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Report of the Workshop on the Necessity for Crangon and Cephalopod Management (WKCCM)

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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

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Executive summary

The Workshop on the Necessity of a Crangon and Cephalopod management (WKCCM) was successfully held at the ICES Headquarters in Copenhagen, Denmark in October 2013. The majority of workshop participants were experts from WGCAN and WGCEPH. Also three stakeholder representatives from Germany and the Netherlands attended the meeting; all three had a special interest in *C. Crangon*.

The workshop aimed to provide advice on the need for management of the currently unregulated *Crangon crangon* (brown shrimp) in the North Sea and cephalopod stocks in the Northeast Atlantic. Potential steps towards a brown shrimp and/or cephalopod management, including due considerations of research needs and required stakeholder feedback have been developed. Given the differences in ecology, distribution area, life history of *C. crangon* and Cephalopods and the fisheries targeting the species; they are treated as different case studies. With regard to cephalopods this report covers the main cephalopod species of commercial interest in European waters, namely *Sepia officinalis*, *Octopus vulgaris*, *Loligo vulgaris* and *Loligo forbesii* in their most abundant and exploited ICES areas.

C. Crangon

The evidence found for the need of management of *C. crangon* is a combination of several factors. During the workshop recent studies and stock indicators were summarized and discussed leading to the conclusion that fishing has a large impact on the *C. Crangon* stock. The high fishing pressure likely led to growth overfishing of the population during recent years, and a reduction of effort is believed to be possible without major losses in catches. Additionally a healthier stock with larger shrimps and higher reproduction could be obtained if gears are adjusted and fishing pressure is released in general and especially on juvenile shrimps. The reduction of “unnecessary” effort would lead to reduced impacts on the ecosystem through reduced discards, bottom impacts, combustion and other adverse ecosystem effects. The control of effort and efficiency, a general effort reduction, which is especially needed when population size is low, and the use of better suited gears are only possible in a controlled and managed fishery. The landings of *C. crangon* for human consumption have constantly increased since the 1970s, most probably due to a decrease in predation pressure and an increase in effort (engine-power) and efficiency. However, the current lack of an efficient management results in situation of uncontrolled and unmonitored effort and efficiency. The development of new and more efficient devices (e.g. pulse beam trawl) increases the call for action.

To conclude: the group requests, as a next step, ACOM to give a pro bono advice in favour of a management of *C. crangon* fisheries. The fishing industry has taken first steps towards sustainable management of their fisheries with the aim to get a MSC label. In this light the industry has developed an lpue-based harvest control rule. The pros and cons of this rule were discussed during the workshop (and in more details elsewhere) and it was concluded that this HCR is a good starting point, as due to the short lifespan and the high seasonal dynamics of the stock a TAC rule is not applicable for *C. crangon*. Suitable management strategies and measures should be identified and (further) developed in a workshop early next year taking into account existing management initiatives by the industry.

Cephalopods

Cephalopods are increasingly targeted by European fisheries and there is evidence from different stocks of full exploitation, overexploitation and possibly even stock collapses due to fishing. Considering their high and increasing importance as fishery resources and significant trophic role, to not undertake any assessment and management is a very risky option. Minimally, under a precautionary approach, we must do more to evaluate the status of these fisheries.

Future actions must distinguish the very different nature of small-scale directed monospecific fisheries and large-scale fisheries in which cephalopods are sometime not targets and sometimes among many target species.

There is a need to consider the possible assessment and management of cephalopods caught by multispecies fisheries but this is challenging. WGCEPH could contribute with further evaluation of single species assessment methods (analytical and otherwise) but to address multispecies assessment and also management will require input from other groups.

There is a clear need to evaluate the feasibility of including very short-lived species in multispecies assessments.

In the small-scale fisheries, there is a need to evaluate assessment and management options. The expertise needed is different and WGCEPH could play a larger role. It will need assessment expertise but also social science input to devise appropriate local and participatory approaches to management and governance.

We recommend holding a further workshop or workshops to advance with devising appropriate methodologies for the two main types of fishery. We recommend that WGCEPH revises its proposed TORs to permit it to make a greater contribution to this process. However, this implies an increased need for assessment expertise within the group.

It is very likely that proposals for monitoring and assessment will require enhanced data collection on cephalopod fisheries; an increased commitment by ICES to address this issue will need to be supported by member states.

1 Introduction

The Workshop on the necessity for Crangon (Brown Shrimp) and Cephalopod management (WKCCM) (Chair: Marc Hufnagl and Josien Steenbergen and co-chaired by Marina Santurtun) was held at ICES HQ, 8–9 October 2013. The majority of the workshop participants were experts from WGCRAN and WGCEPH. For a full list of participants see Annex 1. Also three stakeholder representatives attended the meeting; all three had a special interest in Crangon.

1.1 Background

Fisheries on *Crangon crangon* and on Cephalopods are of high regional economic and ecologic importance. The majority of the cephalopod species, as well as *C. crangon*, are so far only managed by some technical measures with little respect to environmental impact and sustainability of the fisheries. Possible impacts on the ecosystem and the stocks have so far only been considered from a scientific point of view. Although in some cases regional management initiatives exist, the fisheries targeting *C. crangon* in the North Sea and Cephalopods in European waters are generally unregulated in TAC and effort. For those cephalopod fisheries regulated (*Octopus vulgaris* and *Sepia officinalis*) such regulations did not appear to be based on real stock status knowledge, but more on administrative reasons aimed to avoid conflict between spatial occupation of gear exploiting these species. WKCCM therefore focused on identifying whether a stock assessment is possible and whether a management is necessary. Thus the workshop deals mainly with the science plan high priority research topic: “Marine living resource management tools”.

1.2 Terms of reference

The terms of reference for WKCCM were as follows:

- a) Provide **advice on the need for management** of *Crangon crangon*. (brown shrimp) in the North Sea and **cephalopod** stocks in the Northeast Atlantic, considering:
 - i) The role of *C. crangon* and Cephalopods in the ecosystem and foodweb - specifically if they were considered low trophic level species;
 - ii) The impact of the *C. crangon* and Cephalopod fishery on other commercially exploited fish stocks in relation to multispecies and mixed fisheries considerations;
 - iii) The impact of the brown shrimp fisheries on *C. crangon* and the Cephalopod fisheries on the Cephalopods.
- b) Develop a strategy and road map for the **inclusion** of *C. crangon* and cephalopod fisheries data to be included in **ICES multispecies and mixed fisheries assessments** (where relevant);

If a need or a potential need for a management of these currently unregulated resources is identified, then:

- c) Develop potential **steps towards a brown shrimp and/or cephalopod management**, including due considerations of research needs and required stakeholder feedback.

2 Adoption of the agenda

The agenda shown in Annex 2 was agreed among all participants.

There was a general agreement that the biology, ecology, fisheries, assessment and management of *C. crangon* and Cephalopods in-depth discussion of ToRs were to be conducted separately. Plenary sessions were deployed at the beginning and end of the WK to assure consistency on accomplishing ToRs for both species groups.

Following chapters contain per species (*C. crangon* and cephalopod species) short descriptions of the most important biology/ecology and the fisheries targeting and/or bycatching the species followed by a summary of the discussion on the different ToRs and an overview of applicable management strategies, their suitability and applicability.

3 *Crangon crangon*

3.1 Summary information

3.1.1 General life cycle and ecology

C. crangon is a decapod crustacean that belongs to the infraorder Caridea and the family Crangonidae. Its distribution ranges from the Black Sea (Bilgin and Samsun, 2006) over the Mediterranean (Labat, 1977), the North Atlantic to the North and Baltic Seas. Five regional groups have been identified namely the North Sea and Baltic Sea; the North Atlantic Ocean; Portugal and the Adriatic Sea (Bulnheim and Schwenzer, 1993; Luttkhuizen *et al.*, 2008). *C. crangon* mainly inhabits soft bottom substrata but can also be dominant on sandy shores (Beyst *et al.*, 2001). The high tolerance against temperature and salinity variation along with a wide range of possible prey and food sources and high production/growth rates allows *C. crangon* to be one of the most abundant macrozoobenthos species along the coast, in estuaries and the Wadden Sea. This case study focuses on *C. crangon* in the North Sea, the core distribution area of this species.

The life cycle of *C. crangon* is complex and includes several seasonal, sex- and size specific migrations. Ageing of *C. crangon* is not possible due to the short lifespan and the high moult frequency. Moulting leads to a loss of all longer lasting hard structures that might contain age information. Stock and population analysis therefore solely rely on size and growth based analysis. Following the most recent findings of studies that determined growth and mortality rates in combination with observed seasonal succession of specific life stages (juveniles, adults) and mortality analysis the life cycle can be summarized as follows:

- The maximum length (L_{MAX}) of individuals caught in scientific surveys is 109 mm total length. Average asymptotic length (L_{∞}) is 79 mm.
- Sex-specific growth differences exist and therefore commercially caught shrimps (>50 mm) are female dominated whereas juvenile sex ratios are about even.
- Length-at-maturity is for female shrimps about 55 mm where 50% of all females carry eggs.
- Growth rates are temperature and length dependent (the higher/larger the higher/lower) and display high individual variability.
- Eggs are carried by the female and there are two egg production peaks: winter (December–April) and summer (May–August). The potential fecundity of mature females, ranges from 2000–10 000 eggs depending on the length of the female.
- Winter: Hatching of larvae from winter eggs in offshore regions.
- Winter ongoing: Transport of pelagic larval stages towards the coast.
- Late spring: Mass occurrence of juvenile shrimps due to a temperature mediated synchronization of development. These juveniles originate in the cohort that hatched from the winter eggs.
- Summer: Intertidal habitats are used as nursery areas until the juveniles reach a size of 20–30 mm.
- Summer and autumn: Successive migration of larger shrimps to deeper areas (maximum depth 40 m).

- Autumn: Shrimps hatched from winter eggs - that invaded into the shallow areas in spring - reach commercial/adult size (>50 mm).
- Winter: The whole population, especially the adults, migrates to deeper areas where winter eggs are produced to form the new cohort.

In summary: The winter egg cohort is the most important contributor to the peak abundance of commercial catches and the adult shrimp population in autumn. Unclear is what happens with the summer cohort but importance to the stock seems to be minor due to high mortality during summer. Brown shrimps are short lived (1.5–2 years) and maturity is reached within one year (55 mm) at about commercially exploitable size (50 mm). Age determination is not possible and thus classical age-based stock assessment methods are not applicable.

3.1.2 Status and history of the fisheries

Shrimp landings are monitored and reported since the 1950s (Figure 1) for the German fleet and since the 1970s for the Dutch, Belgian and UK fleet and since 1987 and 2000 also for the Danish and French fleet, respectively. Reported landings are generally reliable, however there are inconsistencies in some datasets. One break is in the Dutch data where in 1994 the responsibilities changed and not LEI but VIRIS reported the landings from then on. Accompanying with this change the Dutch landings increased from on average 6500 t to an average value of 14 300 t. Whether the break in the Dutch data was due to the reporting or due to natural or fisheries induced reasons could not be clarified so far. Simultaneously catches from other countries increased as well but not that strong.

