 35).

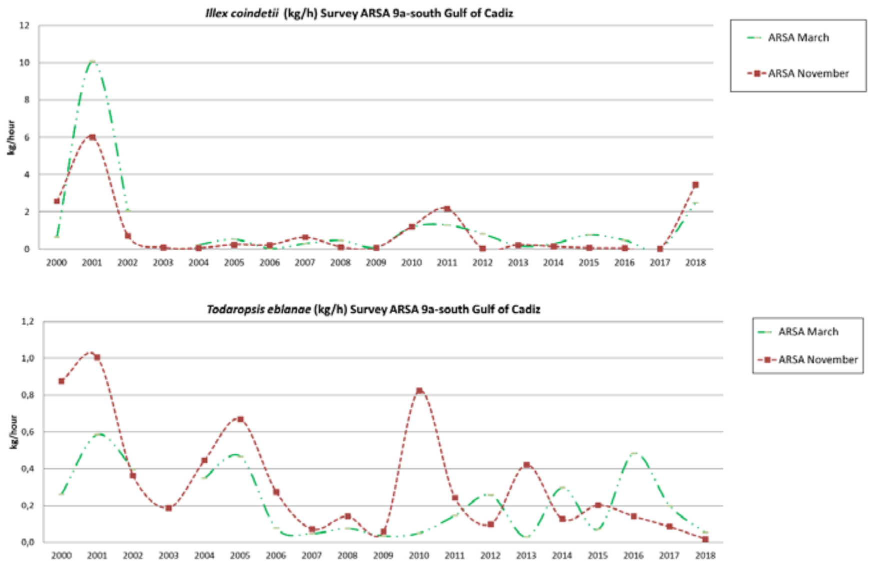



**Figure 35. Abundance Indices of Ommastrephids, *Illex coindetii* (top) and *Todaropsis eblanae* (bottom) in (kg/h) of the Spanish Scientific Surveys in Divisions 9a South (Gulf of Cadiz).**

Portugal provided data on abundance of the main Ommastrephid species from the Portuguese Groundfish Survey in Div. 9a of Portuguese continental waters. *Illex coindetii, Todaropsis eblanae and Todarodes sagittatus* abundance indices for 1981–2018 are presented in Figure 36. Much as in other areas, abundance varies widely with isolated peaks, e.g. for *Illex coindetii* in 1986, for *Todarodes sagittatus* in 1994 and for and *Todaropsis eblanae* in 1996, 1999 and 2003 (Figure 36).

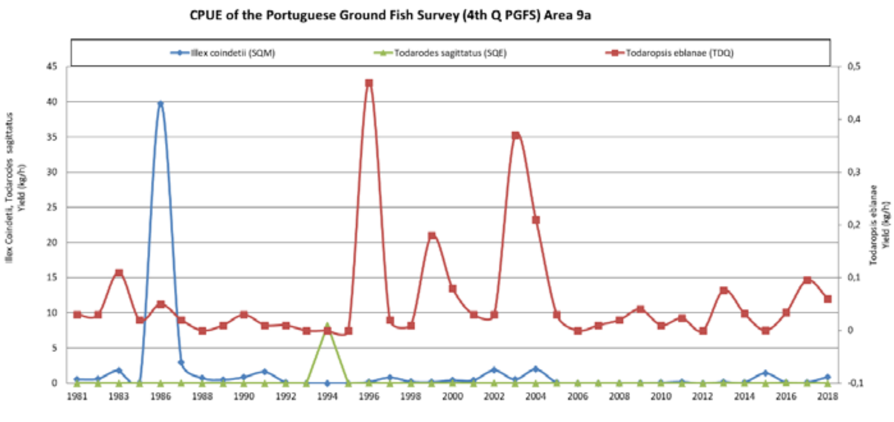



**Figure 36. CPUE of the main Ommastrephidae species in the Portuguese Ground Fish Survey, 1981–2018.**

## Analysis of trends

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 reliable abundance indices for this group of species.

Assessment, 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 37).

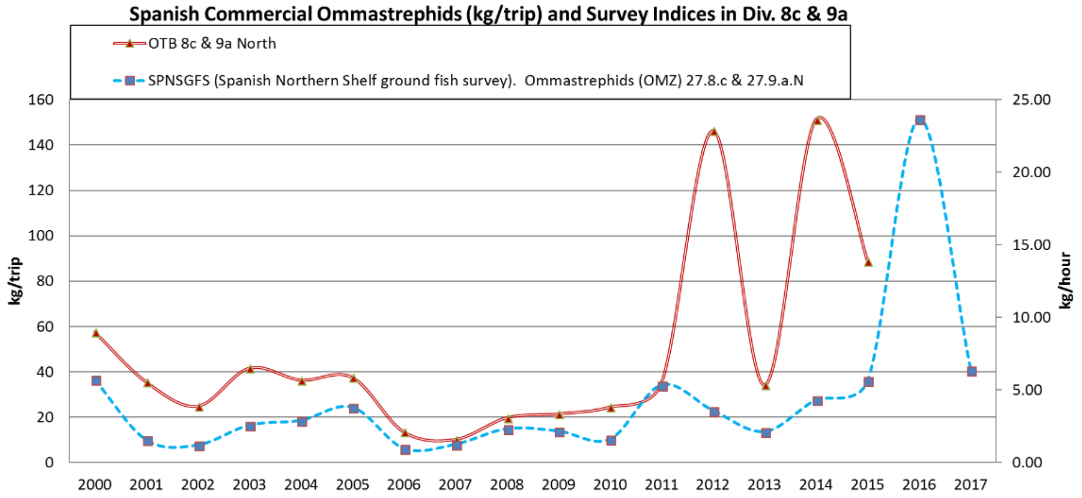



**Figure 37. Comparison of ommastrephid abundance indices between commercial LPUE (kg/trip) and survey CPUE abundance Indices (kg/h), from the Spanish commercial fleet and scientific surveys in Divisions 8c & 9a North respectively.**

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. It should also 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. The survey index showed a less marked peak in abundance than was 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 (Figure 38). These promising results enhance the possibility of using these data series as abundance indices for ommastrephids.

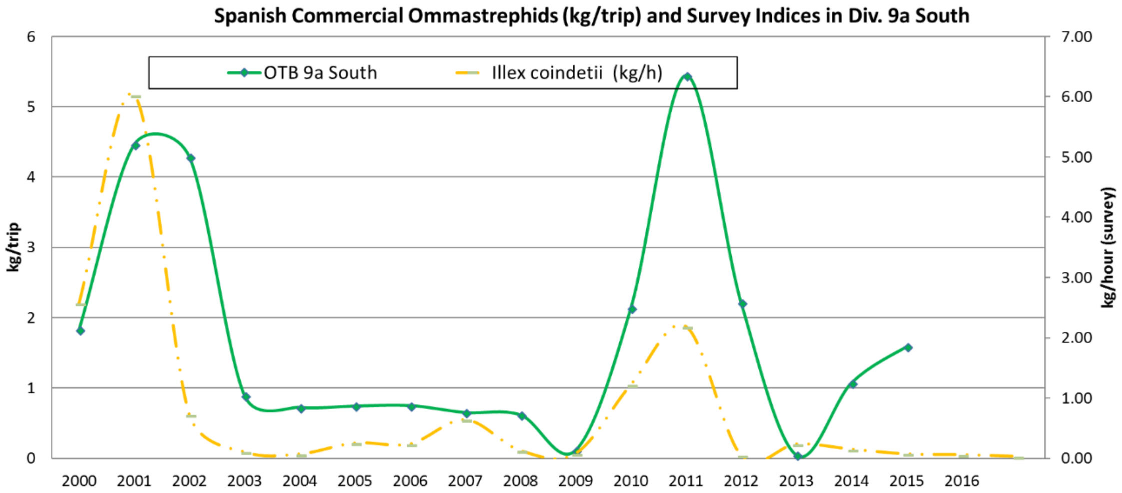



**Figure 38. Comparison between LPUEs (kg/trip) and Abundance Indices (kg/h) trips of the Spanish commercial fleet and Scientific Surveys in Divisions 9a south.**

### Conclusions

In some survey-series Ommastrephidae are occasionally identified to species and it is possible that ratios of the species could be estimated. More promisingly, landings of Ommastrephidae in Galicia (Spain) have been identified to species during market sampling. However, despite some improvement, in general the identification to species in both survey and commercial data needs to be improved.

## 1.2.4 Octopuses (Octopodidae)

Trends in commercial landings in the three species of Octopodidae (common octopus *Octopus vulgaris*, horned octopus *Eledone cirrhosa*, and musky octopus *Eledone moschata*) are analysed in the period 2000–2018 along with survey abundance indices.

### Fisheries

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 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 area 27.3, 27.4, 27.5 y 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 61% reported by Portugal and 35% by Spain on average for the 2000–2018 period, mainly in ICES areas 27.8.c and 27.9.a. Species identification has been provided only for Spain and Portugal in Div. 27.8.c and 27.9.a. The annual average landings for the 2000–2018 period were 14279 t, with minimum in 2006 (9003 t) and maximum in 2013 (21652 t); (Figure 39).

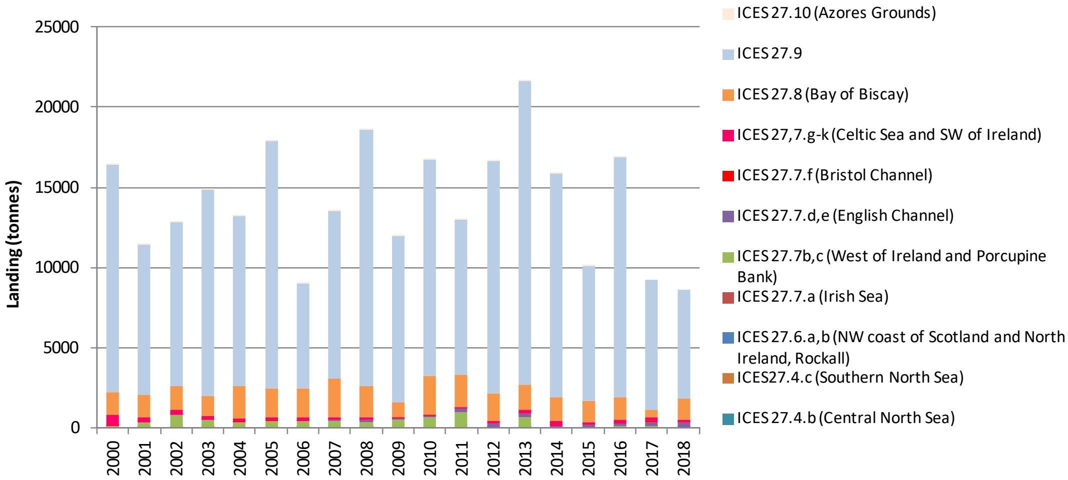



**Figure 39. Octopodidae landings by ICES Division during 2000–2018.**

Discard information by country was provided in the data call for 2018. Analysing data by ICES division, the discard percentage is generally higher for areas with small catches, although some areas which contribute less than 1% of total octopus catches also report a low discard rate. The only area with high catches (27.9.a) has low discards (Table 4).

## Fishery in Subarea 27.7

Landings of octopus in Div. 27.7.d, e are almost all (>85%) reported by England, Wales and Northern Ireland, with 107 t annually on average for the 2000–2018 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 around 194 t.

Landings in ICES Divisions 27.7g-k (Celtic Sea and SW of Ireland) in 2013 were reported by England, Scotland, Ireland and France. Spain reported substantial 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. In 2015, only Spain and France reported landings, with totals of 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 species caught by trawlers was *Eledone cirrhosa*. In 2017, the amount of these landings was similar to 2016. For 2018, Spanish, English and French landings were 80 t, 52 t and 2 t, respectively.

**Table 4. Percentage of Octopodidae discards in relation to total catches (% Discards) and relative percentage of catches by subarea (% Catches) in 2018.**

| Octopodidae | 2018 | |
|---|---|---|
| | % Discards | % catches by area |
| **27.3.a** | 2.3 | 0.04 |
| **27.4.a** | 0.0 | 0.00 |
| **27.4.b** | 83.8 | 0.11 |
| **27.4.c** | 0.0 | 0.03 |
| **27.6.a** | 0.0 | 0.02 |
| **27.6.b** | 100.0 | 0.02 |
| **27.7.a** | 0.1 | 0.01 |
| **27.7.b** | 3.5 | 0.06 |
| **27.7.c** | 39.0 | 0.21 |
| **27.7.d** | 0.3 | 0.06 |
| **27.7.e** | 16.1 | 4.13 |
| **27.7.f** | 7.2 | 0.22 |
| **27.7.g** | 3.4 | 0.42 |
| **27.7.h** | 16.8 | 0.39 |
| **27.7.j** | 28.1 | 1.28 |
| **27.7.k** | 27.5 | 0.03 |
| **27.8.a** | 3.5 | 3.07 |
| **27.8.b** | 5.5 | 2.72 |
| **27.8.c** | 1.1 | 9.66 |
| **27.8.d** | 13.5 | 0.01 |
| **27.9.a** | 0.2 | 77.50 |
| **27.10** | na | na |

Sweden, United Kingdom, The Netherlands, Germany and Ireland provided data in relation to discards, landings and effort in Subarea 27.3, 27.4, 27.7 respectively for at least 2011 and 2013, and Belgium for 2016, 2017 and 2018 reported only catches. Survey data for both areas are also provided. The Netherlands and Germany did not record any Octopodidae in their waters.

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

In ICES Divisions 27.8.a, b, d, catches of Octopodidae species are generally low. Logbook data suggest that *Eledone* spp. account for more than 80% of the total landings in this area. In the last four years, the average Octopodidae landings were estimated at 385 tons and were derived mainly from OTB_DEF_70–99_0_0. The countries contributing to Octopodidae landings in Division 27.8.abd were France and Spain, with 63% and 33% (2000–2018), respectively. The rest was taken by Belgium.

French landings of Octopodidae in 27.8.abd have been fairly stable, with an average of 157 t for the 2013–2018 period. The peaks were of 205 t in 2008 and 312 t in 2013. The Spanish commercial fleet operating in Division 27.8.a, b, d is mostly composed of vessels with base ports in the Basque country. For Spain, landings from Division 27.8.a, b, d varied from 2 t in 2009 to 300 t in 2007, reaching 130 t in 2013, decreasing in 2014–2015, but higher again in 2017 and 2018, at 202 t and 138 t, respectively.

AZTI-Tecnalia is responsible for monitoring cephalopod discards (monthly, by gear) in Div. 27.8.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 landings in 2008, 2017 and 2018.

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 40). 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 41) and ranged from 0 kg per trip in 2008 to more than 230 kg per trip in 2013 (as seen in *O. vulgaris*), declining again from 2014 to 2016 but increasing slightly in 2017 and 2018.

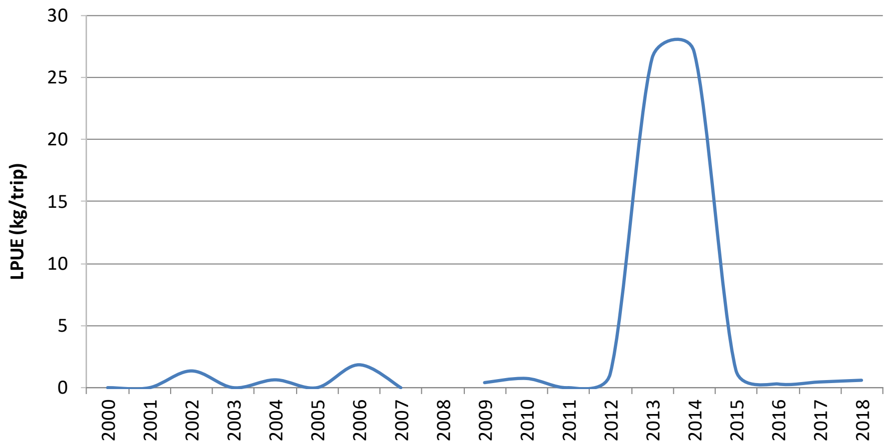



**Figure 40. Commercial LPUE trends of the Spanish (kg/trip) OTB fleet in 27.8.abd for *O. vulgaris*.**

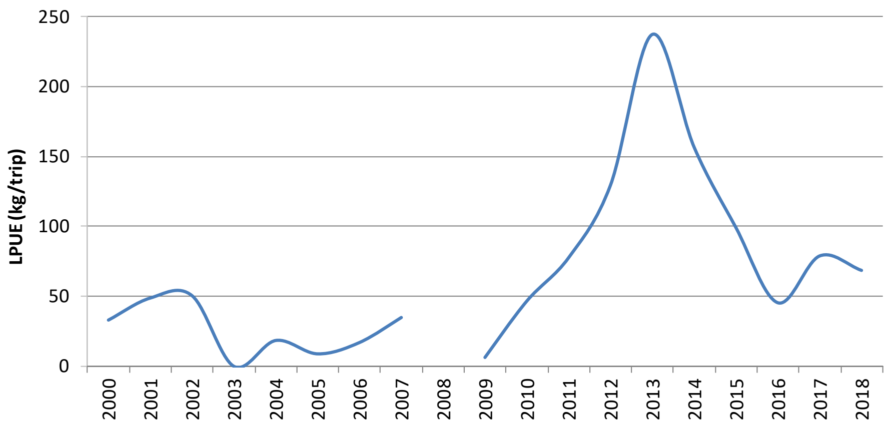



**Figure 41. Commercial LPUE trends of the Spanish (kg/trip) OTB fleet in 27.8.abd for *Eledone cirrhosa***

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 a decrease in the metier targeting demersal species like hake, megrim or anglerfish (OTB_DEF).

No data on Octopodidae from the survey taking place in 27.8.abd, FR-EVHOE were delivered to the group. No exploratory assessment was attempted due to the lack of French Survey data for Div. 27.8.a, b, d.

In 27.8.a, b, d, the relative importance of the two main gears (Bottom Otter trawl and Bottom Pair trawl) changes along the data series (WD2, in ICES WGCEPH Report 2016). It would 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 tactical response to a high abundance of cephalopods.

**Fisheries in Division 27.8.c & 27.9.a**

The Octopodidae landings in Division 27.9.a for the last four years of the time series account for 85%, on average, of total landings for all Subareas/Divisions, Division 27.8.c accounts for 6%. The countries contributing to Octopodidae catches in Division 27.8.c & 27.9.a were Portugal and Spain, *Octopus vulgaris* being the main species caught.

In Spain, *O. vulgaris* is caught by the artisanal and trawler fleets. In the Cantabrian Sea (Division 27.8.c) and Galician waters (Subdivision 27.9.a north), the artisanal fleet accounts for more than 98–99% of *O. vulgaris* landings, mostly from traps. In Portuguese waters (Subdivision 27.9.a.c), a large percentage of *O. vulgaris* comes from the polyvalent (artisanal) fleet, using a range of gears which includes gillnets, trammel nets, traps, pots and hooks lines. In the Gulf of Cadiz (Subdivision 27.9.a.s), 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% was taken by the artisanal fleet using mainly clay pots and hand-jigs. The proportion of catches attributed to the artisanal fleet increased from 77% in 2014 to 2016 to 84–85% in 2017 and 2018, possibly due 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 2018 in Division 27.8.c and 27.9.a were 12496 t (around 4000 t higher than in 2017), mainly landed by the artisanal fleet. Portugal contributed around 74 % of these landings from subdivision 27.9.a in 2018. Spanish bottom trawling contributed to landings only in Subdivision 27.9.a.s, with 90 t.

The available landings data for *O. vulgaris* in Spain cover nineteen years, from 2000 to 2018. In Portuguese waters (Subdivision 27.9.a.c) 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 variation in rainfall and discharges of rivers, as demonstrated in the waters of the Gulf of Cadiz in subdivision 27.9.a.s (Sobrino *et al.*, 2002).

Data on commercial discards of *O. vulgaris* in Iberian waters were available only for bottom otter trawl metiers that operate in this area. The data were collected by the on-board sampling programme (EU-DCR) during the last eight years. In 27.8.c and 27.9.a.n the bottom pair trawler (PTB) metier is also sampled, although *O. vulgaris* was not discarded. In subdivision 27.9.a, the Spanish and Portuguese bottom trawl fleets were estimated to have discarded 0.2% of catches in 2018. 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 WD2.4, WGCEPH 2014).

The two *Eledone* species are not separated in landings statistics but, except in the Gulf of Cadiz (Subdivision 27.9.a.s), where both *E. cirrhosa* with *E. moschata* are present, landings of *Eledone* spp. 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 27.9.a.c show a marked seasonality, with much higher landings during spring months.

Total landings of *Eledone* spp. in Div. 27.8.c and 27.9.a in 2018 were 84 t by Portuguese fleets (subdivision 27.9.a) and 6 t by Spanish fleets (27.8.c and 27.9.a). Landings data for *Eledone* spp. in Spain are available from 2000 to 2018. Annual landings ranged from 1333 t in 2000 to 6 t in 2018.

Discards of horned octopus by Portuguese vessels seemed to be very low in the OTB metier in 2018 (0%). In the case of Spanish vessels, discards from the OTB metier varied between areas and years but were always less than 20%, with lower values in subdivision 27.9.a.s (2% in 2018) than in 27.8.c and 27.9.a.n (7 % and 4%, respectively).

Fishing effort data are available for the Spanish OTB metier, in terms of numbers of fishing trips, in all areas of Iberian waters. The LPUE series (*O. vulgaris* catches/fishing trip) for the OTB metier in the north (Division 27.8.c and 27.9.a.n) and south (Div.27.9.a.s) indicate a much higher LPUE in the south, and the trends are also different in the two areas (Figure 42.).

Portuguese LPUEs (catches 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 onwards seen for Spanish trawlers in the south is also seen for Portuguese trawlers in 27.9.a.c.

Figure 43. shows the trends in LPUE (*Eledone* spp./fishing trip) for the Spanish OTB metier in the north (27.8.c, 27.9.a.n) and south (27.9.a.s). As was the case for *O. vulgaris*, both absolute values and trends differ between the two areas.

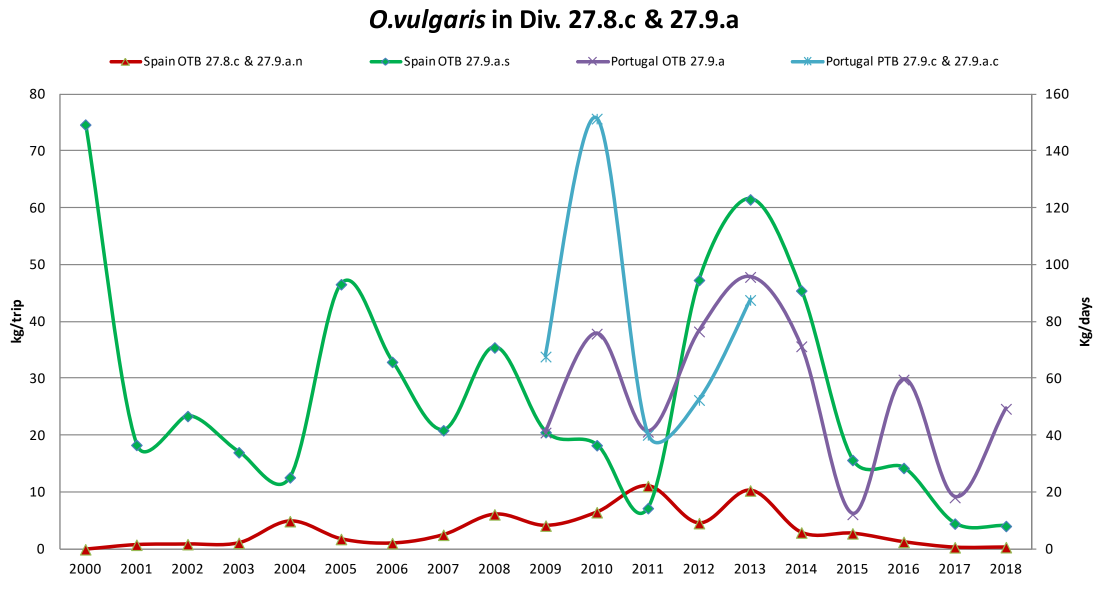



**Figure 42. Commercial LPUE trends for *O. vulgaris*: Spanish trawlers (SP) bottom (kg/trip) in the north (27.8.c, 27.9.a.n) and south (27.9.a.s), and Portuguese (PT) (kg/d) fleets in Div. 27.9.a.c.**

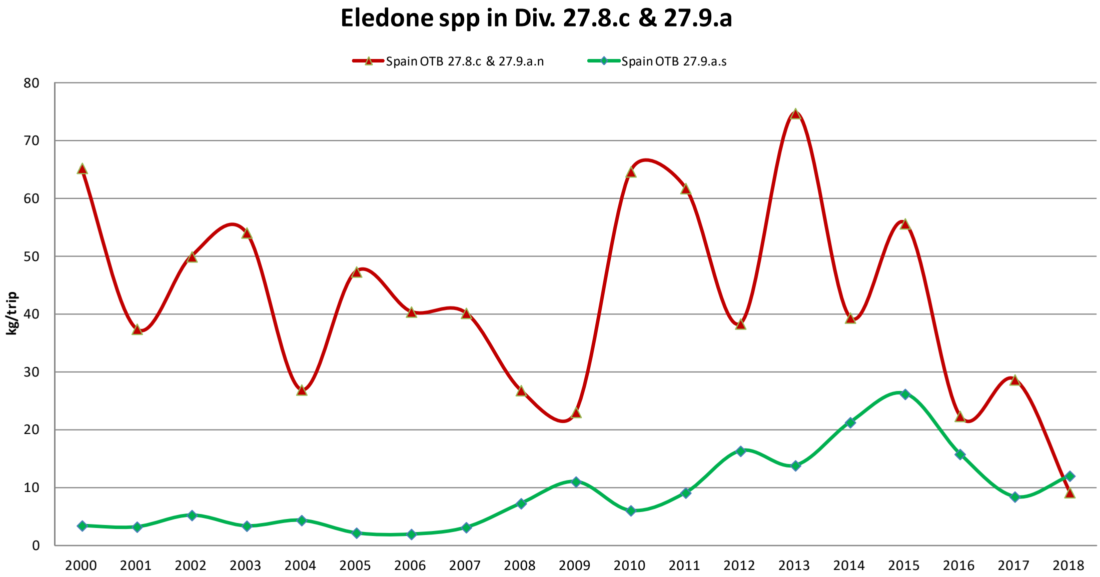



**Figure 43. Commercial LPUE for *Eledone* spp.: trends for the Spanish (kg/trip) fleets in the north (27.8.c, 27.9.a.n) and south (27.9.a.s).**

## 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 27.8.c and 27.9.a.n by Spain, PGFS in 27.9.a.c by Portugal and SP-GCGFS "ARSA" in 27.9.a.s by Spain. The ARSA survey is carried out twice a year, in spring and in autumn, and the mean values derived from both spring and autumn series are used in the Figures below (Figures 44, 45).

The estimated yields (kg/hour) of *Octopus vulgaris* in Spanish DEMERSALES survey in the north during 2000–2018 (figure A6.2.1.) fluctuated widely, reaching a maximum value in 2012 (2.5 kg/h) but dropping to a 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 during the series, most recently in 2014. In both series, an increase was detected in 2016, followed by a decline in 2017. The information of the Portuguese survey is not very informative, with CPUE values less than 0.5 kg/hour. Only 2003–2004 showed higher values, of around 2 kg/hour.

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* (Figure 44). In the ARSA survey, CPUE of *Eledone* spp. (*E. cirrhosa* and *E. moschata*) reached its highest value in 2015–2018 with around 3–4 kg/h (Figure 45), 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.

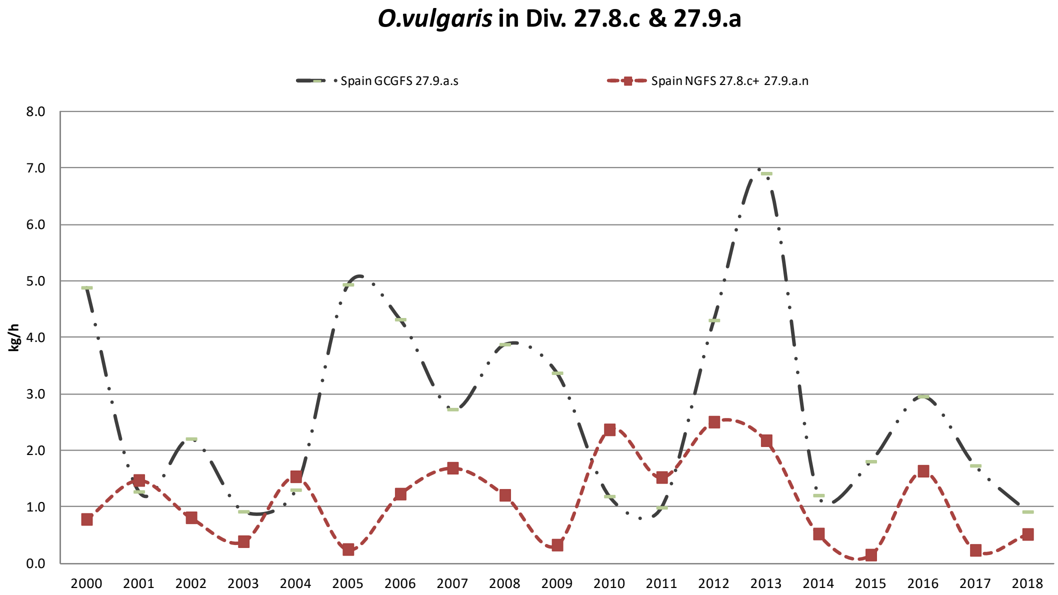



**Figure 44.** ***Octopus vulgaris*. Abundance indices (Kg/h) of the Spanish (SP-GCGFS; SP-NGFS) scientific surveys in Div. 27.8.c and 27.9.a for the 2000–2018 period.**

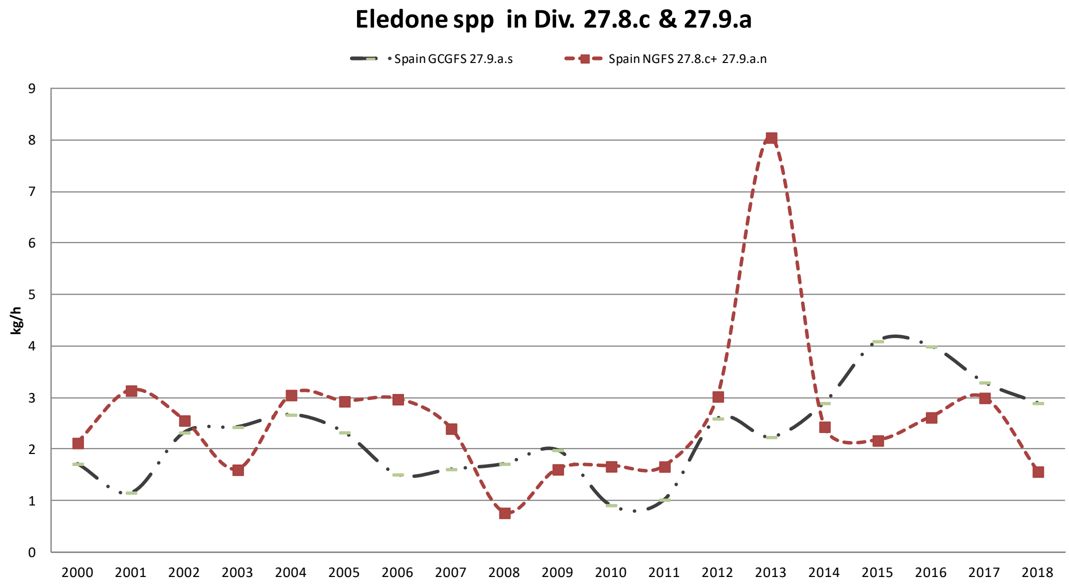



**Figure 45.** ***Eledone* sp. Abundance indices (Kg/h) of the Spanish scientific survey in Div. 27.8.c and 27.9.a.n and 27.9.a.s. 2000–2018 period.**

## Assessment/trends

In order to evaluate the quality of the catch rate series as abundance indices, survey CPUE series have been plotted alongside with corresponding commercial fishing LPUE series for "Baca" Otter trawlers. In all commercial LPUE 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 27.8.c and 27.9.a.n together, since the "DEMERSALES" survey covers these two areas. In division 27.9.a.s, 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 46. shows the Spanish DEMERSALES and Portuguese survey biomass index for *O. vulgaris* plotted jointly with annual LPUE series from the Spanish commercial bottom trawl fleet "Baca" (OTB) in 27.8.c and 27.9.a.n and LPUE indices for Portuguese trawl and polyvalent gears. For 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 during the short period represented. The Portuguese survey biomass indices also show a similar trend with the LPUE series despite of the low CPUE values. The abundance index series for *O. vulgaris* from the commercial fleet (OTB) and ARSA survey biomass index in Subdivision 27.9.a south are shown in Figure 47. In this case, the trends in both sets of data show high similarities over the 2000–2018 time series, the lowest value of the time series for LPUE (OTB) being obtained in 2017–2018.

The DEMERSALES survey biomass index for *E. cirrhosa* in 27.8.c and 27.9.a.n is plotted alongside the annual CPUE series from commercial bottom trawl fleet "Baca" (OTB) in Figure 48. For this species some similarities can be observed in the trends of the series during the same periods, however the trends were opposite during 2001 to 2004 and 2010 to 2012. Both series show a strong peak in 2013 with a 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 27.9.a.s are plotted together in Figure 49. The trends in both series are quite similar, especially during 2009 to 2017 but not in 2018.