The total North Sea fleet includes 523 (2011) to 630 (2009) active vessels with $\frac{2}{3}$ of the fleet size belonging to Germany and the Netherlands. During the last years, total landings from the North Sea from all nations were always >30 000 tons with NL and GER accounting together for >80% of the landings. Lower landings than usual were reported in 1990, 1984 and 1977 but low landings were not observed in the years thereafter. The overall trend in landings of human consumption shrimps is constantly increasing.

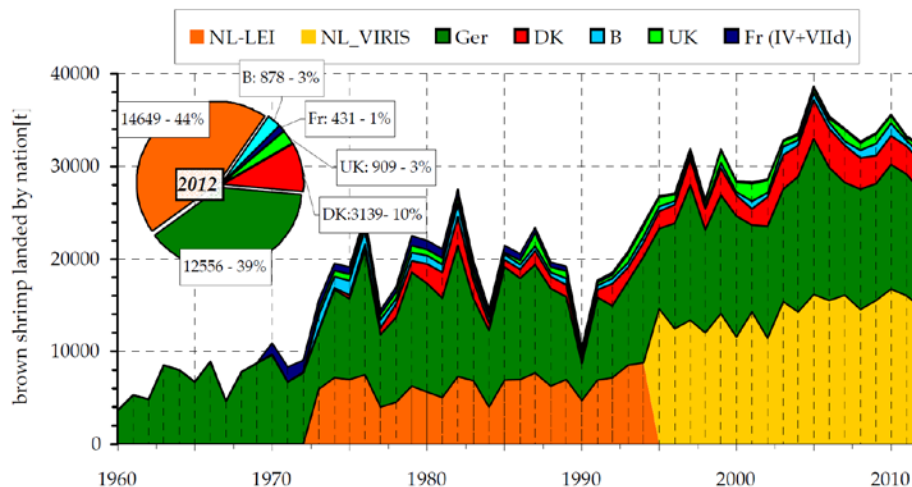


Figure 1. *Crangon crangon* landings from the North Sea [t] by country. Inserted pie chart landings in t and percentage by country for the year 2012.

Shrimpers use bottom trawls with small mesh sizes of 16–26 mm (mean 20 mm). The L_{50} of a 21.7 mm mesh is for shrimps 39.4 mm (Polet *et al.*, 2000) and therefore below the length of 50% maturity, which is 55 mm. On-board and onshore sieving processes use sieves that retain all shrimps with a carapace width larger than at least 6.5 mm¹ corresponding to 45–50 mm total length. Smaller, undersized shrimps along with other bycatch are discarded before the on-board boiling process or after boiling and the second on-board sieving process. Most shrimpers use larger meshed nets (sieve nets) to cover the net opening to avoid bycatch of larger fish which are obligatory by EU law².

Fishing mainly takes place in coastal shallow areas of the Southern North Sea and the UK coast of less than 30 m water depth.

The majority (>90%) of the German cutters are smaller than 20 m, whereas in the Netherlands 60% of the fleet are larger than 20 m. The engine power of German shrimpers is about 200 kW with an increasing trend in engine power since 2002. About 60% of the Dutch fleet has an engine power of more than 200 kW (Figure 2). The fishery concentrates on coastal areas of <30 m water depth. The maximum horsepower of trawlers in the 12 mile zone and the plaice box is 221 kW³.

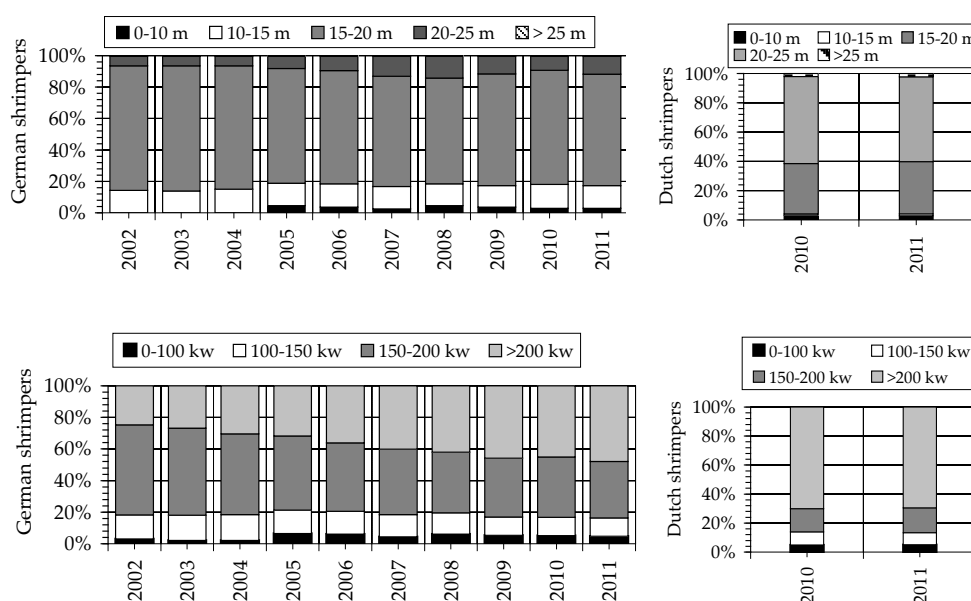


Figure 2. Characteristics of the German (left panels) and Dutch (right panel) shrimper fleet. Upper panels show the vessel size, lower panels the engine power.

¹ EU 2406/96.

² COUNCIL REGULATION (EC) No 850/98 of 30 March 1998 for the conservation of fishery resources through technical measures for the protection of juveniles of marine organisms PB L 125/1. Article 25: EU regulation is requiring all fishers in the European brown shrimp fisheries to use selective gear in order to reduce discarding of juvenile commercial fish species.

³ COUNCIL REGULATION (EC) No 850/98.

In summary: *C. crangon* landings for human consumption constantly increased since the 1970s. Lowest landings were recorded 1990 but in 1991 landings nearly doubled again. Most shrimps are landed by the Netherlands and Germany with the Dutch fleet consisting of larger higher motorized vessels. In the German fleet the fraction of shrimpers with more than 200kW engine power increased from about 25 to 50%.

3.1.3 Information on the stock

Genetic studies have not indicated genetic differentiation within the North Sea *C. crangon* population (Luttikhuizen *et al.*, 2008) and also connectivity studies based on larval drift suggest substantial interconnections of regions although there might be a separation line between the East Frisian and the North Frisian population (Hufnagl, unpublished). However, the whole North Sea population should, with respect to management, be considered as one stock.

Analysis of monthly landings per unit of effort and autumn survey data indicate only a weak and short-term relationship (ICES WGCAN report 2012). Habitat limitations or bottom-up factors as main population driver have been suggested in some studies (Kuipers and Dapper, 1981; Henderson *et al.*, 2006). That the systems carrying capacity is the limiting factor is also underlined by the observation that the lowest observed stock in 1990 was able to rebuild itself within less than two years (Berghahn, 1996). However, a real stock–recruitment relation analysis was so far not possible as a recruitment index is not available. The main scientific surveys (the Dutch Demersal Fish Survey and the German Demersal Young fish survey) are conducted in autumn during the peak in adult abundance; however, this period coincides with the lowest fraction of egg-carrying females but not with the important egg-carrying period in winter. Additionally larval abundance in spring and summer is not monitored regularly and on a large scale. Thus a sound stock–recruitment analysis needs to be performed in future using appropriate methods and surveys.

In first analysis only poor stock–recruit relationships were found. If the outcome of a final analysis would be underline that this is typical for *C. crangon*, the possibility of recruitment overfishing would be reduced. However, there are indications for growth overfishing (Section 3.3.3) and a reduced stock can be expected as soon as the number of recruits falls below the carrying capacity of the system.

In summary: The North Sea population is well mixed and should be treated as one stock. There are indications that the population is so far mainly driven by bottom-up factors and only to a lesser extent by the adult biomass but a classical stock–recruitment analysis is so far not possible due to the lack of suitable datasets and methods.

3.2 Data availability and quality

Several field studies targeted shrimps in the past to analyse abundance, distribution, ecology and biology aspects. However, only a handful of regularly conducted surveys are available that span time-scales of several years. Still ongoing surveys are the Dutch Demersal Fish survey (DFS) and the German Demersal Young Fish survey (DYFS).

The DFS covers the coastal zone from the border between the Netherlands and Belgium up to Esbjerg (Denmark), including the Dutch Wadden Sea, Ems-Dollard Estuary, and Schelde Estuary (Wester-/Oosterschelde). The survey has been conducted each autumn since 1970. A 6 and a 3 m beam trawl with tickler chains and 20 mm

mesh opening (in the codend) have been used (Tulp *et al.*, 2008). The catches of the DFS are performed in deeper water (mean depth ~9.5 m) on a fixed station grid.

The DYFS is a scientific survey performed by the former Bundesforschungsanstalt für Fischerei, now Thünen Institute of Sea Fisheries, Germany, every autumn and in several years in spring since 1974 (Neudecker, 2001). The survey covers mainly shallow waters (mean depth ~5.5 m). A 3 m beam trawl with a mesh opening of 20 mm (stretched mesh), without a tickler chain, was used. Owing to changing hydrographic conditions and sedimentation in the shallow areas of the North Sea, the DYFS has no fixed stations.

In the Marsdiep a fykenet is used since 1960 at the entrance to the Dutch Wadden Sea in a water depth of 1–2 m. The mesh size is 10x10 mm (Campos *et al.*, 2010).

The German Bycatch Series was initiated to monitor the bycatch in the commercial *C. crangon* fishery, but data on the shrimp itself, i.e. length distributions in the catches, were also collected. The data span the periods 1955–1996 (Büsum) and 1958–1993 (East Frisia) and were recorded weekly or monthly (Meyer-Waarden and Tiews, 1965; Neudecker *et al.*, 1999).

Since 2008 discard monitoring has become part of the Data Collection Framework (DCF EC no. 199/2008) and a discard program has been put in place in the Netherlands and Germany. Monitoring is carried out with an observer programme and four to eight trips per year and per country are monitored (Ulleweit *et al.*, 2009).

In addition to the autumn survey scientific surveys were conducted in specific years in winter and spring by the German Thünen Institute.

Besides the long-term scientific and commercial surveys landings and effort data are available as described before in Section 3.1.2.

So far the survey data have been used in a variety of studies to analyse population structure, mortality rates, shrimp bycatch and predator abundance and, ongoing, in a swept-area biomass estimate. However, all scientific surveys use gears that target adult shrimps, whereas juveniles are not caught efficiently. All analyses and estimates that are based on these data are therefore relating to adult, mainly female shrimps (female shrimp grow larger than males). Additionally the autumn surveys target the time when the population size is at its maximum, but not during the important reproduction period. Therefore the surveys provide valuable information on the productivity and stock structure, but information on the reproductive effort cannot be obtained. Comparisons of the survey station grids with VMS data further indicated that the surveys do not target the whole distribution area of the shrimps. The DYFS is mainly conducted in the tidal creeks and the DFS grid is covering deeper areas but VMS data show that fishing takes place even further offshore.

In summary: Several long-term time-series data exist that offer valuable information on the stock (mortality, cpue, biomass estimates, etc.) but questions concerning certain aspects like egg production or densities in deeper areas cannot be answered.

3.3 Advice on the need for management of *Crangon crangon* (ToR a)

3.3.1 Role of *Crangon* in the foodweb; is *Crangon* considered a low trophic level species?

C. crangon can be classified between trophic level 2 (feeding mainly on diatoms as larvae) and level 3 as predator of molluscs, polychaets, copepods and amphipods, as

shown in analysis of stomach contents (Figure 3, del Norte-Campos and Temming, 1998; Pihl, 1985; Evans, 1984; Plagmann, 1939). According to the high variety of food sources, food niche overlaps with other species are present but generally low (Feller, 2006; Pihl, 1985).

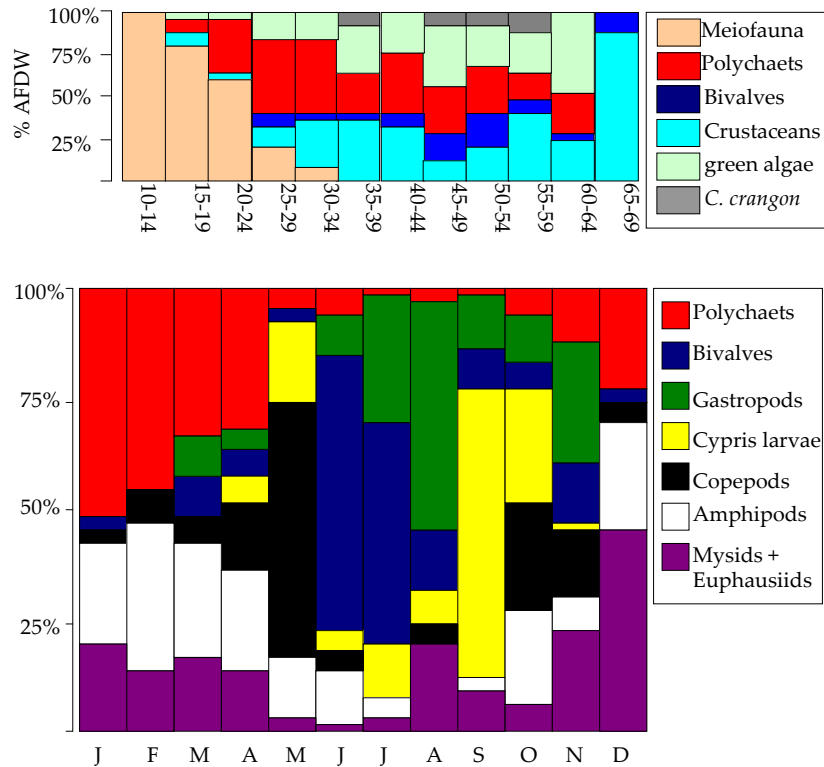


Figure 3. Upper panel *C. crangon* diet composition by length class (n = 553) in ash-free dry weight %. Redrawn from del Norte Campos and Temming (1994). Lower panel: Relative number of prey items by species found in *C. crangon* in one month. Redrawn from Plagmann (1939).

A large variety of species feed on *C. crangon* in the North Sea. These include pelagic and benthic fish species, crustaceans, sea- and shore-birds. Averaged over time and space, biomass-flow from *C. crangon* to its predators is expected to be low ($0.2 \text{ t km}^{-2}\text{y}^{-1}$ of total predation of shrimp compared to $7.8 \text{ t km}^{-2}\text{y}^{-1}$ of total consumption by Sandeel, Norway Pout, Sprat, juvenile Herring, juvenile Whiting, juvenile Haddock, other small gadoids and small demersal fish) derived from an Ecopath model for the North Sea (Mackinson and Daskalov, 2007).

Species preying on *C. crangon* can be separated into two groups preying solely on juvenile shrimps or those preying on juvenile and adult shrimps. The vast majority of predators belong to the first group, mainly due to the fact that most of the predators are of small size even as adults, namely: sand goby (*Pomatochistus minutus*), hook-nose (*Agonus cataphractus*), viviparous eelpout (*Zoarces viviparus*), common sea snail (*Liparis liparis*) and rock gunnel (*Pholis gunellus*). All of the before listed species prey exclusively on shrimp below 50 mm, the majority of prey items being between 10 and 30 mm in length (Kühl, 1964; Redant, 1978; Jansen, 2002).

The second group of key *C. crangon* predators grows, while becoming adult, larger than *C. crangon* and therefore also prey on the larger adult shrimps. These are: cod (*Gadus morhua*), whiting (*Merlangius merlangius*), dab (*Limanda limanda*), bib (*Trisopterus luscus*), short-spined sea scorpion (*Myxocephalus scorpio*) and five bearded rockling (*Ciliata mustela*). However, even these species consume mostly shrimp

<50 mm. The observed shares of large shrimp in the diet were below 2% in dab and five bearded rockling (Kühl, 1964), 14% in whiting (Jansen, 2002) and 18% in short-spined sea scorpion (Kühl, 1964). Of these species whiting is by far the most important predator due to its regularly high 0-group abundances especially in the coastal shallow areas. The only other predator that takes larger shares of *C. crangon* >50 mm is cod, with 18% large shrimp for the 0-group cod in the Wadden Sea (Jansen, 2002) but on average 56% for age groups 0–4 in coastal waters off the barrier islands (Daan, 1989; Hislop, 1997).

Because *C. crangon* is not distributed homogeneously over the North Sea, but can occur in aggregations of high biomass (patchy distribution), it can seasonally form a substantial proportion of the diet of a wide range of predators in certain regions of the North Sea. Therefore, although on average *C. crangon* may not represent the vast majority of any predator's diet, predators may still depend seasonally and regionally on *C. crangon* for their survival.

Is Crangon a lower trophic level (LTL) species?

LTL species play an important role in marine foodwebs because they are the principal means of transferring production from plankton to larger predatory fish and to marine mammals and seabirds. Given its trophic level and the role as food for predators, *C. crangon* can be classified as a Lower Trophic Level species.

There are no general definitions of how to exactly classify lower trophic level species and especially **key** lower trophic level species. Therefore we follow the classifications for key lower trophic level species stated by the Marine Steward Ship Council⁴ which are:

- 1) Species that are not listed already as LTL species by MSC should meet the following criteria:
 - 1.1) The species feeds predominantly on plankton;
 - 1.2) has a trophic level of about 3 (but potentially ranging from 2 to 4);
 - 1.3) is characterized by small body size (<30 cm long as adults);
 - 1.4) early maturity (mean age-at-maturity ≤ 2years);
 - 1.5) high fecundity (>10 000 eggs/spawning);
 - 1.6) short lifespan (maximum age <10 years); and
 - 1.7) forms dense schools.
- 2) Additionally species should, in its adult life cycle phase, meet at least two of the sub criteria):
 - 2.1) there is a large trophic connection between this species and others in terms of a large number of connections (4% or greater of all trophic connections) in the ecosystem; or
 - 2.2) there is a large volume of energy (i.e. a large proportion of the total energy in the ecosystem) passing between this species and both higher and lower trophic levels in the food chain; or

⁴ Marine Stewardship council-technical advisory board TAB directive series. TAB D-036 v1, Assessment of Low Trophic Level (LTL) Fisheries, 15 August 2011. <http://www.msc.org/documents/scheme-documents/msc-scheme-requirements/msc-certification-requirements/view>

- 2.3) there are few other species at this trophic level through which energy can be transmitted from lower to higher trophic levels (i.e. the ecosystem is „wasp-waisted” in number of species per trophic level).

In terms of common biological sense *C. crangon* is a lower trophic level species but is most likely not a **key-LTL** species. Not all criteria listed above are fulfilled but the criteria were mainly designed for vertebrate species and might therefore not be fully applicable. Considering point 2a–c of the MSC criteria one cannot rule-out that *C. crangon* regionally and seasonally indeed forms an essential link of energy in the foodweb for predators. However, system wide (North Sea) and averaged over time, the amount of energy that passes through *C. crangon*, and the presence of alternative species that hold a similar trophic position (30 shrimp species, with *P. borealis* and *C. allmanni* as most important candidates but which have a different spatial distribution), indicates that *C. crangon* do not meet MSC-criteria 2b and 2c either. Too little is known at this point about the number of connections in the foodweb with *C. crangon* to judge whether criterion 2a is met or not.

Removing *C. crangon* from the foodweb will likely not lead to a collapse of the North Sea ecosystem but especially in coastal and estuarine areas larger shifts in energy flows, species composition and performance can be expected.

In summary: *C. crangon* is a Lower Trophic Level Species, but the importance of *C. crangon* as a food source depends on the scale. On the North Sea scale *C. crangon* is not a **key** LTL species, according to the definition of the MSC. On a local scale, especially the undersized shrimp are still an important food source to many other fish. Its role can therefore not be ignored and substantial changes in coastal areas can be expected, if the *C. crangon* population is reduced (e.g. in the case of recruitment overfishing).

3.3.2 The impact of the *C. crangon* fishery on other commercially exploited fish stocks in relation to multispecies and mixed fisheries considerations

ICES advice is provided on an individual stock basis. However the multispecies nature of fisheries ecosystems is important. In fisheries management two types of interactions should be considered: the so called ‘technical interactions’ (or mixed fisheries considerations) and the ‘biological interactions’ (or multi species considerations)⁵.

Given the small mesh size that is used in the shrimp fisheries, bycatch of fish, undersized shrimps and other benthos is inevitable. Since 2002 the use of sievenets to prevent larger fish from entering the codend is mandatory under certain circumstances (in the Netherlands mandatory year-round since 2013)⁶. Sievenets (also known as veil nets) are cone-shaped nets inserted into standard trawls, which direct unwanted bycatch to an escape hole in the body of the trawl (Revill and Holst, 2004). In some cases the escape hole is covered with an 80 mm mesh to catch escaping fish of commercial value. Whether this is general practice or whether only some fisherman do so is unclear so far and needs to be further investigated.

Sievenets work well in reducing the bycatch of fish >10 cm and invertebrates but do not work for fish <10 cm (Polet, 2003; Catchpole *et al.*, 2008). The latter can, during certain times in the year, still make up a substantial amount in the catch (Revill *et al.*,

⁵ ICES Advice 2010, Book 1.

⁶ COUNCIL REGULATION (EC) No 850/98 of 30 March 1998.

1999). Especially the bycatch of juvenile (0-group) plaice is often raised as a concern. The Wadden Sea and adjacent coastal areas are an important nursery area for plaice and other commercial important fish species like sole and dab (Zijlstra, 1972; van Beek *et al.*, 1989; Bolle *et al.*, 1994). Fish bycatch in the shrimp fisheries has been estimated to reduce plaice (by 10%), sole (by 1%), cod (by 1%) and whiting (by 1%) spawning stock at that time (Revill *et al.*, 1999). Nevertheless the plaice stock is on a very high level that indicates only a weak influence of the shrimp fishery during recent years. Other commercial and non-commercial species can also appear in the bycatch in large numbers, however VPA estimates of the impact on the stock are currently not available (e.g. Dab and Flounder).