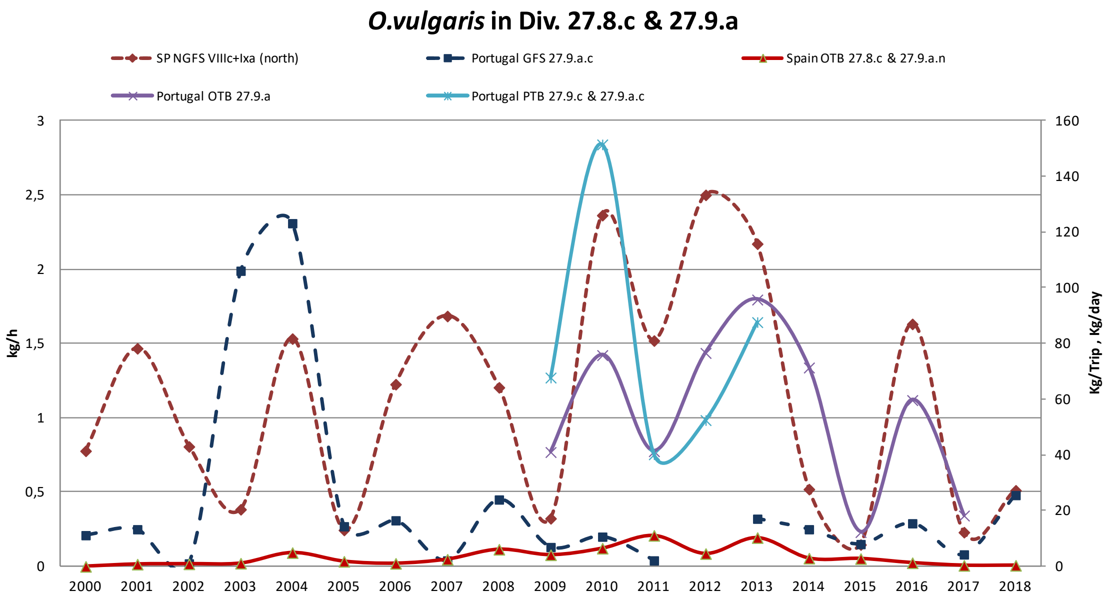



**Figure 46. Comparison of commercial LPUE trends of the Spanish and Portuguese (kg/trip; kg/d) fleets and Spanish scientific survey CPUE (kg/h) in 27.8.c, 27.9.a.n and 27.9.a centre, for *Octopus vulgaris*.**

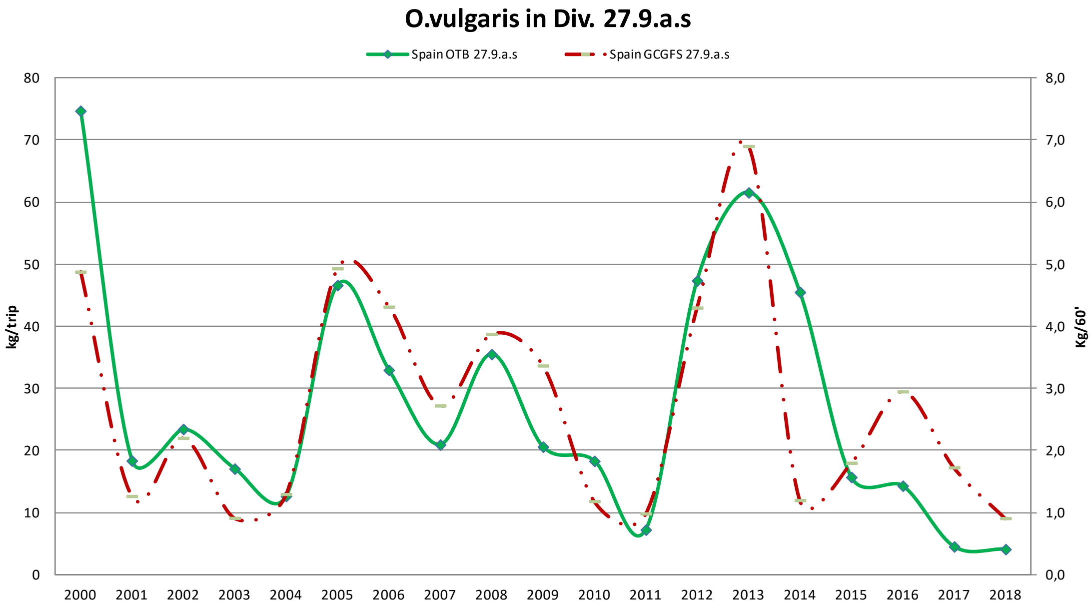



**Figure 47. Comparison of commercial LPUE trends of the Spanish (kg/trip) fleets and Spanish scientific survey CPUE (kg/h) in Div. 27.9.a.s, for *Octopus vulgaris.* (2000–2018 period).**

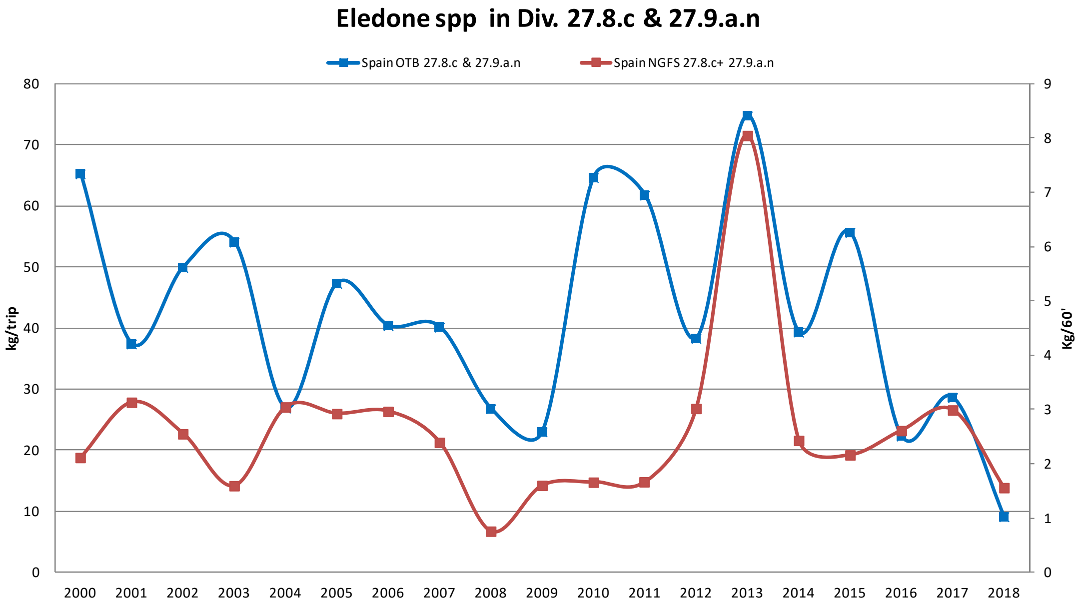



**Figure 48. Comparison of commercial LPUE trends of the Spanish (kg/trip) fleets and Spanish scientific survey CPUE (kg/h) in 27.8.c and 27.9.a.n for *Eledone* spp. (2000–2018 period).**

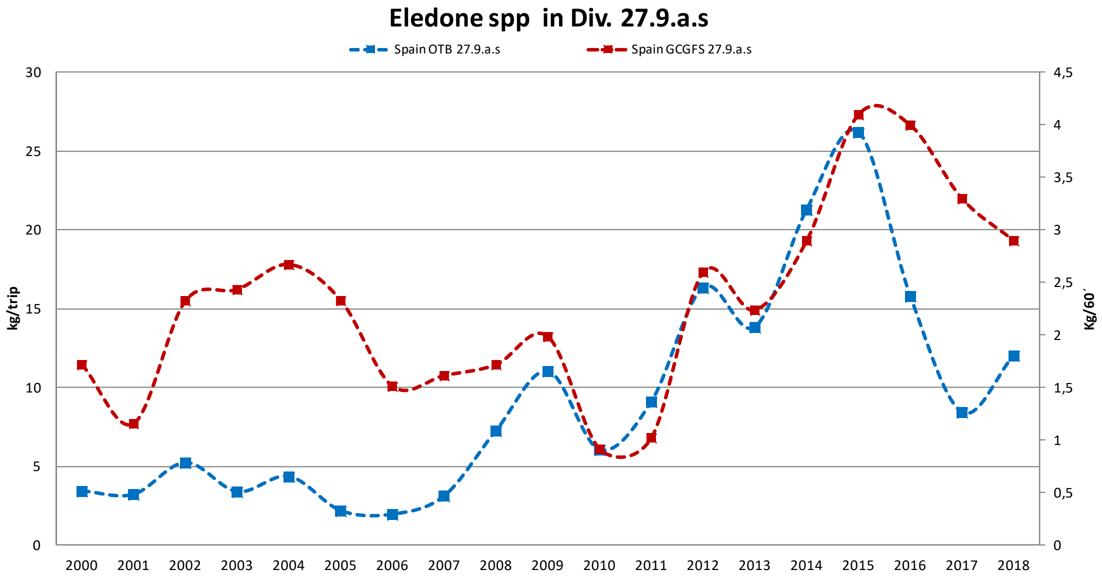



**Figure 49. Comparison of commercial LPUE trends of the Spanish (kg/trip) fleets and Spanish scientific survey (kg/h) in Div. 27.9.a.s for *Eledone* spp. (2000–2018 period).**

Looking at the above figures, the correspondence of survey and commercial abundance series is much more apparent in 27.9.a.s 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 by 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 as shown by the commercial LPUE 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 the future be used as abundance indices for octopods.

## Summary

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 2000–2018 were 14279 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.a, b, d, 27.8 c and 27.9 a), the main countries exploiting these species during 2000–2018 are Portugal (61%), Spain (35%), and France (4%). During the last nineteen years, on average 95% 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.

Abundance trends revealed by commercial LPUE and survey CPUE showed good agreement in some areas.

# 2 ToR B: Preliminary assessments of the main cephalopod species in the ICES area

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.

In 2019, the working group carried out several tasks related to this ToR. Two of these (a and b) were already specifically mentioned in the multi-annual workplan and in the 2018 WGCEPH Report. The third relates to a theme session at the 2019 ICES Annual Science Conference while the fourth task involved application of surplus production models to a range of northeast Atlantic cephalopod stocks. In addition, results from a forecasting model developed for *Octopus vulgaris* in the Gulf of Cadiz, incorporating environmental influences (and now published as Sobrino *et al.*, 2020) are presented within the ToR A text.

a) The analysis of trends in northeast Atlantic cephalopod stocks by applying multivariate time-series tools (DFA and GAM) to a set of abundance indices derived from commercial LPUE data and survey data.
b) Reviews of cephalopod population modelling and assessment tools and the analysis of consequences in terms of management.
c) Organization of a theme session on data-poor species at the ICES Annual Science Conference and preparation of presentations for this session.
d) A forecasting model was developed for *Octopus vulgaris* in the Gulf of Cadiz
e) A stochastic surplus production model in continuous time (SPiCT) model was fitted to a range of northeast Atlantic cephalopod stocks, using the R package spict, with the aim of deriving biological reference points and exploitation diagnostics. In contrast to other production models, SPiCT models both stock dynamics and the dynamics of the fisheries, thus enabling error in the catch process to be reflected in the uncertainty of estimated model parameters and reference points (Pedersen & Berg, 2017).

## 2.1 Trends in northeast Atlantic cephalopod stocks

A manuscript about trends in abundance of European Atlantic cephalopod stocks, intended for publication as a peer-reviewed paper, is in preparation. Since work on this was not completed during the 2019 WGCEPH meeting and it remains incomplete, work will be continued in the period leading up to and including the 2020 meeting. An overview of progress with the exercise was presented at the 2019 ICES Annual Science Conference (oral presentation H133 by Graham J. Pierce and co-authors). Twenty-three of the authors are WGCEPH members. The abstract is copied below.

<u>**Title**</u>: Status and trends of European cephalopod stocks.

<u>Authors:</u> Pierce, G.J., Robin, J-P., Moreno, A., Rocha, A., Santurtun, M., Iriondo, A., Lishchenko, F., Sobrino, I., Silva, L., Valeiras, J., Abad, E., Santos, M.B., González-Lorenzo, J.G., Perales-Raya, C., Laptikhovsky, V., Barrett, C., Oesterwind, D., Villasante, S., Pita, C., Matos, F.L., Monteiro, S., Power, A.M., Piatkowski, U., Hendrickson, L.

<u>Abstract:</u> Cephalopods are short-lived fast growing species which are highly sensitive to environmental variation, as reflected in wide year-to-year fluctuations in abundance. Understanding the relative importance of environmental variation and fishing mortality in determining stock trajectories is essential to underpin appropriate management measures and support sustainable

exploitation of these species. Over three decades ICES WGCEPH has reported on patterns and trends in cephalopod landings in the ICES area but there has been no comprehensive analysis of patterns and trends. We assembled data series on loliginid squid, ommastrephid squid, octopus and cuttlefish from landings (where possible considering landings per unit effort) and survey catches. For most series, it is not possible to be sure of the cephalopod species involved so the main analysis is at family level. We used a combination of standard time series analysis, dynamic factor analysis, generalised additive models and generalised additive mixed models to analyse patterns and trends in these datasets and to try to identify the underlying causes of abundance variation and thus provide a basis for deigning management measures. We quantified common trends so as to assess whether cephalopods are generally increasing in abundance. We also separated out the variation related to taxon, country and gear-type, and compared commercial fishery and research survey data. For survey data we examined seasonal and regional variation in abundance. We tested whether observed interannual variation and trends were related to large-scale environmental variation (as captured by the NAO and similar indices) and to fishery catches in the previous year.

## 2.2 Reviews of stock assessment and fisheries management of cephalopods

A review and synthesis of how ecosystem-based assessment might be applied to cephalopod fisheries in EU waters was progressed during the meeting and subsequently presented at the ICES Annual Science Conference as a poster (by Pierce and co-authors), the abstract of which is copied below. Work on this will continue in 2020. A manuscript by Arkhipkin *et al.* was submitted to the ICES Journal of Marine Science and has subsequently been accepted. This review refers to the work of ICES WGCEPH and four of the authors (by Arkhipkin, Hendrickson, Pierce and Robin) are WGCEPH members. This abstract is also copied below.

**Title**: Assessment of cephalopods in European waters: state of the art and ways forward (ICES CM 2019/H:13, Poster)

Authors: Pierce, G.J., Robin, J.-P., Moreno, A., Santurtun, M., Iriondo, A., Sobrino, I., Silva, L., Valeiras, J., Santos, M.B., Perales Raya, C., Laptikhovsky, V., Barrett, C., Oesterwind, D., Villasante, S., Power, A.M., Piatkowski, U. & Hendrickson, L.,

Abstract: Cephalopod fisheries in EU waters are managed only at national and regional levels. Although data on some stocks are collected through the Data Collection Framework, there is no formal stock assessment and no catch quotas are set. ICES does not issue advice on cephalopod fishing. Cephalopods are landed as targets of several fisheries and as bycatch of others. The increasing focus on cephalopod fishing, as finfish stocks decline and cephalopods apparently proliferate, is likely to necessitate routine assessment and management intervention in the foreseeable future. In addition, marine conservation legislation such as the Marine Strategy Framework Directive (MSFD) requires assessment of the status of cephalopods (among other marine species), while fishery certification programmes such as that developed by the Marine Stewardship Council (MSC) require assessment of the fished species, ecosystem and fishery. Considering the short lives, fast growth and environmental sensitivity of cephalopods and the context of the move towards the (integrated) ecosystem approach to fisheries, we review historical and possible future approaches to assessment of cephalopod stocks and fisheries. These include formal stock assessment models, from production models to depletion models, including advances to account for environmental variation. We also consider simple indices of stock status and trends derived from survey and commercial fishery data and a range of socioeconomic indicators. We review how cephalopods have been included under the MSFD and the certification of cephalopod fisheries under the MSC Scheme. Finally, we review options for future management and governance, in the context of both small-scale and large-scale fisheries.

**Title**: Stock assessment and management of cephalopods: advances and challenges for short-lived fishery resources.

Authors: Arkhipkin, A.I., Hendrickson, L.C., Payá, I., Pierce, G.J., Roa-Ureta, R.H., Robin, J.P. & Winter, A.

Abstract: Cephalopods have become an important global food source, but their sustainable management is challenged by unique life history characteristics associated with short lifespans and semelparous reproduction, high natural mortality rates, rapid and often non-asymptotic growth, and complex population structures. Weak stock-recruitment relationships together with the time-consuming work required for age validation and high-volume annual age determinations make traditional age-based modelling impractical. We propose that the best method for cephalopod assessment involves innovative depletion models, fitted with in-season data on catch numbers and fishing effort, to produce realistic estimates of stock biomass. A "fast lane" assessment approach is suggested that includes high-frequency data collection for separate, in-season stock assessments of each cohort to ensure sustainable exploitation of these short-lived resources. However, most cephalopod fisheries are data-poor and/or lack the infrastructure and resources needed to apply depletion methods; therefore, we also present alternative assessment methods that have been recently applied worldwide. We also offer suggestions for further research on the remaining challenges of cephalopod stock assessment and management.

## 2.3 Theme Session H at the 2019 ICES ASC

WGCEPH coordinated a theme session (H: Drivers of sustainability in fisheries for non-quota and data-poor species) at the 2919 Annual Science Conference and a report on this session is included below.

The session was proposed by Graham Pierce (Spain), Anne-Marie Power (Ireland), Jean-Paul Robin (France), Cristina Pita (Portugal) and Sebastian Villasante (Spain). Pierce, Power and Robin convened the session while Pita and Villasante acted as rapporteurs.

The rationale for the session related the need to ensure sustainable fishing on data-poor non-quota species such as cephalopods, considering the potential for overfishing if fishers switch to target such species at times when target quota species are less abundant. Such switching occurred in the English Channel in summer 2017, when trawlers targeted cuttlefish and high landings were reported, leading to newspaper reports of "black gold". This raises questions such as, can we forecast high abundance episodes in non-quota and data-poor species, can we predict when they are likely to come under pressure (why/when will fishers switch to take these species?) and what measures can we take to control or mitigate the effects of intense exploitation of non-quota species?

The session thus aimed to cover topics such as:

- assessment and forecasting for data-poor species, especially those showing wide fluctuations in abundance;
- separation of environmental, fishery and stock (density dependence) effects on abundance;

- interactions between non-quota and quota species in mixed fisheries; understanding economic drivers of fishing on on/switching to non-quota species; the value chain and markets for such species; appropriate management measures (including transnational cooperation) and governance systems; and obstacles to sustainability and overcoming them.

In relation to cephalopods, the session drew on work by ICES WGCEPH and the current INTERREG project "Cephs & Chefs" and the session also attracted presentations focused on data-poor fish species. There were 13 oral presentations and 3 posters.

Three oral presentations (Barnwell *et al.* H:286, Monteiro *et al.* H:425, and Rocha *et al.* H:430) focused on life cycles, providing information for data-poor cephalopod species and offering insights into implications for assessment methods as well as evidence of spatial and temporal patterns in life history parameters. Thus, in short-lived loliginid squids, size at maturity can vary markedly between years (Barnwall *et al.*).

Four oral presentations looked at methodology to assess data-poor stocks. Scarcella *et al.* (H:476) described three Monte Carlo simulation-based methods. Ramos *et al.* (H:388) described assessment results for four data-poor fish species in Falkland Islands waters. Robin *et al.* (H:542) investigated the use of species associations (and hence the abundance of other species) to improve predictions of squid cohort strength. Larivain *et al.* (H:531) applied various assessment methods to cephalopod stocks to estimate exploitation rates, in particular SPICT, which can deal with a range of data quality issues. A poster by Pierce *et al.* (H:134) speculated on the future of cephalopod stock assessment, including the possible transition to ecosystem-based assessment.

Two other oral presentations concerned the nature and extent of exploitation on non-quota species. Borjesson and Bartolini (H:411) described a method to distinguish targeting of halibut in the prawn fishery, based on examining the spatial distribution of hauls with high halibut catches. Arkhipkin (H:534) showed how uncontrolled fishing in the high seas of the SW Atlantic threatens the sustainability of fishing on the squid *Illex argentinus*. A poster by Valeiras *et al.* (H:205) looked at the extent to which cephalopod catches are discarded in bottom trawl fisheries in northern Spain.

Three oral presentations looked at distribution or abundance trends over time, in cephalopods (Pierce *et al.* H:133, Oesterwind *et al.* H:263) and in fish (Rindorf *et al.* H:634) and possible causes. The squid *Illex coindetii* has apparently shifted its range northwards to become more abundant and probably to breed in the North Sea (Oesterwind *et al.*). The recovery of several fish species sensitive (to overfishing) was investigated (Rindorf *et al.*), following reductions in fishing effort. The species which continued to decline after reductions in effort were all restricted to the North Sea, which is warming rapidly, and may all be at the southern limit of their range in the North Sea. A poster by Abad *et al.* (H:206), looked at environmental correlates of octopus (*Eledone* spp.) abundance.

Finally, Villasante *et al.* (H:563) focused on cephalopods in the value chain, describing trends in cephalopod landings, prices and consumption with a focus on Portugal and Spain, countries whose production, trade and consumption of cephalopods are among the highest in the world.

The presentations and discussions highlighted common issues with assessment of data-poor fish and cephalopod stocks, identifying several promising approaches. The need to bring such species under the umbrella of fishery management regimes was also clear, both for non-quota stocks in EU waters and for commercially important species in the high seas. Another emerging message was the reality of climate change effects on non-quota and data-poor species.

Several of these presentations are described in further detail in other sections of this report. The other presentations specifically relevant to stock assessment of cephalopods and which involved WGCEPH members were as follows:

- "Stock assessment of data-poor fisheries species in Falkland Islands waters" by J.E. Ramos, A. Winter and A.I. Arkhipkin (ICES CM 2019/H:388)
- "Uncontrolled high seas fishery threatens the sustainability of one of the most abundant resources in the Southwest Atlantic, squid *Illex argentinus*" by A.I. Arkhipkin (CM 2019/H:534)
- "Cephalopod species in the English Channel nektonic community sampled during the CGFS surveys. Can interspecific relationships improve predictions of squid cohort strength?" by J.-P. Robin, M.A. Khobzi, C. Menu, A. Larivain, N. Niquil; F. Coppin, R. Girardin and M. Travers-Trolet (ICES CM 2019/H:542)

## 2.4 Forecasting abundance of *Octopus vulgaris* in the Gulf of Cadiz

A forecasting model was developed for *Octopus vulgaris* in the Gulf of Cadiz and has subsequently been published (Sobrino *et al*., 2020). In a working document presented in 2017 we analysed different hydrographic and oceanographic 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). The main conclusions were that the abundance of octopus in the Gulf of Cadiz is influenced mainly by rainfall in the previous year and secondarily by the surface sea temperature in April of the previous year.

A recruitment index was also used, obtained during results from demersal surveys carried out in the zone. The recruitment index obtained in the autumn survey can be used to forecast the landings for next year but this index is influenced by the number of stations surveyed in the recruitment zone, which thus also needs to be taken into account in the model.

The final model used to forecast the landings is

$Landing_{i+1} = s(Recruit_i) + s(Rain_i) + as.factor(ZoneRecru_i)$

We applied the model with data from 2016, 2017 and 2018 (Recruitment Index in November of 2016, 2017 and 2018 and rainfall during October 2015 to July 2016, October 2016 to July 2017 and October 2017 to July 2018). In Table 5 we present the results of the landings forecasts for the last two fishing seasons (Mean and 95% confidence intervals) and the total landings of the commercial fleet in these periods. In both cases, the true value of the total landings falls within the confidence intervals.

**Table 5. Model validation for the periods 2016–2017, 2017–2018 and prediction for 2018–2019. Mean of forecast landings with 95% confidents intervals (CI).**

| Period | $Rain^{-1}$ ($l/m^2$) | Recruit index | Hauls inside recruit zone | Forecast landings (t) Min (95% CI) | mean | Max (95% CI) | Landings (t) |
|---|---|---|---|---|---|---|---|
| 2016/2017 | 478 | 2.42 | 4 | 426 | 706 | 1170 | 1099 |
| 2017/2018 | 587 | 0.99 | 3 | 282 | 412 | 602 | 476 |
| 2018/2019 | 488 | 5.13 | 3 | 1773 | 2553 | 3676 | 1425* |

* Data until May

Using the 2018 data, the model predicted a mean landing of 2553 t with a 95% confidence interval (95%) of 1773 to 3676 t for the period of 2018–2019. During November 2018 until May 2019, the total landings were 1425 t.

The model predictions could be very useful for managing these fishing grounds. In this way, at the beginning of the fishing season in November we would be in a position to predict how the season will develop and, based on that, implement technical measures such as the establishment of daily quotas, extending or shortening fishing periods, modifications of the first catch weight, establishment of zone closures to protect recruits, etc.

## 2.5 Preliminary diagnostics in NE Atlantic Cephalopod Stocks using Surplus Production Models

This exercise, conducted during and following the 2019 WGCEPH meeting, applied production models to data for loliginid and ommastrephid squid and cuttlefish. Results suggested that loliginids were fished sustainably in areas 6a, 7bc, 7a, 7f, 7ghjk and 9a. In the English Channel (7d, 7e), biomass has been below MSY during 9 of the last 11 years and F has been above $F_{MSY}$ since 2005. Poor model fits were obtained for the Rockall area. For cuttlefish in area 7d and 7e, there was a downward trend in estimated biomass between 2015 and 2018, with the 2018 estimate being below $B_{MSY}$, while F was above $F_{MSY}$ in 2017 and 2018. It is not clear yet whether this is a cause for concern. In Bay of Biscay (8abd), the confidence limits for the model were very wide although, since 2010, estimated biomass was generally above $B_{MSY}$ and fishing mortality below $F_{MSY}$. The exercise with ommastrephid data was probably of least value due to the mixture of three species in the catches and the periodic “explosions” of abundance, which lead to $B/B_{MSY}$ being underestimated and $F/F_{MSY}$ being overestimated, with the result that biomass appears to have been permanently well below $B_{MSY}$ and F generally above $F_{MSY}$.

A preliminary version was presented at the 2019 ICES Annual Science Conference (oral presentation H531 by Angela Larivain and co-authors). It involved nine members of WGCEPH. A working document describing the exercise and its outputs is annexed to this report. The abstract is copied here.

**Title**: Do non-quota species might be overexploited? Preliminary diagnosis in Northeast Atlantic Cephalopod Stock using Surplus Production models

Authors: Larivain, A., Iriondo, A., Ibaibarriaga, L., Petroni, M., Power, A.M., Moreno, A., Pierce, G.J., Sobrino, I., Laptikhovsky, V., Robin, J.-P.

Abstract: The lack of management leaves fishery resources vulnerable to increase in fishing pressure which is sometimes only reduced when the stock collapses. In spite of their economic importance, most Northeast Atlantic cephalopod stocks are un-managed non-quota species with only some harvest control rules implemented at the local -inshore- scale. Stock assessment in cephalopod resources is often hampered by the characteristics of their biology and population dynamics. Monitoring short lived and fast growing species is also data demanding and even the largest fisheries are not always included in data collection protocols. Since the past two decades several stock assessment exercises were carried out in European cephalopods but the variety of models that were tested to tackle species distinctive features makes it difficult to compare outputs. Surplus production models are among the oldest tools adapted to data limited situations. In their basic form the maximum sustainable yield reference points that they provide (MSY, FMSY, BMSY) correspond to the long term average which may not be very well adapted to cephalopods. Nevertheless, such preliminary diagnostics can be refined in a second step (for instance taking into account environmental variation). In this study, Generalised Surplus Production Model is fitted to a series of Northeast Atlantic squid and cuttlefish stocks ranging from Scottish waters to Spanish and Portuguese fishing grounds. All models are fitted with the R package SPiCT (Stochastic production model in continuous-time) and the homogeneous protocol allows comparisons between data sets and facilitates discussions about how fishing fleets opportunistically exploit these resources.

# 3 ToR C: Information on life history parameters

ToR C: Update information on life history parameters including variability in these parameters. Define cephalopod habitat requirements.

## 3.1 Manuscript on the life history and ecology of cephalopods in European waters

The main task for the report on ToR C in 2019 was to update and restructure the manuscript on the life history and ecology of cephalopods in European waters. The review has been focused around the most promising and least developed fields of cephalopod research relevant to fisheries and aquaculture, as well as practical steps needed to ensure sustainable fishing, as identified by Jereb *et al.* (2015) in ICES CRR 235, examining progress achieved in the last 7 years (2013–2019) and proposing topics for future studies. Work continued on the manuscript during the 2019 meeting and subsequently. In particular, two new sections were added, while the whole manuscript was reformatted to ensure consistency among the sections devoted to particular species. In total, the current review covers more than 200 journal articles and conference papers devoted to biology, ecology, culture and exploitation of 16 cephalopod species. This manuscript is expected to be submitted to *Fisheries Research* prior to the 2020 WGCEPH meeting (Title: "A review of recent studies on the life history and ecology of European cephalopods with emphasis on species with the greatest commercial fishery and culture potential"; Authors: Lishchenko, F., Perales-Raya C., Barrett, C., Oesterwind, D., Power A.M., Larivain A., Laptikhovsky V., Karatza A., Badouvas N., Lishchenko A., Pierce G.J.).

As noted in the previous reports, species with the highest commercial fishery or aquaculture value are the most well-studied species (as judged by number of publications) but we also included information on species with fishery potential and/or of interest to local fisheries. Thus, the species for which most studies were published in the review period were *Octopus vulgaris*, *Sepia officinalis* and *Loligo vulgaris*. There were fewer publications on *Eledone cirrhosa*, *E. moschata*, *S. elegans*, *S. orbignyana*, *L. forbesii*, *Ommastrephes caroli*, *Illex coindetii*, *Todarodes sagittatus* and *Todaropsis eblanae*. Very few articles were devoted to *Sepietta oweniana*, *Alloteuthis subulata*, *A. media* and *Gonatus fabricii*, despite their value as scientific models, as indicated in Jereb *et al.* (2015).

Several topics identified as important for future study/action in the ICES Cooperative Research Report were relevant to all European cephalopods. These include improvement of reporting protocols for fishery landings (at the moment, as noted in previous report and in previous sections of the present report, cephalopod catches often are reported at the genus or family level, which limits the usefulness of such data for monitoring and assessment of stocks status) and the assessment of impacts of climate change on cephalopod stocks. Stock identification and location of spawning sites remain as basic requirements for the development of appropriate fishery management strategies. Other priority topics are specific to particular cephalopod families. In the Octopodidae, priority topics included studies on early life stages, while in the Sepiidae, clarification is needed on the systematics of the group and of the position of individual species within the group. Development of identification tools was considered essential for long-finned squids (Loliginidae, Myopsida) and further information on life history traits is needed for short-finned squids (Ommastrephidae, Oegopsida).

The majority of priority topics were species-specific. For *O. vulgaris*¸ a species with great culture potential currently limited by poor survival of paralarvae in culture, these topics include the development of diets to support the culture of paralarvae. In *S. officinalis*, work is needed on the trace element and isotopic composition of hard structures and on age determination techniques. This need reflects the specific phenology and life history traits of cuttlefish, a species which can breed at one year or two years old, and the value of such data for fisheries management. In *Loligo vulgaris* more work on trophic relationships is proposed, for example to help understand the likely ecological consequences of outbreaks of high squid abundance. Topics proposed for other species include investigations on basic biology and ecology, growth (including validation of the periodicity of statolith and beak increment deposition), egg and juvenile development, parasites and aggregation patterns. In the review we have grouped these topics under several main headings:

1. Environmental effects on life history, distribution and abundance, including effects of climate change;
2. Basic life-history traits;
3. Stock assessment;
4. Diet and nutrition;
5. Other studies (e.g. impacts of pollution and MPAs, trophic relations, fishery management, processing technologies, etc.).

The review showed that some topics have advanced significantly over the last 7 years. In particular, impacts of environmental condition changes on European cephalopod species were addressed in a large number of studies. Cephalopod identification guides were developed for some areas within the ICES zone (see also ToR E of this report). Age and growth of cuttlefishes and squids were addressed in several studies.

Nevertheless, knowledge gaps remain that could limit the success of fishery monitoring, stock assessment and management measures, needed to underpin sustainable fishing, at such time as these are more widely introduced in Europe. Knowledge gaps also exist in relation to use of cephalopods as indicators of environmental health (e.g. under the EU Marine Strategy Framework Directive).

It is clear that systematic collection of fishery and fish survey data at species level, with sufficient temporal resolution, and adequately monitoring all fishing activity (e.g. recreational fishing, discarding and illegal fishing), continues to be an issue. Basic parameters such as length-weight scaling metrics should be reported for all parts of species' distributions and regularly updated (to account for variation over time). Such basic data can be applied in numerous meta-analyses, for instance, as a measure of biomass and how this may be altered by global warming. Reliable methods are needed to assess and forecast abundance, accounting for life cycle plasticity and environmental sensitivity.

Better species identification tools are still needed, suitable for use by fishers, fishery inspectors, buyers, and scientists undertaking sampling, across the ICES area. Further research is needed on stock identification methods in all species and it is essential to apply these techniques to identify true stocks, thus ensuring that management units are meaningful. Genetic markers may provide resolution to define stocks, but alternative methods could provide backup (e.g. based on geometric morphometrics, which can also provide useful insights into life history).

The integration of novel data sources such as inshore fisheries observer networks and citizen scientists (dive clubs etc.) should be explored.

Current studies on some myopsid and oegopsid squids (e.g. *L. vulgaris*, *L. forbesii*, *I. coindetii*) show the requirement for the regular monitoring of life history traits of these species, including research on the seasonal distribution of different life history phases, from eggs to spawners, and the reproductive status of stocks. The plasticity of life cycle phenology, growth forms and maturation patterns can result in external pressures having unexpected effects on stocks and fisheries (c.f. the disappearance of the giant form of *Dosidicus gigas* in the eastern Pacific).

Species such as *S. officinalis* could represent sensitive bioindicators of environmental status, for example in relation to toxic element and noise pollution. However, in many cases, the mechanisms underlying species responses to anthropogenic pressures remain to be addressed in future studies.

## 3.2 Other work on life history and ecology of cephalopods in European waters

Further work on life history and ecology of European cephalopods linked to WGCEPH was presented at the ICES Annual Science Conference (Session H) in 2019. The presentations are summarised below.

**Title**: Insights into Ommastrephid squid life cycles from fishery and survey catches in the Iberian Peninsula (ICES CM 2019/H:425)

Authors: Monteiro, S., Matos, F.L., Cavaleiro, C., Moreno, A., Valeiras, J., Abad, E., Pierce, G.J, Pita, C.

Abstract: Diversification of fisheries is strategic for the European Union. Adding value to underexploited and non-quota seafood species, such as cephalopods, represents an alternative source of income in fisheries, especially when commercial species show signs of unsustainable overexploitation. Although cephalopods are fished in significant quantities across the Atlantic, challenges such as poor species identification and lack of stock assessment may preclude achievement of their potential as an alternative source of sustainable catches. While there is little or no market interest in much of northern Europe, the short-finned squid (*Illex coindetii*, *Todaropsis eblanae*, *Todarodes sagittatus*, family Ommastrephidae) are a relatively important fishing resource in the Atlantic Iberian Peninsula, particularly along the north Spanish coast. However, the current understanding of their life cycles and stock status is limited. The present study aims to describe interannual and seasonal patterns in ommastrephid species landings, considering the varying proportions of the various species landed over time in the Iberian Peninsula, including information from Portugal and Spain. Biological characteristics (length, weight, sex and maturity distribution) are also described based on DCF sampling. Finally, we discuss possible management measures for ommastrephid fishing, e.g. should fishing be restricted to certain seasons or areas, to help decision makers to define science-informed management and conservation strategies.

**Title**: Long term trends in length at maturity and life history of *Loligo forbesii* in European waters (ICES CM 2019/H:286)

Authors: Barnwall, L., Allcock, A.L., Johnson, M.P., Pierce, G.J., Petroni, M., Robin, J.-P., Sheerin, E., Power, A.M.

Abstract: Cephalopods have been termed 'weeds of the sea' and many groups have apparently increased over recent decades. Commercially relevant cephalopods such as *Loligo forbesii* have increased in landings in recent years, but little is known about their vulnerability to over-fishing given their short lifecycles and status as non-quota species. Some trends in landings of this species will be presented, with an analysis of data gaps for its sustainable exploitation. Despite its commercial appeal, basic information including length-maturity data are not routinely captured for *L. forbesii*. However, several discrete EU projects have collected this information in the last three decades. These data have been gathered by the Cephs & Chefs project and will be analysed to provide spatial and temporal trends in length-maturity as well as life-history (sex ratio) and biomass (length-weight) indices. Trends over time in this information will be examined in the context of changing ocean temperatures in the north-east Atlantic.

**Title**: Catch and discards of cephalopods in bottom trawl fisheries of north Spanish waters (ICES CM 2019/H:205 (poster))

Authors: Valeiras, J., Abad, E., Velasco, E., Castro, J., Teruel, J., Araujo, H., Punzón, A., Velasco, F.

Abstract: Cephalopod species are an important marine resource in the Northern Spain fisheries landed by both commercial and artisanal fleets. Fishing catches and species composition have been relatively poorly documented in the past. The bottom trawling in north Iberian waters is a mixed fishery operating in the northern (Cantabrian Sea) and western (Galicia) Spanish waters (ICES Divisions 8c and 9a). Trawl métiers operate on the continental shelf and upper slope and catch a large group of demersal and benthic species. The bottom trawl survey on the Northern Spanish Shelf (DEMERSALES) aim to provide data and information for the assessment of the commercial species and the ecosystems on the Galician and Cantabrian Shelf (ICES divisions VIIIc and IXa North). A standardized scientific observer program is carried out on board bottom trawl in north Iberian waters to analyse and raise the data to obtain discard estimates for stock assessment. The aim of this work is to present information on abundance indices, geographic abundances and length frequency distributions as well as cephalopod fishing rates (landings and estimated discards) of the main cephalopods species caught by trawl fleet.

**Title**: Identifying factors that affect horned octopus *Eledone cirrhosa* abundance at North Spanish fishing grounds (ICES CM 2019/H:206 (poster))

Authors: Abad, E., Valeiras, J., Velasco, E., Velasco, F., Serrano, A., Punzón, A., Pierce, G.J.

Abstract: The horned octopus *Eledone cirrhosa* represents an important bycatch in the catches of several North Spanish otter trawl fisheries. Its economic value gives it a relatively high importance among the exploited molluscs. *E. cirrhosa* presents a significant amount in landings but also a mean discard rate of 23% by fishing trip. The study area covers the Galician and Cantabrian continental shelf and upper slope from 70 to 700 m depth. This study aims to develop predictive models of horned octopus abundance in relation to physical and environmental conditions. Species abundance indices from scientific surveys (IEO Demersales annual surveys) were analysed in relation to hydrographic (bottom temperature and salinity), geographical (latitude, longitude) and sediment characteristics variables. Sediment characteristics were determined in each haul using a box-corer to obtain weight percentages of particle diameter and organic matter. Time series data collected during research surveys by IEO were analysed using generalized additive models (GAMs) to predict the spatial distribution of presence/absence and abundance of the species in relation to environmental variables. GAM analyses indicate that environmental factors influence the presence/absence and abundance of the species. Knowledge of the relationships between environmental-geographical conditions and octopus abundance is useful to predict abundance of this benthic species with applications in ecosystem modelling and catch and discarding forecasting.

**Title**: Regionalised life-history parameters of cuttlefish (*Sepia officinalis*) in Portugal as a tool to assess species vulnerability to fishing (ICES CM 2019/H:430)

Authors: Rocha, A., Gaspar, M., Figueiredo, I., Pereira, F., Vasconcelos, P., Moreno, A.

Abstract: Cuttlefish (*Sepia officinalis*) is presently the 12th most valued fishing resource in Portugal. This species is one of the top species exploited by the local small scale fisheries using a diversity of fishing gears. Cuttlefish has a prominent role in traditional gastronomy and represents a high level of economic dependence for several local fishing communities. Currently there are no catch quotas and no formal stock assessment for cuttlefish and available data on the life history parameters has been scarce. The Data Collection Framework (DCF) in Portugal collects biological and length composition data from landings since 1997, however, due to the characteristics of the SSF in Portugal, in particular the very high number of vessels involved (6716 boats registered in 2017), the level of biological sampling effort is very low especially when compared with other resources. Nevertheless, the data already collected under DCF may constitute an important source of information to derive life history of cuttlefish. This work analyses and compares the population structure and biological parameters of cuttlefish from different Portuguese coastal regions, essential to assess species vulnerability to local fishing.