There is a possible competition between the fisheries and (large) other important gadoid species, like cod and whiting. Bodekke (1971) pointed at gadoid predation as the key factor in the fluctuating shrimp stock (Welleman and Daan, 2001). Invasion of these two species in the early 1990s led to depletion of the shrimp stock at that time (Berghahn, 1996) leaving hardly any shrimp for the fisheries. As elaborated in Section 3.3.1 mainly small shrimp <50 mm are targeted by the gadoids and other predators. At the moment there is no competition between fisheries and gadoids as especially the cod and whiting stocks are very low (ratio F/M Section 3.3.3). However, if gadoids will recover, one could expect that the predators predate on shrimp before they are available to the fisheries. An effect the other way around (that the *C. crangon* fishery takes away the food of gadoids) is expected to be less pronounced as the fishery targets the large shrimps. These are a less favourable food source for gadoids. Besides that, gadoids will most probably find also alternative food sources, as *C. crangon* is not a key lower trophic level species. Thus, we do not expect that the *C. crangon* fishery is limiting the food availability for gadoid predators. With regard to multispecies considerations, only a one way interaction (impact of gadoids on the *C. crangon* population) is suggested to be considered.

Mixed fisheries considerations

C. crangon is not taken into account in the present framework of the ICES advice regarding mixed fisheries. In some cases the escape holes of the sievenets are covered with nets (larger mesh width) to retain commercially exploitable bycatch. Cutters can change the métier but do not target flatfish and shrimps at the same time. However, the fact that many juvenile commercial species are caught as bycatch and are discarded should not be ignored and substantial amounts of 0-group fish can be removed from the system leading to the reduction of other stocks (e.g. 10% of plaice stock decrease due to shrimp fisheries). Hence we recommend that in future also the shrimp fishery is included in the mixed fisheries approach. An appropriate way needs to be developed.

Multispecies considerations

A recovery of gadoids can possibly influence the abundance of *C. crangon* that is available for the fisheries. A multispecies approach is advised to be considered in the modelling (analysis of F/M ratio for shrimp) and $F_{0.1}$ determination, but an effect of shrimp fisheries on (the recovery of) gadoid stock is not likely as the gadoids are considered a.) more efficient than the shrimp fisheries and b.) to target to a large extend also undersized, not commercially used, juvenile shrimp.

3.3.3 The impact of the *C. crangon* fisheries on *C. crangon*

Until recently the general assumption was that the *C. crangon* stock could not be easily overfished and that natural mortality was significantly higher than fishing mortality (i.e. exploitation is low). This was based on a.) the observation that after the low of 1990 the stock rebuilt itself within one year, b.) only weak predictive capacity of future stock sizes from current stock sizes over longer periods than six month and not across cohorts (e.g. not from June to September as the new cohorts starts reaching commercial size after August, ICES WGCAN report 2012) and c.) the evaluation by Welleman and Daan (2001) who quantified that the magnitude of the total annual shrimp landings was low compared with the fraction of shrimp consumed by cod and whiting (the main predators).

All three points mentioned above have their limitations and uncertainties, e.g. during the 1990 low the egg production of female shrimps was also low (Siegel *et al.*, 2008) indicating a potential effect of SSB besides high whiting predation on the population. Correlation to predict stock abundance have only been made with l_{pue} obtained from commercial landings and not with fecund females and their potential egg production (as these are not available) and the Welleman and Daan study did compare landings (only adult shrimps) with predator consumptions of all shrimps (juveniles+adults) leading to results biased towards predation.

In combination with field studies focusing on condition of shrimps (Hufnagl *et al.*, 2009), on the consumption rates of shrimps (Kuipers and Dapper, 1981), the variability of adult abundance vs. juvenile abundance (Henderson *et al.*, 2006) and also by considering the interannual variability of landings, it can be concluded that the population is, at the moment, to a large extent bottom-up controlled by the carrying capacity of the habitat. This also means that there is currently no recruitment overfishing although this needs further investigation as so far reliable data on recruitment strength are lacking. Several findings point towards growth overfishing of the population especially during recent years as outlined below and an influence of the adult population can be expected as soon as the number of recruits falls below the carrying capacity of the system.

Fishing in relation to predation induced mortality

The analysis made by Welleman and Daan (2001) has currently been extended for the years 1996–2011 (Temming and Hufnagl, in prep.) using updated stock assessment and predator distribution data. The abundance of the predators cod and whiting combined with consumption rates and the shares of shrimps observed in the stomachs in the past allows for an estimate of the predation impact which can be contrasted to the North Sea wide landings.

Based on this analysis the amount of shrimps (>50 mm) landed exceeds the amount of shrimps (>50 mm) eaten by the main shrimp predators cod and whiting since the 1990s. This is mainly due to decreasing predator abundances in the North Sea and is reflected in increasing landing volumes since 1990. Since then total landings for human consumption increased to a level of above 30 000 t per year.

Zhou *et al.* (2012) determined, based on a meta-analysis of 245 fish species, that $F_{MSY} = 0.87 \cdot M$. In recent years the *C. crangon* fisheries induced mortality is about 3 to 5 times higher than the predator induced mortality and therefore exceeds this F_{MSY} value 3.4 to 5.7 fold. This study by Zhou *et al.* did not focus on shrimp species and was based on fish species only, however, it included short-lived and fast-growing species as

well which indicates that the determined F for the shrimp fisheries is possibly on a too high level to be sustainable.

The lpue increased after the fishing stop 2011

In 2010 a strong *C. crangon* cohort was present in the North Sea which led to generally increased landings from November 2010 on (Figure 4). The increased landings in combination with a special market situation lead to very low prices paid to the fishermen per kg. The fishermen reduced the hours spent at sea from March 2011 on from and effort was significantly reduced compared with the average of 2002 to 2011. End of April and early May in 2011 the whole German fleet and large parts of the remaining North Sea fleet (mainly the Netherlands and Denmark) stopped operating. When correcting the lpue for the cohort effect (as indicated in the lowest pane of Figure 4) by using the period from 28.10.2010 to 11.3.2011 (from where lpue were significantly higher than the years before to the period where effort was significantly decreased) it can be seen that lpue significantly (one sample t-test, $p < 0.01$) increase from the week on where effort is significantly reduced (grey shaded in Figure 4).

The reduced fishing pressure in combination with the strong cohort altered the landings statistics and the observed lpue increased to 6 kg-horse power⁻¹ ·days at sea⁻¹ (kg/hp-das) in contrast to an average of 3 kg/hp-das in the German fleet (Figure 5, WGCRAN 2013). In the Dutch fleet lpue increased by about a factor of 2.5 as well. Similar developments were seen in the Danish fleet for the same period (WGCRAN 2012).

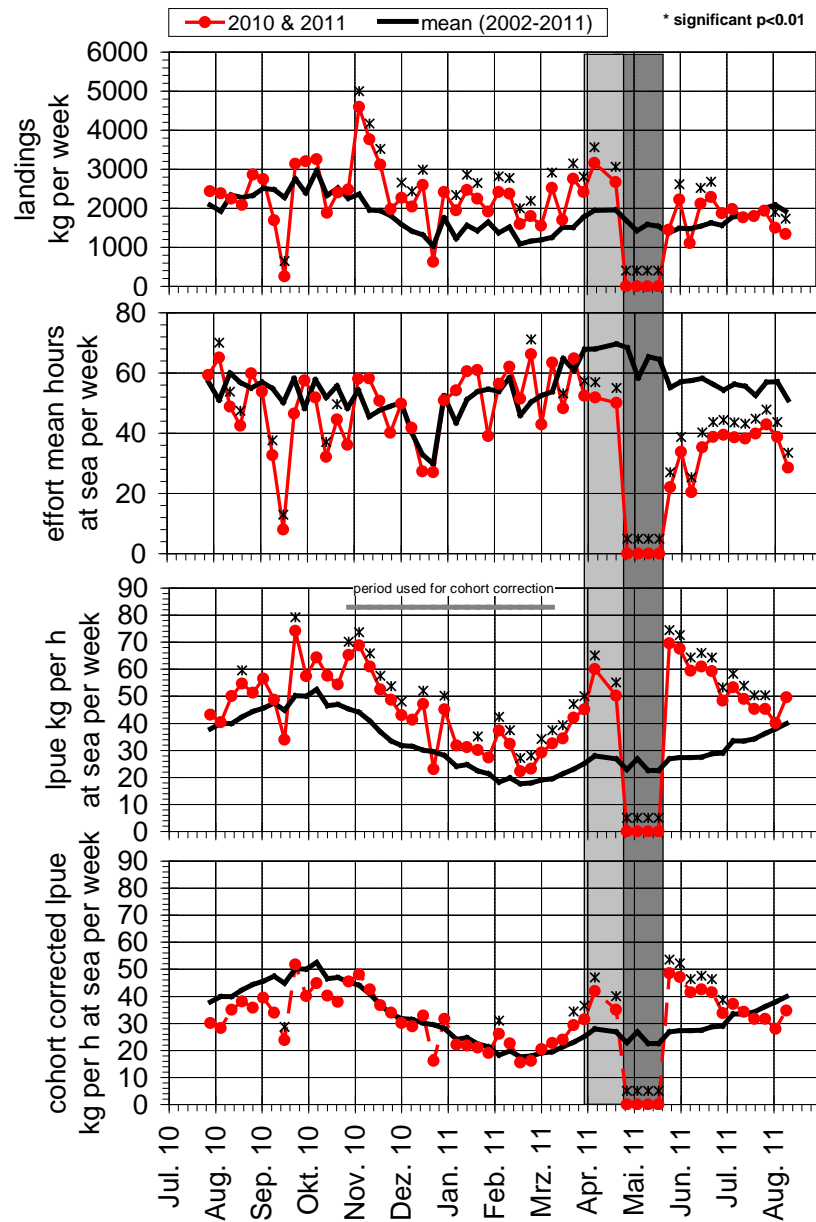


Figure 4. Based on German fleet data from top to bottom: Weekly mean (all active vessels) 1.) landings in kg, 2.) effort in hours at sea, 3.) lpue in kg/h at sea and 4.) cohort corrected lpue in kg/h at sea. Black line: average for the period 2002 to 2011. Red line: observations in 2010 and 2011. Stars indicate 2010 and 2011 values that are significant different from the long-term mean. The grey horizontal line in panel 3 indicates the period that was used to correct lpue in panel 3 for the cohort effect so that the red line in panel 4 is the outcome. Light grey vertical surface: period with significantly reduced effort. Dark grey vertical surface: strike period.

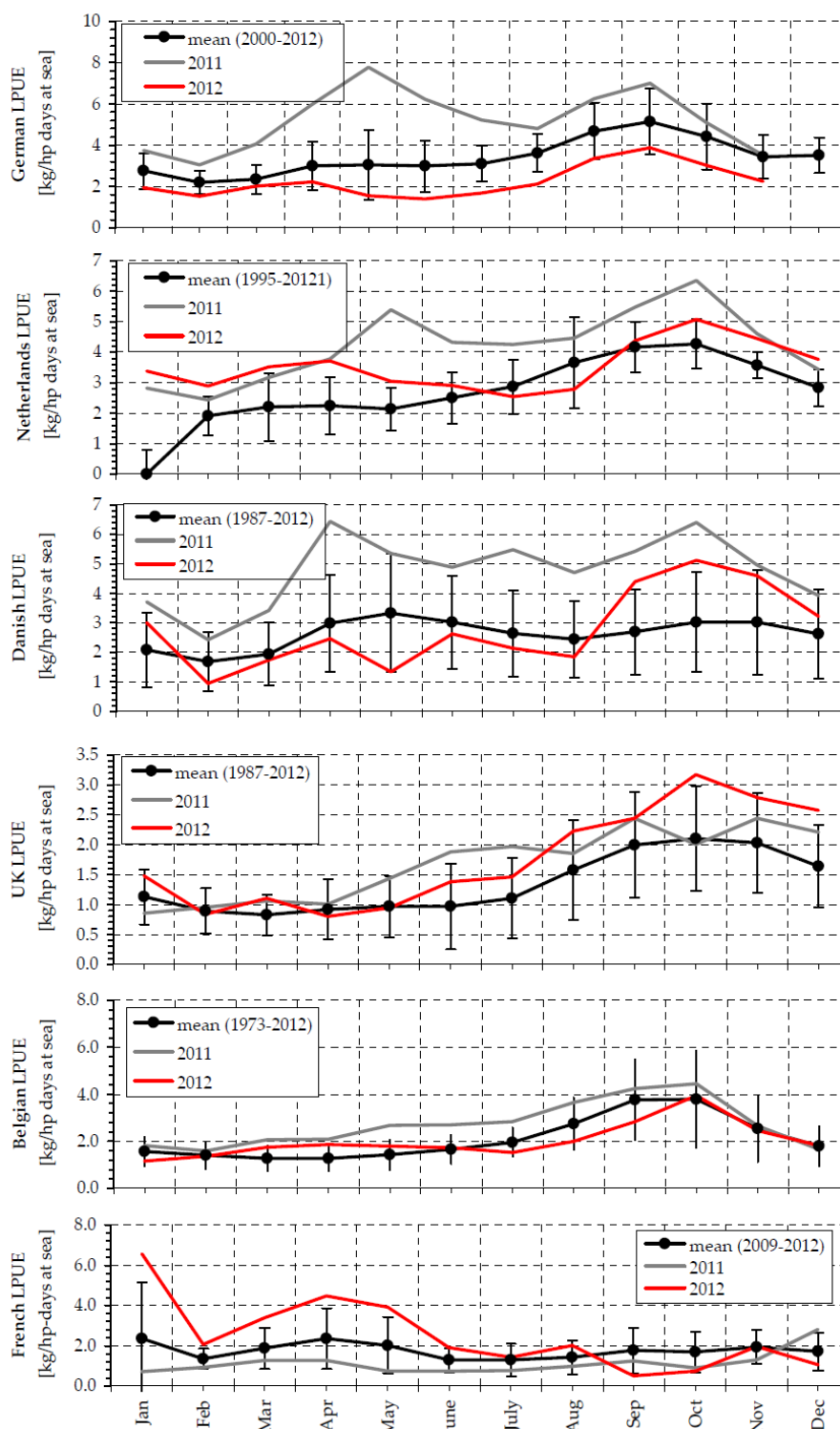


Figure 5. Monthly landings per unit of effort in kg per horsepower days at sea. Black line and whiskers indicate the long-term mean and standard deviation for each nation. Grey line indicates the effort for 2011 and the red line the effort for 2012. For Germany, Denmark, Belgium and France: days at sea = returning to harbour - leaving time in hours x 24 for Netherlands calendar days at sea. No data for Belgium and UK.

This finding can be contrasted to a back of the envelope calculation. Studies based on length–frequency analysis indicated that the total mortality is $Z=5 \text{ a}^{-1}$. F/M is in the most extreme case 5 and thus $F = 5 \cdot M$ and $Z = F+M$ and thus $5 = 5 \cdot M+M$ and therefore in $M=5/6$, $F=5 \cdot 5/6=25/6$ and $Z= 5$. The growth rate of a 50 mm shrimp at 10°C is about 0.1 mm d^{-1} and the length–weight relationship is $W \text{ [g]} = 4.625 \cdot 10^{-6} \cdot L^{3.084} \text{ [mm]}$. Assuming a situation with 30 days of fishing ($Z=F+M=5$) the initial shrimp cohort size would be reduced to 67% whereas in a situation without fishing it would only be reduced to 93%. The weight per shrimp would in both cases increase from 0.8 g to 0.96 g. Multiplying the abundance and the wet weight results in a 20% reduced biomass in the fishing scenario but a 12% biomass increase in the non-fishing scenario.

This calculation shows that when the effort is reduced the growth of the population leads to a surplus that can be harvest. This was the situation in 2011 before and during the strike. The population, already on a high level, increased and thus l_{pue} increased as well. These findings indicate also that a reduced mortality on only part of the population (e.g. the undersized shrimps) can be beneficial. If small shrimps are protected, a larger yield of larger shrimps could be gained at a later time. Adjusting the catchability of the used gears and nets could therefore lead to a healthier size structure (more and larger shrimps) of the population and hence to higher landings volumes and a higher quality and value of the catch.

Yield-per-recruit (Y/R) based analysis

The back of the envelope calculation done in the previous section can be done in a more accurate and detailed way. A *C. crangon* specific Yield-per-recruit (Y/R) Model (based on Beverton and Holt, 1957) was parameterized and applied to analyse the current situation of the shrimp stock. The model is a cohort model that includes a spawning index (Temming and Damm, 2002), size and temperature dependent growth rates (Hufnagl and Temming, 2011), stage and season-specific mortality rates, seasonal effort patterns of the fleet (WGCRAN, 2012), the total mortality rates of adult shrimps (Hufnagl *et al.*, 2010) and is structured as indicated in Figure 6 (Temming and Hufnagl, in prep.).

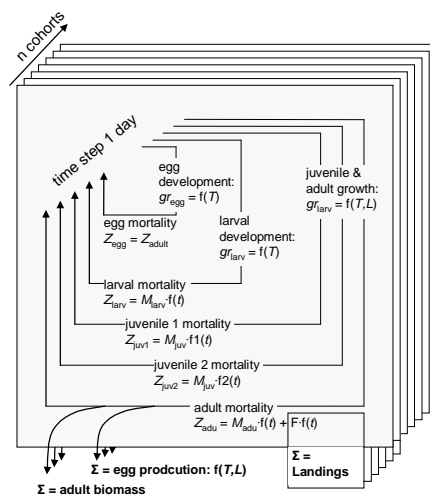


Figure 6. Structure of the *C. crangon* specific Yield-per-recruit model.

The model was used to determine total yield (landings) in relation to different ratios of fishing mortality (F , landings from Netherlands, Germany and Denmark) to natural mortality (M , from updated Welleman and Daan, 2001 estimates as described before) and total mortality rates estimated using length-based methods (Hufnagl *et al.*, 2010 and 2012). From the results (Figure 7 left) F_{MAX} and $F_{0.1}$ were determined with F_{MAX} defined as the fishing mortality at which the maximum landing can be achieved. $F_{0.1}$ was defined as the fishing mortality at which the marginal gain is 10% of the gain at the origin (Gulland, 1968). The annual F values (obtained from the landings, predation, total mortality analysis) were compared to model derived F_{MAX} (Figure 7 right). Since the 1990s with exception of 1994, 2001 and 2007, F always exceeded F_{MAX} (Temming and Hufnagl, in prep.).

The results indicate growth overfishing and hence that effort can be reduced while obtaining similar or even higher landings.

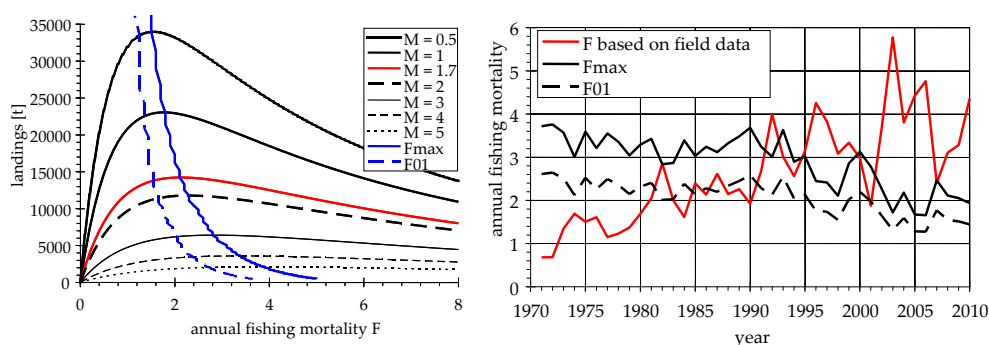


Figure 7. Results of the *C. crangon* specific Yield-per-recruit model using different F to M ratios (Temming and Hufnagl, in prep.). Left panel: black lines show results of scenarios with M varying between 0.5 and 5 a^{-1} . The red line indicates the M level of the most recent years. The blue lines indicate F_{MAX} and $F_{0.1}$. Right panel: F estimated using total mortality Z (see Section 5 and Hufnagl *et al.*, 2010) and the ratio of shrimps consumed by predators to landed shrimps. The black lines indicate F_{MAX} and $F_{0.1}$ based on model results using the F and M values determined for the respective year.

Demographic structure and fraction of large shrimps

The fraction of large shrimps collected in scientific surveys constantly decreased between the 1970s and 1980s from 10 and 30% being larger than 70 and 60 mm to 2 and 20% during recent years (updated analysis based on Hufnagl *et al.*, 2010). During the late 1980s the lowest values were observed and slightly increased again since then (Figure 8). This can have two reasons: either mortality increased over time or productivity (growth) was reduced. The main reason is most likely the increased mortality rate. From 1960 to 1993 total mortality increased from 4.5 to 7.5 a^{-1} . After 1993 mortality decreased again and was during recent years about 5 to 5.5. Since 1995 a slight increase in total length was observed again. The 1980s and the years before were also characterized by high eutrophication which could have favoured shrimp growth by higher food availability. The larger sizes could therefore also be partly a result of higher productivity in former times.

At 60 mm about 75% of the female shrimps carry eggs and one 60 mm sized female carries about 4000 eggs. At 70 mm 96% of the females carry eggs and a female of that size carries about 6400 eggs. Mean length-at-maturity of adult female *C. crangon* is 50 to 55 mm (Oh *et al.*, 1999) and the number of eggs varies, depending on size of the female, between 2000 (50 mm) and 10 000 (80 mm) eggs (Bilgin and Samsun, 2006; Redant, 1978; Havinga, 1930). Using these numbers and assuming a population

which is consisting of 10% 70 mm, 20% 60 mm and 70% 50 mm animals (~situation 1955) would produce 11.4 times more eggs than a population consisting of 2% 70 mm, 18% 60 mm and 80% 50 mm shrimps (~current situation).