**Title**: Changes in North Sea cephalopod fauna and their commercial landings (ICES CM 2019/H:263)

Authors: Oesterwind, D., Laptikhovsky, V., Sell, A.

Abstract: There are different studies illustrating that fauna and flora in marine oceans have changed significantly over the last decades. Many of those studies focus on taxa with long-living species, particularly fish. In contrast, cephalopod species with annual live cycles are able to adjust faster to changing environments and may therefore benefit from global change. But while for many fish species, especially species of commercial interest, long time series exists and form the basis for their assessment and management, information about cephalopods is limited. Long-term data collections are rare, and many monitoring data sets are of poor quality, in particular in areas where cephalopods have not been used commercially. A good example is the European North Sea, where cephalopods are non-quoted 'bycatch' species, and therefore no management and stock assessment exists. However, during the last years, monitoring of the cephalopod fauna became mandatory within the ICES coordinated North Sea International Bottom Trawl Survey (NS-IBTS), and new knowledge has been gained. Our analysis illustrates recent life cycle changes of North Sea cephalopods, as it is the case for *I. coindetii* for example. It seems that a new spawning stock of *Illex coindetii* has established within the last years. Furthermore, fishery data show a positive common trend in North Sea cephalopod landings consistent to the increasing abundance in fishery research monitoring.

# 4 ToR D: Social and economic profile of the cephalopod fisheries

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).

Three main tasks were envisaged under this ToR:

a) Evaluate the social and economic profile of the cephalopod fisheries,
b) Describe and analyse the importance and management of octopus fisheries in Europe
c) Investigate the value-chain for selected cephalopods fisheries.

A report on the first task, on the social and economic profile of European cephalopod fisheries, was delivered in 2018 (see 2018 WGCEPH report, Annex 12) and work in 2019 thus focused on advancing with the two papers (tasks b and c).

## 4.1 Review of the management of octopus fisheries in Europe

A paper on this topic is close to completion and is expected to be submitted to a journal during 2020, possibly prior to the 2020 WGCEPH meeting. The abstract is copied here.

**Title**: The importance of octopus fisheries in Europe

Authors: Pita, C., Matos, F., Roumbedakis, K., Fonseca, T., Villasante, S., Pita, P., Bellido, J.M., Gonzalez, A.F., García Tasende, M., Lefkaditou, E., Adamidou, A., Cuccu, D., Belcari, P., Pierce, G.J.

Abstract: The European market is one of the most important markets in the world for cephalopods. Currently, the fisheries targeting octopus in Europe are of substantial importance, especially in southern European waters where more octopus are consumed as part of the traditional diet and the small-scale fishing industry targeting these species is of considerable social and economic importance. Octopus in Europe are excluded from quota regulations under the Common Fisheries Policy, and EU member states manage their fisheries employing different input and output control measures. The level of participation of the fishing industry in the management of their activity varies and some management arrangements in place are tailored at the local level. This manuscript focuses in four European countries with important artisanal octopus fisheries. It describes and compares the current status of small-scale octopus fisheries in each country, its socioeconomic importance, the management arrangements in place, and the opportunities and challenges for the future of the octopus fisheries in the four countries. Despite the increasing importance of octopus fisheries in southern Europe, few countries have collected detailed data on these artisanal fisheries. The information provided contributes to increase the knowledge about the human dimensions of octopus fisheries in Europe.

## 4.2 Value-chain of cephalopods fisheries

A peer review paper is in preparation and an overview of the work was presented at the 2019 ICES Annual Science Conference (oral presentation session H by Sebastian Villasante and co-authors). This will be submitted to a journal during 2020. The abstract is copied here.

**Title**: Feeding global seafood markets through cephalopods: current and future trends

Authors: Villasante, S., Garcia Rodrigues,. J., Pita, P., Pita, C., Matos, F.L., Monteiro, S., Olim, S., Longo, C., Verutes, G., Power, A.M.

Abstract: With capture fishery production relatively static since the late 1980s, while assessed cephalopod landings have seen an increase over the past two decades, although the biological status of these populations is still in large part unassessed. The socio-economic impacts related to the increase in cephalopod landings are still largely unknown. The role of cephalopods in global seafood markets are also poorly characterized and this limits the ability to generalize or predict responses to institutional, economic, and environmental changes.

To cover this research gap, we analyse the value chain of selected cephalopod fisheries in the Iberian Peninsula by identifying the key players of cephalopod production and consumption. To do this, we combine data collected from in-depth interviews with producers and wholesalers to selected value chains and data from official databases (FAO and UN Comtrade) to map patterns and flows of production and final consumption of cephalopods at global and local scales.

We discuss the expansion of the cephalopod harvest industry and observed shifts in the trade of these species between marine areas, markets and consumers over time, using the Iberian fisheries as a case-study. The results have the potential to identify potential risks and opportunities for European producers and consumers of cephalopods, informing policy for responding to changes and thus building resilience in the global seafood system.

# 5 ToR E: Tools for identification cephalopod species and data collection

ToR E: Recommend tools for identification cephalopod species and update best practices for data collection.

## 5.1 Identification guide

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 was to produce a cephalopod identification guide suitable for use on-board commercial and research vessels for different regions, to help with identification of the main commercial species in the survey or fishing area. The guide(s) 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 high quality photos and drawings (provided by WGCEPH members) to facilitate 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, e.g. maximal length, weight, depth of occurrence.

During 2017 to 2019, the North Sea ID guide (Figure 50) was revised and additional species information, drawings and photos were added. Currently, the guide is being tested on-board during the North Sea International Bottom Trawl Survey, and will be finalised based on the experience and feedback received. This guide is suggested as a model for other potential regional ID guides. The North Sea ID guide is due to be published in English. Translations into other languages and other regional ID guides might be published in future and work on this is proposed for 2020–2022. A list of available cephalopod guides was updated every year during 2017–2019 and appears below (Table 6). Note that taxonomic revisions will have affected the validity of some older guides.

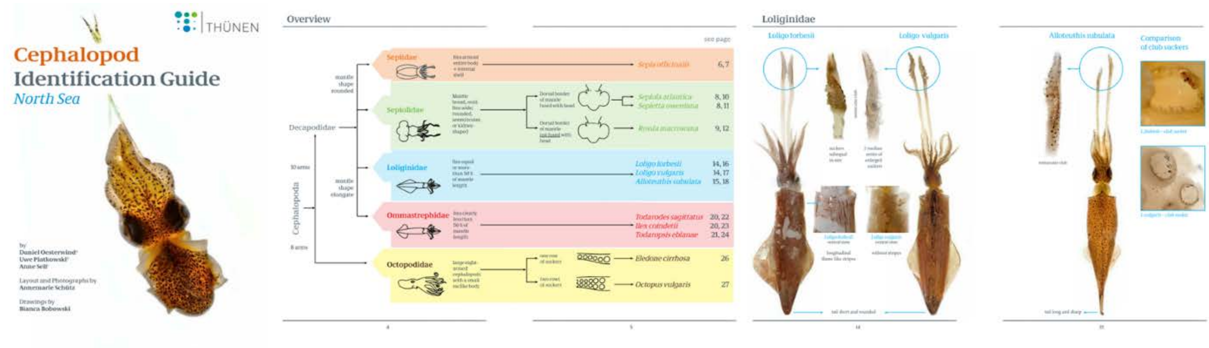



**Figure 50. Front page, Overview page and Loliginidae page as an example of the regional cephalopod identification guide for the North Sea.**

**Table 6. Updated list of guides to cephalopod identification (this list excludes guides focused solely on the beaks).**

| Year | Institution, Country | Contact | Language | Title | Author(s) | Geographical focus | Photos / drawings | Comments | Source of text / photos (if known) | Physical format | Availability |
|---|---|---|---|---|---|---|---|---|---|---|---|
| In prep | Thünen, GEOMAR, Germany | Daniel Oesterwind, Uwe Piatkowski, Anne Sell | German | Cephalopod Guide for the North Sea | Daniel Oesterwind, Uwe Piatkowski, Anne Sell | North Sea | Photos and drawings | Final version expected in summer 2020 | Own photos and drawings | | Forthcoming |
| 2019 | Icelandic Institute of Natural History, Iceland | Alexey Golikov | Icelandic / English | http://www.ni.is/biota/animalia/mollusca/cephalopoda | A Golikov, RM Sabirov, G Gudmundsson | Iceland | Drawings | Derived from Jereb & Roper, 2010, mainly | Iceland | Digital | |
| 2019 | University of Algarve, Portugal; Anglia Ruskin University, UK | Christian Drerup, Gavan Cooke | English | Cephalopod ID Guides for the North Sea, North-East Atlantic and Mediterranean | Christian Drerup, Gavan Cooke | North Sea, North-East Atlantic, Mediterranean | Drawings and photos | From the project: "Cephalopod Citizen Science" | Several e.g.: ICES CRR 325; FAO | Paper / digital | http://drgmcooke.co.uk/wp-content/uploads/2019/03/ |
| 2019 | Tree of Life project | R.E. Young, M. Vecchione, K.M. Mangold | English | http://tolweb.org/Cephalopoda/19386 | Different authors, depend on group/species | World Ocean (including ICES area) | Drawings and photos | Open source, in development, only digital version | Partly own, partly taken from other sources | Digital | http://tolweb.org/Cephalopoda/19386 |
| 2017 | Instituto de Ciencias del Mar, Spain | Fernando Fernandez-Alvarez, Roger Villanueva | English | Towards the identification of the ommastrephid squid paralarvae (Mollusca: Cephalopoda): morphological description of three species and a key to the north-east Atlantic species | Fernando Fernandez-Alvarez, Catarina Martins, Erica Vidal, Roger Villanueva | Northeast Atlantic | Drawings and photos | Focused on ommastrephid paralarvae | Own photos, drawings based on various cited published sources | Digital | Zoological Journal of the Linnean Society 180 (2), 268–287 |

| Year | Institution, Country | Contact | Language | Title | Author(s) | Geographical focus | Photos / drawings | Comments | Source of text / photos (if known) | Physical format | Availability |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2017 | Cefas, UK | Chris Lynam, Vlad Laptikhovsky | English | Identification guide for shelf cephalopods in the UK waters (North Sea, the English Channel, Celtic and Irish Seas) | Vladimir Laptikhovsky & Rosana Ourens | North Sea, English Channel, Celtic and Irish Seas, Scotland | Drawings and photos | Guide for the shelf and upper slope cephalopods of the area, depth < 400 m | Photos/drawings from ICES, FAO and individual authors. Copyright agreed. | Paper / digital | http://www.nmbaqcs.org/media/1717/cephalopod-guide-150917.pdf |
| 2015 | IFREMER, France | Pascal Laffargue | French | Fiches d'aide à l'identification Poissons, céphalopodes et décapodes mer du Nord, Manche, Golfe de Gascogne et mer Celtique (Version 2015) | F. Garren, S.P. Iglesias, J.C. Quéro, P. Porche, J.-J. Vayne, J. Martin, Y. Verin, J.-L. Dufour, L. Metral, D. Le Roy, E. Rostiaux, S. Martin, K. Mahe | Bay of Biscay, Celtic Sea, Channel, North Sea | Photos and drawings | Guide for cephalopods and fish species. A complementary guide has been specifically developed for Sepiolidae and is not included in that one. | Cephalopod and other invertebrate content mostly taken from Martin J (2011) Les invertébrés du golfe de Gascogne à la Manche orientale. Editions QUAE | | excerpt on *Loligo* on ICES IBTS SharePoint. |
| 2015 | ICES | Patrizia Jereb, Louise Allcock, Graham Pierce | English | Cephalopod biology and fisheries in Europe: II. Species Accounts | Jereb *et al.* | European waters | Drawings and photos | Species accounts including identification | Mainly the authors; outside sources all acknowledged | Digital | http://www.ices.dk/sites/pub/Publication%20Reports/Cooperative%20Research%20Report%20(CRR)/CRR325.pdf |
| 2015 | ICES | Núria Zaragoza, Antoni Quetglas, Ana Moreno | | Identification guide for cephalopod paralarvae from the Mediterranean Sea | Núria Zaragoza, Antoni Quetglas, and Ana Moreno | Mediterranean | Drawings and photos | Identification guide for paralarvae | All sources acknowledged | Digital | http://www.ices.dk/sites/pub/Publication%20Reports/Cooperative%20Research%20Report%20(CRR)/CRR324.pdf |

| Year | Institution, Country | Contact | Language | Title | Author(s) | Geographical focus | Photos / drawings | Comments | Source of text / photos (if known) | Physical format | Availability |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2015 | Instituto Español de Oceanografía, Spain | @ieodesmar, www.mapdescar.org, www.ieo.es | Spanish | Guía Visual de las Especies Demersales de la plataforma continental de Galicia y Cantábrico | Julio Valeiras, Esther Abad, Eva Velasco, Antonio Punzón, Alberto Serrano, Francisco Velasco | Galician Waters | Photos | From the project: Mapdescar | By the authors | Paper | http://www.repositorio.ieo.es/e-ieo/handle/10508/9230 |
| 2014 | FAO, Italy | | English | Cephalopods Of The World An Annotated And Illustrated Catalogue Of Species Known To Date. Volume 3. Octopods and Vampire Squids | Eds. P. Jereb, C.F.E. Roper, M.D. Norman, J.K. Finn | World Ocean (including ICES area) | Drawings | Available from FAO | Drawings and text from different resources | Paper / digital | http://www.fao.org/3/a-i3489e.pdf |
| 2013 | Institute of Marine Research, Norway | Rupert Wienerroither | Norwegian | Nøkkel til BLEKKSPRUTER i norske og tilstøtende farvann | Rupert Wienerroither | Norway and adjacent waters | Drawings | Includes some oceanic and deep-water species | Based on the FAO volumes | Paper / digital | Copy on ICES IBTS SharePoint |
| 2012 | Instituto Español de Oceanografía, Spain | Julio Valeiras, Esther Abad | Spanish | PROTOCOLOS BIOLÓGICOS DE CEFALÓPODOS Versión 6.0 | Julio Valeiras & Esther Abad | Spanish Atlantic coast | Photos | Originally issued in 2007 and regularly updated. | Photos by the authors | Paper / digital | Available from IEO |
| 2010 | Naturalis, Netherlands | A De Heij & J Goud | English | *Sepiola tridens* spec. nov., an overlooked species (Cephalopoda, Sepiolidae) living in the North Sea and north-eastern Atlantic Ocean | A De Heij & J Goud | North Sea and Northeast Atlantic | Photos and drawings | Describes newly recognized *Sepiola* species | | Paper / digital | Basteria 74 (1–3), 51–62 |
| 2010 | FAO, Italy | | English | Cephalopods Of The World An Annotated And Illustrated Catalogue Of Species Known To Date. Volume | Eds. P. Jereb & C.F.E. Roper | World Ocean (including ICES area) | Drawings | Available from FAO | drawings and text from different resources | Paper / digital | http://www.fao.org/3/i1920e/i1920e.pdf |

| Year | Institution, Country | Contact | Language | Title | Author(s) | Geographical focus | Photos / drawings | Comments | Source of text / photos (if known) | Physical format | Availability |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 2. Myopsid and Oegopsid Squids | | | | | | | |
| 2008 | GEOMAR, Germany | Uwe Piatkowski, Daniel Oesterwind | German | Cephalopods in the North Sea - A field guide (draft) | Karsten Zumholz, | North Sea | Photos and drawings | In draft form. Plan to produce new guide. | Some photos still without copyright clearance. | Digital | |
| 2008 | VNIRO, Russia | V. Bizikov | Russian / English | Evolution of the shell in Cephalopoda | V. Bizikov | World Ocean (including ICES area) | Drawings and photos | Description of vestigial shells of cephalopods, possible to use for identification | Own drawings / photos | Paper | |
| 2005 | FAO, Italy | | English | Cephalopods Of The World An Annotated And Illustrated Catalogue Of Species Known To Date. Volume 1. Chambered Nautiluses and Sepioids (Nautilidae, Sepiidae, Sepiolidae, Sepiadariidae, Idiosepiidae and Spirulidae) | Eds. P. Jereb, C.F.E. Roper | World Ocean (including ICES area) | Drawings | Available from FAO | Drawings and text from different resources | Paper / digital | http://www.fao.org/3/a-a0150e.pdf |
| 2004 | Greenland Institute of Natural Resources, Greenland | Rikke Petri Frandsen (DTU) | English | Cephalopods in Greenland Waters – a field guide | Rikke Petri Frandsen, Karsten Zumholz | Greenland | Photos and drawings | Technical report no. 58, Pinngortitaleriffik, Greenland Institute of Natural Resources | Various. some from acknowledged published sources | Digital | https://natur.gl/wp-content/uploads/2019/07/57-Technical_Report_57.pdf |

| Year | Institution, Country | Contact | Language | Title | Author(s) | Geographical focus | Photos / drawings | Comments | Source of text / photos (if known) | Physical format | Availability |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2002 | Institut Für Meereskunde, Kiel, Germany | Uwe Piatkowski | English | Early life and juvenile cephalopods around seamounts of the subtropical eastern North Atlantic: Illustrations and a key for their identification | Rabea Diekmann, Uwe Piatkowski, Matthias Schneider | Eastern North Atlantic | Drawings and photos | Key plus descriptions, drawings and photos | Own drawings / photos | | BERICHTE aus dem INSTITUT FÜR MEERESKUNDE an der CHRISTIAN-ALBRECHTS-UNIVERSITÄT · KIEL Nr. 326 |
| 1997 | VNIRO, Russia | JuA Filippova, DO Alekseev, VA Bizikov, DN Khromov | Russian | Commercial and mass cephalopods of the world ocean. A manual for identification | D.O. Alekseev, V.A. Bizikov | World Ocean (including ICES area) | Drawings of low quality | Only commercially exploited species, digital version hardly available | Own drawings | Paper / digital | |
| 1995 | Istituto Arion, Italy | G. Bello | English | A Key for the identification of Mediterranean sepiolids (Molluska: Cephalopoda) | G. Bello | Mediterranean sea | Drawings | Only family Sepiolidae | Own drawings | Paper / digital | https://www.researchgate.net/publication/280775230_A_key_for_the_identification_of_the_Mediterranean_sepiolids_Mollusca_Cephalopoda |
| 1995 | Marine Institute, Ireland | Colm Lordan | English | Identification of squid in Irish waters | Colm Lordan | Ireland | Photos and drawings | Unpublished, used by Marine Institute | Own photos and drawings | Digital | |
| 1995 | Marine Institute, Ireland | Colm Lordan | English | Identification of Sepiolids in Irish waters | Colm Lordan | Ireland | Photos and drawings | Unpublished, used by Marine Institute | Own photos and drawings | Digital | |
| 1994 | University of Aberdeen, UK | Cynthia Yau | English | Guide for the identification of cephalopods from Scottish and adjacent waters | Cynthia Yau | Scottish waters | Drawings and photos | Chapter 7 in PhD thesis "The ecology and ontogeny of juvenile cephalopods in Scottish waters" | Own drawings, phots Andy Lucas | Digital | University of Aberdeen library |

| Year | Institution, Country | Contact | Language | Title | Author(s) | Geographical focus | Photos / drawings | Comments | Source of text / photos (if known) | Physical format | Availability |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1992 | Smithsonian Institution, USA | M.J. Sweeney, C.F.E. Roper, M.R. Clarke, S. v. Boletzky | English | "Larval" and Juvenile Cephalopods: A Manual for Their Identification | M.J. Sweeney, C.F.E. Roper, K.M. Mangold, M.R. Clarke, S. v. Boletzky | World Ocean (including ICES area) | Drawings | Identification guide for cephalopod juveniles | Roper *et al.*, 1984 | Paper / digital | https://repository.si.edu/handle/10088/5414 |
| 1992 | Instituto de Investigaciones Marinas, Spain | A. Guerra | Spanish | Fauna Iberica Vol. 1: Mollusca, Cephalopoda | Angel Guerra | Spanish waters | Photos and drawings | Complete guide to cephalopods of the Iberian Peninsula (95 species) | Own text, drawings and photos | Paper | Museo Nacional de Ciencias Naturales, CSIC, Madrid. ISBN: 84–00–07267–7 |
| 1990 | Instituto de Investigaciones Marinas, Spain | A. Guerra | English, Spanish | Fishery potential of North Eastern Atlantic squid stocks | A. Guerra, R. Ledo | North East Atlantic | Drawings | Eurosquid project, unpublished | Drawings and maps from Roper *et al.* | Paper | |
| 1987 | Russia | K. Nesis | English (Original in Russian) | Cephalopods of the world: squids, cuttlefishes, octopuses, and allies | K. Nesis (translated by B.S. Levitov, edited by L.A. Burgess) | World Ocean (including ICES area) | Drawings | Translated from the 1982 Russian publication "Kratkiĭ opredelitel' golovonogikh molliuskov Mirovogo okeana". Partially out of date | Own drawings | Paper | |
| 1981 | Netherlands | | Dutch | De inktvissen (Cephalopoda) van de Nederlandse kust | A.W. Lacourt, P.H.M. Huwae | Wadden Sea | | Issue 145 of Wetenschappelijke mededelingen van de Koninklijke Nederlandse Natuurhistorische Vereniging, ISSN 0167–5524 | | Paper | |

| Year | Institution, Country | Contact | Language | Title | Author(s) | Geographical focus | Photos / drawings | Comments | Source of text / photos (if known) | Physical format | Availability |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1969 | Smithsonian Institution, USA | | English | An Illustrated Key to the Families of the Order Teuthoidea (Cephalopoda) | C.F.E. Roper, R.E. Young, G.L. Voss | World Ocean (including ICES area) | Drawings | Identification only to Family level | Drawings and text from different resources | Paper / digital | https://repository.si.edu/handle/10088/5700 |
| 1963 | ICES | ICES | English | ICES Identification sheet Cephalopoda: Decapoda: Sepioidea | B. J. Muus | North Atlantic | Drawings | | Drawings from different resources | Digital | ICES library: compiled within IDPlankton_187.pdf, http://www.ices.dk/sites/pub/Publication%20Reports/Plankton%20leaflets/IDPlankton_187.PDF |
| 1963 | ICES | ICES | English | ICES Identification sheet; Cephalopoda: Decapoda: Teuthoidea: Loliginidae | B. J. Muus | North Atlantic | Drawings | | Drawings from different resources | Digital | |
| 1963 | ICES | ICES | English | ICES Identification sheet Cephalopoda: Decapoda: Teuthoidea: Ommastrephidae, Chiroteuthidae, Cranchiidae | B. J. Muus | North Atlantic | Drawings | | Drawings from different resources | Digital | |
| 1963 | ICES | ICES | English | ICES Identification sheet Cephalopoda: Decapoda: Teuthoidea: Octopoteithidae, Gonatidae, Onychoteuthidae, Histioteuthidae, Branchioteuthidae | B. J. Muus | North Atlantic | Drawings | | Drawings from different resources | Digital | |
| 1963 | ICES | ICES | English | ICES Identification sheet Cephalopoda: Octopoda | B. J. Muus | North Atlantic | Drawings | | Drawings from different resources | Digital | |
| 1959 | Sweden | Barbara Bland | Danish | Danmarks fauna 65: skallus, sötänder bläcksprutter | Bent J Muus | Danish waters | Drawings | Original drawings by Poul H. Winther and the author. Published 1959. | Published by Dansk Naturhistorisk Forening | | Available on ICES IBTS SharePoint |

| Year | Institution, Country | Contact | Language | Title | Author(s) | Geographical focus | Photos / drawings | Comments | Source of text / photos (if known) | Physical format | Availability |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1925 | Germany | - | German | Schlüssel zur Bestimmung der in der Nordsee vorkommenden Cephalopoden nach äusseren Merkmalen | P. Grimpe | North Sea | no | published within: Grimpe, G. 1925. Zur Kenntnis der Cephalopodenfauna der Nordsee. Wissenschaftliche Meer-esuntersuchungen Helgoland, 16(3): 1–124 [in German]. | | Paper | |

## 5.2 Data collection recommendations

### 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 this framework the Member States (MS) collect, manage and make available a wide range of fisheries data needed for scientific advice. MS are required to submit multiannual Working Plans (WP) (Article 4 of Reg. 199/2008). These WP are set for three years (currently 2017–2019) and specify the MS' obligations to collect and provide data relevant to their region/fisheries/sectors pursuant to the EU Multiannual Programme.

MS Annual Reports summarise results from the implementation of the yearly National Programme. Standard 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:

- *Planning of the sampling*: Member State, species, region, RFMO/RFO/IO, area/stock, frequency, length, age, weight, sex ratio, sexual maturity and fecundity;
- *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.

Some MS include cephalopods as species to be sampled under 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 WGCEPH 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 different scales (regional [within MS], country, RMFO, European), respondents were asked to indicate the scale to which they referred. Because current MS work plans started in 2017, and cover a 3-year period, it was understood that the data collected might not be used immediately. Thus, a question about plans for future use of data was also included. Results of the survey appear below.

**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 life history, distribution, abundance and fisheries in UK waters have been carried out, notably through a series of collaborative EU projects since 1990 (see Boyle & Pierce, 1994; Piatkowski *et al.*, 2001; Boyle *et al.*, 2002; Pierce *et al.*, 2005, 2010; Payne *et al.*, 2006; Gonzalez *et al.*, 2010; Jereb *et al.*, 2015; these volumes also contain work from colleagues in other EU countries and elsewhere) and some preliminary stock assessment exercises have been carried out, e.g. a PhD thesis on *Sepia* by Matthew Dunn in 1999 (see Dunn, 1999) and papers by Young *et al.* (2004, 2006).

Data on cuttlefish abundance in the English Channel were used for stock assessment exercises undertaken by WGCEPH, using two-stage biomass models (e.g., Gras *et al.*, 2014; WGCEPH, 2016; Alemany *et al.*, 2017). 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. A manuscript on the results is in preparation.

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 the potential importance for future decision-making than by any formal use in assessment and management, although WGCEPH clearly has this latter ambition. Cefas is also progressing 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 Cefas 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.

**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. The cephalopod data collected are not used for management or advice. There is no information about any future plan to use cephalopod data.

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 infrequently and these species are not sampled. These data are used for projects and publications by the University of Caen (e.g. Challier *et al.*, 2005; Royer *et al.*, 2006; Gras *et al.*, 2014, 2016; Alemany *et al.*, 2017; see also other papers in the volumes cited above) as well as for assessment exercises conducted by WGCEPH.

**Spain:** The Spanish Data Collection Program includes the main commercial species of cephalopods. Data on Spanish landings of cephalopods are collected on an annual basis by the Sampling and Information Network of the Spanish Institute of Oceanography (IEO), for catches from the ICES sub-areas 7, 8abd, 8c and 9a. The landing information from logbooks and sales sheets is provided by the Fishing General Secretary of the Spanish Government.

The main cephalopod species (*Octopus vulgaris*, *Sepia officinalis*, *Loligo vulgaris*, *Loligo forbesii*, *Eledone cirrhosa*, *Eledone moschata* and Ommastrephidae) were selected based on criteria such as their importance in landings, in order to estimate different biological parameters (sex-ratio, maturity and length-size relationship). Biological sampling is carried out for all Area/Stock combinations (ICES Area: 8c, 9a North and 9a South; Mediterranean Sea: Medits 1.1 and CECAF Area: currently Mauritanian and Guinea-Bissau waters). In addition, length sampling is carried out for cephalopods caught during the sampling conducted at sea for the métier targeting demersal species in the SSF of Canary Islands (EU waters, CECAF area 34.1.2.). Length is the only biological data collected from the SSF of Canary Islands. IBTS research surveys carried out under the DCF include standardized sampling of all cephalopods (not only the main commercial species) to obtain abundance, length structure and maturity data. These surveys include the Western IBTS 4th quarter surveys in Spanish Atlantic and Mediterranean waters, i.e. DEMERSALES (ICES 8c9a North), ARSA (9a South) and MEDITS (Medits 1.1).

Data are used to investigate trends in fished population abundance and trends in fisheries captures (including discards) and in some cases (notably for *Octopus vulgaris*) to support regional fisheries advice. Stock assessments have been made in Gulf of Cadiz for *Octopus vulgaris* (ICES 9aS), and assessment exercises have been carried out (during the WGCEPH meeting) for *Eledone* and Ommastrephidae caught by North Iberian fisheries (ICES 8c and 9aN). Cephalopod data collected by IEO have also been used to obtain cephalopod-based indicators in the context of the EU Marine Strategy Framework Directive.

**Portugal:** The Portuguese Data Collection Program includes the collection of all commercial species of cephalopods. Data on landings of cephalopods are recorded on a daily basis for catches in the ICES sub-areas 9.a. in the fisheries database, by the Directorate of Marine Resources (DGRM) of the Portuguese Government. Information from logbooks and sales sheets is also collected by this institution. IPMA is responsible for the biological data collection of landings and dis-cards under a concurrent regional sampling scheme. Data on length composition and discards are collected for all cephalopod species. Additionally, biological data to estimate sex-ratio, maturity and length-weight relationship is collected monthly for *Loligo vulgaris*, *Octopus vulgaris* and *Sepia officinalis*. These species were selected based on their importance in landings volume and value. In addition, all cephalopod species are sampled during the PT IBTS 4th targeting demersal fish and the UWTV Survey targeting *Nephrops*. None of these two surveys is considered to be useful to provide independent fisheries data for the assessment of *Octopus vulgaris* or *Sepia officinalis* stocks. Data from DCF have been used extensively for scientific publications on fisheries, biology and ecology, to support regional fisheries advice, namely *O. vulgaris* and to obtain cephalopod-based indicators in the context of the EU Marine Strategy Framework Directive. Despite the large amount of data collected the sampling design is not the most suitable to assess the Portuguese cephalopod stock, which are mainly explored by the small-scale fisheries.

**Greece:** The National Fisheries Data Collection Programme in Greece includes the main commercial species of cephalopods. It is carried out for three GSAs (20, 22, 23) of the Eastern Mediterranean Sea by two partners, the Hellenic Agricultural Organization – Demeter (HAO-DEMETER) that is the project's Scientific Co-ordinator and the Hellenic Centre for Marine Research (HCMR). Three institutes contribute on an annual basis to delivery of the National Plan (NP): the Fisheries Research Institute (FRI (HAO-DEMETER)), the Agricultural Economics Research Institute (AGRERI (HAO-DEMETER)) and the Institute of Marine Biological Resources & Inland Waters (IMBRIW (HCMR)). Data concerning cephalopods, that are collected in the framework of the Greek DCF include:

a) Landings of 5 commercial categories (Loliginids, Ommastrephids, Common cuttlefish, Common octopus and Eledonids) by fleet segment (5 segments based on vessel size) for 5 fishing gear types/metiers (Bottom Trawl: OTB, Purse Seine: PS, Boat Seine: SB-SV, Trammel Nets: GTR, Pots and Traps: FPO) in 3 GSAs (Mediterranean Geographical Divisions by GFCM-FAO) with relevant fishing effort are recorded on a monthly basis. Fishing vessels with overall length over 12 m are required to report landings using the Electronic Report System (ERS), those of 10–12 m overall length are required to fill out paper logbooks, and for smaller vessels the monitoring of fishing activity is achieved using an interview survey, based on face-to-face interviews with structured questionnaires.

b) Length-frequency data for the commercial and discarded portions of all cephalopod species are reported by on-board and on-shore observers during fleet sample surveys on a monthly basis. The sampling method that is chosen for these surveys is simple random sampling, in each fleet segment of the Greek fishing fleet. The total number of trips to be sampled per metier is proportional to the effort (number of days at sea for each metier).

c) Detailed biological information is collected for 5 cephalopod species (*Octopus vulgaris*, *Sepia officinalis*, *Loligo vulgaris*, *Illex coindetii* and *Eledone moschata*) during on-board, on-shore and market surveys. Sampling is on a seasonal basis, depending on the species availability in the catches of the main metiers. The size of samples collected over the year is determined according to the species landings by GSA and the portion contributed by the main metiers. Minimum sample sizes are given in Table 7. Biological information for these species is also obtained from samples collected during the Mediterranean Bottom Trawl Survey (MEDITS), carried out annually during summer in all 3 GSA.

**Table 7. Minimum sample sizes per season for detailed biological data collected under the Greek DCF, per area and per species.**

| Species | GSA 20 | GSA 22 | GSA 23 |
|---|---|---|---|
| *Octopus vulgaris* | 100 | 500 | - |
| *Sepia officinalis* | 250 | 250 | 100 |
| *Loligo vulgaris* | 400 | 260 | - |
| *Illex coindetii* | 150 | 150 | - |
| *Eledone moschata* | 100 | 100 | - |

## 5.2.2 Revised Data Collection guidelines

Cephalopods are included in the EU MAP and annual Working Plans for several Member States. There is routine collection of monitoring data on the fisheries as well as biological data. Where cephalopods are sampled, the periodicity of sampling is still quarterly or yearly. Some countries do not specify 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. Finally, not all Member States have implemented yet a sampling program for cephalopods.

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), for stock assessment (assuming that in-season assessment is needed) it would be necessary to monitor biological variables regularly, ideally every week or (more realistically) every month. Quarterly sampling is insufficient for cephalopod assessment and management (although simple retrospective assessments, e.g. using production models, could still be carried out). 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. To include the sampling of cephalopods in any fishery that either (a) targets both cephalopods and demersal fishes or (b) takes cephalopods as an important bycatch in target metiers for EU-MAP. Length distribution sampling as well as biological sampling is needed for assessment of stock and fishery status in the short-term.
2. Increases in the level of cephalopod sampling in métiers where these are highly valuable, considering the short life cycle of cephalopods. 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 characterization of the length compositions of the multiple micro-cohorts that are often present, while avoiding unproductive sampling effort at times of low abundance.
4. Reliable species identification is essential to improve data collected from landings, discards and surveys. For this propose, training in cephalopod identification

should be given to people involved in sampling and data collection. It would be useful to monitor identification quality using photographic records and/or barcoding.

5. 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). Standardized biological sampling protocols to collect maturity data for each species are necessary.

In relation to biological sampling protocols for maturity data, standard sampling protocols and maturity keys were proposed for all major cephalopod groups in Europe, by species, during the ICES Workshop on Sexual Maturity Staging of Cephalopods, held in 2010 (ICES WKMSCEPH, 2010). The new standardised maturity keys have subsequently been used in Division .9a-s. However, there is a need to review which stages should be considered immature and which mature to obtain the size of first maturity, for all species. It should be noted that ICES WKASMSF (2018) stated that "stage 2b" cephalopods, should be considered as mature for the purposes of determining size at maturity. These are animals with fully developed reproductive tracts (e.g. in females, "Oviducts fully developed but empty") which were interpreted as representing "specimens that have finished a reproductive cycle and are preparing to start another one". Although this is possibly consistent with the idea of intermittent terminal spawning (Rocha *et al.*, 2001), the fact that most cephalopods are semelparous suggests that the proposal could be inappropriate.

Monitoring trends in landings and stock status is essential to avoid overfishing. One of the objectives of WGCEPH is to assess stock status and to implement stock assessment in a short-term. Improved sampling programs will help ensure that the data are usable in the analyses and permit us to move forward with more robust evaluations of stock status.

# 6 Actions list

WGCEPH issued no formal recommendations in 2019. However, several aspects of the work completed in the 2017–2019 cycle require further work by WGCEPH during 2020–2022. General areas for further work are captured in the proposed ToRs for WGCEPH in 2020–2022. Some specific topics include the following:

- Investigation of evidence for shifts in species distribution and their causes (relevant to proposed ToR F) and review of how this is affecting/may affect the associated fisheries. This would include analysis of spatial catch patterns and trends for cuttlefish in the English Channel in order to understand the changes in the relative importance of the UK and French fleets over the last few years.
- More detailed examination of trends in *Octopus vulgaris* abundance, for example using LPUE in the Portuguese OTB fishery in areas 9.a.cn, 9.a.cs and 9.as, and Portuguese survey CPUE for *Eledone cirrhosa* (not included in the 2019 report).
- Given that fisheries statistics are available regionally in Spain, it would be useful to compare trends in regional data (e.g. from Pesca de Galicia) and national data.
- Investigation of the reliability of discard rate estimates and of the factors influencing the discarding of cephalopods. A more detailed analysis of discard data (and possibly more detailed data) is needed. It would be useful to review available information of the survival of discarded cephalopods.
- Re-examination of reported landings from small-scale cephalopod fisheries, an exercise last undertaken by WGCEPH around 20 years ago, involving application of the interview-based Gomez-Muñoz model to estimate landings and compare those with official landings.
- Examination of catches and abundance of *Gonatus* spp. (Gonatidae).
- Review of the status of ongoing barcoding work to identify cephalopods (under the Cephs & Chefs project).
- The ICES Workshop on Sexual Maturity Staging of Cephalopods (ICES MKMSCPH, 2010) proposed new standardised maturity keys for cephalopods. There is a need to review which stages should be considered immature and which mature to obtain the size of first maturity, for all cephalopod species.