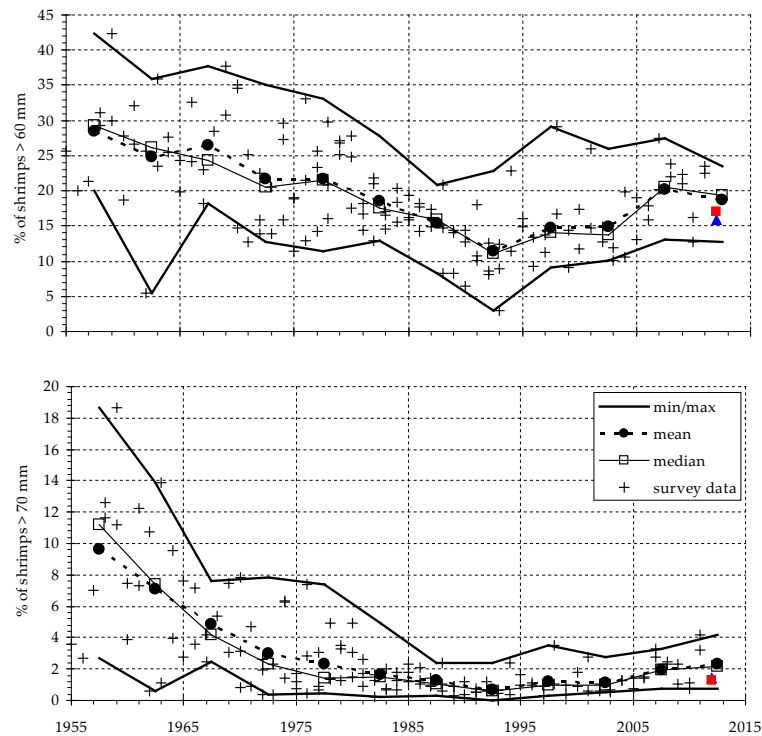


Figure 8. Fraction of shrimps >60 mm (upper panel) and >70 mm (lower panel) estimated using different surveys (German Demersal Young Fish Survey: DYFS, Dutch Demersal Fish Survey DFS, German Bycatch Series from East Frisia and BÜsum, Hufnagl *et al.*, 2010). Data for 2012 are indicated by red rectangles (DFS) and blue triangles (DYFS).

Swept-area based biomass and production estimate

A measure of the total stock abundance can be obtained from the catch per swept-area obtained from the scientific surveys multiplied with the area populated by *C. crangon* (Tulp *et al.*, in prep.). Here the estimate was calculated by the sum of the stratified arithmetic means of the catch weights (by 5 m depth strata) multiplied by the surface of each depth stratum for different areas covered by the Demersal Fish Survey (DFS). Missing values were extrapolated using the program TRIM (TRENds and Indices for Monitoring data). Due to the high P/B ration of the population a comparison of landings with biomass might distort the relation. Therefore besides the biomass estimate a production estimate is calculated using annual total mortality rates. Total mortality can be used as in an equilibrium situation it can be assumed that $P/B=Z$ and therefore $P = Z \cdot B$ (Allen, 1971). The estimate has been corrected for net selectivity, for gear catchability, for behaviour and shrimp availability, the relation of the autumn biomass to the annual average biomass. The estimates includes an extension to deeper areas, beyond the area covered by the surveys up to 40 m depth and an error estimate that includes all afore mentioned correction factors.

Following this analysis average annual total adult shrimp biomass varies between values below 5000 t in 1972, 1976, 1977 and 1990 and values above 20 000 t in nine years mainly since 1999. Translating the biomass estimates to production rates in $t \cdot year^{-1}$ values between 50 000 t and 250 000 t were determined. Low values coincide with years of high whiting abundance like 1990, 1998 and 2007. In these low produc-

tion years annual catches about equal the total annual production of adult shrimp biomass.

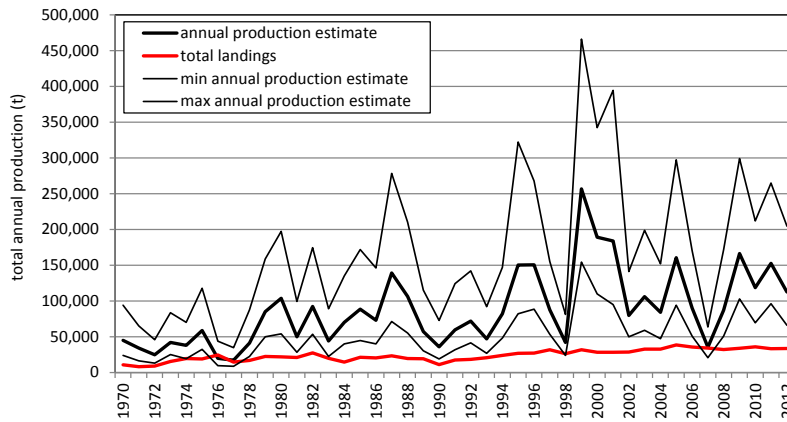


Figure 9. Preliminary production estimate (thick black line) based on swept-area calculations including uncertainty bands (thinner black lines) and contrasted to total North Sea landings (red line) (Tulp *et al.*, in prep.).

In summary, Impact of the *C. crangon* fisheries on *C. crangon* clearly point towards a situation where the stock is growth overfished. We base this on the following aspects:

- The findings of a decreased fraction of large shrimps in scientific surveys;
- The high ratio of F to M of larger 1 and up to 5 in recent years. This corresponds to a level of F that is up to 5.7 times higher than F_{MSY} (Using rates determined for fish);
- The significant increase in lpue after the strike and a stop of the fisheries in 2011;
- The landings volume that in certain years equals the total annual production;
- Results from the yield-per-recruit model that indicate that F was always higher than $F_{0.1}$ since 1990 (except 2001).

Growth overfishing also implies that effort can be reduced while obtaining similar or even higher landings and shrimp of a higher quality (larger). Reducing F would mean that effort in certain seasons or in general needs to be reduced and that gears need to be adjusted. This is only possible in a controlled and managed fishery.

3.3.4 Conclusion: do we need management?

In the sections above and especially the previous section, evidence of the need of *C. crangon* management was discussed. The evidence of the need of management is a combination of several factors. Our argumentation pro management follows mainly four arguments.

- 1) The stock is probably growth overfished and a reduction of effort is possible without major losses in landings in the short term and with potential increase in the medium or long term.
- 2) Each reduction of unnecessary effort will lead to a reduced impact on the ecosystem through reduced discards, bottom impacts, combustion, etc.

- 3) The lack of an efficient management results in situation of uncontrolled and unmonitored effort and efficiency. The development of new and more efficient devices (e.g. pulse beam trawl) increases the urge for a controlled fishery.
- 4) The high interest of the fishing industry and the fishermen to participate in the process which led to an already implemented self-management initiative within the MSC application process.

The *C. crangon* fishery in the North Sea is, besides some gear restrictions (minimum mesh size, minimum sieving width, maximum number of licences) largely unmanaged and uncontrolled. From parts of the fleet essential information on used gear types, exact effort and catch are missing. The lack of management and hence the limited urge for data collections results in a situation where (increased) fishing effort and efficiency is at the moment largely unmonitored. The fleet of active shrimpers in the North Sea consists of 523 (2011) to about 630 (2009) that induce a fishing pressure 3 to 5 times higher than the natural mortality. The F varied during the last decade between 2 and 5 while $F_{0.1}$ was determined to be located below 2 and a release of the fishing pressure over a relatively short period already doubled the l_{pue} and in various years the total annual production of adult shrimps is harvested.

Reducing the effort will lead to a better product (larger shrimps) and comparable or even higher landing volumes (as shown by the situation after the strike in 2011). The reduced effort is not only envisaged from an economic but mainly from an ecological point of view. Every reduction in effort will lead to less bycatch, less discard, less bottom impact, less combustion of fuel, etc. If not a general effort reduction can be achieved at least a temporal release of the fishing pressure (due to fleet wide effort reduction) can help in years with low shrimp population size (e.g. due to high predation, low reproduction, etc.) to allow for a recovering of the stock and a guarantee for the next years population.

Although effort levels, in measures of boats or days at sea, remained fairly constant during recent years there are clear indications that the efficiency of the used vessels (e.g. increase in horse power) increased. New upcoming innovations like pulse beam trawl fishing will lead to a further increase in gear efficiency. Increased efficiency can be an advantage (in terms of less bycatch and bottom contact per kg of shrimp caught), but only if an efficient monitoring and adjusted management is in place. Hence an innovation like this should not be introduced without monitoring of impact and management considerations.

There is a significant risk that if no management is implemented the impact of the fisheries on *C. crangon* availability and on marine ecosystems will increase due to inefficient yielding. Management of the Crangon fisheries should lead to an increase of the efficiency of the fisheries and to a reduction of *unnecessary* effort. This reduction of unnecessary effort will directly lead to a decrease of bycatch of unwanted organisms and reduce other adverse effects on the ecosystem.

In addition, the industry (in the Netherlands, Germany and recently also in Denmark and UK) is aiming for the MSC certificate for sustainable fisheries. Following the principles (1 and 2) of MSC, the industry is aiming for sustainable fisheries with minimal environmental impact. This implies also the development of an effective management system of their fisheries (principle 3). However, attempts by the industry to control landings nationally have led to fines from the Dutch Consumers Authority in the past (NMA). At present the NMA keeps a close watch on the developments with-

in the industry. As a consequence producers' organizations or other groups representing shrimp fishers are not allowed to make any agreements about prices, market and landing amounts. This situation makes it impossible for the industry to install a sustainable management to their fisheries themselves and pleas for an international (EU-level) accepted and implemented management system.

Fishing activities of the Dutch, German and Danish shrimpers are confined to the coastal areas and the Wadden Sea, an area which for a large part has been designated as a Natura2000 area. Relevance for management is therefore also present on MS and local level.

Following the Marine Strategy Framework Directive the ecosystem and each of its components should be in a healthy state until 2020. Implementing an effective management could increase the size of the shrimps in the population, could reduce the impact on shallow coastal benthic habitats and would reduce bycatch of demersal fish and invertebrate species while retaining the landings on a comparable level.

3.4 Strategy and road map for the inclusion of *C. Crangon* in ICES multispecies and mixed fisheries assessment

See Section 3.3.2 for multispecies and mixed fisheries considerations.

3.4.1 Mixed fisheries

Given the inevitable bycatch of juvenile plaice and other commercial important (flat)fish, we advise an inclusion of the shrimp fisheries in the mixed fisheries assessments in future. Additionally steps need to be undertaken to improve our knowledge of:

- 1) recent seasonal and interannual variation of bycatch volume and composition in the shrimp fisheries;
- 2) natural, density-dependent and fisheries induced mortality of juvenile fish and shrimp;
- 3) the *impact* of the shrimp fisheries practices on the stocks of commercially exploited fish.

3.4.2 Multispecies

With regard to multispecies considerations more information on biological interactions and the role of *C. crangon* in the foodweb is needed. These refer especially to the following topics:

- 1) The role of *C. Crangon* as predator of mussel/plaice larvae and the influence on their recruitment strength needs to be updated and enumerated and eventually taken into account.
- 2) With respect to the interaction of the shrimp fisheries and the gadoid predation on the shrimp population a close monitoring of the gadoid stocks and the distribution of especially the 0-group cod and whiting needs to be considered in a *C. crangon* management.
- 3) Natural mortality of undersized shrimps is an important but so far not determinable variable influencing the productivity of the stock. For a more sound determination updated stomach content data in combination with stock size estimates of potential predators are required.

- 4) So far all multispecies analysis is based on data from 1991. New stomach content data of potential *C. crangon* predators are therefore highly necessary.