# 7 References

Alemany, J., Rivot, E., Foucher, E., Vigneau, J. & Robin, J.-P., 2017. A Bayesian two-stage biomass model for stock assessment of data-limited species: An application to cuttlefish (*Sepia officinalis*) in the English Channel. Fisheries Research 191, 131–143.

Boyle, P.R., Collins, M.A. & Pierce, G.J. (Guest Editors), 2002. Cephalopod biomass and production. Bulletin of Marine Science 71 (1–2), 1–1146.

Boyle, P.R. & Pierce, G.J. (Guest Editors), 1994. Fishery biology of Northeast Atlantic squid. Fisheries Research 21 (1–2).

Challier, L., Royer, J., Pierce, G.J., Bailey, N., Roel, B.A. & Robin, J.-P., 2005. Environmental and stock effects on recruitment variability in the English Channel squid *Loligo forbesi*. Aquatic Living Resources 18, 353–360

Dunn, M.R., 1999. Aspects of the stock dynamics and exploitation of cuttlefish, *Sepia officinalis* (Linnaeus, 1758), in the English Channel Fisheries Research, 40 (3), 277–293.

Fernández-Álvarez, F.Á., Braid, H.E., Nigmatullin, Ch.M., Bolstad, K.S.R., Haimovici, M., Sánchez, P., Sajikumar, K.K., Ragesh, N. & Villanueva, R., 2020. Global biodiversity of the genus *Ommastrephes* (Ommastrephidae: Cephalopoda): an allopatric cryptic species complex. Zoological Journal of the Linnean Society XX, 1–23.

González, A.F., Pecl, G.T. & Pierce, G.J. (Guest Editors), 2010. Cephalopod life history, populations and environment. Selected papers of CIAC ´09. ICES Journal of Marine Science 67(7).

Gras, M., Roel, B., Coppin, F., Foucher, E. & Robin, J.-P., 2014. A two-stage biomass model to assess the English Channel cuttlefish (*Sepia officinalis* L.) stock. ICES Journal of Marine Science 71, 2457–2468.

Gras, M., Safi, G., Lebredonchel, H., Quinquis, J., Foucher, E., Koueta, N. & Robin, J.-P., 2016. Stock structure of the English Channel common cuttlefish *Sepia officinalis* (Linnaeus, 1758) during the reproduction period. Journal of the Marine Biological Association of the United Kingdom 96, 167–176.

ICES. 2010. Report of the Workshop on Sexual Maturity Staging of Cephalopods, 8–11 November 2010, Livorno, Italy. ICES CM 2010/ACOM:49. 97 pp.

ICES. 2018. Report of the Workshop for Advancing Sexual Maturity Staging in Fish (WKASMSF), 30 April - 4 May 2018, ICES Headquarters, Copenhagen, Denmark. ICES CM/EOSG: 38. 75 pp.

Jereb, P., Allcock, A.L., Lefkaditou, E., Piatkowski, U., Hastie, L.C. & Pierce, G.J. (Editors), 2015. Cephalopod biology and fisheries in Europe II: Species Accounts. Co-operative Research Report No 325, International Council for the Exploration of the Sea, Copenhagen, 360 pp. ISBN 978–87–7482–155–7.

Kooij, J., Engelhard, G.H., and Righton, D.A., 2016. Climate change and squid range expansion in the North Sea. Journal of Biogeography 43, 2285–2298. doi:10.1111/jbi.12847

Moreno, A. 1995. Aspectos da biologia de *Alloteuthis subulata* e distribução de *Alloteuthis* spp. Relatorios Cientificos e Técnicos do Instituto Português de Investigação Marítima, 8. 16 pp.

Payne, A.G., Agnew, D.J. & Pierce, G.J. (Guest Editors), 2006. Trends and Assessment of Cephalopod Fisheries - Proceedings of the CEPHSTOCK Cephalopod Assessment Workshop. Fisheries Research 78 (1), 1–106.

Pedersen, M.W. & Berg, C.W., 2017. A stochastic surplus production model in continuous time. Fish and Fisheries 18, 226–243.

Piatkowski, U., Pierce, G.J. & Morais da Cunha, M. (Guest Editors), 2001. Impact of cephalopods in the food chain and their interaction with the environment. Fisheries Research 52 (1–2), 1–142.

Pierce, G.J., Allcock, L., Bruno, I., Bustamante, P., González, A.F., Guerra, A., Jereb, P., Lefkaditou, E., Malham, S., Moreno, A., Pereira, J., Piatkowski, U., Rasero, M., Sánchez, P., Santos, M.B., Santurtún, M., Seixas, S., Sobrino, I. & Villanueva, R. (Editors), 2010. Cephalopod biology and fisheries in Europe.

Cooperative Research Report 303, International Council for the Exploration of the Sea, 175 pp. 175 pp. ISBN 978-87-7482-078-9.

Pierce, G.J., Portela, J.M. & Robin, J.-P. (Guest Editors), 2005. Environmental effects on cephalopod life history and fisheries. Aquatic Living Resources 18 (4), 325–400.

Rocha, F., Guerra, Á., and González, A. F. 2001. A review of reproductive strategies in cephalopods. Biological Reviews, 76: 291–304.

Rodhouse, P.G., Dawe, E.G. & O'Dor, R.K. (Editors), 1998. Squid recruitment dynamics. The genus *Illex* as a model. The commercial *Illex* species. Influences on variability. FAO Fisheries Technical Paper. No. 376. Rome, FAO. 1998. 273 pp.

Royer, J., Pierce, G.J., Foucher, E. & Robin J.P., 2006. The English Channel stock of *Sepia officinalis*: modelling variability in abundance and impact of the fishery. Fisheries Research 78, 96–106

Sobrino, I., Rueda, L., Tugores, M.P., Burgos, C., Cojan, M. & Pierce, G.J., 2020. Abundance prediction and influence of environmental parameters in the abundance of Octopus (*Octopus vulgaris* Cuvier, 1797) in the Gulf of Cadiz. Fisheries Research 221, 105382.

Tasende, M., Quintero, F., Arnáiz, Bañón, R., Campelos, J. M., Lamas, F., Gancedo, A., *et al.*, 2005. La pesquería de calamar (*Loligo vulgaris*) y puntilla (*Alloteuthis* spp.) con boliche en las Rías Baixas gallegas (1999–2003). In Los Recursos Marinos de Galicia. Serie Técnica No. 3, Consellería de Pesca e Asuntos Marítimos, Xunta de Galicia. 108 pp.

Young, I.A.G., Pierce, G.J., Daly, H.I., Santos, M.B., Key, L.N., Bailey, N., Robin, J.-P., Bishop, A.J., Stowasser, G., Nyegaard, M., Cho, S.K., Rasero, M. & Pereira, J.M.F., 2004. Application of depletion methods to estimate stock size in the squid *Loligo forbesi* in Scottish waters (UK). Fisheries Research 69, 211–227.

Young, I.A.G., Pierce G.J., Murphy, J., Daly, H.I. & Bailey, N., 2006. Application of the Gómez-Muñoz model to estimate catch and effort in squid fisheries in Scotland. Fisheries Research 78, 26–38.

# Annex 1: List of participants

**WGCEPH 2019 meeting**

(* = remote participation)

| Name | Institute | Country | Email |
|---|---|---|---|
| Esther Abad | IEO, Vigo | Spain | esther.abad@ieo.es |
| Alexander Arkhipkin * | FIFD | Falkland Islands | AArkhipkin@fisheries.gov.fk |
| Nicholas Badouvas | HCMR | Greece | n.badouvas@hcmr.gr |
| Nikolaos Fotiadis | HCMR | Greece | n.fotiadis@hcmr.gr |
| Ángel F. González * | IIM-CSIC | Spain | afg@iim.csic.es |
| Lisa Hendrickson * | NOAA | USA | lisa.hendrickson@noaa.gov |
| Ane Iriondo * | AZTI | Spain | airiondo@azti.es |
| Ana Juarez * | IEO | Spain | ana.juarez@ieo.es |
| Alexandra Karatza | HCMR | Greece | hatori.alexandra@gmail.com |
| Vladimir Laptikhovsky | CEFAS | UK | vladimir.laptikhovsky@ce-fas.co.uk |
| Angela Larivain | Université de Caen | France | angela.larivain@unicaen.fr |
| Evgenia Lefkaditou | HCMR | Greece | teuthis@hcmr.gr |
| Fedor Lishchenko * | A.N. Severtsov Institute of Ecology and Evolution | Russia | fedor-ln@ya.ru |
| Fábio L. Matos | Universidade de Aveiro | Portugal | fmatos@ua.pt |
| Silvia Monteiro | Universidade de Aveiro | Portugal | s.monteiro@ua.pt |
| Ana Moreno | IPMA | Portugal | amoreno@ipma.pt |
| Daniel Oesterwind | Thünen-Institut | Germany | daniel.oesterwind@thuenen.de |
| Catalina Perales-Raya * | IEO, Tenerife | Spain | catalina.perales@ieo.es |
| Michael Petroni | NUI Galway | Ireland | michael.petroni@nuigalway.ie |
| Uwe Piatkowski | GEOMAR | Germany | upiatkowski@geomar.de |
| Graham J. Pierce | IIM-CSIC | Spain | g.j.pierce@iim.csic.es |
| Cristina Pita | Universidade de Aveiro | Portugal | c.pita@ua.pt |
| Anne Marie Power | NUI Galway | Ireland | annemarie.power@nuigalway.ie |
| Jean-Paul Robin | Université de Caen | France | jean-paul.robin@unicaen.fr |
| Alberto Rocha | IPMA | Portugal | arocha@ipma.pt |
| Elina Samara | INALE | Greece | Elinas@inale.gr |
| Marina Santurtun * | AZTI | Spain | msanturtun@azti.es |

**WGCEPH 2018 meeting**

| Name | Institute | Country | Email |
|---|---|---|---|
| Alberto Rocha | Instituto Português do Mar e da Atmosfera | Portugal | arocha@ipma.pt |
| Ana Moreno | Instituto Português do Mar e da Atmosfera | Portugal | amoreno@ipma.pt |
| Ane Iriondo | AZTI-Tecnalia | Spain | airiondo@azti.es |
| Carlos Monteiro | Marine Stewardship Council | Spain | carlos.montero@msc.org |
| Catalina Perales Raya | Instituto Español de Oceanografía | Spain | catalina.perales@ieo.es |
| Daniel Oesterwind | Thünen Institute of Baltic Sea Fisheries | Germany | daniel.oesterwind@thuenen.de |
| Eugenia Lefkaditou | HCMR | Greece | teuthis@hcmr.gr |
| Fedor Lishchenko | | Russia | fedor-ln@yandex.ru |
| Giorgos Gitarakos | Fisheries Research Institute (Hellenic Agricultural Organization) | Greece | geogitar@yahoo.gr |
| Graham Pierce (Co-Chair) | Instituto de Investigaciones Marinas, Consejo Superior de Investigaciones Cientificas | Spain | g.j.pierce@iim.csic.es |
| Jean-Paul Robin (Co-Chair) | Université de Caen Basse-Normandie Esplanade de la Paix | France | jean-paul.robin@unicaen.fr |
| Marina Santurtun | AZTI-Tecnalia | Spain | msanturtun@azti.es |
| ***Remote Contributions*** | | | |
| Ana Juarez (by correspondence) | Instituto Español de Oceanografía | Spain | ana.juarez@ieo.es |
| Begoña Sotillo De Olano (by correspondence) | Instituto Español de Oceanografía | Spain | begona.sotillo@ieo.es |
| Christopher Barrett (by correspondence) | Centre for Environment, Fisheries and Aquaculture Science (Cefas) | UK | christopher.barrett@cefas.co.uk |
| Cristina Pita (by skype and by correspondence) | Universidade de Aveiro | Portugal | c.pita@ua.pt |
| Fabio Matos (by correspondence) | Universidade de Aveiro | Portugal | fmatos@ua.pt |
| Ignacio Sobrino (by correspondence) | Instituto Español de Oceanografía | Spain | ignacio.sobrino@ieo.es |
| Jennifer Smith (by correspondence) | University of Aberdeen | UK | jennifer.smith@abdn.ac.uk |
| Jessica Jones (by correspondence) | Falkland Islands Fishery Department | UK | JJones@fisheries.gov.fk |
| Julio Valeiras (by correspondence) | Instituto Español de Oceanografía | Spain | julio.valeiras@ieo.es |
| Louise Allcock (by correspondence) | National University of Ireland, Galway | Ireland | louise.allcock@nuigalway.ie |
| Luis Silva (by correspondence) | Instituto Español de Oceanografía | Spain | luis.silva@ieo.es |
| Sebastian Villasante (by correspondence) | Universidad de Santiago de Compostela | Spain | sebastian.villasante@usc.es |
| Sonia Seixas (by skype and by correspondence) | Universidade Aberta | Portugal | Sonia.Seixas@uab.pt |
| Vladimir Laptikhovsky (by correspondence) | Centre for Environment, Fisheries and Aquaculture Science (Cefas) | UK | vladimir.laptikhovsky@cefas.co.uk |

**WGCEPH 2017 meeting**

| Name | Institute | Country | Email |
|---|---|---|---|
| Graham Pierce (Co-Chair) | IIM-CSIC | Spain/UK | g.j.pierce@iim.csic.es |
| Jean-Paul Robin (Co-Chair) | University of Caen Normandy | France | jean-paul.robin@unicaen.fr |
| Alberto Rocha | Instituto Português do Mar e da Atmosfera | Portugal | arocha@ipma.pt |
| Ana Moreno | Instituto Português do Mar e da Atmosfera | Portugal | amoreno@ipma.pt |
| Anastasia Lischenko | Russian Federal Research Institute of Fisheries and Oceanography | Russia | gvajta@ya.ru |
| Ane Iriondo | AZTI Tecnalia | Spain | airiondo@azti.es |
| Catalina Perales Raya | IEO | Spain | catalina.perales@ieo.es |
| Christopher Barret | CEFAS | UK | christopher.barrett@cefas.co.uk |
| Daniel Oesterwind | Thünen-Institut | Germany | daniel.oesterwind@thuenen.de |
| Eugenia Lefkaditou | HCMR | Greece | teuthis@hcmr.gr |
| Fedor Lischenko | Russian Federal Research Institute of Fisheries and Oceanography | Russia | fedor-ln@yandex.ru |
| Ignacio Sobrino | IEO | Spain | ignacio.sobrino@ieo.es |
| Jennifer Smith | University of Aberdeen | UK | jmarierobertson@yahoo.co.in |
| Luís Silva | IEO | Spain | luis.silva@ieo.es |
| Margarida Hermida | Observatório Oceânico da Madeira | Portugal | margaridahermida@gmail.com |
| Marina Santurtun | AZTI Tecnalia | Spain | msanturtun@azti.es |
| Sílvia Lourenço | Observatório Oceânico da Madeira | Portugal | slourenco@ciimar.up.pt |
| Sónia Seixas | Universidade Aberta | Portugal | soniabseixas@gmail.com |
| Uwe Piatkowski | Helmholtz centre for Ocean Research | Germany | upiatkowski@geomar.de |

# Annex 2: WGCEPH Resolution 2017-2019

The **Working Group on Cephalopod Biology and Life History** (WGCEPH), chaired by Graham Pierce, Spain, and Jean-Paul Robin, France, will work on ToRs and generate deliverables as listed in the Table below.

| | Meeting dates | Venue | Reporting details | Comments (change in Chair, etc.) |
|---|---|---|---|---|
| Year 2017 | 6–9 June | Madeira, Portugal | Interim report by 1 September to SSGEPD | |
| Year 2018 | 5–8 June | San Sebastian, Spain | Interim report by 1 August to SSGEPD | |
| Year 2019 | 4–7 June | Athens, Greece | Final report by 1 August to SCICOM | |

**ToR descriptors**

| ToR | Description | Background | Science Plan codes | Duration | Expected Deliverables |
|---|---|---|---|---|---|
| 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. | This task is fundamental to support the assessment task and will involve a Data Call. | 5.2 | Years 1, 2 and 3 | Annual report |
| 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. | The purpose is to assess the status of cephalopods stocks and contribute to Integrated Ecosystem Assessment and Management. | 1.3; 5.1; 6.1 | Years 1, 2 and 3 | Peer-reviewed manuscript on assessment methodologies and results (year 3) |
| C | Update information on life history parameters including variability in these parameters. Define cephalopod habitat requirements. | There is a need to undesrtand variability in life history parameters in the wild and to provide knowledge to support captive rearing. | 1.7; 5.2 | Years 1 and 2 | Publication on rearing conditions and habitat preferences (Year 2) |
| 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). | There is a need to better quantify the social and economic of cephalopod fisheries across Europe. | 5.8; 7.2 | Year 1, 2 and 3 | Report on social and economic importance of cephalopod fisheries (Year 3) |
| E | Recommend tools for identification cephalopod species and update best practices for data collection. | Currently cephalopods are not consistently identified to species in commercial and survey catches. | 1.6; 3.2 | Year 1, 2 and 3 | Manual for cephalopod field identification and data collection (Year 3) |

**Summary of the Work Plan**

| | |
|---|---|
| Year 1 (2017) | Report on updated trends in Cepahlopod landings and abundance indices .(a)<br>Report on updated cephalopod stock assessments (b)<br>Report on scientific articles in relation to life-history and habitat requirements (c)<br>Report on social and economic profile of cephalopod fisheries (d)<br>Report on available information for species identification (e) |
| Year 2 (2018) | Report on status and trends in cephalopod stocks (a and b))<br>First draft of paper in relation to population modeling and assesment tools (b)<br>Peer review paper on rearing conditions and/or habitat preferences (c)<br>Report on mechanisms that add value to cephalopod products (e.g. certifications) (d)<br>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)<br>Peer-review paper on cephalopod population modeling and assesment tools (b)<br>Report on socio-economic issues related to cephalopod management options<br>Manual for cephalopod field identification and data collection guidelines (e) |

**Supporting information**

| | |
|---|---|
| Priority | The current activities of this Group will inform ICES about the role of Cephalopods in the ecosystem and evaluate their importance as part of directed and indirected fisheries. Cephalopods are important components of marine ecosystems, as predators and as prey, more important than their biomass might suggest due to their high productivity and large year-to-year variation in abundance. Cephalopod catches are replacing depleted finfish catches in some fisheries and ecological replacement is also hypothesised. Thus, for promoting the sustainable use of the seas and conserving marine ecosystems, cephalopod biology and life history has to be understood. As an example, directed cephalopod fisheries, especially small-scale fisheries, are increasingly important and it is necessary to have in place a useful system of data collection and stock evaluation that would be adequate to support managementthese activities are considered. These activities are believed to have a very high priority. |
| Resource requirements | As noted in several previous reports, participation in WGCEPH is limited by availability of funding, especially as many members and potential members are university staff with no access to “national funds” for attendance at ICES meetings. Although there are no specific resource requirements, funding to assist wider particupation would be beneficial. |
| Participants | In recent years the group has fluctuated from around 15 attendees and as few as 6 to 8 regular members, with a strong bias towards participants from the Iberian peninsula. There is a need to broaden participation to ensure good attendance every year |
| Secretariat facilities | None. |
| Financial | No specific financial implications (but see resource requirements). |
| Linkages to ACOM and groups under ACOM | The results of WGCEPH are potentially relevant for advice in the case that formal assessment and management are introduced for any of these species. |
| Linkages to other committees or groups | Possible links with groups working on predators of cephalopod (e.g. WGBIE, WGCS, WGMME).<br>WGCEPH would like to encourage improved data collection on cephalopods during trawl surveys. It will make available (e.g. to IBTSWG) detailed diagrams and protocols for identifying cephalopods and collecting biological parameters during the scientific surveys.<br>WGCEPH will provide information to SCICOM and its satellite committees as required to respond to requests for advice/information from NEAFC and EC DG Fish. |

| | |
|---|---|
| Linkages to other organizations | Cost Action (FA 1301) CephsinAction, Cephalopod International Advisory Council (CIAC). |

# Annex 3: Supplementary Information and Working Documents

## Supplementary Information ToR_A: Tables of annual landings per groups of species and ICES Divisions

**Table A3. Landings (in tonnes) of Octopods (Eledone spp. and Octopus vulgaris mainly).**

| Country | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *ICES Area 27.3.a* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 2 | 5 | 4 |
| Netherlands | | | | | | | | | | | | | | | | | | | | | | | | | 0 | 0 | |
| Sweden* | | | | | | | | | | | | | | | | | | | | | 1 | 1 | | | 2 | 5 | 4 |
| *ICES Area 27.4.a* | 31 | 10 | 2 | 2 | 2 | 6 | 13 | 17 | 15 | 6 | 1 | 11 | 5 | 2 | 1 | 3 | 3 | 0 | 0 | 0 | 1 | 2 | 0 | 4 | 53 | 17 | 0 |
| Denmark | | | | | | | | | | | | | | | | | | | | | | | | | | 0 | |
| England, Wales & N. Ireland | 0 | 0 | 0 | | | | | | | | | | | | | | | | | | | | | | 44 | | |
| Netherlands | | | | | | | | | | | | | | | | | | | | | | 0 | | | | 0 | |
| Scotland | 31 | 10 | 2 | 2 | 2 | 6 | 13 | 17 | 15 | 6 | 1 | 11 | 5 | 2 | 1 | 3 | 3 | | | | 1 | 2 | | 4 | 9 | 17 | |
| Sweden | | | | | | | | | | | | | | | | | | | | | | | | | | 0 | |
| *ICES Area 27.4.b* | 33 | 13 | 8 | 0 | 0 | 0 | 4 | 7 | 6 | 8 | 2 | 3 | 3 | 3 | 3 | 1 | 2 | 0 | 0 | 0 | 3 | 1 | 1 | 1 | 3 | 4 | 2 |
| Belgium | 24 | 10 | 3 | 0 | | | 2 | 5 | 5 | 6 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | | | | | | | | 1 | 1 | 1 |
| England, Wales & N. Ireland | 8 | 1 | 4 | 0 | 0 | 0 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | | | | 2 | 0 | 1 | 1 | 2 | 1 | 0 |
| France | | | | | | | | | | | | | | | | | | | | 0 | | | | 0 | 0 | 0 | 0 |
| Netherlands | | | | | | | | | | 1 | 0 | 0 | | 0 | 0 | 0 | | | | | | | | | 0 | 1 | 0 |
| Scotland | 1 | 2 | 1 | 0 | 0 | 0 | 1 | 1 | | 0 | | | | | | | | | | | 1 | 0 | | | 0 | 1 | |
| Sweden | | | | | | | | | | | | | | | | | | | | | | 0 | | | 0 | 0 | |
| *ICES Area 27.4.c* | 1 | 1 | 5 | 10 | 4 | 3 | 0 | 2 | 1 | 1 | 3 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 2 |
| Belgium | 0 | 1 | 1 | 2 | 0 | 2 | | 2 | 1 | 1 | 1 | 1 | | | | 1 | 0 | | | | | | | | 0 | 0 | 0 |
| England, Wales & N. Ireland | 1 | | 4 | 8 | 4 | 1 | | | | | 0 | 0 | | | | 0 | 0 | | | | | 0 | 0 | | | 0 | 2 |
| Netherlands | | | | | | | | | | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | | 0 | 0 | 0 |
| France | | | | | | | | | | | | | | | | | | | | | | | | 2 | | | 0 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *ICES Area 27.6.a,b* | 11 | 1 | 3 | 5 | 29 | 38 | 45 | 1 | 1 | 0 | 0 | 2 | 2 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 5 | 2 | 0 | 5 | 12 | 3 | 2 |
| Belgium | 0 | 0 | 0 | 0 | 0 | 1 | | | | | | | | | | 0 | 0 | | | | | | | | | | 0 |
| England, Wales & N. Ireland | 4 | | 1 | | | | 2 | 0 | | | | 2 | 2 | | | 0 | 0 | 0 | 0 | 0 | | | | | 0 | 0 | 0 |
| Ireland | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | | | | | | | 0 | 2 | 0 | 0 | 0 | 4 | 0 | 0 | 4 | 0 | 0 | 0 |
| Scotland | 3 | 1 | 2 | 4 | 1 | 1 | | 0 | 0 | | | | | | | | | | | | 1 | 1 | | | 12 | 3 | 2 |
| Spain | 4 | 0 | 0 | 0 | 27 | 35 | 42 | 0 | | | | 0 | 0 | | | 0 | 0 | 0 | | 0 | 0 | 0 | | 0 | 0 | 0 | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *ICES Area 27.7.a* | 16 | 12 | 38 | 17 | 3 | 19 | 27 | 4 | 5 | 11 | 32 | 21 | 5 | 1 | 2 | 0 | 1 | 0 | 1 | 1 | 2 | 0 | 3 | 1 | 0 | 2 | 1 |
| Belgium | 14 | 8 | 14 | 14 | 3 | 18 | 26 | 4 | 5 | 11 | 31 | 20 | 5 | 1 | 2 | 0 | 1 | | | | | | | | 0 | 1 | 1 |
| England, Wales & N. Ireland | 2 | 4 | 24 | 2 | 0 | 1 | | | | 0 | 0 | 0 | | | | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 3 | 0 | 0 | 1 | 0 |
| Ireland | 0 | 0 | | 1 | | 0 | 1 | 0 | | | 1 | 1 | | | | | | 0 | 1 | 0.1 | | 0 | 0 | | 0 | 0 | 0 |
| France | 0 | | | | 0 | 0 | | | | | | | | | | | | | | | | | | 0 | 0 | 0 | 0 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | |

| | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *ICES Area 27.7.b,c* | 0 | 3 | 2 | 2 | 33 | 40 | 46 | 39 | 60 | 304 | 745 | 443 | 357 | 424 | 409 | 407 | 384 | 499 | 647 | 993 | 18 | 642 | 38 | 19 | 66 | 66 | 16 |
| England, Wales & N. Ireland | 0 | | | | 4 | 3 | 5 | 3 | 4 | 20 | 3 | 6 | 15 | 4 | 10 | 10 | 5 | 109 | 167 | 138 | 6 | 2 | 9 | | 16 | 11 | 5 |
| France | 0 | 0 | | 0 | 0 | 0 | 0 | | 8 | 1 | 0 | 0 | | 2 | 10 | | | | | 3 | 2 | 8 | 10 | 12 | 23 | 15 | 10 |
| Ireland | 0 | 3 | 2 | 2 | 2 | 4 | 0 | 2 | 4 | 5 | 1 | 6 | | 1 | | 0 | 0 | 1 | 17 | 21 | 0 | 1 | 2 | | 1 | 1 | 0 |
| Scotland | | | | | | | | | | 2 | | 1 | | | | 0 | 0 | | | | 6 | | | 8 | 4 | 3 | 0 |
| Spain | | | | | 27 | 33 | 41 | 34 | 44 | 276 | 741 | 430 | 342 | 417 | 389 | 397 | 379 | 389 | 463 | 832 | 4 | 630 | 17 | | 22 | 36 | 1 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *ICES Area 27.7.d,e* | 45 | 43 | 91 | 128 | 99 | 45 | 20 | 17 | 35 | 21 | 29 | 31 | 16 | 31 | 30 | 70 | 94 | 97 | 124 | 181 | 250 | 241 | 108 | 162 | 199 | 277 | 355 |
| Belgium | 1 | 2 | | 6 | 1 | 1 | | | | 0 | 2 | 2 | 2 | 1 | 3 | 5 | 8 | | | | | | | | 9 | 23 | 41 |
| Channel Islands | | | | 0 | 0 | 0 | 0 | | | | | 3 | | | | | | | | | | | | | | | 46 |
| England, Wales & N. Ireland | 20 | 21 | 60 | 77 | 75 | 37 | 17 | 9 | 22 | 15 | 20 | 21 | 14 | 21 | 21 | 65 | 86 | 97 | 108 | 174 | 248 | 235 | 101 | 153 | 183 | 245 | 215 |
| France | 24 | 20 | 31 | 45 | 23 | 7 | 3 | 8 | 13 | 5 | 7 | 5 | | 9 | 6 | | | | 14 | 7 | 0 | 1 | 7 | 9 | 7 | 8 | 46 |
| Netherlands | | | | | | | | | | | | | 0 | | | | | 0 | 2 | | | 0 | | | 0 | 0 | 0 |
| Scotland | | | | | | | | | | | | | | | | | | | | | 2 | 5 | | | | | 0 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | 9 |
| *ICES Area 27.7.f* | 12 | 29 | 35 | 19 | 14 | 16 | 6 | 7 | 23 | 5 | 24 | 21 | 33 | 21 | 22 | 26 | 11 | 0 | 1 | 0 | 0 | 0 | 3 | 0 | 14 | 31 | 18 |
| Belgium | 2 | 4 | 6 | 9 | 6 | 6 | 3 | 3 | 13 | 1 | 9 | 13 | 24 | 10 | 16 | 20 | 9 | | | | | | | | 11 | 25 | 13 |
| England, Wales & N. Ireland | 8 | 13 | 26 | 8 | 6 | 9 | 3 | 4 | 10 | 4 | 13 | 8 | 9 | 10 | 5 | 6 | 2 | | | | | | 2 | | 3 | 6 | 5 |
| France | 2 | 12 | 3 | 2 | 2 | 1 | 0 | | | | | | | 1 | 1 | | | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 |
| Spain | | | | | | | | | | | 2 | | | | | | | | | | | | | | | | |
| Scotland | | | | | | | | | | | | | | | | | | | | | | | | | 0 | 0 | |
| *ICES Area 27.7.g-k* | 210 | 213 | 352 | 629 | 290 | 229 | 268 | 390 | 656 | 305 | 294 | 174 | 154 | 221 | 169 | 195 | 148 | 33 | 71 | 79 | 152 | 238 | 266 | 149 | 215 | 236 | 147 |
| Belgium | 2 | 6 | 10 | 27 | 17 | 13 | 11 | 10 | 16 | 6 | 12 | 13 | 12 | 5 | 6 | 6 | 3 | | | | | | | | 12 | 26 | 24 |
| England, Wales & N. Ireland | 22 | 57 | 77 | 144 | 127 | 66 | 58 | 16 | 78 | 105 | 141 | 99 | 113 | 131 | 103 | 137 | 104 | 30 | 58 | 52 | 68 | 13 | 94 | | 66 | 62 | 52 |
| France | 6 | 10 | 7 | 2 | 0 | 1 | 9 | 8 | 32 | 19 | 18 | 11 | | 17 | 13 | | | | 11 | 4 | 9 | 181 | 31 | 37 | 48 | 45 | 50 |
| Ireland | 1 | 1 | 2 | 4 | 25 | 3 | 2 | 7 | 7 | 9 | 11 | 17 | | 29 | 3 | 3 | 7 | 2 | 1 | 23 | 34 | 39 | 8 | | 2 | 7 | 6 |
| Scotland | 0 | 0 | 0 | 0 | 5 | 1 | 9 | 1 | 5 | 10 | 1 | 6 | | 7 | 8 | 12 | 31 | | | | 40 | 5 | | | 6 | 12 | 12 |
| Spain | 179 | 139 | 256 | 452 | 116 | 145 | 179 | 348 | 518 | 156 | 111 | 28 | 29 | 32 | 36 | 37 | 3 | 1 | 1 | | | | 133 | 112 | 81 | 84 | 2 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *ICES Area 27.8* | 2732 | 2306 | 1651 | 1957 | 2654 | 2634 | 2927 | 1659 | 1415 | 1407 | 1472 | 1289 | 2052 | 1788 | 1823 | 2366 | 1978 | 963 | 2366 | 2084 | 1718 | 1535 | 1471 | 1348 | 1417 | 488 | 1324 |
| Belgium | 0 | 7 | 6 | 3 | 1 | 4 | 4 | 17 | 4 | 5 | 13 | 1 | 5 | 3 | 6 | 15 | 8 | | | | | | | | 32 | 24 | 35 |
| England, Wales & N. Ireland | 0 | 0 | 0 | | 5 | 23 | 1 | | 0 | | | 1 | 29 | 8 | | 0 | 0 | | | | | | | | | | 0 |
| France | 77 | 163 | 57 | 68 | 49 | 84 | 78 | 225 | 104 | 54 | 60 | 45 | 130 | 103 | 95 | 114 | 205 | | 106 | 134 | 109 | 184 | 145 | 193 | 227 | 251 | 312 |
| Netherlands | | | | | | | | | | 6 | | | | | | | | | | | | | | | | | 0 |
| Portugal | 144 | | 154 | 107 | 113 | 75 | 57 | 156 | 250 | 70 | 70 | 98 | 164 | 102 | 73 | | | | | 15 | 68 | 88 | 62 | 66 | 65 | | 0 |
| Spain | 2511 | 2136 | 1434 | 1779 | 2486 | 2448 | 2787 | 1261 | 1057 | 1272 | 1329 | 1144 | 1724 | 1572 | 1649 | 2238 | 1765 | 963 | 2260 | 1935 | 1541 | 1263 | 1264 | 1090 | 1093 | 212 | 976 |

| | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *ICES Area 27.8.a,b,d* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 312 | 236 | 207 | 370 | 477 | 486 |
| Belgium | | | | | | | | | | | | | | | | | | | | | | | | | 32 | 24 | 35 |
| England, Wales & N. Ireland | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| France | | | | | | | | | | | | | | | | | | | | | | 182 | 144 | 192 | 226 | 251 | 312 |
| Netherlands | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Portugal | | | | | | | | | | | | | | | | | | | | | | 0 | 0 | 0 | 0 | 0 | |
| Spain | | | | | | | | | | | | | | | | | | | | | | 130 | 92 | 15 | 113 | 202 | 138 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *ICES Area 27.8.c* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1290 | 1235 | 1142 | 1047 | 11 | 838 |
| Belgium | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| England, Wales & N. Ireland | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| France | | | | | | | | | | | | | | | | | | | | | | 2 | 1 | 1 | 1 | 0 | 0 |
| Netherlands | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Portugal | | | | | | | | | | | | | | | | | | | | | | 155 | 62 | 66 | 65 | | |
| Spain | | | | | | | | | | | | | | | | | | | | | | 1133 | 1172 | 1075 | 980 | 11 | 838 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *ICES Area 27.9* | 12975 | 10091 | 11076 | 13449 | 14514 | 12708 | 9648 | 13588 | 14224 | 9366 | 10224 | 12842 | 10571 | 15382 | 10238 | 10479 | 15994 | 10360 | 13527 | 9621 | 14501 | 18967 | 14004 | 10893 | 15026 | 8124 | 6784 |
| Portugal | 9476 | 7099 | 7319 | 9708 | 11523 | 9078 | 6350 | 9098 | 9019 | 7203 | 7288 | 10038 | 7784 | 11372 | 7074 | 8452 | 13258 | 7940 | 10471 | 7266 | 9654 | 13062 | 10728 | 7609 | 10568 | 5851 | 5048 |
| Spain | 3499 | 2992 | 3757 | 3741 | 2991 | 3630 | 3298 | 4490 | 5205 | 2163 | 2936 | 2804 | 2787 | 4010 | 3164 | 2027 | 2737 | 2421 | 3056 | 2355 | 4847 | 5905 | 3276 | 3283 | 4458 | 2274 | 1736 |
| | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | |
| *ICES Area 27.9.a* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 18967 | 14004 | 10891 | 15026 | 8124 | 6784 |
| Portugal | | | | | | | | | | | | | | | | | | | | | | 13062 | 10728 | 7609 | 10568 | 5851 | 5048 |
| Spain | | | | | | | | | | | | | | | | | | | | | | 5905 | 3276 | 3283 | 4458 | 2274 | 1736 |
| *ICES Area 27.9.b* | 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 |
| Portugal | | | | | | | | | | | | | | | | | | | | | | | | | 0 | 0 | 0 |
| Spain | | | | | | | | | | | | | | | | | | | | | | | | | 0 | 0 | 0 |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| *ICES Area 27.10* | 11 | 7 | 7 | 8 | 16 | 64 | 39 | 12 | 9 | 14 | 16 | 16 | 15 | 10 | 13 | 19 | 13 | 6 | 14 | 6 | 11 | 24 | 23 | 5 | 7 | 0 | 0 |
| Portugal | 11 | 7 | 7 | 8 | 16 | 64 | 39 | 12 | 9 | 14 | 16 | 16 | 15 | 10 | 13 | 19 | 13 | 6 | 14 | 6.2 | 11.3 | 24.2 | 23 | 5 | 7 | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Total** | **16077** | **12729** | **13270** | **16226** | **17658** | **15802** | **13043** | **15743** | **16451** | **11447** | **12841** | **14854** | **13214** | **17883** | **12709** | **13567** | **18630** | **11959** | **16752** | **12965** | **16662** | **21652** | **15917** | **12588** | **17015** | **9252** | **8654** |

* Data revised in WGCEPH 2014; Data 2016 revised in WGCEPH 2017

# Working Document: Spanish Cephalopod landings and discards

## Working Document presented to the ICES WGCEPH Working Group on Cephalopod Fisheries and Life History (2019)

### An Update of Cephalopod Landings-Discard Data of the Spanish Fishing Fleet Operating in ICES Area for 2000-2016

Ana Juárez[1], Ignacio Sobrino[1], Luis Silva[1],
[1] *Instituto Español de Oceanografía, Centro Oceanográfico de Cádiz*
*Puerto Pesquero, Muelle de Levante s/n 11006 Cádiz, SPAIN*
*Telf.(34)956294189 e.mail:* luis.silva@ieo.es

Data of Spanish landings of cephalopods on an annual basis were collected both by the Instituto Español de Oceanografía (IEO) Sampling and Information Network, for catches from the ICES sub-areas 27.7, 27.8.abd, 27.8.c and 27.9.a. 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 2000-2018 period.

Table 1. Spanish cephalopod annual landings (in tons) caught in the ICES Area by species group and total annual during the 2000-2018 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** |
| *2018* | 515 | 3316 | 3181 | 1057 | **8069** |

Figure 1 shows the trend of total annual landings through the analyzed time period (2000-2018). Mean annual landings along the time series were around 9367 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 54 % of the averaged landings for the analyzed period, followed by Ommastrephidae (23%), 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 (18%). However, an increase was detected in 2016 for all groups, mainly in Octopodidae. In 2017, there was a general decrease in landings that begins to recover in 2018.

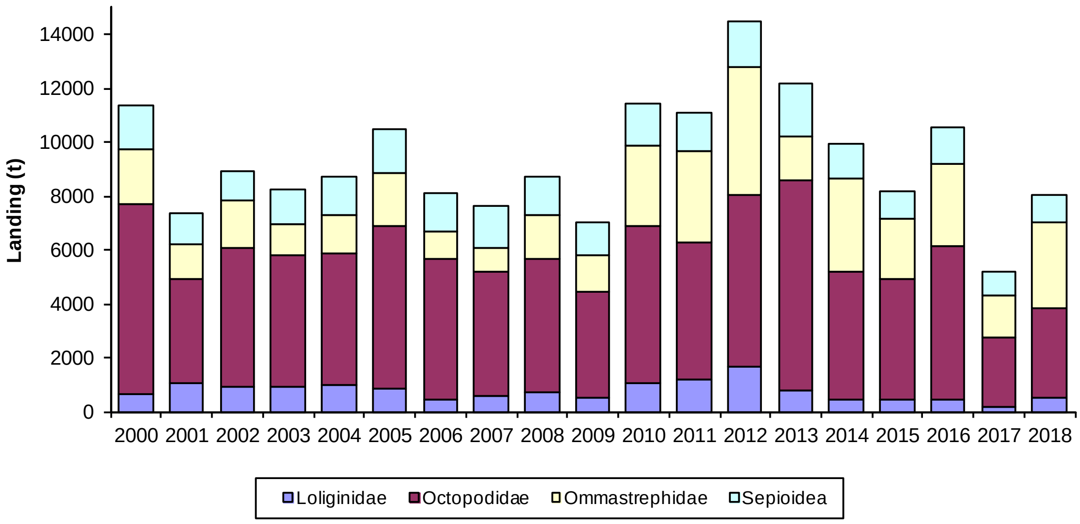
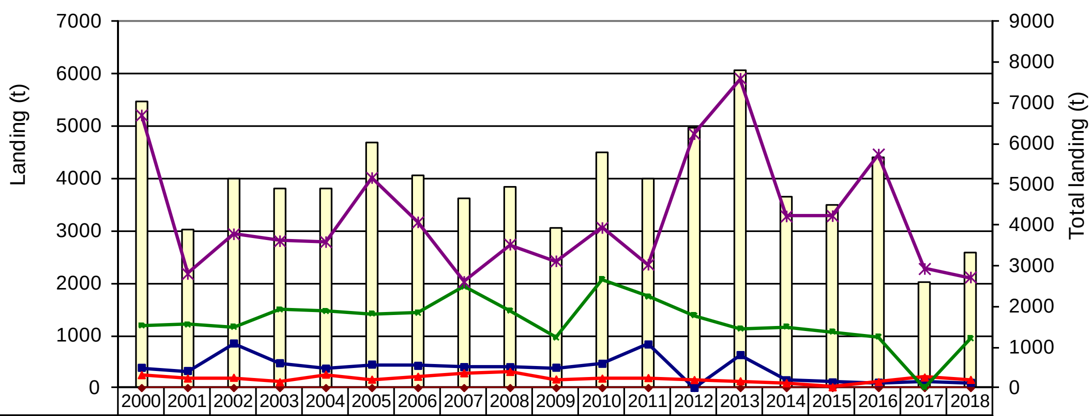



Figure 1. Spanish cephalopod annual landings (in tons) caught in the ICES area by species group for the 2000-2018 period.

### *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 27.9.a.s.

Figure 2 shows the total octopods landings trend by Subarea/Division in the last nineteen 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, catches were reduced by half (2606 t) increasing to 3316 in 2018.




| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 7032 | 3896 | 5150 | 4888 | 4882 | 6040 | 5238 | 4643 | 4920 | 3935 | 5776 | 5122 | 6391 | 7798 | 4689 | 4480 | 5654 | 2606 | 3316 |
| 27.7.6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 27.7.7 | 387 | 326 | 851 | 475 | 371 | 449 | 425 | 400 | 399 | 389 | 464 | 832 | 4 | 630 | 149 | 108 | 103 | 120 | 101 |
| 27.8.abd | 247 | 182 | 197 | 112 | 257 | 161 | 216 | 282 | 308 | 164 | 181 | 191 | 153 | 130 | 92 | 15 | 113 | 202 | 156 |
| 27.8.c | 1193 | 1209 | 1165 | 1498 | 1466 | 1421 | 1433 | 1933 | 1476 | 961 | 2075 | 1743 | 1387 | 1133 | 1172 | 1075 | 980 | 11 | 947 |
| 27.9.a | 5205 | 2179 | 2936 | 2804 | 2787 | 4010 | 3164 | 2027 | 2737 | 2421 | 3056 | 2355 | 4847 | 5905 | 3276 | 3283 | 4458 | 2274 | 2111 |

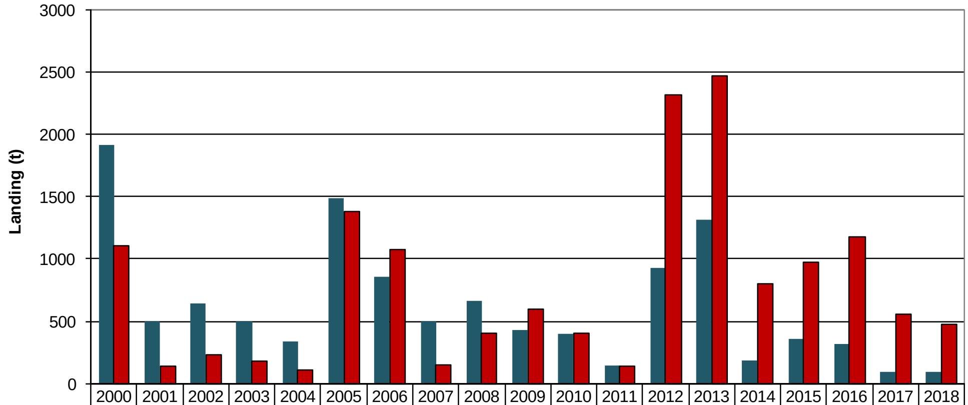
Figure 2. Spanish landings (in tons) of octopus species (Fam. Octopodidae) by ICES Subarea/Division for the 2000-2018 periods

More than 90% of octopodidae were caught along the Spanish coast (Divisions 27.9.a and 27.8.c), where common octopus *O. vulgaris* is the main species caught (Figure 3). In Division 27.8.c and Subdivision 27.9.a.n 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 27.9.a.s (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 4), along the time series. In the last years, the artisanal landings was highest than the trawl landings, providing between 70-85% 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 27.9.a.s contributes to the total landings from the Division 27.9.a 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 27.9.a.s, with the minimum values in 2011 (285 t) and maximum values in 2013 (3785 t). However, this interannual fluctuations are less pronounced in Subdivision 27.9.a.n. Possibly, such oscillations in Subdivision 27.9.a.s may be related with environmental changes such as rainfall and discharges of rivers (Sobrino *et al.*, 2002).

Most of the horned octopus *E. cirrhosa* is caught by the bottom-trawl fleet, which landings account for the bulk of the octopod landings in Subarea 27.7 and Subdivisions 27.8.abd. In the last years, the trend was decresing. Horned octopus landings in Division 27.8.c was of 137 t in 2018 (Figure 4), on average, of total octopods landings along the time series. In Sub-division 27.8.c-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.

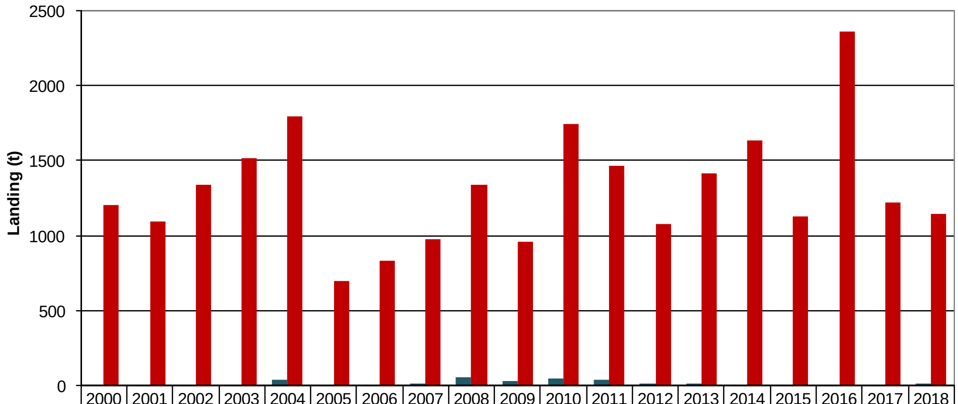
***Octopus vulgaris***

**Subdivision area 9.a.s**



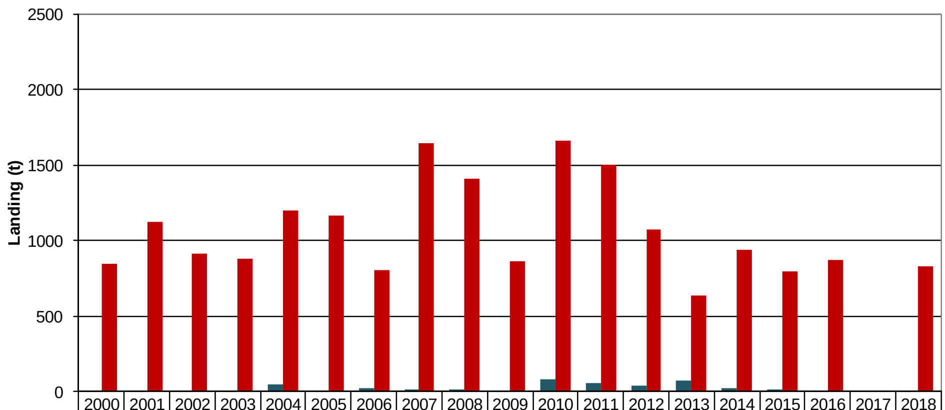

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Trawler fleet | 1915 | 498 | 645 | 496 | 342 | 1490 | 855 | 497 | 663 | 434 | 396 | 146 | 927 | 1317 | 187 | 359 | 321 | 97 | 90 |
| Artisanal fleet | 1101 | 139 | 234 | 182 | 112 | 1381 | 1077 | 149 | 402 | 595 | 403 | 139 | 2315 | 2468 | 803 | 974 | 1181 | 553 | 480 |

**Subdivision area 9.a.n**



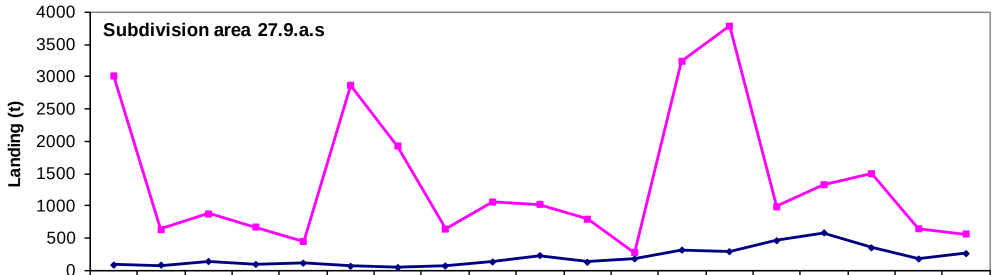

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Trawler fleet | 0 | 7 | 5 | 10 | 37 | 4 | 4 | 18 | 54 | 29 | 50 | 42 | 12 | 18 | 9 | 3 | 1 | 2 | 15 |
| Artisanal fleet | 1201 | 1097 | 1337 | 1518 | 1798 | 701 | 837 | 977 | 1342 | 958 | 1741 | 1463 | 1078 | 1416 | 1633 | 1133 | 2360 | 1218 | 1146 |

**Division area 27.8.c**

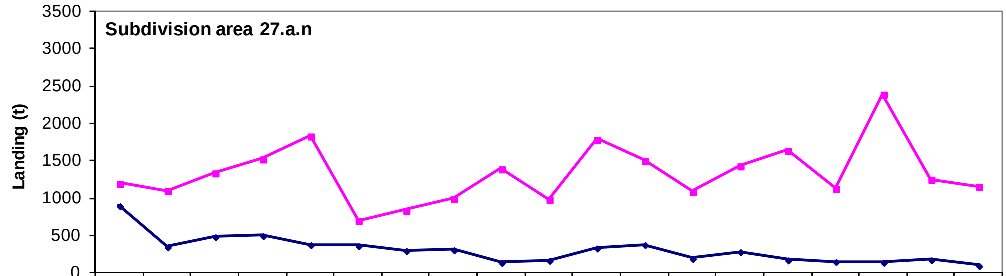



| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Trawler fleet | 6 | 7 | 4 | 5 | 51 | 4 | 23 | 15 | 16 | 3 | 80 | 55 | 37 | 76 | 20 | 17 | 7 | 0 | 3 |
| Artisanal fleet | 843 | 1126 | 914 | 881 | 1195 | 1168 | 802 | 1648 | 1412 | 860 | 1659 | 1502 | 1075 | 639 | 942 | 795 | 869 | 0 | 828 |

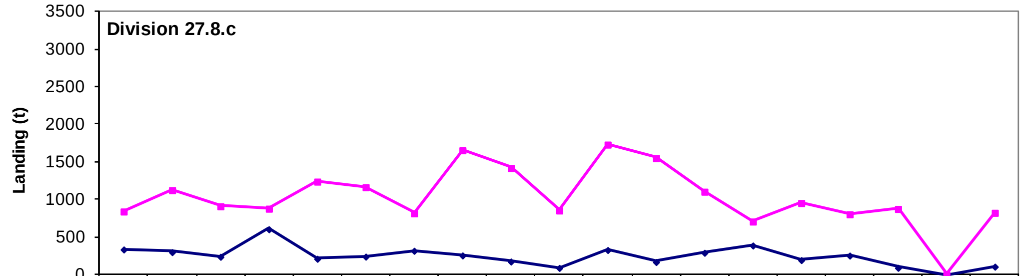
Figure 3. *O. vulgaris* landings (in tons) by fleet in Sub-division 27.9.a.s, Sub-division 27.9.a.n and Division 27.8.c, for the 2000-2018 period.




| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Eledone spp | 88 | 88 | 144 | 99 | 118 | 70 | 51 | 74 | 136 | 235 | 132 | 184 | 320 | 296 | 466 | 587 | 356 | 182 | 266 |
| O. vulgaris | 3016 | 638 | 879 | 677 | 454 | 2871 | 1932 | 646 | 1065 | 1029 | 799 | 285 | 3243 | 3785 | 990 | 1333 | 1503 | 651 | 570 |




| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Eledone spp | 901 | 350 | 486 | 501 | 380 | 364 | 301 | 311 | 141 | 170 | 335 | 380 | 194 | 286 | 175 | 154 | 144 | 176,8 | 99 |
| O. vulgaris | 1201 | 1104 | 1342 | 1528 | 1835 | 705 | 840 | 996 | 1395 | 987 | 1791 | 1505 | 1090 | 1435 | 1642 | 1136 | 2396 | 1256 | 1161 |




| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Eledone spp | 344 | 308 | 247 | 612 | 220 | 249 | 326 | 264 | 184 | 99 | 337 | 177 | 300 | 396 | 203 | 263 | 100 | 2,03 | 115 |
| O. vulgaris | 849 | 1133 | 918 | 886 | 1246 | 1172 | 825 | 1663 | 1428 | 863 | 1739 | 1559 | 1112 | 715 | 962 | 812 | 883 | 8,51 | 832 |

Figure 4. Octopodidae landings by species in Division 27.8.c and 27.9.a (north and south) for the 2000-2018 period.

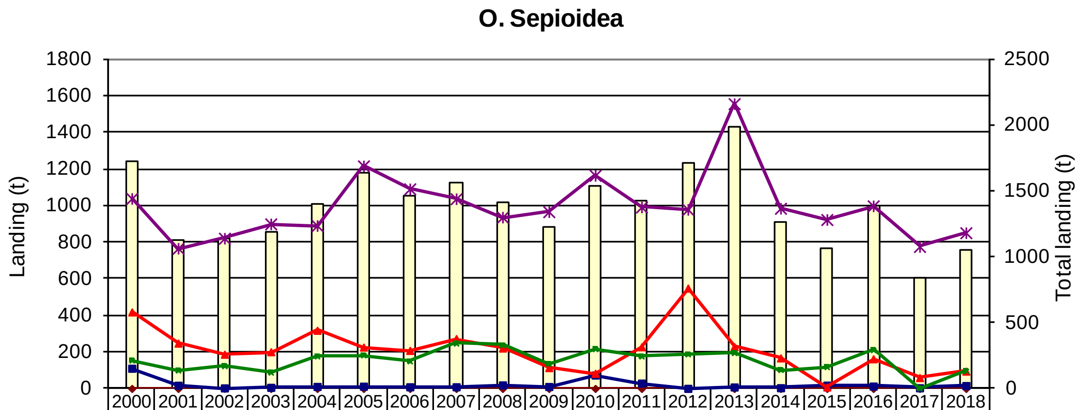
The contribution of Eledone spp. in the total cephalopod landings from Division 27.9.a was higher in Subdivision 27.9.a.n than 27.9.a.s. for period 2000-2018 but since 2014, the landing of Eledone in Subdivision 27.9.a.s was higher than 27.9.a.n. The percent of Eledone spp was 19,2-32 % in 27.9.a south and 5,7-12,3 in 27.9.a.n. In 2018, Eledone spp landings contributed with only 12 % to the total octopodidae catches in 27.9.a north but with 22 % in 27.9.a south (Figure 4).

In Subdivision, 27.9.a south, the main landed species is the musky octopus *E. 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 27.9.a south, there was an 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 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. In 2018 we observe a little recovery.

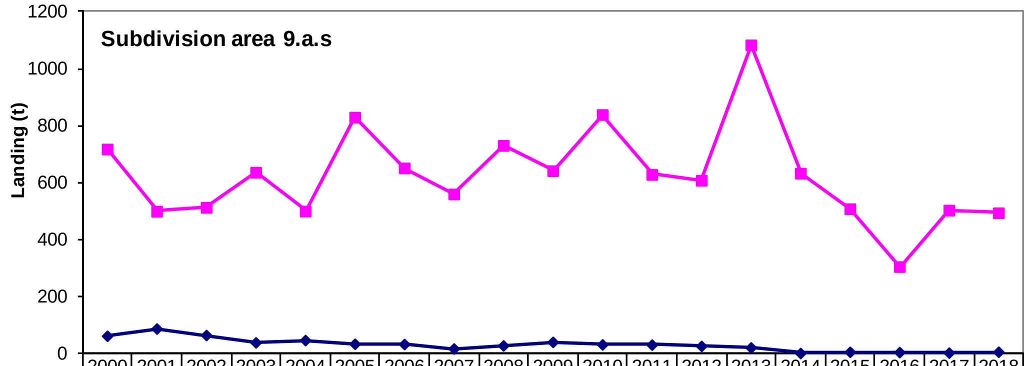
The average contribution of Division 27.9.a of total cuttlefish landings by the Spanish fleet is between 73% in 2012 and 92% in 2017. Most of this percent is provided by Subdivision 27.9.a.s (Gulf of Cadiz). Landings in Division 27.8.c increased at the end of the analysed period, reaching 117 t in 2015 and 210 in 2016, whereas in Division 27.8.abd 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 a minimum of 59 t in 2017, and only 8 t in 2015.  Landings in Subarea 27.7 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.




| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 1719 | 1129 | 1133 | 1193 | 1394 | 1635 | 1456 | 1563 | 1412 | 1224 | 1535 | 1423 | 1714 | 1985 | 1257 | 1066 | 1382 | 840 | 1057 |
| 27.7.6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 27.7.7 | 110 | 18 | 3 | 6 | 11 | 12 | 9 | 9 | 19 | 11 | 73 | 29 | 1 | 8 | 4 | 18 | 13 | 4 | 16 |
| 27.8.abd | 418 | 247 | 187 | 200 | 318 | 226 | 208 | 272 | 221 | 114 | 83 | 227 | 548 | 228 | 167 | 8 | 162 | 59 | 95 |
| 27.8.c | 154 | 99 | 123 | 88 | 176 | 182 | 149 | 246 | 237 | 134 | 216 | 176 | 187 | 194 | 102 | 117 | 210 | 1 | 96 |
| 27.9.a | 1037 | 765 | 820 | 899 | 889 | 1215 | 1090 | 1036 | 935 | 965 | 1164 | 991 | 978 | 1555 | 984 | 922 | 997 | 775 | 850 |

Figure 5. Spanish landings (in tons) of cuttlefish species (O. Sepioidea) by ICES Subarea/Division for the 2000-2018 period.

Cuttlefish (O. Sepioidea) landings from Subarea 27.7 and Divisions 27.8.abd 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 *S. officinalis* and *S. elegans* are present in landings from Divisions 27.9.a and 27.8.c. Data on the proportion of each species is only available for Subdivision 27.9.a.s, where *S. officinalis* makes up to 95% of cuttlefish landed (Figure 6). In this area, *S. elegans* and *S. orbignyana* appeared mixed in the landings, although the last specie is quite scarce. The commercial value of *S. elegans* is high, and for this reason is separated in the catch. During the 2014-2018 periods, the landings of *S. elegans* in Subdivision 27.9.a.s showed an important drop.



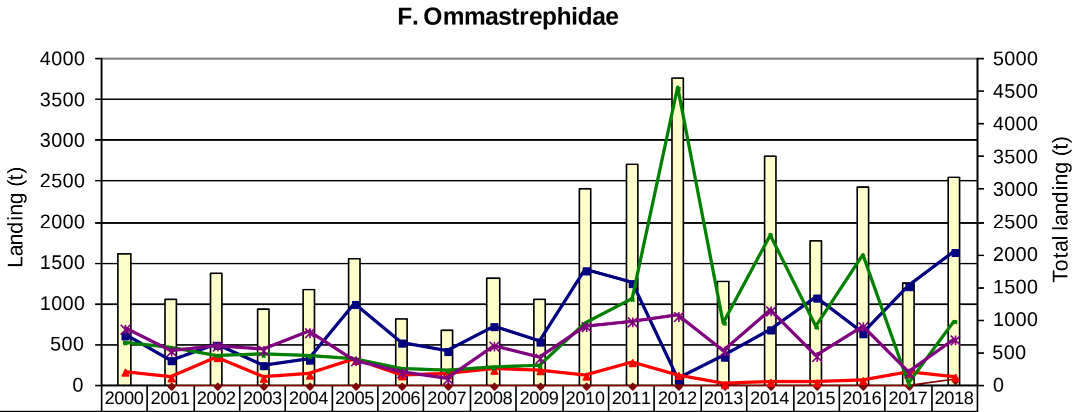

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S.elegans | 63 | 89 | 66 | 40 | 48 | 35 | 34 | 19 | 29 | 42 | 33 | 32 | 28 | 22 | 3 | 7 | 6 | 4 | 7 |
| S.officinalis | 718 | 500 | 514 | 637 | 501 | 830 | 652 | 561 | 731 | 642 | 839 | 629 | 609 | 1084 | 634 | 509 | 306 | 504 | 495 |

Figure 6. Sepiidae landings by species in Subdivision 27.9.a.s for the 2000-2018 period.

### *Ommastrephidae*

Short-finned squid landings (Fam. Ommastrephidae) comprise mainly broad-tail short-finned squid *Illex coindetii* and lesser flying squid *Todaropsis eblanae*. European flying squid *Todarodes sagitattus* also appears in catches, but it is very scarce. Figure 7 illustrates the trends of both total landings of short-finned squids and by Subarea/Division. Total landings presented a average value of 2139 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. In 2018 the landings was 3181 t.

The analysis by area shows scarce landings in Subarea VI throughout the time series. From 2000 to 2004, the Division 27.9.a contributed with the highest landings, ranging between 700 and 430 t. Since 2004, landings from Subarea 27.7 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 27.9.a experiencing a significant recovery in 2008. In 2010, all the Subareas and Divisions reached the maximum values, except Division 27.8.abd which presented a slightly decrease in relation to the previous years. At the end of the time series, both Division 27.9.a and 27.8.c showed considerable increases, mainly in Division 27.8 c, a value 300% greater than in 2011 (3651 t) was reached in 2012. Subdivision 27.9.a.s 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 27.7, which showed a significant recovery. The decrease was most important in Division 27.8.c, 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 27.7 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 27.8.c and 27.9.a. On the other hand, subdivisions 27.8.abd and 27.7 showed an increase of 2017 landings of this family in 2018, there were an increase in all areas except in 27.8.abd.




| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 2017 | 1305 | 1718 | 1164 | 1471 | 1950 | 1018 | 834 | 1636 | 1314 | 3023 | 3397 | 4718 | 1580 | 3508 | 2209 | 3042 | 1555 | 3181 |
| 27.7.6 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 73 |
| 27.7.7 | 616 | 313 | 501 | 252 | 320 | 1003 | 528 | 426 | 731 | 541 | 1413 | 1257 | 79 | 356 | 689 | 1080 | 643 | 1220 | 1641 |
| 27.8.abd | 172 | 101 | 351 | 98 | 136 | 315 | 127 | 141 | 196 | 190 | 124 | 289 | 133 | 20 | 48 | 42 | 69 | 156 | 109 |
| 27.8.c | 530 | 462 | 373 | 377 | 359 | 319 | 199 | 180 | 219 | 240 | 756 | 1062 | 3651 | 771 | 1848 | 722 | 1601 | 17 | 791 |
| 27.9.a | 699 | 429 | 492 | 438 | 656 | 312 | 164 | 87 | 491 | 342 | 730 | 788 | 854 | 433 | 923 | 365 | 729 | 162 | 568 |

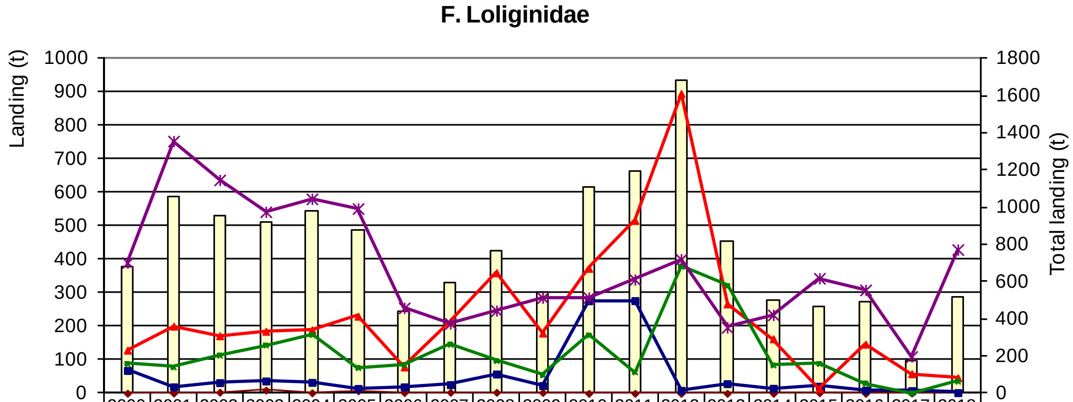
Figure 7. Spanish landings (in tons) of short-finned squid species (Fam. Ommastrephidae) by ICES Subarea/Division for the 2000-2018 period.

***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 27.9.a.s, showing low catch levels in Sub-Division 27.9.a.n during the same years.

Figure 8 shows the trend of total long-finned squid landings and by Subarea/Division. Total landings presented a maximum value 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 27.7. 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 27.8.abd and an appreciable increase in the 27.9.a. 2017 showed a decrease of total landings in general and in every area. In 2018, total landings present an increase respect to 2017. This increase is mainly due to the landings in the 27.9.a area.

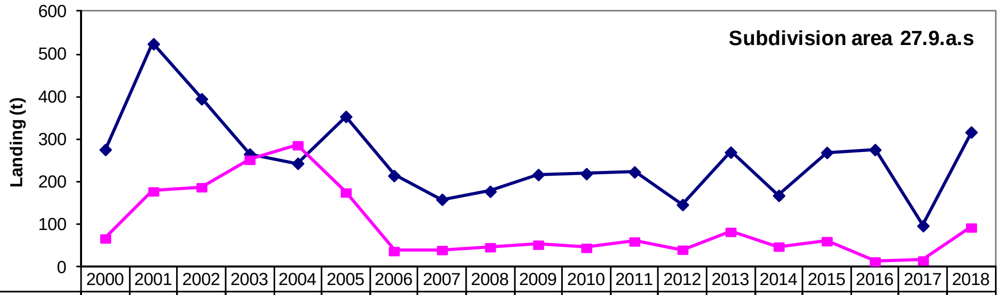
The analysis by Subarea/Division showed that the Division 27.9.a recorded the highest landings from 2001 to 2005, with values ranging between 753 and 552 t, respectively. The 2007 landings fell to 200 t and remained stable during three years with an increasing trend up to 2012 when the maximum value 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 27.8.abd and 27.8.c were lower than in 27.9.a, 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 27.8.abd, recovering 130 t in 2016 but decreasing again in 2017 remaining low in 2018. Landings in Subarea 27.7 were also very low as compared with other areas, but they showed a significant increase in 2010 and 2011, as also happened in Division 27.8.c and 27.8.abd. 2018, with 2 t, is the lowest value of landings in Subarea 27.7. 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 2018, and being almost zero en 2016.



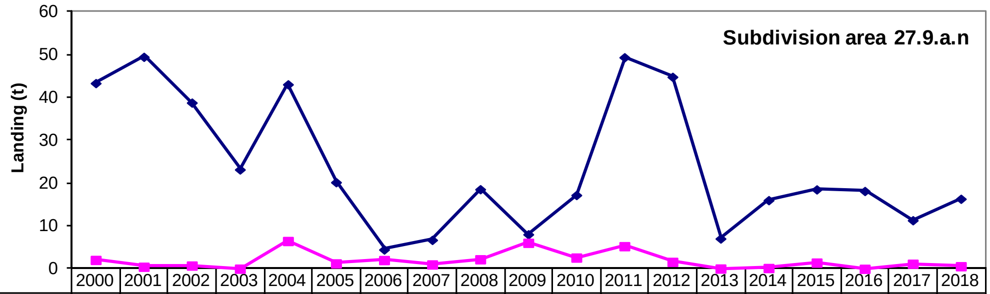

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 676 | 1052 | 958 | 917 | 980 | 880 | 441 | 598 | 765 | 546 | 1109 | 1196 | 1683 | 814 | 496 | 470 | 495 | 179 | 515 |
| 27.7.6 | 0 | 1 | 3 | 10 | 2 | 8 | 2 | 3 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 1 | 2 |
| 27.7.7 | 68 | 19 | 32 | 37 | 33 | 15 | 19 | 26 | 58 | 23 | 277 | 277 | 9 | 29 | 15 | 21 | 10 | 8 | 2 |
| 27.8.abd | 129 | 201 | 172 | 185 | 190 | 230 | 79 | 214 | 360 | 180 | 373 | 516 | 895 | 267 | 163 | 15 | 147 | 58 | 47 |
| 27.8.c | 88 | 78 | 113 | 144 | 175 | 76 | 85 | 146 | 97 | 55 | 173 | 63 | 378 | 321 | 84 | 88 | 30 | 1 | 36 |
| 27.9.a | 390 | 753 | 637 | 542 | 581 | 552 | 255 | 209 | 247 | 286 | 286 | 340 | 401 | 197 | 234 | 343 | 309 | 110 | 429 |

Figure 8. Spanish landings (in tons) of long-finned squid species (Fam. Loliginidae) by ICES Subarea/Division for the 2000-2018 period.

Both in Sub-divisions 27.9.a south and north, *Loligo spp* and *Alloteuthis* spp landings appear separated due to their high commercial importance. Figure 9 shows the proportion of each species group by Sub-Division. Both groups yielded higher landings in 27.9.a south than in 27.9.a.n. *Alloteuthis* spp landings in 27.9.a.s ranged between 286 t in 2004 (i.e. higher landings than *Loligo* spp ones in this year) and 38 t in 2006, whereas in 27.9.a 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 27.9.a.n, with landings of around 45 t. In 2013, the landings of these species decreased significantly in Subdivison 27.9.a.n, while in 27.9.a 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 27.9.a.s and almost zero in 27.9.a.n. However, Loligo sp showed a slight increase in 27.9.a.s and remained stable in 27.9.a.n. In 2017, Loligo sp. is still lower than in 2016 showing a increase in 2018 in both areas. Finally, it is worth mentioning that in the last few years *Alloteuthis africana* is also occasionally present in the Gulf of Cadiz (27.9.a.s) 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 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 | 317,8 |
| 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 | 93,69 |




| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 | 16,38 |
| 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 | 0,63 |

Figure 9. Long finned squid landings by species in Sub-Division 27.9.a.s and 27.9.a.n for the 2000-2018 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 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-27.7 exhibits the higher estimates of discards, while the smaller values were registered in the Sub-Division 27.9.a.s. The most discarded species for the time period 2003-2018 were *E. cirrossa*, with mean values around 47% of the total catch in subareas 27.7 and 48% in 27.8.c-27.9.a.n. The Ommastrephidae group accounted for 46% in the Sub-areas 27.7. 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 27.9.a south. These discard, for the period 2015-2018, oscillated between 2-16 % for *Eledone sp* and 0-6 % for *O. vulgaris*. The mean of discards in this period for *Loligo sp*, Ommastrephides and *S. officinalis*.was lower than 4% The highly multispecific nature of the OTB_MCD metier in the Sub-Division 27.9.a, 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 2. Estimated discarded fraction of the total catch for the main species/groups of species by Sub-area/Division. (2003-2018 period).

| | | Spain | % discard from total catches | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Metier** | **Area** | **Species** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | *Average* |
| OTB | 27.7.6+ 27.7.7 | *Eledone cirrhosa* | 59 | 34 | 51 | 46 | 67 | 60 | 72 | 39 | 71 | 97 | 13 | 53 | 24 | 28 | 14 | 30 | 47 |
| | | *Loligo spp.* | 52 | 24 | 73 | 80 | 92 | 65 | 26 | 12 | 4 | 35 | 1 | 1 | 11 | 33 | 25 | 0 | 33 |
| | | *Octopus vulgaris* | 0 | 100 | 100 | 91 | 0 | 0 | 0 | 37 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 21 |
| | | *Ommastrephidae* | 90 | 79 | 69 | 71 | 79 | 74 | 77 | 29 | 11 | 74 | 33 | 18 | 12 | 8 | 2 | 3 | 46 |
| | | *Sepia officinalis* | 77 | 9 | 6 | 77 | 5 | 22 | 2 | 0 | 1 | 95 | 22 | 1 | 0 | 0 | 0 | 0 | 20 |
| OTB | 27.8.c + 27.9.a.n | *Eledone cirrhosa* | 8 | 26 | 8 | 23 | 19 | 6 | 37 | 5 | 24 | 14 | 36 | 22 | 12 | 12 | 16 | 6 | 17 |
| | | *Loligo spp.* | 2 | 1 | 12 | 1 | 1 | 2 | 7 | 2 | 61 | 0 | 43 | 1 | 0 | 2 | 0 | 0 | 8 |
| | | *Octopus vulgaris* | 6 | 4 | 34 | 7 | 39 | 1 | 12 | 3 | 25 | 1 | 0 | 0 | 1 | 25 | 21 | 0 | 11 |
| | | *Ommastrephidae* | 11 | 27 | 19 | 11 | 21 | 19 | 14 | 7 | 27 | 6 | 73 | 4 | 7 | 1 | 22 | 2 | 17 |
| | | *Sepia officinalis* | 61 | 1 | 13 | 60 | 1 | 1 | 18 | 6 | 34 | 11 | 0 | 3 | 0 | 7 | 0 | 0 | 14 |
| PTB | 27.8.c + 27.9.a.n | *Eledone cirrhosa* | 0 | 0 | 64 | 63 | 94 | 32 | 90 | 96 | 37 | 1 | 0 | 95 | 100 | 98 | 0 | 0 | 48 |
| | | *Loligo spp.* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 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 |
| | | *Ommastrephidae* | 2 | 2 | 10 | 4 | 3 | 3 | 9 | 0 | 1 | 0 | 2 | 1 | 2 | 0 | 0 | 4 | 3 |
| | | *Sepia officinalis* | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13 |
| OTB | 27.9.a.s | *Alloteuthis spp* | - | - | - | 0 | 0 | 0 | 3 | 4 | 7 | 0 | 3 | 1 | 0 | 0 | 37 | 3 | 4 |
| | | *Eledone spp* | - | - | - | 0 | 1 | 5 | 17 | 19 | 11 | 0 | 4 | 2 | 2 | 5 | 16 | 2 | 6 |
| | | *Loligo vulgaris* | - | - | - | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 4 | 0 | 1 |
| | | *Octopus vulgaris* | - | - | - | 3 | 0 | 19 | 35 | 0 | 2 | 2 | 0 | 0 | 0 | 2 | 6 | 6 | 6 |
| | | *Ommastrephidae* | - | - | - | 0 | 0 | 0 | 2 | 6 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 14 | 2 |
| | | *Sepia elegans* | - | - | - | 0 | 0 | 2 | 9 | 3 | 1 | 0 | 21 | 5 | 0 | 10 | 0 | 2 | 4 |
| | | *Sepia officinalis* | - | - | - | 4 | 0 | 0 | 0 | 1 | 0 | 3 | 1 | 0 | 0 | 1 | 0 | 0 | 1 |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Average 2003-2018* | *Eledone cirrhosa* | 22 | 20 | 41 | 44 | 60 | 32 | 66 | 46 | 44 | 37 | 16 | 57 | 45 | 46 | 10 | 12 |
| | *Loligo spp./ L. vulga* | 18 | 8 | 28 | 20 | 23 | 17 | 8 | 4 | 16 | 10 | 12 | 0 | 3 | 9 | 7 | 0 |
| | *Octopus vulgaris* | 2 | 35 | 45 | 25 | 10 | 5 | 12 | 10 | 7 | 1 | 3 | 0 | 0 | 7 | 7 | 2 |
| | *Ommastrephidae* | 34 | 36 | 33 | 22 | 26 | 24 | 26 | 11 | 10 | 20 | 27 | 6 | 5 | 2 | 6 | 6 |
| | *Sepia officinalis* | 46 | 3 | 6 | 35 | 1 | 6 | 30 | 2 | 34 | 27 | 6 | 1 | 0 | 2 | 0 | 0 |

## References


Santos J., L. Silva, I. Salinas, H. Araujo and N. Pérez, 2012. Estimates on Cephalopods Discards by Spanish NE Atlantic Trawl Fishing Fleets. Working Document in Report of ICES Working Group on Cephalopods Fisheries and Life History (WGCEPH) ICES CM *2012*/SSGEF:04. 241 pp.