3.5 Potential steps towards a *C. crangon* management

3.5.1 “Classical” age-based methods

ICES typically provides catch advice on a stock by stock basis. For a stock with a population size estimate and a clear age structure, the catch that achieves a desired fishing mortality is calculated on a yearly basis. Classical tools like Virtual population based analysis (VPA) or other age based methods are not applicable for the shrimp stock as age cannot be determined. Furthermore the life cycle is short and shrimps that hatch in winter reach adult size in the following autumn. Where the spring abundance is somewhat related to the previous autumn abundance (as it is the same cohort) the autumn abundance is generally independent from the previous spring abundance (new cohort enters the fishery in August) and is mainly bottom-up controlled. A management is therefore only possible on short terms - in the order of weeks to months - and would be based on length-based methods and densities (e.g. commercially or scientifically raised cpue or lpue).

3.5.2 Technical measures and effort management

A basic management on allowed gears (minimum mesh size 16 mm), bycatch reduction (sieve net), minimum landing size (6.5 mm sieves) and maximum number of licences is already in place. More data are currently raised concerning mesh selectivity and the effect of using larger sieve width on the stock (CRANNET Project). Additional management of technical measures should go hand in hand with the proposed effort management and should rather be introduced by benefit based approaches and not by restrictions or limitations to allow for reduced controlling effort and legislation or bureaucracy.

3.5.3 Methods used for short-lived and data-limited stocks

C. crangon is a short-lived species and typically for these stocks the ICES MSY framework for short-lived aims at achieving a target escapement biomass ($MSY B_{escapement}$, the amount of biomass left to spawn). $B_{escapement}$ represents the minimum biomass level that is robust against recruitment failure if recruitment is uncertain. However, this approach requires information on stock size and factors acting on recruitment (SSB or other indices). Stock size estimates are rather uncertain and a stock-recruitment relation not available.

For short-lived and data-limited stocks, where biomass and recruitment estimates for the current year are unknown, no fishing opportunities are calculated. Also if a very poor stock-recruit relationship is typical for *C. crangon* the possibility of recruitment overfishing is reduced. In other words the applicability of $B_{escapement}$ for *C. crangon* fisheries management is questionable and the definition of a value for $B_{escapement}$ difficult. Taking the lowest observed landings, for example the value observed in 1990, would not be applicable for the current situation as predation pressure changed significantly since then.

ICES provides alternative approaches for stock with limited data (data-limited stocks, DLS). The DLS methods however were mostly applied to long(er)-lived species.

Therefore further work may be required to develop specific methods for short-lived species which have limited data.

3.5.4 Harvest Control Rule (HCR)

A harvest control rule based on the reported landings and hours outside the harbour (or hours spent fishing) has been suggested by the industry in the MSC process. As soon as l_{pue} fall below a predefined threshold effort shall be reduced. This “*ad hoc*” short time l_{pue} based management tool is seen as possible management for the typical short lived and highly productive *C. crangon* in contrast to the “classical” annual systems. It allows for giving extreme short notice on changes in the shrimp stock developments and would follow the general principal of a precautionary approach targeting towards guaranteeing a $B_{escapement}$.

l_{pue} thresholds inducing an effort reduction as well as the necessary level of effort reductions have already been evaluated scientifically based on German logbook data and reported effort in combination with the yield-per-recruit model. The HCR was found to be a suitable strategy for the moment but definitely needs further ground-truthing, validation and testing as in the past $cpue$ based systems failed due to inappropriate effort and efficiency measures. Additionally there needs to be a fair way to “distribute” the effort reduction among the fishermen.

To optimize an HCR based management the relation between commercial and scientifically raised $cpue$, the relation between boat parameters and $cpue$, the optimal reference point, $B_{escapement}$ and critical population thresholds need to be analysed and determined thoroughly. Also a HCR is typically only fair when the fleet applied to, is homogenous. In *C. crangon* fisheries, fishing patterns and landings vary for different regions and should thus be taken into account with the implementation of the HCR.

A regular revaluation of the management is recommended for a HCR based management as effort and efficiency changes will lead to biased $cpues$. This would therefore include a regular ground-truthing of l_{pue} and recommended effort (HCR or short-term TAC). One possible way could be to extend the scientific surveys or, what would be a better resolution concerning spatial and temporal coverage, to include the fishermen to survey (e.g. once per quarter) the stock with standardized gears in a standardized fashion. An additional survey of adult shrimps in winter or of juvenile shrimps in late spring that can be used to identify the recruitment strength of the incoming cohort is highly recommended.

An efficient monitoring and a successful application of a HCR are only possible if information on efficiency and effort are transparent and available in short time. This needs a high level of stakeholder involvement in the management.

3.5.5 Biomass model

Van der Hammen and Poos (2010, in WGCAN 2010) used a biomass model to calculate maximum sustainable yield (MSY). The results restricted by the dataset used and the method did not provide a reliable biomass estimate nor applicable reference points, even if the most reliable series (DFS survey series) was used. This was mainly based on the fact that the interannual variation in l_{pue} was too low and that the time-series did not cover many “bad” years. Because of the complicated life history, spatial distribution and the lack of a good $cpue$ index there is still much doubt about whether reliable yearly reference points for shrimp can be estimated with this method in future.

3.5.6 Yield-per-recruit analysis

A yield-per-recruit model has been parameterized and used to estimate F_{MAX} and $F_{0.1}$ (see Section 3.3.3). The model can be used in a retrospective way (needs length-based data from the surveys to estimate Z , distribution and abundance of cod and whiting 0-group to estimate M , landings to estimate F , but cannot be used in a predictive forecast mode. Furthermore in a situation where predation pressure and natural mortality increases each yield-per-recruit model would suggest increasing F to obtain the maximum biomass. This is from an economic standpoint reasonable but not from an ecological, as the biomass could fall under a critical threshold biomass that would guarantee recruitment. However, the model gives valuable information on growth overfishing and can be used to adjust reference points and for scenario testing.

3.5.7 Biomass and other stock status indicators

Biomass can be estimated based on scientific surveys and/or fisheries catch data. So far the swept-area estimate that is discussed in Section 3.3.3 generates valuable information on the stock size and its interannual variability. Based on the surveys used so far it can only be used in a limited way to forecast biomass as the survey is conducted only once and targets adult shrimps. With respect to the annual life cycle one sampling is not enough (even at the right time) to give a catch advice. A survey that targets juvenile shrimps and the new incoming cohort does not exist so far but would be a very useful tool to predict recruitment strength. In addition, and although no age-based information is available, information on length-frequency distributions can be used to determine total mortality rates or to analyse stock structure (e.g. fraction of large shrimps, etc.). All data combined give a reasonable picture of the status but again only retrospectively.

Commercially obtained data on density information, like $lpue$ obtained from logbook data, generate additional information that can be used as indicator of the available biomass. However the validation and applicability needs to be analysed and needs to take into account all factors that influence efficiency, effort and catchability. A fleet inventory including used gear types, vessel data, etc. is therefore recommended.

3.5.8 Alternative methods

A new General Depletion Model was introduced during the workshop that is stock independent and uses only fisheries data. The model needs to be evaluated and tested concerning the applicability for the *C. crangon* stock and might be used for assessment.

In summary

Due to the short lifespan of *C. crangon* a classical age-based management based on stock-recruitment relations is not possible. The most suitable solution seems to be for a start an $lpue$ based harvest control rule with regular ground-truthing through standardized survey data in combination with retrospective analysis on fishing and natural mortality, available biomass, demography and other stock status indicators.

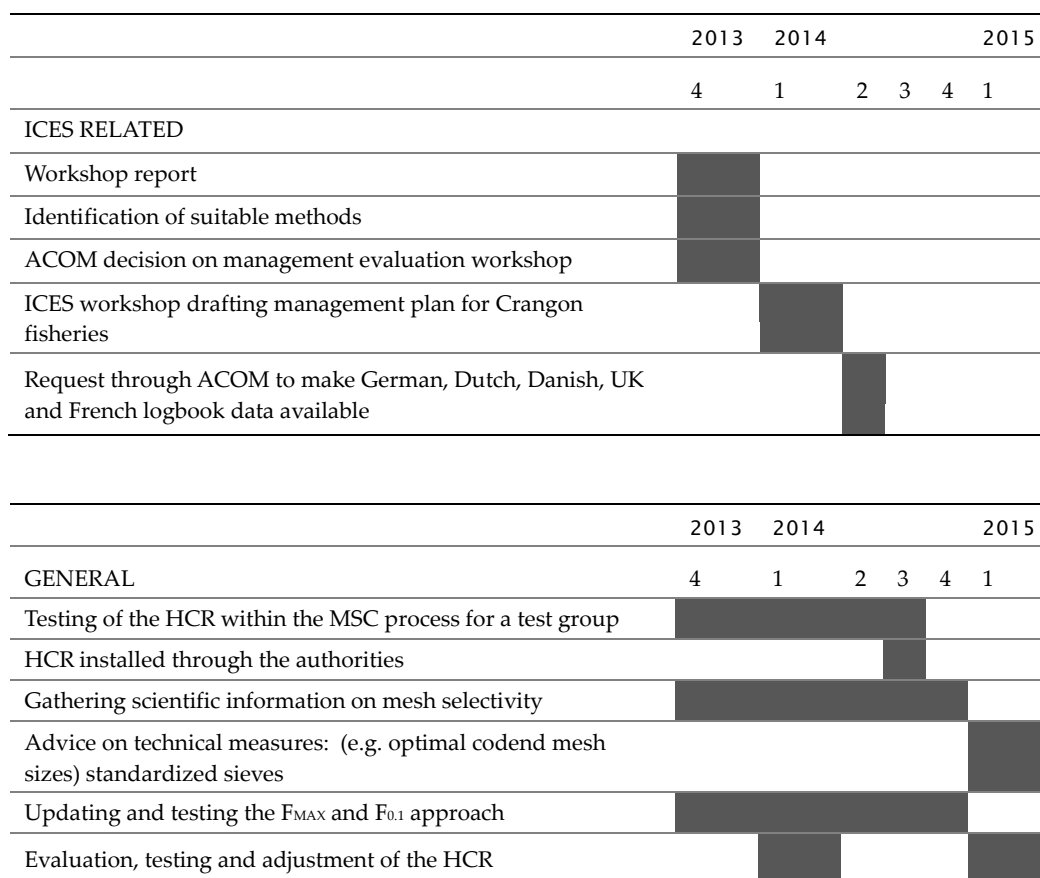
In general the management plan should:

- 1) guarantee a sustainable fishery e.g. by an in time effort reduction in case of reduced stock sizes (e.g. due to reduced recruitment, increased natural mortality, etc.)

- 2) encourage effort reductions in situations of growth overfishing to optimize the use of the resource while reducing the impact on the ecosystem.
- 3) encourage to use fishing gears that minimize the catch of undersized shrimps, the fish bycatch and the bottom impact.
- 4) minimize adverse effects on the environment.