Silva, L., Sobrino, I., Ramos, F., 2004. Reproductive biology of *Eledone moschata* (Cephalopoda: Octopodidae) in the Gulf of Cadiz (south-western Spain, ICES Division 27.9.a). J. Mar. Biol. Ass. UK., 84, 1221-1226.

Silva, L., Vila, Y., Torres, M., Sobrino, I., Acosta, JJ., 2011.Cephalopod assemblages, abundance and species distribution in the Gulf of Cadiz (SW Spain) Aquat. Living Resour. 24, 13-26.

Sobrino, I., Silva, L., Bellido, J.M., Ramos, F., 2002. Rainfall, river discharges and sea temperature as factors affecting abundance of two coastal benthic cephalopod species in the Gulf of Cadiz (SW Spain). Bull. Mar. Sci., 71 (2), 851–865.

# Working Document: Preliminary diagnosis in Northeast Atlantic Cephalopod Stock using Stochastic Surplus Production models

## Working Document presented to the Working Group on Cephalopods Fisheries and Life History (2019)

*Not to be cited without prior reference to the authors*

**Angela Larivain[1], Ane Iriondo[2], Leire Ibaibarriaga[2], Michael Petroni[3], Anne Marie Power[3], Ana Moreno[4], Graham J. Pierce[5], Ignacio Sobrino[6], Vladimir Laptikhovsky[7], Esther Abad[8], Julio Valeiras[8], Jean-Paul Robin[1]**

1. UNICAEN, Normandie Univ., Biologie des ORganismes et Ecosystèmes Aquatiques BOREA (MNHN, UPMC, UCBN, CNRS-7208, IRD-207) CS 14032, 14032 Caen, France.
2. AZTI, Sustainable fisheries management, Txatxarramendi Ugartea z/g. E-48395 Sukarrieta - Bizkaia, Spain.
3. NUI, National University of Ireland Galway, Ryan Institute, School of Natural Sciences, Galway, Ireland.
4. IPMA, Instituto Português do Mar e da Atmosfera, Divisão de Modelação e Gestão dos Recursos da Pesca, Departamento do Mar e dos Recursos Marinhos, Rua Alfredo Magalhães Ramalho nº 6, 1495-006 Lisboa, Portugal.
5. IIM-CISC, Instituto de Investigaciones Marinas (Consejo Superior de Investigaciones Cientificas), Departamento de Ecología y Recursos Marinos, Eduardo Cabello 6, 36208 Vigo, Vigo, Spain
6. Centro Oceanográfico de Cadiz, Instituto Español de Oceanografía, Muelle Pesquero s/n, 11006 Cadiz, Spain
7. CEFAS, Group of Fisheries and Ecosystems Management Advice, Fisheries Division, Pakefield Rd. Lowestoft, Suffolk, NR33 0HT, U.K.
8. Centro Oceanográfico de Vigo, Instituto Español de Oceanografía, Subida a Radio Faro 50, 36390 Vigo, Spain

### Abstract

The lack of management leaves fishery resources vulnerable to increases in fishing pressure. In spite of their economic importance, most Northeast Atlantic cephalopod stocks are non-quota species with no catch or effort limits in large-scale fisheries and only some harvest control rules implemented at the local scale in inshore fisheries. Specific life traits and population dynamics in cephalopods are often argued to prevent the use of classical stock assessments methods i.e. cephalopods are short-lived, fast growing species, with highly plastic life history characteristics and wide year to year variation in abundance linked to environmental variation. Monitoring such species is also data-demanding and some of the largest EU cephalopod fisheries are not included in fishery data collection protocols. Over the past two decades, several stock assessment exercises were carried out in European cephalopods but the wide variety of models that were tested to tackle distinctive features of different species makes it difficult to compare results.

Surplus production models are among the oldest assessment tools adapted to data-limited situations. In their basic form, the maximum sustainable yield reference points that they provide (MSY, FMSY, BMSY) correspond to the long term average, which may not be very well adapted to cephalopods. Nevertheless, such preliminary diagnostics can be refined in a second step (for instance taking into account environmental variation).

In the present study, Generalised Surplus Production Models were fitted to abundance time series for several Northeast Atlantic cephalopod stocks, including loliginid and ommastrephid squid and cuttlefish, the distributions of which range from Scottish to Spanish and Portuguese fishing grounds. All models were fitted with the R package SPiCT (Stochastic production model in continuous-time) and the homogeneous protocol allowed comparisons between data sets. In

the nine cases presented, the model converged and the exercise provided useful preliminary diagnostics, allowing long-term trends in productivity to be considered reasonable in eight of them (only the exercise for *Loligo* at Rockall exercise showed unreliable outputs). For several loliginid stocks, results allowed statements to be made about whether biomass and fishing effort were above or below MSY reference values. However, results for Sepiidae and, especially, Ommastrephidae showed very wide confidence intervals, such that it was generally not possible to be sure whether biomass and fishing effort were above or below reference levels. The possible causes for this uncertainty will have to be explored.

The study is a first step to better understand how fishing fleets opportunistically exploit these resources and what aspects of their population dynamics are important to take into account to ensure sustainable fishing. Several refinements to the approach taken are proposed for future work.

**Key-words**: *Data-limited methods, Pella-Tomlinson model, SPiCT, biological reference points, cephalopods population dynamics, stock assessment.*

# I Introduction

Cephalopods are major resource for European fishing fleets with ~ 50 000 t tonnes landed per year (56 500 t on average in 2014-2018). Such commercially exploited stocks lack scientific advice whereas their abundance, productivity and sustainability remained undetermined or highly uncertain regarding the input of solely rare local measures. The need to better understand their stocks dynamics, particularly in North-eastern Atlantic waters, will allow their consideration in Fisheries Policy.

Different assessment tools have been proposed to determine the status of several EU cephalopod stocks during the past two decades. Depletion methods, cohort analysis and a two-stage biomass model were successfully applied to a range of stocks. However, while cohort analysis suggested that growth overfishing (and $F_{opt}$) might depend on cohort abundance, the two other methods do not include the estimation of Biological Reference Points (BRP) and thus were only used to quantify recruitment variability (Royer et al, 2002; Young et al, 2004; Royer et al, 2006; Gras et al, 2014).

Cephalopods, specifically cuttlefish, loliginid and ommastrephid squids and octopods fall under ICES category 3, which comprises stocks for which relative abundance indices exist, e.g. survey indices or fishery-dependent LPUEs and CPUEs, along with information on the mean length of animals in the catch), that can provide reliable indications of abundance trends. For a variety of reasons, quantitative assessments and forecasts for category 3 stocks are often considered to indicate only trends in fishing mortality, recruitment and biomass (ICES 2012a, b).

Since European fishing fleets are increasingly exploiting cephalopod resources, sustainable exploitation of these stocks is more and more desirable and thus diagnostics of stock status are needed. Instead of testing various tools in different cases the approach agreed was to apply a common assessment method to a series of data sets.

In the present study, we used data for loliginid squid, ommastrephid squid and cuttlefish. The Octopodidae are also important fishery resources. Among the Octopodidae species present in European shelf waters, although *Eledone* spp. are of minor commercial importance, *Octopus vulgaris* is of substantial importance in Spanish and Portuguese fisheries, especially small-scale fisheries. In the Gulf of Cadiz, the influence of environmental variables on the population dynamics of *Octopus vulgaris* has been modelled (Sobrino et al 2020, see also previous WGCEPG reports). We aim to include octopus in the next round of assessment exercises.

Following the recommendations of ICES WKProxy (ICES, 2016) and WKLIFE (ICES, 2012b, 2017), the objective of this work was to apply a Stochastic Surplus Production Model in Continuous Time (SPiCT) (Pedersen & Berg, 2017) to provide a preliminary assessment for a range of cephalopods stocks in the Northeast Atlantic, thus to obtain comparable results and provide a basis for further analysis (ICES, 2016), with the ultimate aim of facilitating routine stock assessment in support of management. In contrast to other production models, SPiCT models both stock dynamics and the dynamics of the fisheries, thus enabling error in the catch process to be reflected in the uncertainty of estimated model parameters and reference points (Pedersen & Berg, 2017).

# II Material & Methods

In each of the assessed stocks surplus production models require minimally total catch data and an abundance index (which can be obtained from research surveys or derived from commercial data).

### 1.1. Stock definition

Reflecting the fact that European cephalopod stocks are not formally assessed there is no current formal definition of stocks. Previous genetic studies have tended to confirm what might be expected based on the mobility of these species: there is less evidence of the existence of separate stocks in those species which routinely undertake longer migrations (Trites, 1983; Sims et al, 2001; Wolfram et al, 2006). Thus we would expect fewest distinct stocks in ommastrephids, followed by loliginids, cuttlefish and octopus. Previous studies on *Loligo forbesii* indicate a single genetic stock throughout European coastal waters, with some evidence of differences in offshore areas (Rockall, Faroe) and only one clearly differentiated stock, in the Azores (Brierley et al. 1995; Shaw et al. 1999). However, the situation is complicated by the presence of multiple species within commercial fishery categories and often also within survey data categories. Thus, the two *Loligo* species are rarely distinguished from each other. Therefore, decisions about stock definition for the purposes of assessment are necessarily pragmatic. The management units (i.e. pragmatic stocks) that are selected in this study are based on groups of ICES divisions that ICES WGCEPH has used since 1992 to monitor trends in Northeast Atlantic Cephalopod fisheries.

### 1.2. Landings data

Total landings by country and ICES divisions are compiled by calendar year (January-December) by ICES WGCEPH. In recent years this is derived from the ICES data call (see Table 1). Non-reported values were considered as missing (NA) and limited gaps can be taken into account in the fitting procedure. Discards data suggest that discarding occurs only in areas where cephalopod catch is low (ICES, 2019). For example, onboard observations provided by the Ifremer program "OBSMER" and to France's and UK's declarations, there is a low squid discard level in the English Channel, always below 6% (ICES, 2011; 2017). Thus, in this study, discards are considered to be negligible.

**Table 1:** Cephalopods stocks used for SPiCT assessments in Northeast Atlantic Waters.

ToR A table is the compilation of annual landings statistics carried out by WGCEPH. (in two stocks landings figures preceeded by "<" are overestimates computed for the whole 9.a division). Survey acronyms are as follows: Marine Scotland Science (MSS), Scottish West Coast International Bottom Trawl Survey (SWC-IBTS), Scottish Groundfish Survey (SCOGFS), Irish Groundfish Survey (IGFS), EValuation des ressources Halieutiques de l'Ouest Européen (EVHOE), North West Groundfish Survey (NWGFS), Channel Groundfish Survey (CGFS), Spanish Ground Fish Survey on the Gulf of Cádiz (SP-ARSA), Portuguese International Bottom Trawl Survey (PT-IBTS). Abundance indices derived from commercial fishery statistics: France Otter Bottom Trawl delta-GLM standardized LPUE (FR-OTB std.LPUE), Spain Otter Bottom Trawl LPUE (SP-OTB-LPUE) Landings figures for each group are Average Annual landings (tons) and this figures expressed as a percentage of the total Northeast Atlantic landings. See Appendix A for further details of survey indices.

| Group | AREA | Figure | Landings | Data sources and time periods | |
|---|---|---|---|---|---|
| | | | | Origin of catch data | Origin of survey abundance indices |
| **Loliginidae** | 6.a; 7.b,c | 1 | 532 (6%) | ToRA table (1992-2018) | 2 MSS (1981 -2012), SWCIBTS + SCOGFS (1997-2018), IGFS (2003 -2018) |
| | 6.b | 2 | 315 (3%) | ToRA table (1992-2018) | MSS (1981 - 2018) |
| | 7.a; 7.f; 7.g,h,j,k | 3 | 996 (10%) | ToRA table (1992-2018) | EVHOE (1997-2018), NWGFS (1988-2018) |
| | 7.d,e | 4 | 3,577 (36%) | ToRA table (1992-2018) | FR-OTB std.LPUE (1989-2018), CGFS (1990-2017) |
| | 8 a,b,d | 5 | 1,856 (19%) | ToRA table (1997-2016) | EVHOE (1992-2016) |
| | 9.a.s | 6 | <962 (10%) | PT + ES landings (1993-2018) | SP-ARSA (March) + PT-IBTS (Nov.) (1993-2018) |
| **Sepiidae** | 7.d,e | 7 | 10,495 (57%) | ToRA table (2001-2018) | FR-OTB LPUE (2001-2018) |
| | 8. abd | 8 | 4,695 (19%) | ToRA table (2000-2018) | FR-OTB LPUE (2000-2018) |
| **Ommastre-phidae** | 8.c; 9.a n | 9 | <1,073* (31%) | ES landings (2000-2018) | SP-IBTS + SP-OTB-LPUE (2000-2018) |

### 1.3. Abundance indices from surveys

Research trawl surveys are seldom designed specifically to describe cephalopod abundance and the seasonal timing or spatial extent may not always correspond to the species life cycle. Nevertheless, rigorous protocols and species identification make time series of survey indices a major source of time series of abundance indices. All surveys used in the assessments are listed in table 1 (with more details in Appendix A).

### 1.4. Commercial catch-effort data: standardised landings per unit effort (lpue)

When fishery-independent data is not available commercial catch and effort data can be used to derive abundance indices provided biases related to changes in the fishery are properly taken into account. The standardization procedure is based on the Delta-GLM method (Stefansson, 1996; Gras et al., 2014). This approach is designed to extract the temporal component of the LPUE data while disentangling it from other effects such as changes in the spatial distribution of the fleet or distribution of the animals, changes in the size of the boats, changes in the seasonality of the abundance, giving the best image of inter-annual variation in the whole area.

French commercial landings and effort data were extracted from national databases maintained by the French ministry for fisheries (Direction des Pêches Maritimes et de l'Aquaculture (DPMA)) and Ifremer (Système d'Information Halieutique (SIH)). Commercial squid and cuttlefish landings (kg) and effort (hours of trawling) for French bottom otter trawls (OTB) were collected by fishing sequence (i.e. groups of hauls carried out during the same day and within the same ICES rectangle), year, months, ICES statistical rectangle and engine power class.

In the case of Loliginidae, species are not distinguished in French commercial data. Therefore, the standardized times series describe the abundance of the mix of *Loligo forbesii* and *Loligo vulgaris* in the English Channel (7.d and 7.e).

In the cuttlefish *Sepia officinalis*, the same initial database was used (French OTB detailed catch and effort data) but engine power ship class was missing, so LPUE values are averaged by year (in a shorter period: 2001-2018), accounting for effects of the previously mentioned variables except for power. The assessments based on these "lpue-derived indices" are listed in table 1.

It is worth noting that in spite of the heterogeneous distribution of fishing activities (both in time and space) commercial data is abundant and corresponds to a wider temporal extent than survey data. Besides, cephalopods being no-quota species are less susceptible to misreporting than managed resources. Detailed fishery statistics needed for the standardization procedure are now included in the WGCEPH data call and in the English Channel UK beam trawl data has already been used to model cuttlefish abundance (Gras et al, 2014).

### 1.5. Model

The population dynamics is described in terms of biomass and the model combines the main biological processes (recruitment, growth, natural mortality) in a single function. Only catches and abundance/biomass indices are required to fit the model. The approach is based on the deterministic state equation of the Pella-Tomlinson model (Pella and Tomlinson, 1969):

$$\frac{dB_t}{dt} = rB_t\left(1 - \left[\frac{B_t}{K}\right]^{n-1}\right) - F_tB_t,$$

Where *r* is the intrinsic growth rate parameter, *k* the carrying capacity and *n* the asymmetry parameter of the production curve. This latter parameter allows the surplus production function to be asymmetric with respect to the biomass and determines the maximum level of productivity.

SPiCT (R package, version 1.2.7) was used to fit a stochastic surplus production model in continuous time to abundance index series for several cephalopods stocks occurring in Northeastern Atlantic waters. The model incorporates both fisheries and biomass dynamics and also observation errors for both catches and biomass indices (Pedersen and Berg, 2017). The package, available on GitHub (https://github.com/DTUAqua/spict), is still under development.

For each stock, the input data applied in SPiCT runs are listed in Table 1.

Default priors were used as follows: *n* around 2; $\alpha$=$\beta$=1. An attempt to impose preliminary estimated priors was carried out for the stock of *Loligo vulgaris* in the Gulf of Biscay (8.abd) (16 runs), see **supplementary** material for details about the different runs for this particular stock.

# III Results

Surplus production models were fitted with SPiCT for the nine stocks listed in Table 1. Fisheries characteristics have been described in WGCEPH reports (see for instance ICES 2019) and there is no need to repeat this here. However, it is worth to remind that most stocks are shared resources that can be exploited (at least at some time in the year) by different countries.

## III.1 – Loliginidae assessment

### West Coast of Ireland and Scotland (6.a and 7.b,c)

For this stock, five abundance indices were included in the assessment: two derived from Marine Scotland Science (MSS) (divisions 6.a and 7.b.c, separately), two from DATRAS (divisions 6.a and 7.b.c, separately) and one from the Irish Groundfish Survey (IGFS) (division 7.b.c only). See Appendix A for description of data and sources. The MSS aggregated dataset may be less reliable than the DATRAS dataset since it is a combination of surveys not all standardised in the same way, using various gears and sampling strategies. Despite this, both data sets showed similar trends for the period in common and model would not converge without the MSS dataset.

This stock probably comprises mainly *L. forbesii* although the two European *Loligo* species are not distinguished in the landings data, as *L.vulgaris* is rare in the area.

The model diagnostics (Fig. 1 and Fig.1.A in Appendix B) were considered satisfactory, except that autocorrelation was evident at lag 1 for the abundance index from the Scottish Surveys (DATRAS) in division 6a. The model also provided a consistent performance until the early 2000s, after which becomes slightly noisy towards the present day (Fig 1.1.B Appendix B). The production curve (Fig. 1) was skewed slightly to the left as might be expected for cephalopod stocks, which are characterised by very high growth rates, particularly at low densities. With increasing densities, the population production might decline not only because of competition for food etc., but due to cannibalism within animals of the same generation – a particular trait of cephalopods (Ibañez & Keyl, 2010) (Fig 1.).

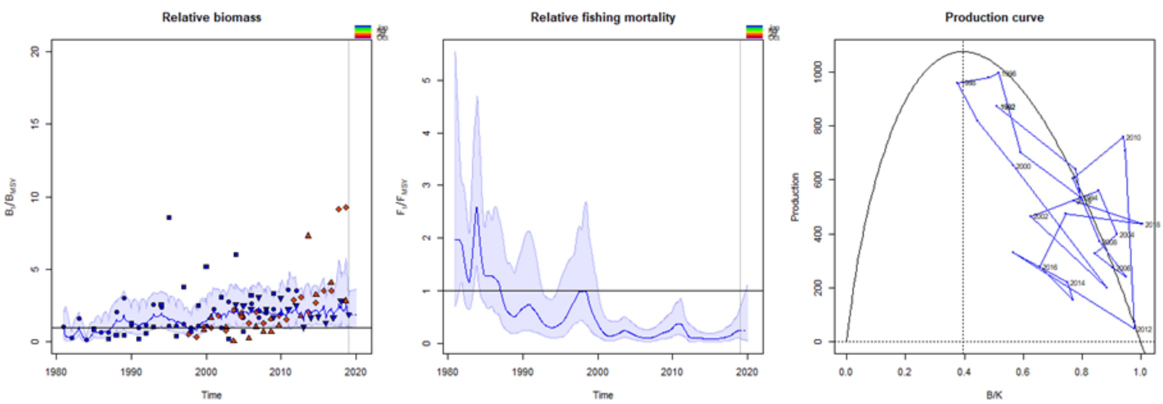



**Figure 1. Stock metrics of Loliginidae for West Coast of Ireland and Scotland (6.a and 7.b,c) estimated by SPiCT. Ratios of biomass ($B/B_{MSY}$) and fishing mortality ($F/F_{MSY}$) and production curve given. The relative biomass plot axes were adjusted to provide a clear image of the confidence interval widths.**

The Irish-Scottish West Coast stock status appears to be fished sustainably with in recent years the biomass above that of optimal exploitation ($B/B_{MSY}>1$) and fishing mortality below that of optimal exploitation ($F/F_{MSY}<1$)

## Rockall (6.b)

The SPiCT model produced overall unsatisfactory results whereby convergence was achieved but produced very wide confidence intervals. Nevertheless, given the great importance given to Rockall as a squid hotspot (referred to as 'squid alley' by fishers), the results are presented here. The stock of interest was represented by mixture of two European *Loligo* species in the landings data, but the abundance indices effectively consisted of *L. forbesii* using a CPUE index generated by combining Marine Scotland Science (MSS) survey data from 1981 to 2018. The model diagnostics (Fig 2 and Fig 1.2.A in supplementary material) produced otherwise satisfactory results, other than evidence of autocorrelation in the abundance index at Lag 2. The model also provided somewhat consistent but noisy performance in retrospective (Fig 1.2.B in supplementary material) and a bizarre production curve skewed slightly to the left but extending into negative productivity values (Fig 2.).

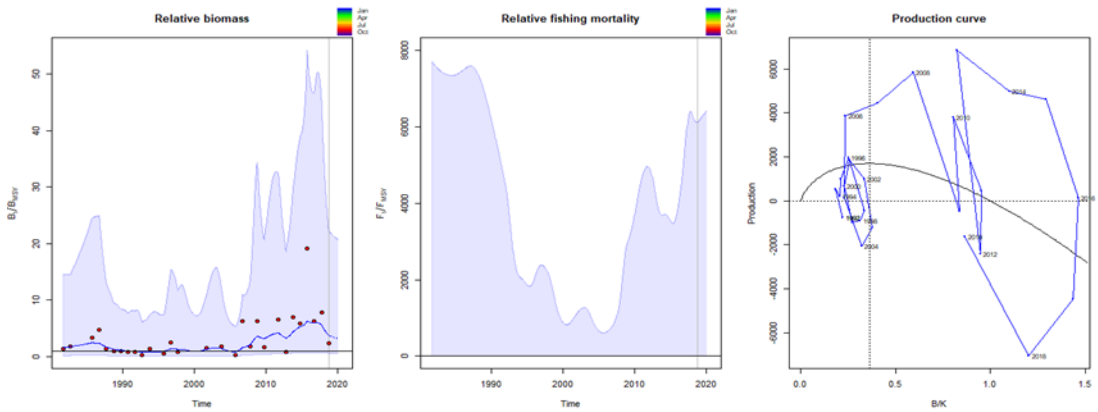



**Figure 2. Stock metrics of Loliginidae in Rockall (6.b) estimated by SPiCT. Relative biomass and fishing mortality and production curve given.**

Results suggest that B> $B_{MSY}$ but the relation between fishing mortality and $F_{MSY}$ could not be assessed with any confidence. Given the degree of uncertainty, as well as the reliability of the data, it would not be recommended that outputs such as these, be used for management decisions. The lack of reliable data, however, clearly highlights the need to further surveying efforts in this area if reliable stock management advice is to be given.

## Irish and Celtic Seas (7.a, 7.f and 7.g,h,j,k)

The stock of interest was represented by mixture of two European *Loligo* species in the landings data, but the abundances effectively consisted of *L. forbesii*. Two abundance indices of CPUE were input from the North West Groundfish Survey (NWGFS) covering areas 7.a,f,g from 1988 to 2018 and the French EVHOE survey covering area 7.g,h,j,k from 1997 to 2018.

The model diagnostics (Fig 1.3.A Appendix B) were considered satisfactory, with Catch data showing several minor issues with autocorrelation and non-normality. The model provided a consistent performance (Fig 1.3.B Appendix B) and production curve skewed slightly to the left as expectable for cephalopod stocks (Fig 3).

The Irish and Celtic Seas stock was assessed to be in a good condition and exploited sustainably as $B>B_{MSY}$ and $F<F_{MSY}$ with favourable forecast (Fig 3.). The SPiCT likely might be applied to its assessment in future.

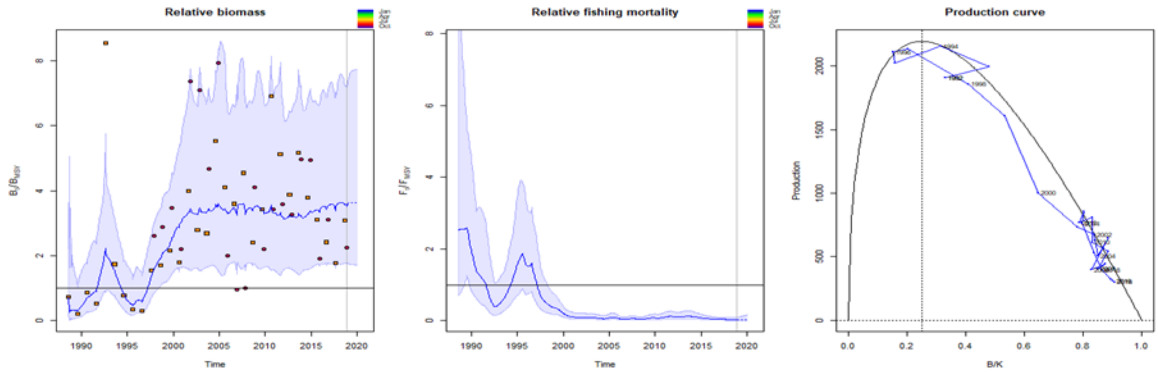



**Figure 3. Stock metrics of Loliginidae in Irish and Celtic Seas (7.a, 7.f and 7.g,h,j,k) estimated by SPiCT. Relative biomass and fishing mortality and production curve given.**

## English Channel (7.d and 7.e)

The stock of interest is regrouping both species of Loligo (*L. vulgaris* and *L. forbesii*. Data landings provided an annual coverage through January-December from 1992 to 2018. Two abundance indices were used: CPUEs from the Channel Ground Fish Survey (CGFS) from 1990 to 2017 (September-October) and standardised French commercial LPUEs (through the all year) for selected region (7.d and 7.e). The distinction between the two *Loligo* species was possible and computed in the LPUE series according to the species proportions sampled at the Port-en-Bessin fish market each month by the University of Caen, France since 1993.

The model diagnostics (Fig. 4 and Fig 1.4.A Appendix B) were considered satisfactory as the result did not point significant bias (mean of the residuals different from zero) or auto-correlation from LPUE index. Both QQ-plot and the Shapiro test shows normality in the residuals. The retrospective pattern (Fig 1.4.B Appendix B), demonstrated reasonably consistent trend in recent biomass being at or slightly below $B_{MSY}$, and fishing mortality being at or slightly above $F_{MSY}$. The shape of the production curve seems to indicate a Schaefer model (n = 2) and according to the KOBE-plot (Fig 4. bottom right).

## Bay of Biscay (8.a,b,d)

In this area Loliginid resources are most likely dominated by *Loligo vulgaris*. Species-specific EVHOE survey data indicate that in autumn *L. vulgaris* represents on average 83% of biomass indices (ICES, 2019). A series of 16 different initial conditions were tested in order to obtain convergence of the SPiCT fitting procedure (Table 2) and model selection was based on the lowest AIC.

Results of the retained model (alpha=beta=1 and n=2; Schaefer model) are still highly uncertain, with graphs showing huge confidence intervals (Fig. 5). Thus, biological reference points derived from this exercise should be considered as preliminary indications. Fishery diagnostics suggesting $B/B_{MSY} > 1$ and $F/F_{MSY} > 1$ should also be considered as preliminary indications. It is worth noting however that these ratios are similar to those of a surplus production model fitted to the same stock a few years ago with a Bayesian procedure (Ibaibarriaga et al, 2015).

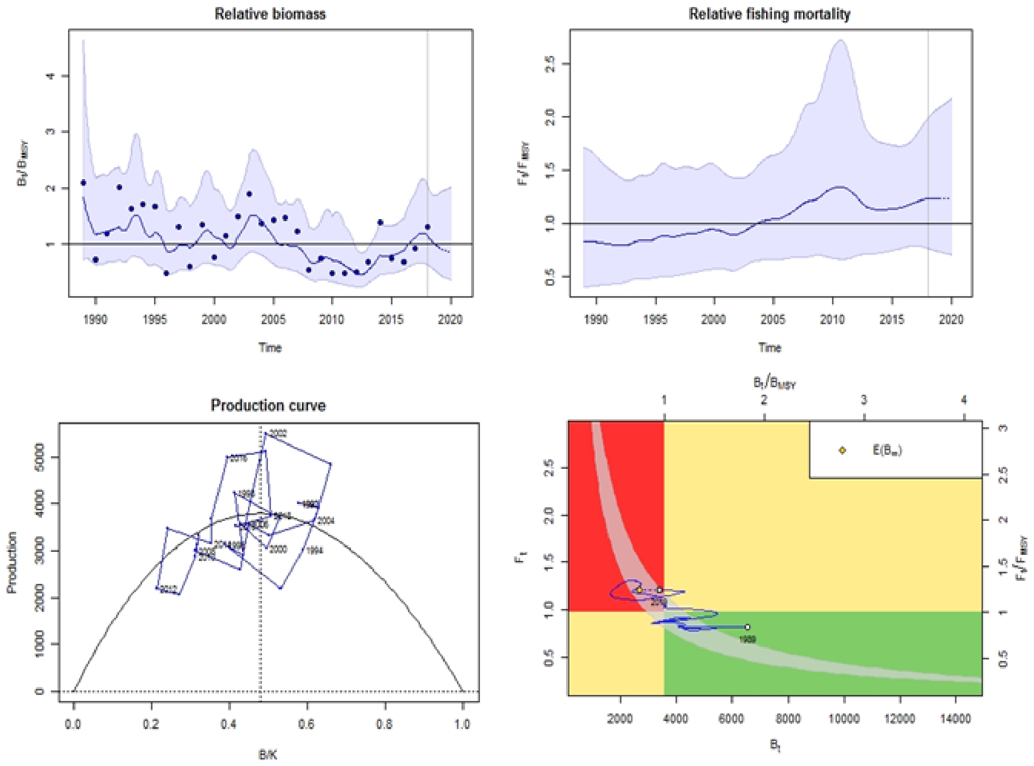



**Figure 4.** Stock metrics of Loliginidae in the English Channel (7.d and 7.e) estimated by SPiCT. Relative biomass and fishing mortality, production curve and KOBE-plot are given

**Table 2.** Different cases conducted. trying to fix model priors. Red cases did not converge. green did and Case 6a* is the one retained giving best model fitting (Schaeffer model).

| SPICT | n=estimated | n=2 | n=estimated Prior r | n=2 Prior r |
|---|---|---|---|---|
| No priors | Case 0a | | Case 0b | |
| α estimated β estimated | Case 1a Case 2a | Case 5a | Case 1b Case 2b | Case 5b |
| α=1, β=1 | Case 3a | **Case 6a*** | Case 3b | Case 6b |
| α=4, β=1 | Case 4 | Case 7a | Case 4b | Case 7b |

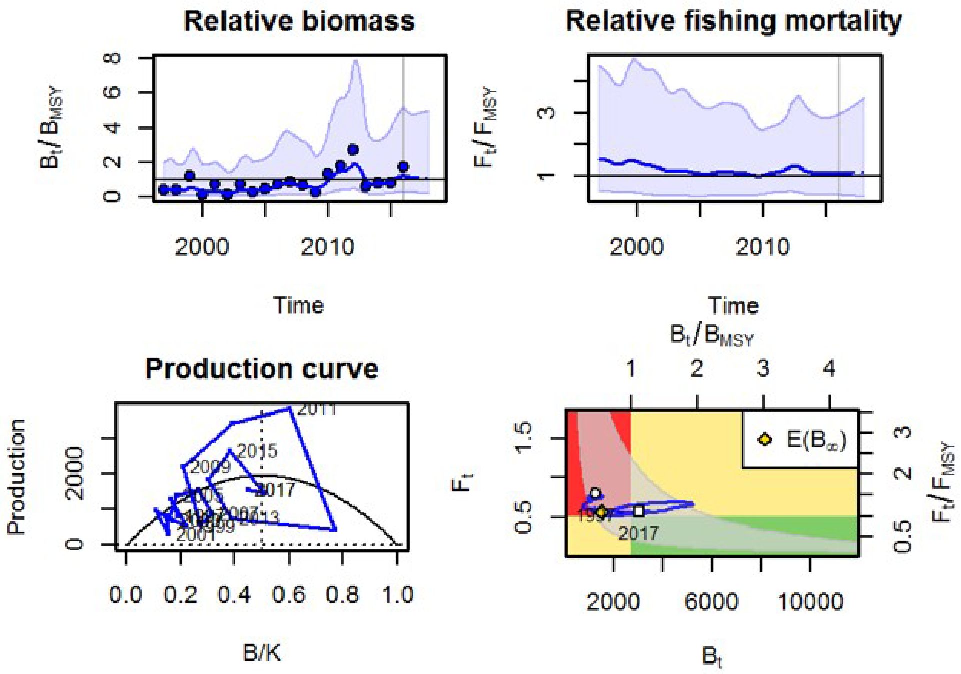



Figure 5. Stock metrics of Loliginidae in the Bay of Biscay (8.a,b,d) estimated by SPiCT. Relative biomass and fishing mortality, production curve and KOBE-plot are given.

## Gulf of Cadiz (9.a south)

Combined landings of artisanal and trawl fisheries and CPUEs of 2 research surveys (March for Spain and November for Portugal) for 1993-2018 period were used.

The stock of interest was represented by mixture of two European *Loligo* species, but effectively consisted of *L.vulgaris*, as *L.forbesii* is rare in the south of Iberian Peninsula. The model diagnostics were considered to be satisfactory (Fig 1.5.A Appendix B).

The model also provided a consistent performance in retrospective (Fig 1.5.B Appendix B) and a production curve with the peak shifted left as expectable for cephalopod stocks (Fig 6.). The stock was assessed to be in a good condition and exploited sustainably as $B>B_{MSY}$ and $F<F_{MSY}$ with favourable forecast (**Fig 5.**). The SPiCT likely might be applied to its assessment in future.

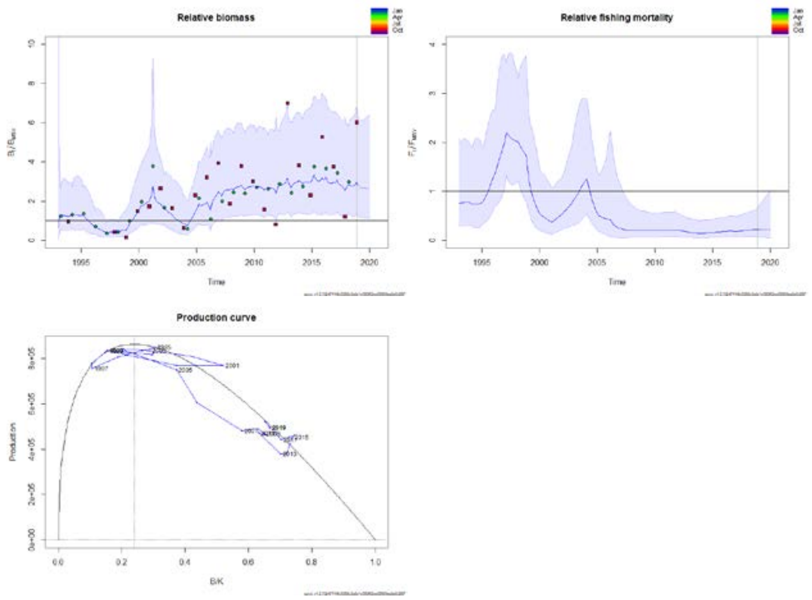



Figure 6. Stock metrics of Loliginidae in Gulf of Cadiz (9.a south) estimated by SPiCT. Relative biomass and fishing mortality and production curve given.

## III.2 – Sepiidae assessment

### English Channel (7.d and 7.e)

Here we consider *Sepia officinalis* annual landings from 2001 to 2018. French Otter Bottom Trawl catch and effort data were used to compile a time series of annual average abundance index for the period 2001-2018 and for the selected area (ICES divisions 7.d and 7.e).

The SPiCT model seemed to be acceptable for this assessment unit. The model's output shows reasonable confidence intervals. However, although the best estimates of B and F in 2018 suggest overexploitation, confidence intervals are too wide to be certain of this (**Fig. 7**). The model diagnostics (Fig 1.6.A Appendix B) were considered satisfactory as the result did not show significant bias (mean of the residuals different from zero) or auto-correlation from LPUE index. Both the QQ-plot and the Shapiro test showed normality in the residuals.

The stock was assessed to be in a good condition and exploited sustainably between 2001 and 2016 as $B>B_{MSY}$ and $F<F_{MSY}$ with favourable forecast but the possible recent overexploitation needs further investigation (**Fig 7.**).

Following WKLIFE and WKDLSLSS advice about the **1 over 2 rule**, abundance variation was tested for cuttlefish through survey and commercial indices for 2017-2018 and 2018-2019 (Table 3).

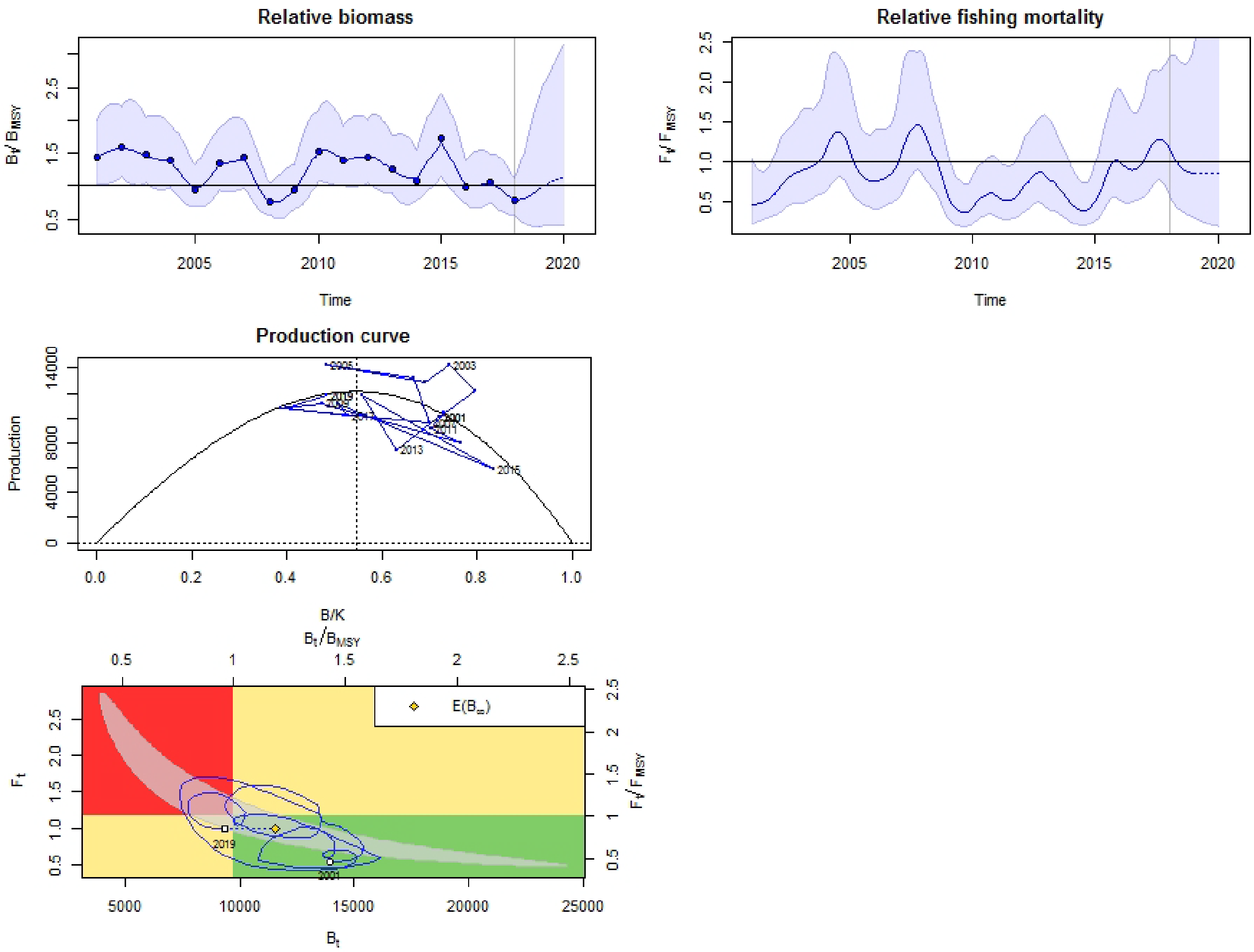



**Figure 7. Stock metrics of Sepiidae in English Channel (7.d and 7.e) estimated by SPiCT(1.2.7). Relative biomass and fishing mortality, production curve and KOBE-plot are given.**

**Table 3.** Application of the 1 over 2 rule to trends in catches and in abundance in English Channel cuttlefish ($X_t$ = value of variable X for Year t)

| Calculation | Total catch | Abundance Indices | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | st.FR LPUE | CGFS nb | CGFS biomass | BTS 7d | SW BEAM | TBB oct | TBB nov | surveyQ1 |
| $X_{2018}$ / (mean ($X_{2016}$, $X_{2017}$)) | 77.8% | 71.1%* | | | | 74.6% | 53.4% | 89.0% | 116.6% |
| $X_{2017}$ / (mean ($X_{2015}$, $X_{2016}$)) | 97.3% | 102.5% | 44.94% | 35.46% | 90.08% | 115.9% | 123.9% | 105.9% | 91.6% |

***Cuttlefish declined by 28.9% in abundance in 2018-2019 according to commercial fisheries data.**

## Bay of Biscay (8.abd)

The stock of interest is also mainly considering *S. officinalis* annual coverage landings from 2000 to 2018. French commercial landings were used to compile an abundance index averaged for 2000-2018 period for selected region (8.abd).

The SPiCT model result is uninformative for this assessment unit as confidence intervals are very wide. Nevertheless, the trend of the model output suggests overexploitation between 2000 and

2010 with F>$F_{MSY}$ and B<$B_{MSY}$, and since 2010 the exploitation seems stabilised at an underexploited level with F<$F_{MSY}$ and B>$B_{MSY}$. Biomass was especially high in 2016 (**Fig. 8**). This model could be further investigated using abundance index series from other countries like Portugal or Spain.

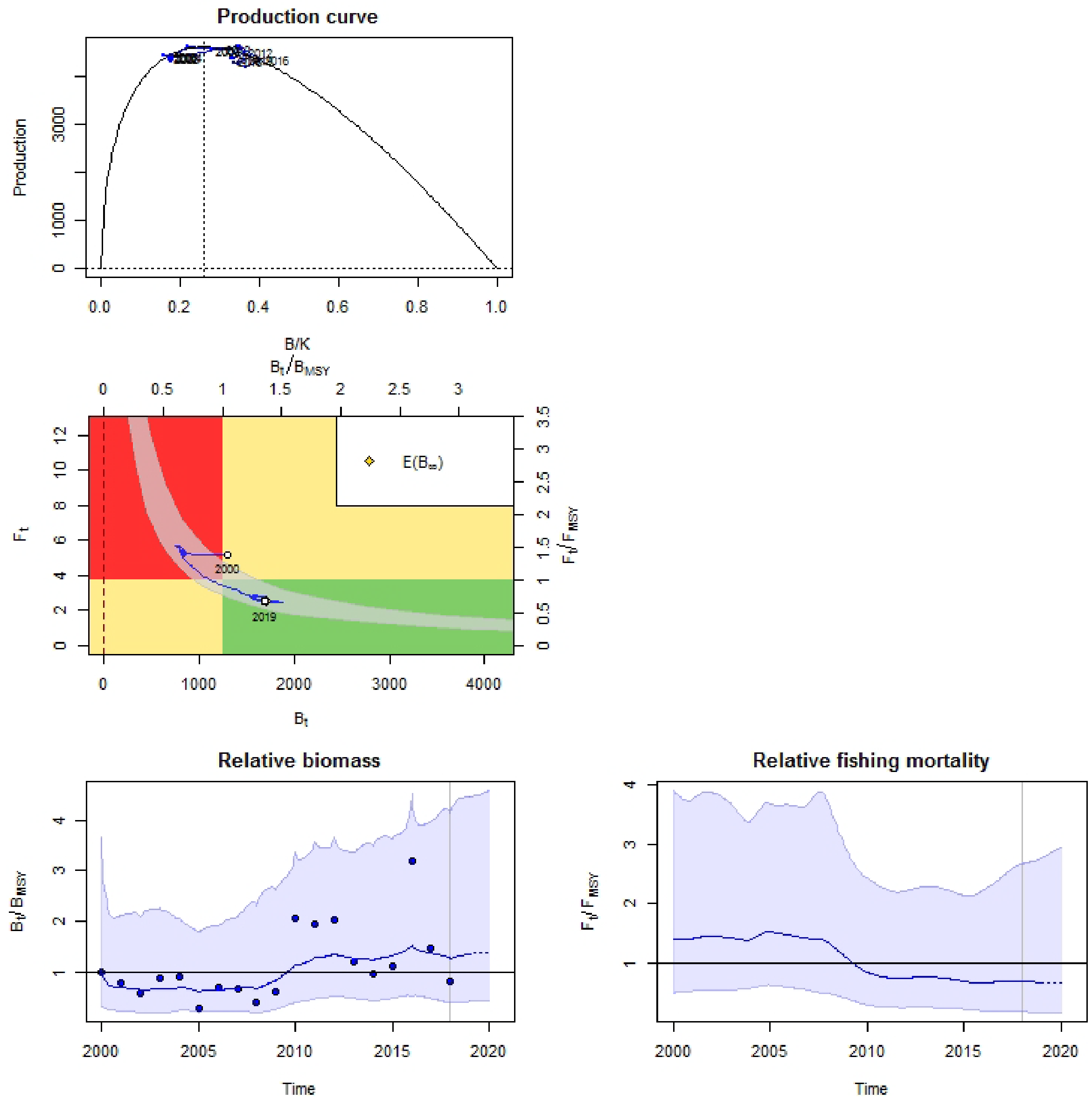



**Figure 8. Stock metrics of Sepiidae in Bay of Biscay (8.abd) estimated by SPiCT (1.2.7). Relative biomass and fishing mortality, production curve and KOBE-plot are given.**

# III.3 – Ommastrephidae assessment

## Northwest Iberian Peninsula (8.c. 9.a north)

To assess the Ommastrephid stocks off the Northwest Iberian Peninsula, landings for a period 2000-2018 and two tuning series were used: Spanish IBTS Trawl survey 8c9aN (September – October) and LPUEs of the Spanish Trawlers in the area. The model had satisfactory diagnostics

(**Fig 1.8.A Appendix C**) and suggested that Ommastrephid stocks are below $B_{MSY}$. and fishing mortality is at or above $F_{MSY}$ suggesting an overexploitation through the time series (**Fig. 9**).

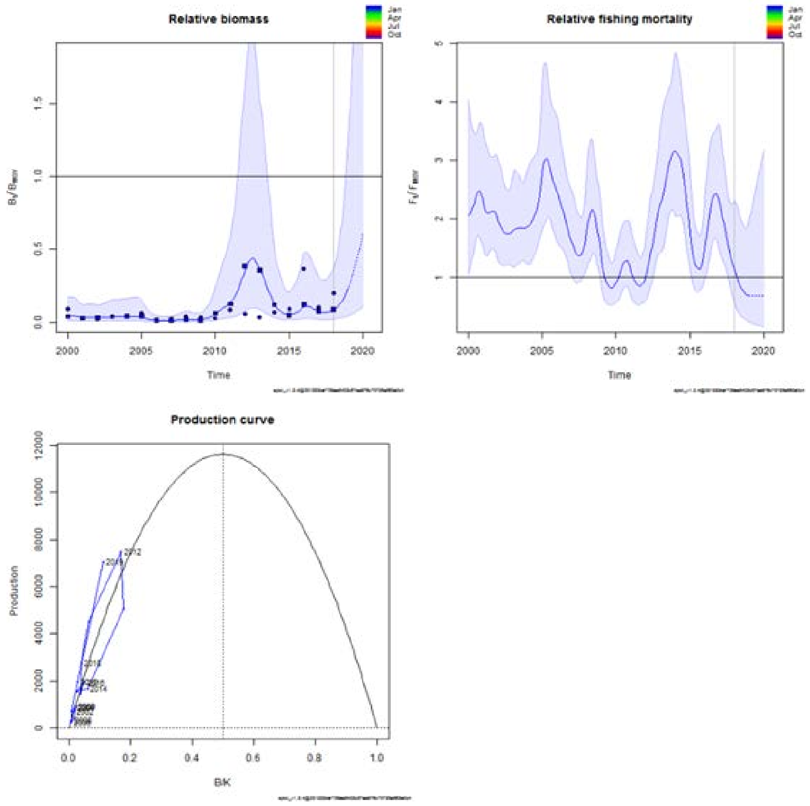



**Figure 9. Stock metrics of Ommastrephidae in the Northwest Iberian Peninsula (8.c, 9.a.north) estimated by SPiCT. Relative biomass and fishing mortality and production curve are given.**

However, results of such exercise should be treated cautiously as Ommastrephidae in the region comprise a mixture of three species (*Todaropsis eblanae*, *Illex coindetii* and *Todarodes sagittatus*). Although the proportion of each species in the catches is unknown and probably very variable from year to year, *T. eblanae* and *I. coindetii* are thought to be more abundant than *T. sagittatus*. All these squids have wide ranges of distribution and a long pelagic "paralarval" stage when products of the spawning might be transported far away from the spawning area by oceanic currents. The reliability of the model in such a situation is questionable. Also, occasional "explosions" in abundance might lead to overestimation of $B_{MSY}$ and hence to underestimation of $B/B_{MSY}$ and overestimation of $F/F_{MSY}$.

## III.4 Overview of preliminary diagnostics

In the nine studied stocks, fitted models outputs correspond to preliminary diagnostics and candidate biological reference points. With the exception of the Rockall squid fishery (Loliginidae in area 6.b) the models seem to be valid in spite of the large confidence intervals displayed in Fig. 2 to 9. The comparison of average catches in the four last years and MSY, and the ratios $B/B_{MSY}$ and $F/F_{MSY}$, seem to indicate that large stocks (English Channel Sepiidae, Bay of Biscay Loliginidae) may be more prone to overexploitation (Table 4).

**Table 4.** Summarised Biological Reference Points (BRP) obtained with SPiCT models (C = catch in tonnes, averaged over the last 4 years with available data; $MSY_s$ = Stochastic Maximum Sustainable Yield (tonnes). Relative estimates of stochastic Biomass ($B/B_{MSY}$) and Fishing Mortality ($F/F_{MSY}$) refer to the final year for which data were available (refer to the index time periods in Table 1).

| Cephalopod group | Area | C | $MSY_s$ | $B/B_{MSY}$ | $F/F_{MSY}$ |
|---|---|---|---|---|---|
| Loliginidae | 6.a + 7.bc | 360 | 1095 | 2.173 | 0.139 |
| Loliginidae | 6.b | 873 | 1129 | 5.483 | 0.121 |
| Loliginidae | 7.a +7.ghjk | 374 | 2195 | 3.508 | 0.050 |
| Loliginidae | 7.de | 4359 | 3480 | 1.158 | 1.161 |
| Loliginidae | 8.abd | 1520 | 1376 | 1.275 | 1.113 |
| Loliginidae | 9.a all | 717 | 1076 | 2.796 | 0.224 |
| *S. officinalis* | 7.de | 10920 | 11336 | 0.796 | 1.155 |
| *S. officinalis* | 8.abd | 4172 | 4649 | 1.261 | 0.701 |
| Ommastrephidae | 8.c.+ 9.a north | 1193 | 11254 | 0.084 | 1.153 |

# IV Discussion

Following recommendations of ICES WKProxy (ICES, 2016) and WKLIFE (ICES 2012b, 2017), a Stochastic Surplus Production Model in Continuous Time (SPiCT) was applied by the WGCEPH to data available for several cephalopod stocks. This is a preliminary application and the exercises will continue during future WGCEPH meetings.

Results for Loliginidae from the West Coast of Scotland, Celtic Sea and Gulf of Cadiz were found to be valid in the sense that the final diagnostics were obtained with confidence limits which do not overlap threshold ratios ($B/B_{MSY}$ and $F/F_{MSY}$). Results for Sepiidae in the English Channel and Ommastrephidae in the Northwest Iberian Peninsula were considered to be satisfactory but estimated values for stock biomass and fishing mortality had wide confidence limits.

The model is applicable only to stocks for which exploitation rate is high enough to drive the stock dynamics and this might not be the case for many cephalopods in the study area. Taking into account the short-lived nature of cephalopods, for future work, the use of seasonally-averaged (i.e. by quarter) values of catches and abundance indices (by month or by quarter) rather than annual values might be recommended for the next trials. Mildenberger *et al.* (2019) underlined that taking into account seasonal changes in stock productivity improved the stock sustainability reference levels. A related possibility, when the seasonality of catches is clearly defined, catches are identified to species and the life cycle is around 1 year in duration (the latter is not always true for cuttlefish), would be to focus on those months during which an annual cohort is fished. Thus for *Loligo forbesii* in Scotland, each year of data might run from August to May. While some animals live longer than 12 months and in some years there has been evidence of a second, summer breeding, cohort, use of July to June to represent a "fishing year" is probably a better option than the calendar year (e.g. Boyle et al., 1995).

Pedersen & Berg (2017) point out that consideration of the shape of the production curve is important in order to obtain unbiased reference points and recommend trying a run without fixing the shape parameter *n*. Nevertheless, previous work by ICES WKLIFE group of ICES suggested that fixing n (except to 1, which refers to the Fox model) could reduce estimation error and generate narrower confidence intervals. It is suggested to try first running models without a prior knowledge of *n* and then redo the models, fixing the *n* parameter based on the previous estimates, possibly also aiming for a production curve tilted to the left.

## References


Boyle, P.R., Pierce, G.J., Hastie, L.C., 1995. Flexible reproductive strategies in the squid *Loligo forbesi*. Marine Biology 121, 501-508.

Gras, M., Roel, B.A., Coppin, F., Foucher, E., Robin, J.-P., 2014. A two-stage biomass model to assess the English Channel cuttlefish (*Sepia officinalis* L.) stock. ICES Journal of Marine Science 71 (9), 2457–2468 .

Ibaibarriaga, L., Iriondo A., Robin, J.-P., Santurtun, M., 2015. Estimating the abundance of squid (*Loligo vulgaris*) in the Bay of Biscay. Working Document, ICES WGCEPH, 8-11 June 2015, Tenerife (Spain); in ICES, 2015 Interim Report of the Working Group on Cephalopod Fisheries and Life History (WGCEPH), ICES CM 2015/SSGEPD:02, 129 pp.

Ibánez, C.M., Keyl, F., 2010. Cannibalism in cephalopods. Reviews in Fish Biology and Fisheries, 20(1), 123-136.

ICES, 2012a. ICES Implementation of Advice for Data-limited Stocks in 2012 in its 2012 Advice. ICES CM 2012/ACOM 68. 42 pp.

ICES, 2012b. Report of the Workshop on the Development of Assessments based on LIFE history traits and Exploitation Characteristics (WKLIFE). 13–17 February 2012. Lisbon. Portugal. ICES CM 2012/ACOM:36. 140 pp.

ICES, 2016. Report of the Workshop to consider MSY proxies for stocks in ICES category 3 and 4 stocks in Western Waters (WKProxy). 3–6 November 2015. ICES Headquarters. Copenhagen. ICES CM 2015/ACOM:61. 183 pp.

ICES, 2017. Report of the ICES Workshop on the Development of Quantitative Assessment Methodologies based on Life-history traits. exploitation characteristics. and other relevant parameters for stocks in categories 3–6 (WKLIFE VI). 3–7 October 2016. Lisbon. Portugal. ICES CM 2016/ACOM:59. 106 pp.

ICES, 2019. Interim Report of the Working Group on Cephalopod Fisheries and Life History (WGCEPH), 5–8 June 2018, Pasaia, San Sebastian, Spain. ICES CM 2018/EPDSG:12. 194 pp.

Mildenberger, T.K., Berg, C.W., Pedersen, M.W., Kokkalis, A., Nielsen. J.R., 2019. Time-variant productivity in biomass dynamic models on seasonal and long-term scales. ICES Journal of Marine Science. doi:10.1093/icesjms/fsz154.S

Pedersen, M.W., Berg, C.W., 2017. A stochastic surplus production model in continuous time. Fish and Fisheries 18, 226-243.

Royer J., Pierce G.J., Foucher E., Robin J.-P., 2006. The English Channel Stock of *Sepia officinalis*: variability in abundance and impact of the fishery. Fisheries Research 78, 96-106.

Royer, J., Peries, P., Robin, J.-P., 2002. Stock assessments of English Channel Loliginid squid: updated depletion methods and new analytical methods. ICES Journal of Marine Science. 59 (3), 445-457.

Sims, D.W., Genner, M.J., Southward, A.J., Hawkins, S.J., 2001. Timing of squid migration reflects North Atlantic climate variability. Proceedings of the Royal Society of London. Series B: Biological Sciences 268 (1485), 2607-2611.

Sobrino, I., Rueda, L., Tugores, M.P., Burgos, C., Cojan, M., Pierce, G.J., 2020. Abundance prediction and influence of environmental parameters in the abundance of Octopus (*Octopus vulgaris* Cuvier, 1797) in the Gulf of Cadiz. Fisheries Research 221, 105382.

Trites, R.W., 1983. Physical oceanographic features and processes relevant to *Illex illecebrosus* spawning in the western North Atlantic and subsequent larval distribution. NAFO Scientific Council Studies 6, 39-55

Wolfram, K., Mark, F. C., John, U., Lucassen, M., Pörtner, H.O., 2006. Microsatellite DNA variation indicates low levels of genetic differentiation among cuttlefish (*Sepia officinalis* L.) populations in the English Channel and the Bay of Biscay. Comparative Biochemistry and Physiology Part D: Genomics and Proteomics 1 (3), 375-383.

Young, I.A.G., Pierce, G.J., Daly, H.I., Santos, M.B., Key, L.N., Bailey, N, Robin, J.-P., Bishop, A.J., Stowasser, G., Nyegaard, M., Cho, S.K., Rasero, M., Pereira, J.M.F., 2004. Application of depletion methods to estimate stock size in the squid *Loligo forbesi* in Scottish waters (UK). Fisheries Research 69, 211-227.

# Supplementary material

## Appendix A – Description of surveys indices:

**North West Groundfish Survey (NWGFS)** covered ICES Divisions 7a, 7f and 7g combined, from 1988 to 2018. The CPUE was given as an annual average number of individuals per hour of haul. For the years 2014 and 2015, no survey data was available from the NWFS survey. To have a complete time series, 2014 was replaced by the average of 2013 and 2016 and 2015 was given the average of 2014 and 2016. Data was sourced directly from CEFAS.

**Irish Groundfish Survey (IGFS)** covered ICES Divisions 6a and 7a,b,c,g,j,k separately from 2003 to 2018. The CPUE was given as an annual simple mean weight (kg) per hour of haul for each division for *Loligo forbesii*. Due to the patchiness of the time series, Divisions 7c and 7k were not used. The data for this data was sourced from DATRAS.

**South West Beam Trawl Survey Q1 (SWBEAM)** data covered ICES Divisions 7.a,f,e combined from 2006 to 2018. The CPUE was given as the annual mean of the number of individuals per hour of haul. Data sourced from CEFAS.

**Channel Beam Trawl Survey (BTS)** covered ICES Division 7.d from 1989 to 2017. The CPUE was given as the annual mean of the number of individuals per hour of haul, data sourced from CEFAS.

**EVHOE** data were extracted for the Celtic Sea portion of the Survey covering ICES Division 7.g,h,j,k combined, from 1997 to 2018. The CPUE was provided as an annual stratified mean weight (kg) per swept area of haul for *Loligo forbesii*. Data sourced from IFREMER.

**Channel Groundfish Survey (CGFS)** data covered ICES divisions 7.d and 7.e of the English Channel from 1990 to 2017. The CPUEs are both available as an annual average number or biomass (kg) of individuals per square kilometre. Data sourced from IFREMER.

**Scottish Surveys**

Data were sourced from DATRAS for the **Scottish West Coast IBTS (SWC-IBTS)** survey and the **Scottish Groundfish Survey (SCOGFS) (**1997 to 2018) for ICES Division 6.a. The CPUE was given as the annual mean of the number of individuals per hour of haul.

In addition, previously extracted Scottish survey data from **Marine Scotland Science (MSS)** were provided by Graham Pierce which included the SWC-IBTS, SCOGFS, International Young Fish Survey (IYFS), Scottish Monk and Megrim Survey, Mackerel Recruitment Survey, Deepwater surveys, experimental surveys, Pre-recruit surveys and several other trawl surveys. The data was selected for ICES Divisions 6.a and 7.b, from 1981 to 2012 – more recent data has still not been provided. The abundance is expressed as an annual simple mean of the number of individuals per hour haul for each.

**Rockall**

As for the Scottish surveys, index data for Rockall were derived from **DATRAS Scottish Rockall surveys** from 2001 to 2018, with an abundance index represented as an annual simple mean weight (kg) per hour of haul, and **MSS source**; which included an aggregation of data from the Groundfish, Pre-recruit, Haddock, Demersal and Hydrographic surveys at Rockall, together producing a continuous time series from 1981 to 2012 for ICES Division 6.b. The abundance index was represented as an annual simple mean of the number of individuals per hour of haul. Surveys took place in the 2nd and 3rd Quarters.

The model would not converge using the abovementioned datasets. Several modifications of the CPUE were attempted in order to get convergence, with success. Instead of producing the CPUE as a number per haul, a length-weight relationship formal from Young et al. (2004), given as:

$$W\ (g) = 0.00094 \times L\ (mm)^{2.33295}$$

Then, W (per haul) = W x No. at Length class

Where the weight was calculated for each length class and multiplied by the number of individuals of that length class in a haul. So CPUE is now measured as the annual average of the calculated weight (kg) per hour of haul.

In both datasets, data were missing from 2002, 2004 and 2010 and an average of the previous and following year was used to replace each missing year. To complete the time series, the DATRAS data series from 2011 was added to the other time series. This approach is not ideal as it collates indices from different surveys, gears and calculated weights but it was considered to be a necessary trade-off so as to have a sufficiently long and complete time-series to allow models to converge.

## Appendix B – Diagnostics and retrospective plots for Loliginidae, Sepiidae and Ommastrephidae

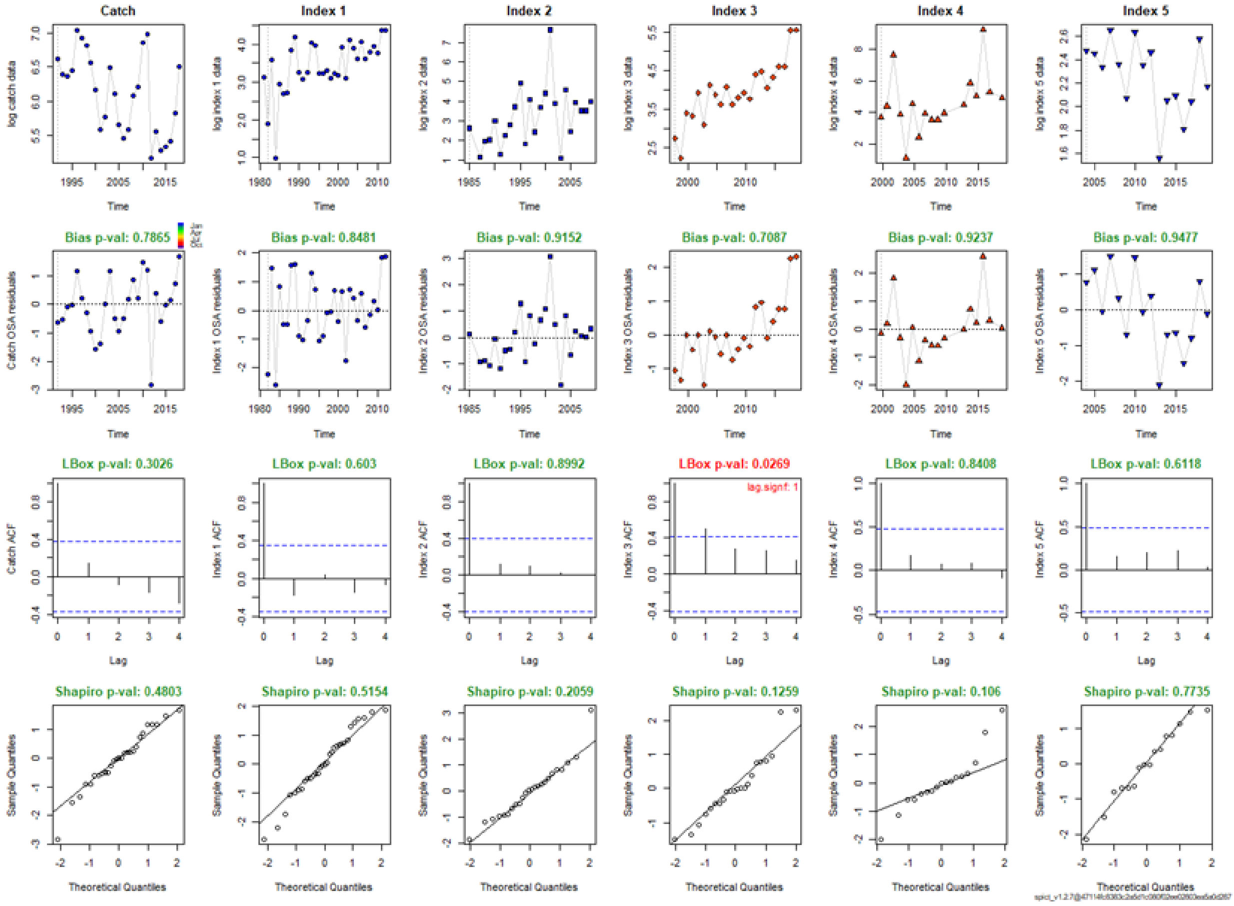



**Figure 1.1.A. SPiCT diagnostic for Loliginid squid of West Coast of Ireland and Scotland (6.a and 7.b.c). Row 1 Log of the input dataseries. Row 2 OSA residuals with the p-value of a test for bias. Row 3 Empirical autocorrelation of the residuals with tests for significance. Row 4 Tests for normality of the residuals. QQ-plot and Shapiro test.**

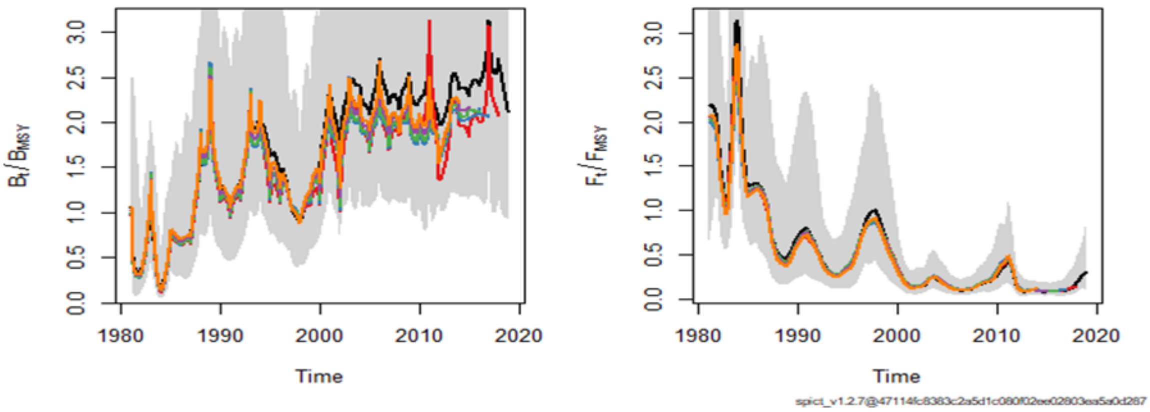



**Figure 1.1.B. Loliginid squid of West Coast of Ireland and Scotland (6.a and 7.b.c) - 5 years retrospective analysis. Relative biomass and fishing mortality respectively on left and right.**

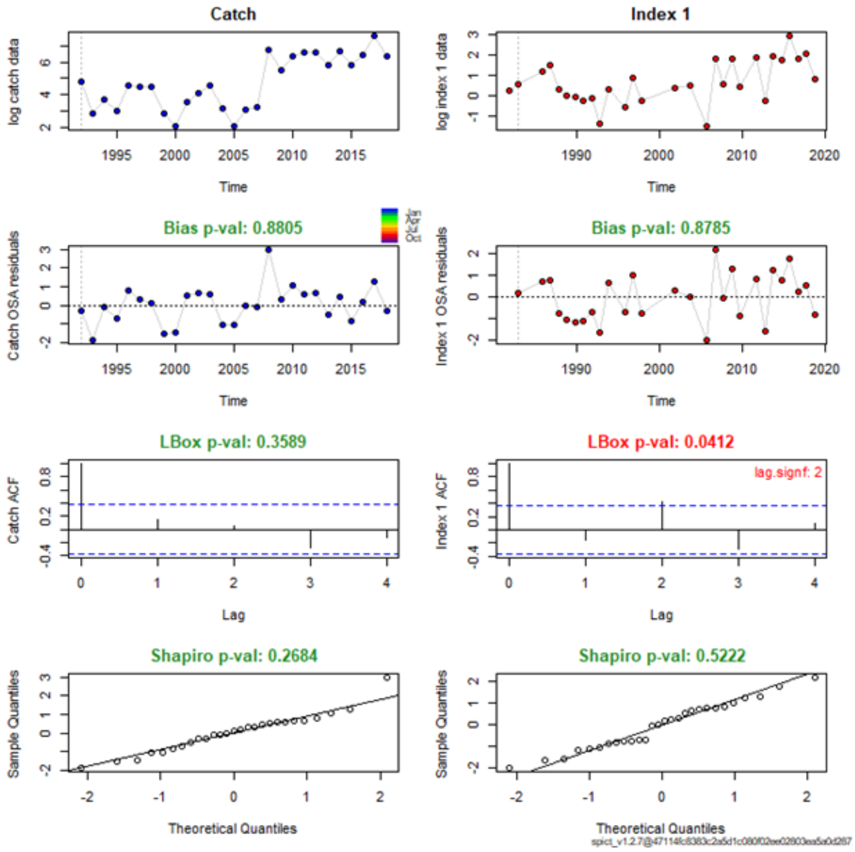



**Figure 1.2.A. SPiCT diagnostic for Loliginid squid of Rockall (6.b). Row 1 Log of the input data series. Row 2 OSA residuals with the p-value of a test for bias. Row 3 Empirical autocorrelation of the residuals with tests for significance. Row 4 Tests for normality of the residuals. QQ-plot and Shapiro test.**

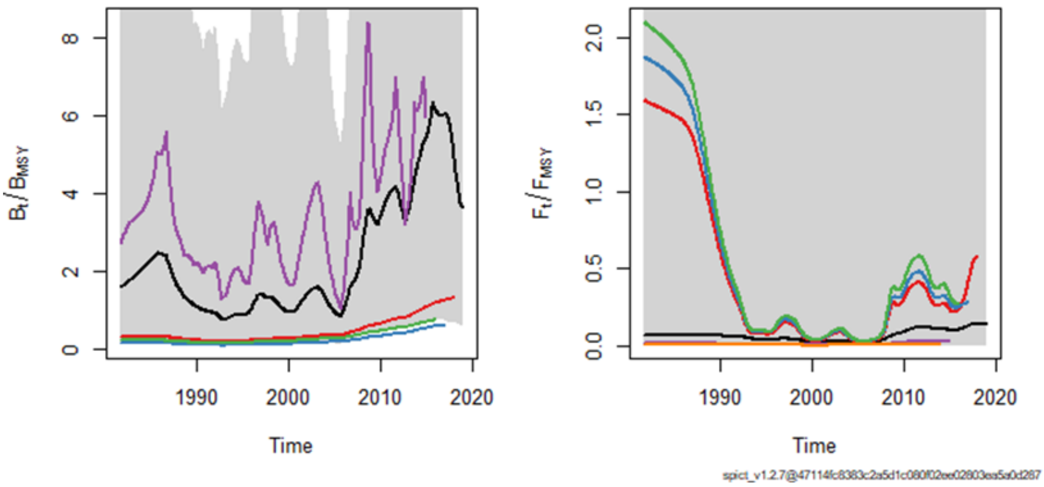



**Figure 1.2.B. Loliginid squid of West Coast of Rockall (6.b) - 5 years retrospective analysis. Relative biomass and fishing mortality respectively on left and right.**

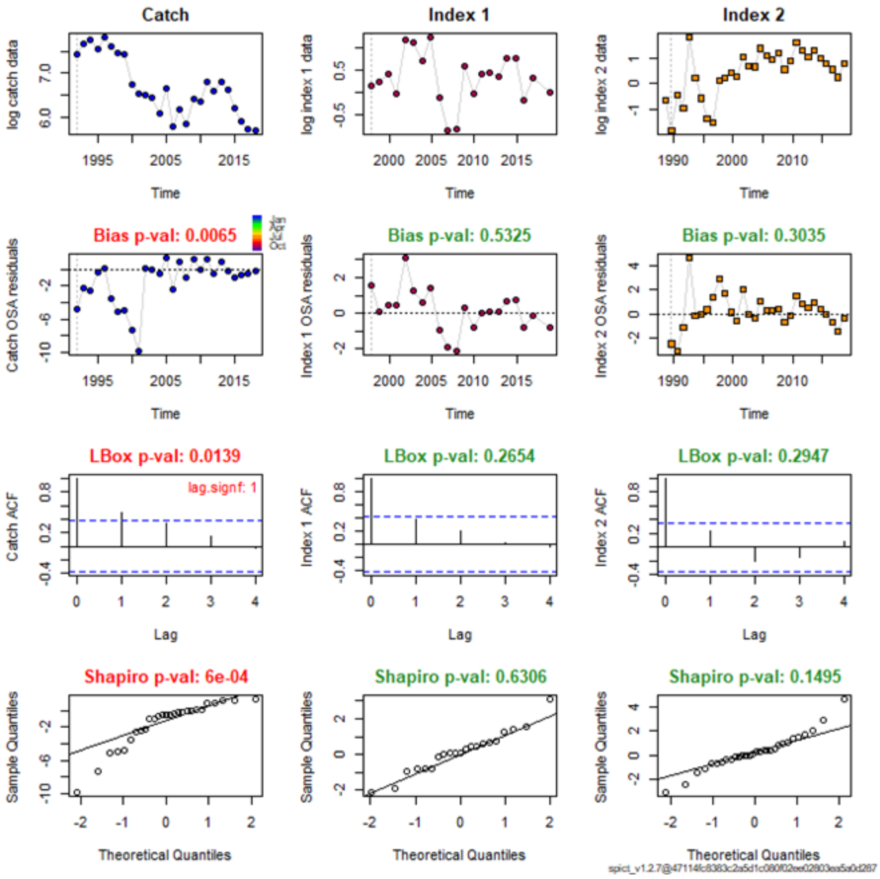



**Figure 1.3.A. SPiCT diagnostic for Loliginid squid of Irish Sea and Celtic Sea (7.a. 7.f and 7.g.h.j.k). Row 1 Log of the input datas eries. Row 2 OSA residuals with the p-value of a test for bias. Row 3 Empirical autocorrelation of the residuals with tests for significance. Row 4 Tests for normality of the residuals. QQ-plot and Shapiro test.**

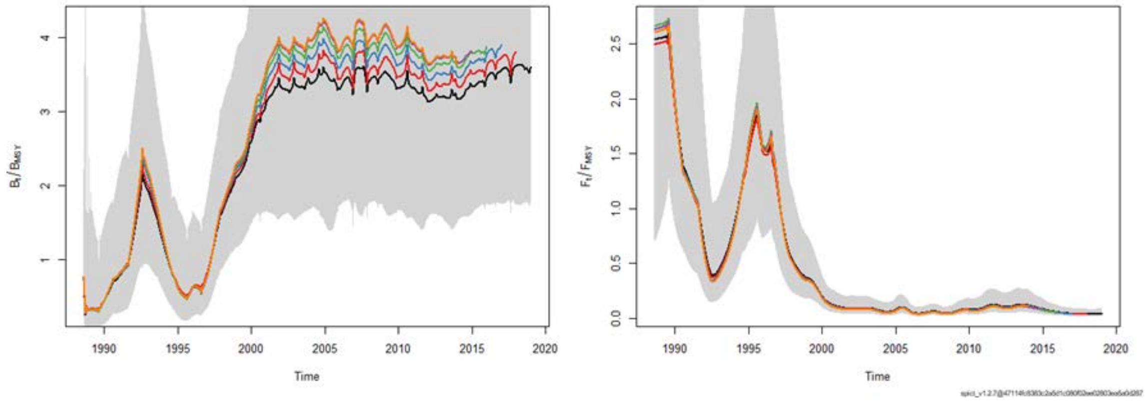



**Figure 1.3.B. Loliginid squid of Irish Sea and Celtic Sea (7.a. 7.f and 7.g.h.j.k) - 5 years retrospective analysis. Relative biomass and fishing mortality respectively on left and right.**

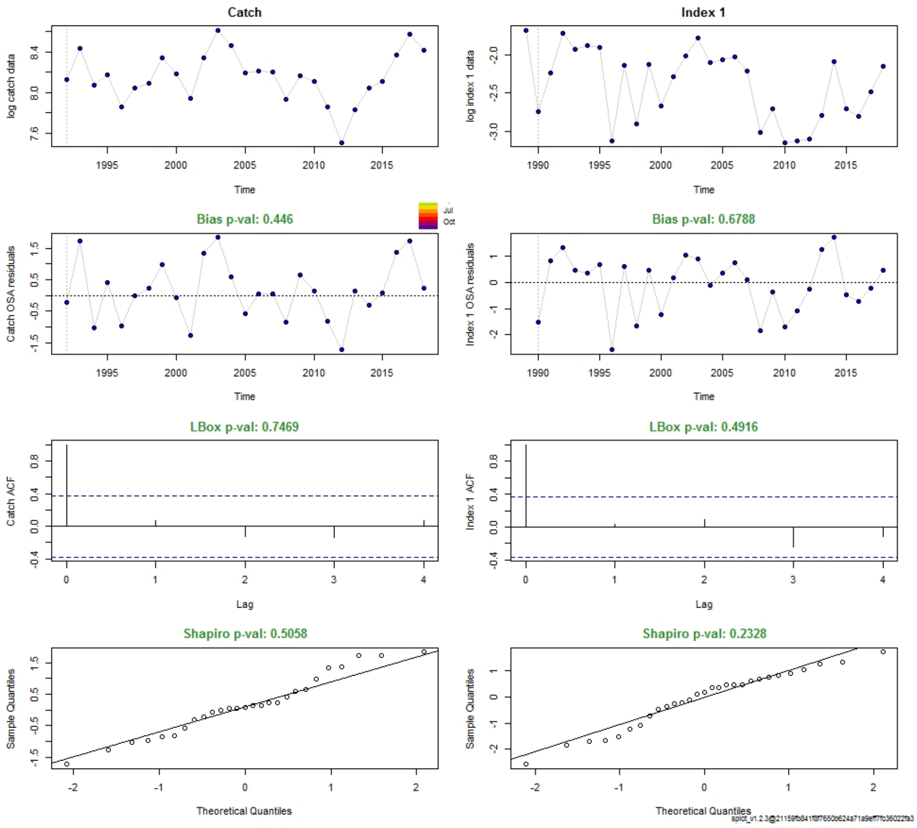



**Figure 1.4.A. SPiCT diagnostic for Loliginid squid of English Channel (7.d and 7.e). Row 1 Log of the input data series. Row 2 OSA residuals with the p-value of a test for bias. Row 3 Empirical autocorrelation of the residuals with tests for significance. Row 4 Tests for normality of the residuals. QQ-plot and Shapiro test.**

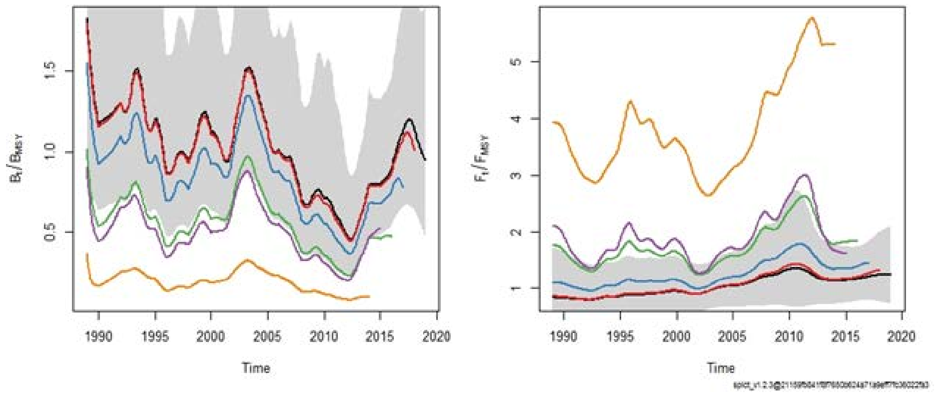



**Figure 1.4.B. Loliginid squid of English Channel (7.d and 7.e) - 5 years retrospective analysis. Relative biomass and fishing mortality respectively on left and right.**

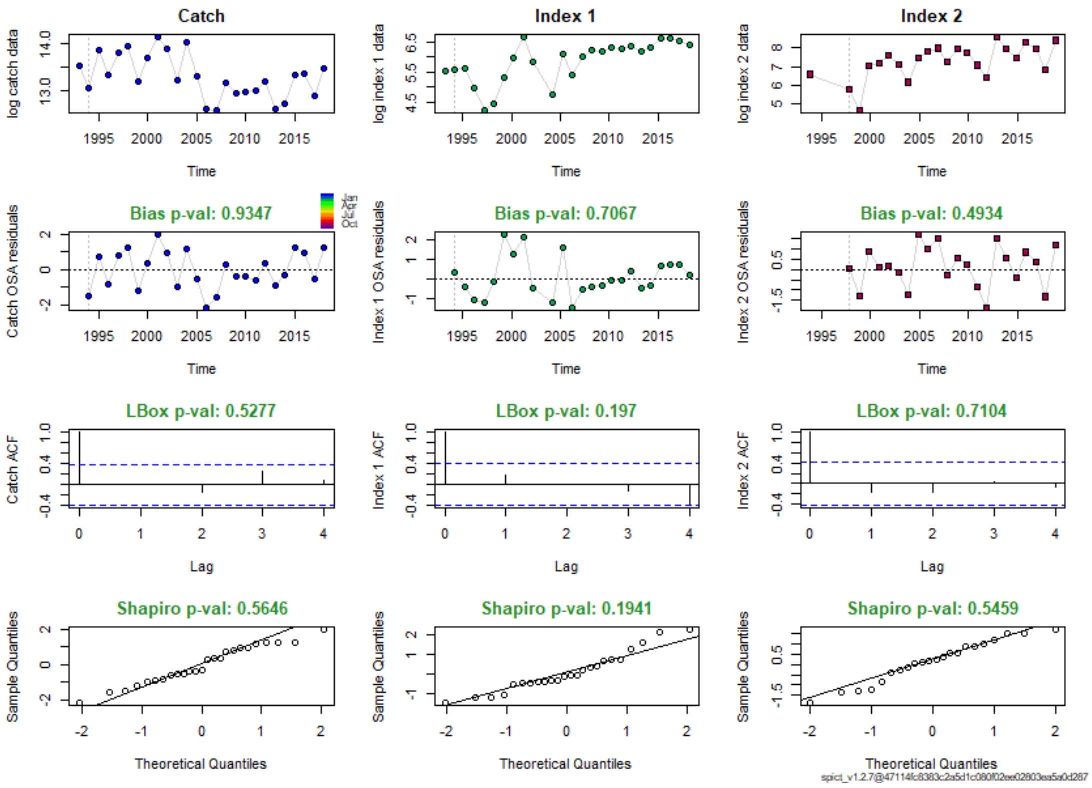



**Figure 1.5.A. SPiCT diagnostic for Loliginid squid of Gulf of Cadiz (9.a south). Row 1 Log of the input dataseries. Row 2 OSA residuals with the p-value of a test for bias. Row 3 Empirical autocorrelation of the residuals with tests for significance. Row 4 Tests for normality of the residuals. QQ-plot and Shapiro test.**

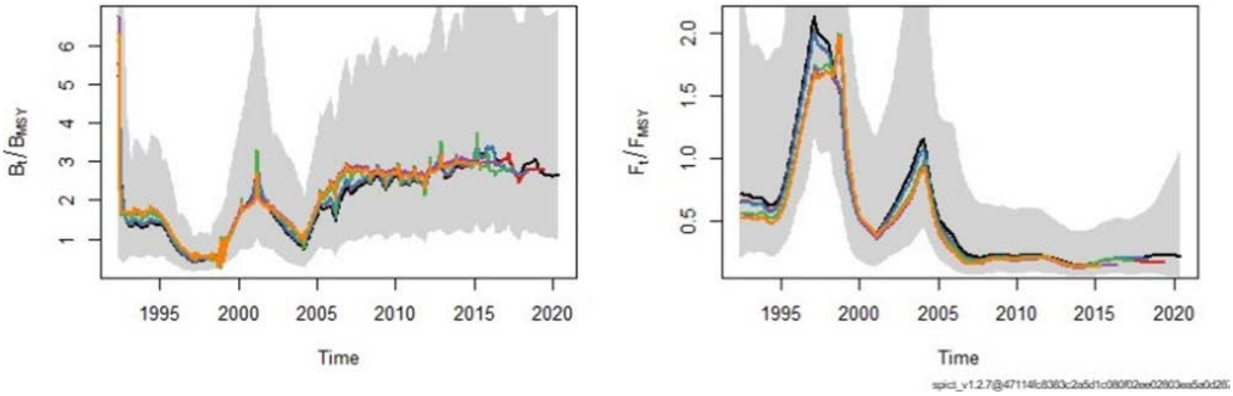



**Figure 1.5.B. Loliginid squid of Gulf of Cadiz (9.a south) - 5 years retrospective analysis. Relative biomass and fishing mortality respectively on left and right.**

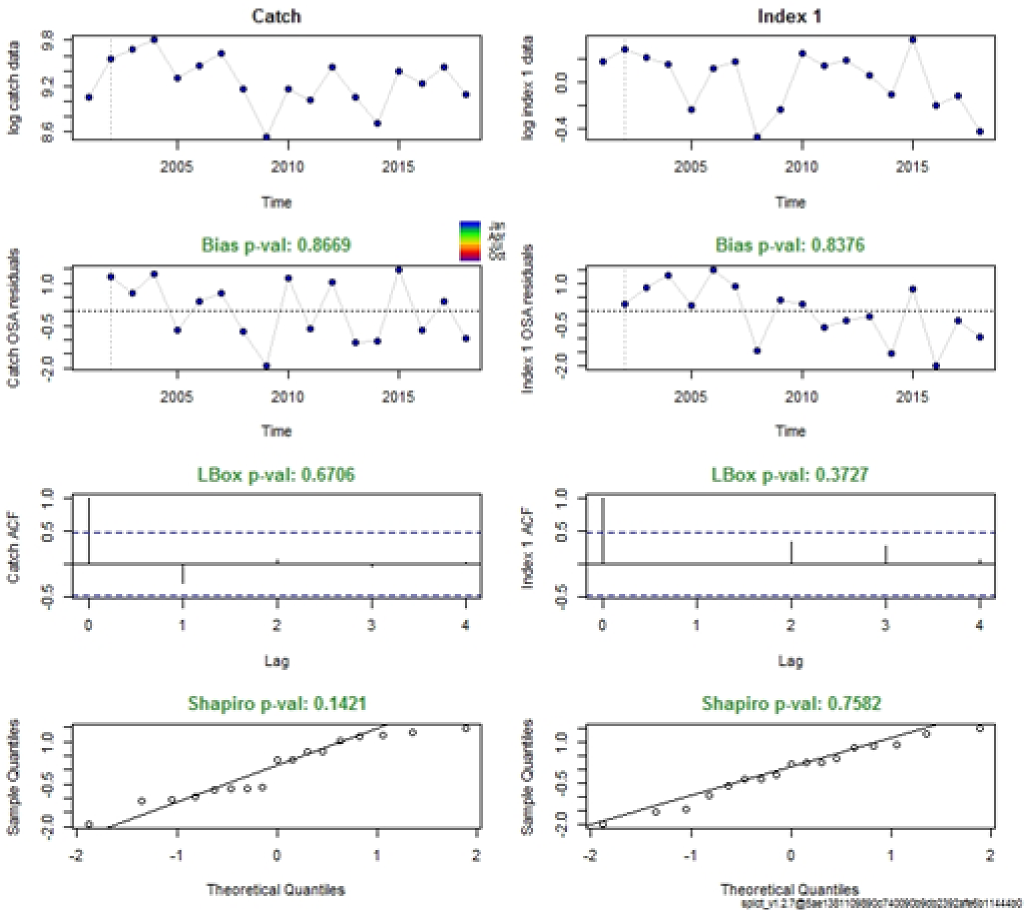



**Figure 1.6.A. SPiCT diagnostic for Sepiidae of the English Channel (7.d and 7.e). Row 1 Log of the input data series. Row 2 OSA residuals with the p-value of a test for bias. Row 3 Empirical autocorrelation of the residuals with tests for significance. Row 4 Tests for normality of the residuals. QQ-plot and Shapiro test.**

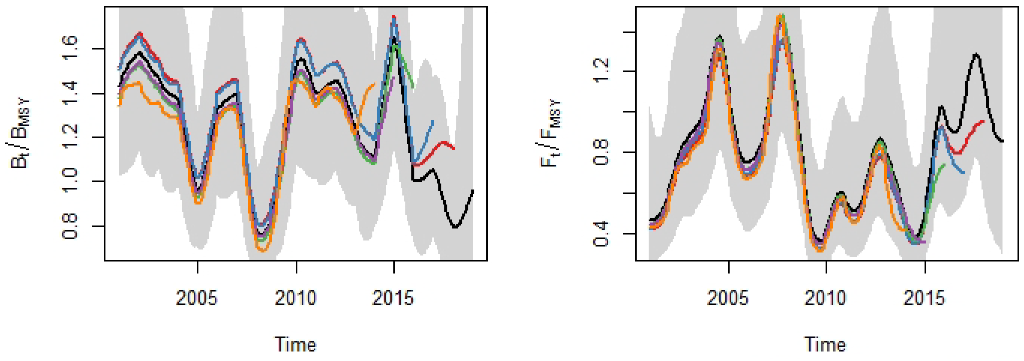



**Figure 1.6.B. Sepiidae of the English Channel (7.d and 7.e) - 5 years retrospective analysis. Relative biomass and fishing mortality respectively on left and right.**

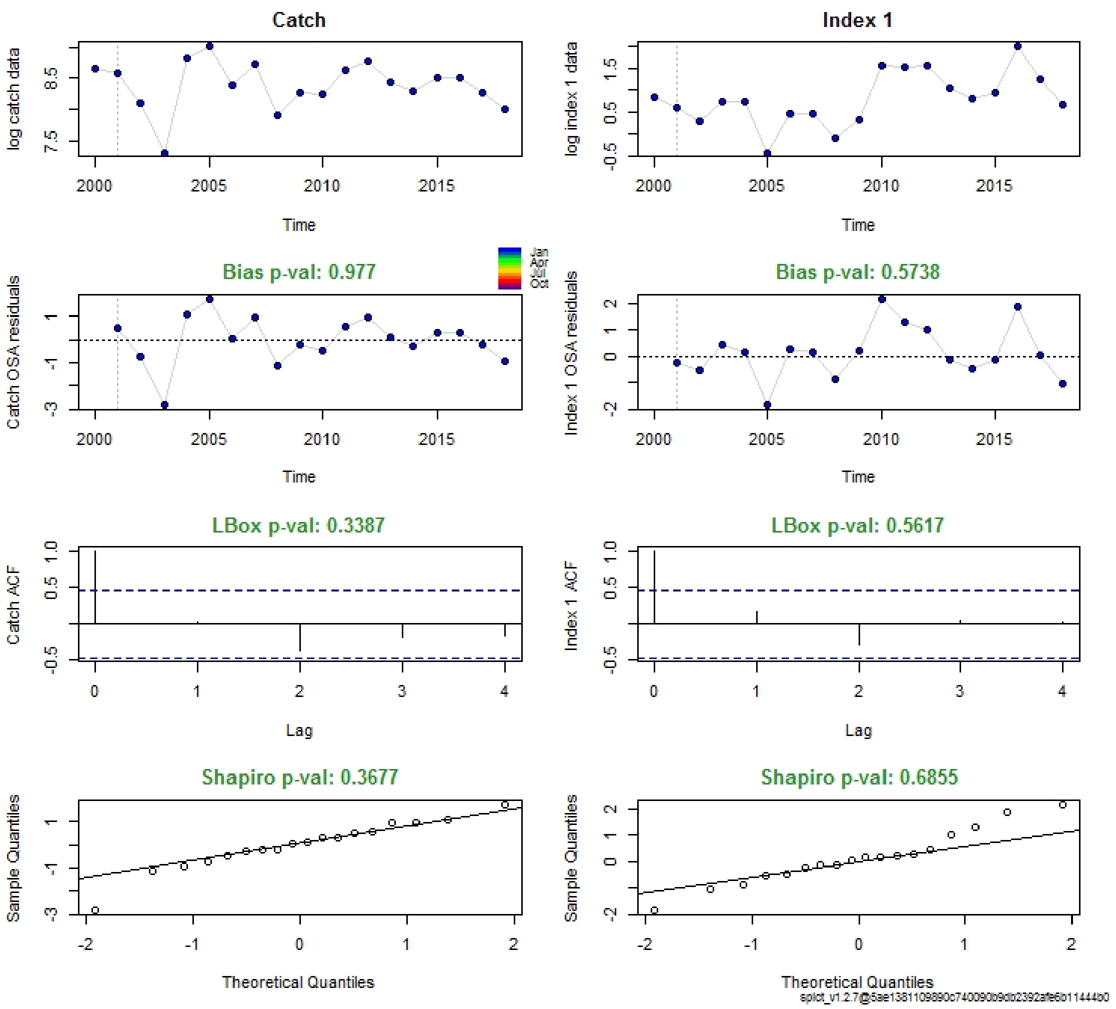



**Figure 1.7.A. SPiCT diagnostic for Sepiidae of the Bay of Bisacy (8.a,b, d). Row 1 Log of the input data series. Row 2 OSA residuals with the p-value of a test for bias. Row 3 Empirical autocorrelation of the residuals with tests for significance. Row 4 Tests for normality of the residuals. QQ-plot and Shapiro test.**

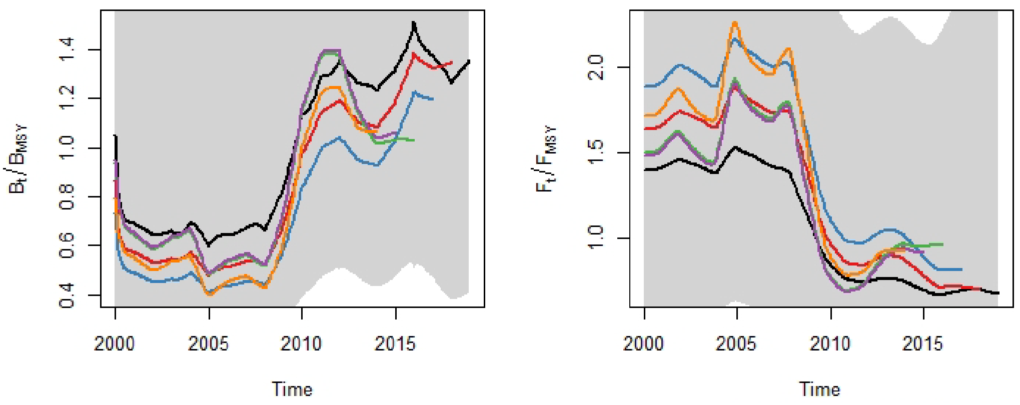


**Figure 1.7.B. Sepiidae of the Bay of Bisacy (8.a,b, d) - 5 years retrospective analysis. Relative biomass and fishing mortality respectively on left and right.**

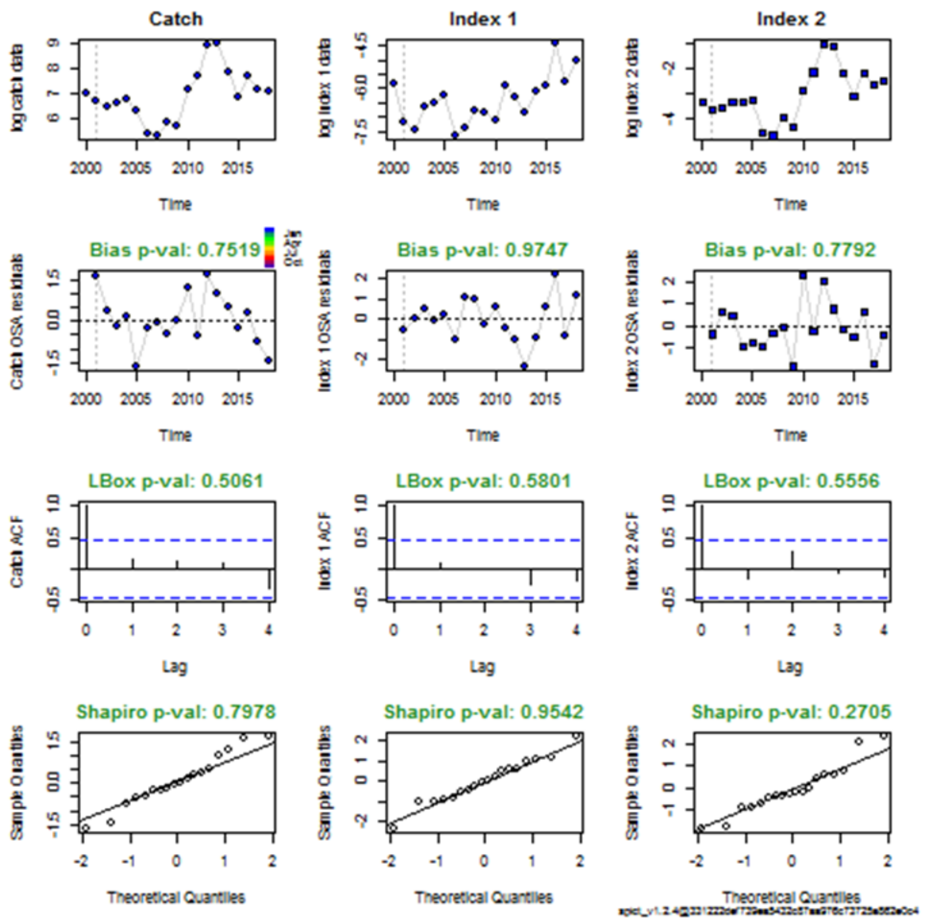



**Figure 1.8.A. SPiCT diagnostic for Ommastrephidae of Northwest Iberian Peninsula (8.c. 9.a north). Row 1 Log of the input data series. Row 2 OSA residuals with the p-value of a test for bias. Row 3 Empirical autocorrelation of the residuals with tests for significance. Row 4 Tests for normality of the residuals. QQ-plot and Shapiro test.**

## Appendix C – Loligo vulgaris exercise in the Bay of Biscay

### Model simulations fixing parameters - *Loligo vulgaris* in the Gulf of Biscay

When using the default values the models do not converge and results show wide confidence intervals. Trying to fix the model, some assumptions were made to set parameters values: for example, using Schaeffer model (fixing n=2). In one of the results, convergence was achieved and relatively acceptable results were obtained to estimate relative stock biomass (Table 3.1.).

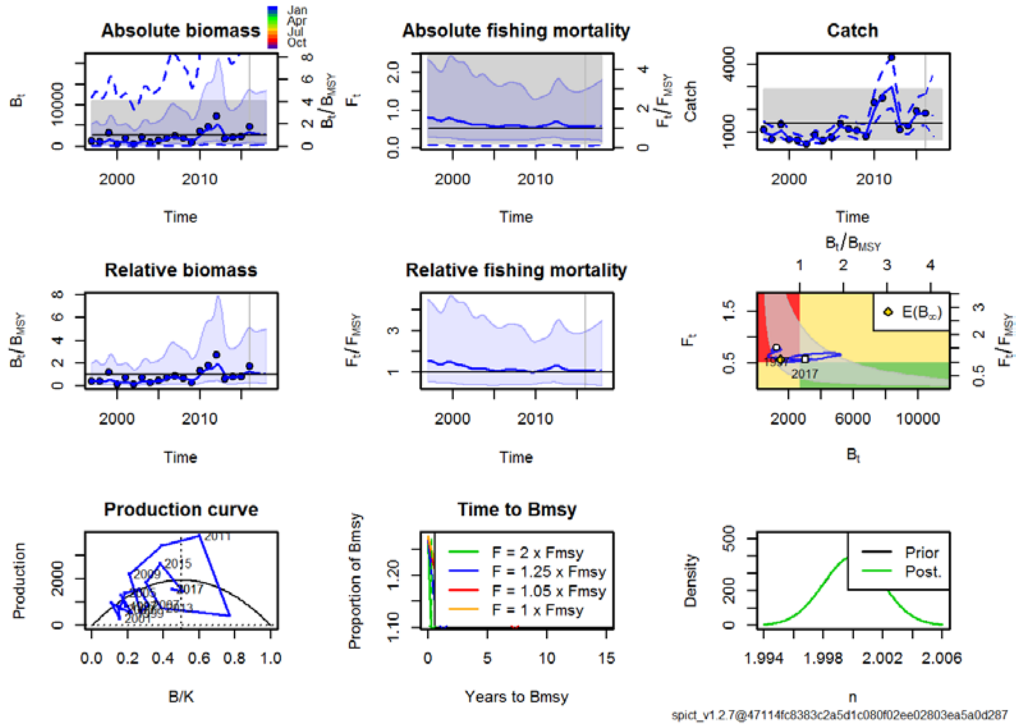
These results are part of an exercise and they will be considered as an example of the possible assumptions that will be done to fix the SPiCT model.

**Table 3.1.** Different cases conducted. trying to fix model priors. Red cases did not converge. green did and Case 6a* is the one retained giving best model fitting (Schaeffer model).

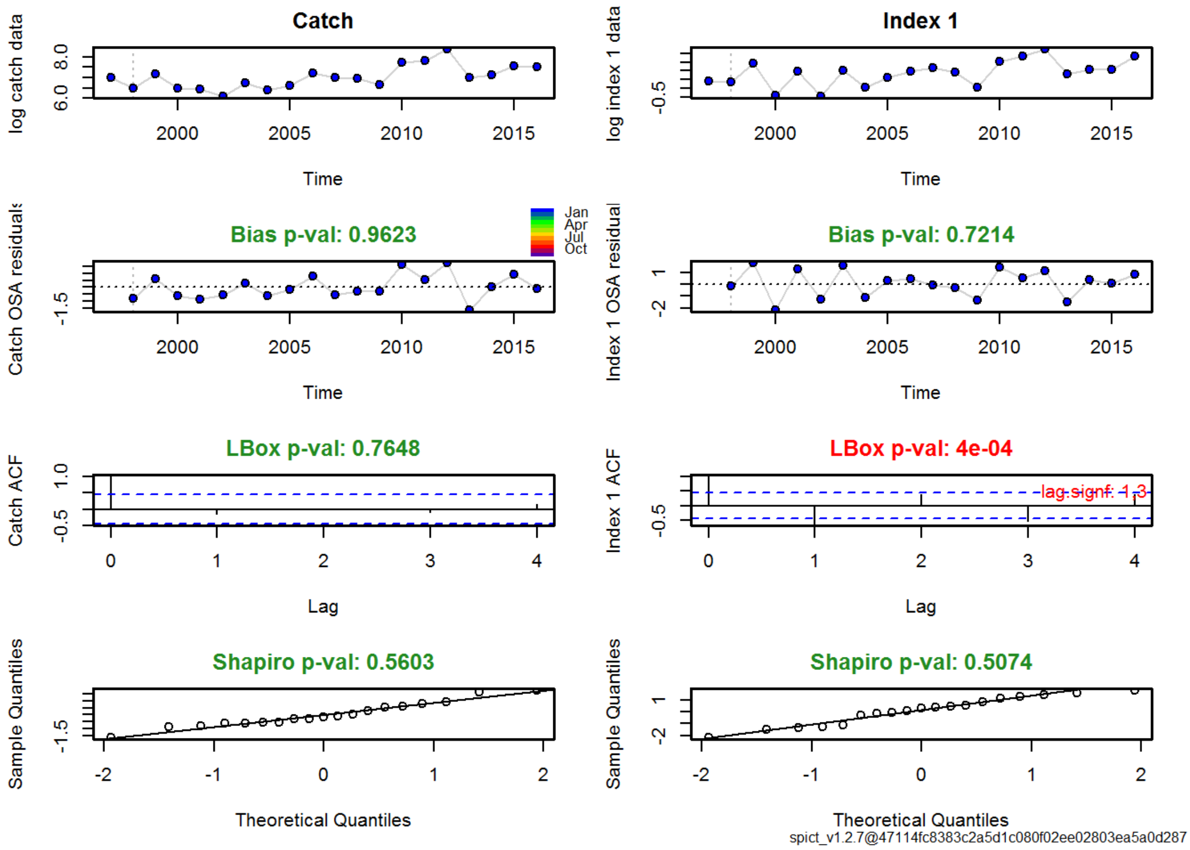
| SPICT | n=estimated | n=2 | n=estimated<br>Prior r | n=2<br>Prior r |
|---|---|---|---|---|
| No priors | Case 0a | | Case 0b | |
| α estimated<br>β estimated | Case 1a<br>Case 2a | Case 5a | Case 1b<br>Case 2b | Case 5b |
| α=1, β=1 | Case 3a | **Case 6a*** | Case 3b | Case 6b |
| α=4, β=1 | Case 4 | Case 7a | Case 4b | Case 7b |

**Diagnostics and retrospective plots for Case 6a: α=β=1 and n=2 (Schaefer model)**

Assessment results




Residual diagnostics



Model parameters and 95% CI

| | estimate | cilow | Ciupp |
|---|---|---|---|
| **alpha** | 1 | 0.998 | 1.002 |
| **beta** | 1 | 0.998 | 1.002 |
| **r** | 1.145 | 0.295 | 4.442 |
| **rc** | | | |
| **rold** | | | |
| **M** | 1938 | 1075 | 3494 |
| **K** | 6772 | 1589 | 28866 |
| **Q** | 0.001 | 0 | 0.012 |
| **N** | 2 | 1.996 | 2.004 |
| **Sdb** | 0.487 | 0.354 | 0.671 |
| **Sdf** | 0.224 | 0.135 | 0.369 |
| **Sdi** | 0.487 | 0.354 | 0.671 |
| **Sdc** | 0.224 | 0.135 | 0.369 |

Reference points: (Loliginidae in the Bay of Biscay)

**Deterministic reference points**

| | estimate | $ci_{low}$ | $ci_{upp}$ | log.est |
|---|---|---|---|---|
| **$B_{MSY}$d** | 3386 | 794 | 14433 | 8.127 |
| **$F_{MSY}$d** | 0.572 | 0.147 | 2.221 | -0.558 |
| **MSYd** | 1938 | 1075 | 3494 | 7.569 |

**Stochastic reference points**

| | estimate | $ci_{low}$ | $ci_{upp}$ | log.est | rel.diff.Drp |
|---|---|---|---|---|---|
| **$B_{MSY}$s** | 2698 | 665 | 10937 | 7.900 | -0.255 |
| **$F_{MSY}$s** | 0.523 | 0.110 | 2.474 | -0.649 | -0.095 |
| **MSYs** | 1376 | 656 | 2883 | 7.227 | -0.409 |

**Stock status**

| | estimate | $ci_{low}$ | $ci_{upp}$ | log.est |
|---|---|---|---|---|
| **B2016.00** | 3441 | 369 | 32056 | 8.143 |
| **F2016.00** | 0.582 | 0.064 | 5.262 | -0.542 |
| **B2016/$B_{MSY}$** | 1.275 | 0.316 | 5.146 | 0.243 |
| **F2016/$F_{MSY}$** | 1.113 | 0.417 | 2.973 | 0.107 |

(Note: Biomass is above $B_{MSY}$ but F is above $F_{MSY}$)

Retrospective plot Case 6a data until 2016