3.5.9 Next steps

Next steps are related to the outcome of the ACOM in December 2013 meeting dealing with this issue. Assuming that ACOM agrees in favour of an advice on *C. crangon* in the North Sea and agrees that management is indeed necessary as suggested by the experts during the workshop the following steps include the drafting of a first advice and the identification of suitable management strategies and measures (see gantt chart below). As the industry already test the applicability of a HCR rule and is willing to implement a management there is in this process so far already close cooperation with the industry. These existing initiatives and cooperations need to be intensified and are mandatory. For a sound evaluation of the strategies all logbook information, as well as a fleet inventory that includes ship and gear characteristics, are needed. Additionally the so far proposed and developed strategies and methods need to be further ground-truthed with new data e.g. on gear selectivity and efficiency.



4 Cephalopods

With regard to Cephalopods there are twelve species of greatest important for European fisheries. These species are: (1) *Octopus vulgaris* (2) *Eledone cirrhosa*, (3) *Eledone moschata* (4) *Sepia officinalis*, (5) *Sepia elegans*, (6) *Loligo vulgaris* (7) *Loligo forbesii*, (8) *Alloteuthis subulata*, (9) *Alloteuthis media* (10) *Illex coindetii*, (11) *Todarodes sagittatus*, and (12) *Todaropsis eblanae*. However, only four of these species are both routinely targeted and of significant economic value; the remainder, while marketed at least locally, are mainly landed as a bycatch. The only ICES subdivision in which all these species are known to occur is IXa, although most are present in Subareas IV, VI, VII, and Divisions VIIIabd and VIIIc (Table 1). This report covers the four most important cephalopod species of commercial interest in European waters, namely *Sepia officinalis*, *Octopus vulgaris*, *Loligo vulgaris* and *Loligo forbesii* in their most abundant and exploited ICES areas (WGCEPH, 2013).

Species	ICES SUBDIVISION								
	II + III	IV	V	VI	VII	VIIIabd	VIIIc	IXa	X
<i>Octopus vulgaris</i>	-	X	-	-	X	X	X	X	-
<i>Eledone cirrhosa</i>	X	X	X	X	X	X	X	X	-
<i>Eledone moschata</i>	-	-	-	-	-	-	-	X	-
<i>Sepia officinalis</i>	-	X	-	X	X	X	X	X	-
<i>Sepia elegans</i>	-	X	-	X	X	X	X	X	-
<i>Loligo vulgaris</i>	-	X	-	X	X	X	X	X	-
<i>Loligo forbesii</i>	-	X	X	X	X	X	X	X	X
<i>Alloteuthis subulata</i>	-	X	-	X	X	X	X	X	-
<i>Alloteuthis media</i>	-	X	-	X	X	X	X	X	-
<i>Illex coindetii</i>	-	X	-	X	X	X	X	X	-
<i>Todarodes sagittatus</i>	X	X	X	X	X	X	X	X	X
<i>Todaropsis eblanae</i>	X	X	-	X	X	X	X	X	-

Three species groups of cephalopods in different ICES area were chosen to be discussed during this workshop. Under this approach, five case studies were chosen: 1 *Octopus vulgaris* in IXa north (Portugal), 2 *Octopus vulgaris* in IXa south (Gulf of Cadiz); 3 *Sepia officinalis* in VIIId, e (English Channel), 4 *Loligo* spp. in Subarea IV (Moray Firth) and 5. *Loligo* spp. in Division VIIIabd (Bay of Biscay). The lack of information about stock identity leads us to consider these combinations of species and ICES area as case studies (CSs) throughout this report.

4.1 Summary information

A full version of information on *Octopus vulgaris*, *Sepia officinalis* and *Loligo vulgaris* and *Loligo fobesi* can be found in WGCEPH (2013) and much of the material was, in turn, derived from the forthcoming ICES CRR on European cephalopod species. A summary of this information can be also found in Annex 4.

4.1.1 General life cycle and ecology

Cephalopods have fast growth and short lives: they complete the life cycle in one or two years. In general, they present fast, variable and non-asymptotic growth (Challier

et al., 2006) with high metabolic rate and high O₂ consumption. It is well known that growth rate is sensitive to temperature, and other environmental variables. Within populations, reproduction occurs during a period of 2–3 months. Such a long spawning period is quite long for species that live only one year, but this could be explained by the existence of a series of micro-cohorts each spawning at a slightly different time.

Cephalopod abundances are very variable and highly sensitive to climatic variation. For instance, annual *Octopus vulgaris* abundances are strongly related to the amount of rainfall in the previous year and to the wind strength causing upwellings (Sobrinho *et al.*, 2002 and Otero *et al.*, 2008). *Loligo forbesii* grow faster in warmer temperatures. It is also known that there is a delayed hatching under some cold conditions. Thus, it has been proposed, based on model simulations, that under an increment of 3 degrees in temperature during early life, adults could reach a final body weight up to ten times in the size attained in cooler environments (Forsythe, 2004).

Most cephalopods have a well-defined depth range. Distribution is also generally limited by (low) salinity and low and high temperature extremes. Migration and dispersal may be linked to oceanic currents. The most benthic and demersal species may prefer particular substrata (for dens, egg attachment, etc.).

Cephalopods have an important ecological role as prey in marine ecosystems. Many fish species eat cephalopods (e.g., Benguela hakes eat ~1 million tonnes of cephalopods per year). Also, many seabirds take squid (e.g. petrels, albatrosses, penguins, auks, terns, etc.). Thirty-one out of 33 pinnipeds worldwide feed on cephalopods at least occasionally. In case of cetaceans, 80% of toothed whale species and two baleen whale species eat cephalopods. Sperm whales could eat 213–320 million tons of squid per year (Clarke, 1996). Recent studies based on Ecopath models suggest that squid can have a keystone (trophic) role in ecosystems (Gasalla *et al.*, 2012).

4.1.2 Status and history of the fisheries

The contribution of cephalopods to global marine fisheries with regional variation and indirect contribution in percentage is presented in the following figure (Figure 10) for the period 1990 to 2004 (Hunsicker *et al.*, 2010).

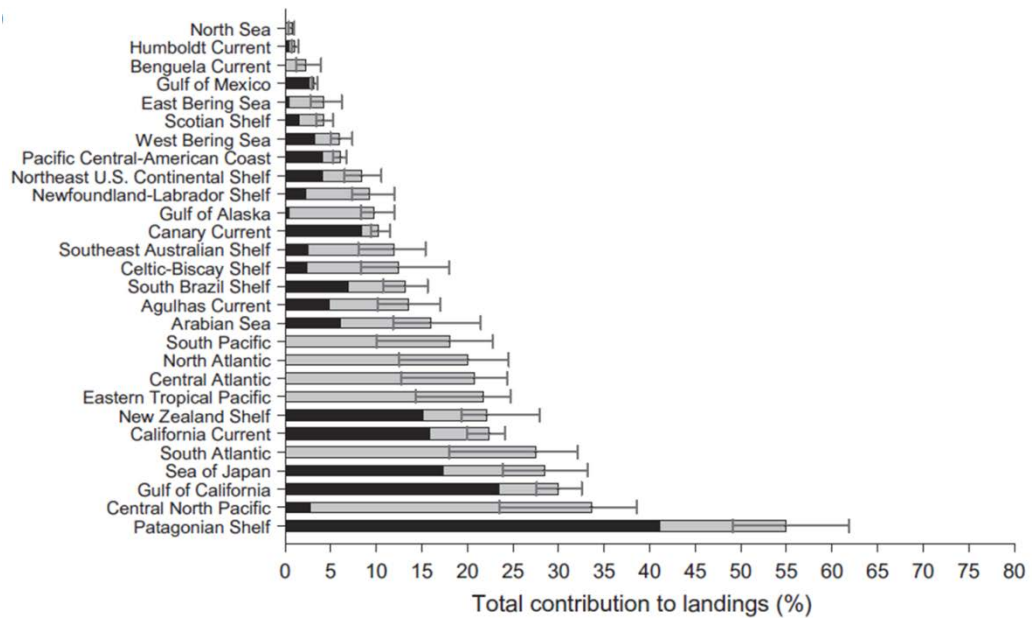


Figure 10. Percentage contribution of cephalopods to landings. Black bars represent commodity contribution while the grey ones represent the estimated support contribution. (Hunsicker *et al.*, 2010). The figure has been used under permission of the editors of Fish and Fisheries. Licence number: 3280881492627).

It has been hypothesized that cephalopods may be replacing fish in the sea in areas where fish stocks have been overexploited, although evidence of this is largely unconvincing (see Caddy and Rodhouse, 1998; Balguerías *et al.*, 2000). Cephalopod fisheries in the NE Atlantic have expanded dramatically since 1950 reaching a maximum of 60 000 t in the early 2000s (Figure 11) but in many areas of the world the trend is now downwards. Short-lived ommastrephid squid are characterized by irregular outbreaks, as in the case of (*Todarodes sagittatus*) which contributed highly to Norway's cephalopod catches from 1980 to 1985 (ICES, 2013).

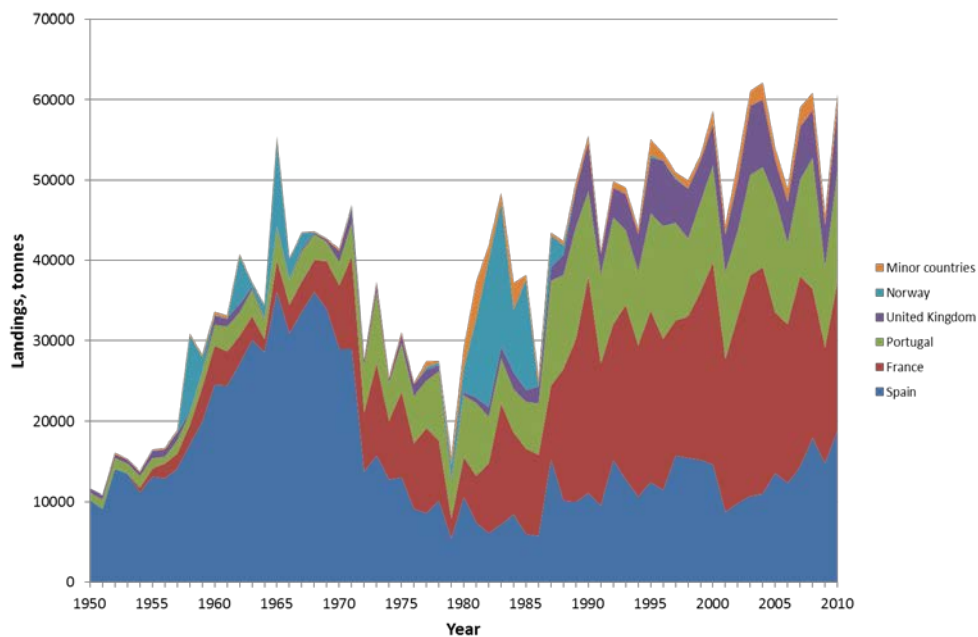


Figure 11. Landings in ton of cephalopods in the Northeastern Atlantic Area (based on FAO data (FAO Fishstat J, 2011)).

When analysing the main species or species groups contributing to catches in the NE Atlantic, outbreaks of ommastrephids (as mentioned above) are notable (1980–1985). In the last decade, *Octopus vulgaris*, *Sepia officinalis* and various species of squids comprised the highest percentages of the Northeast Atlantic catches (Figure 12).

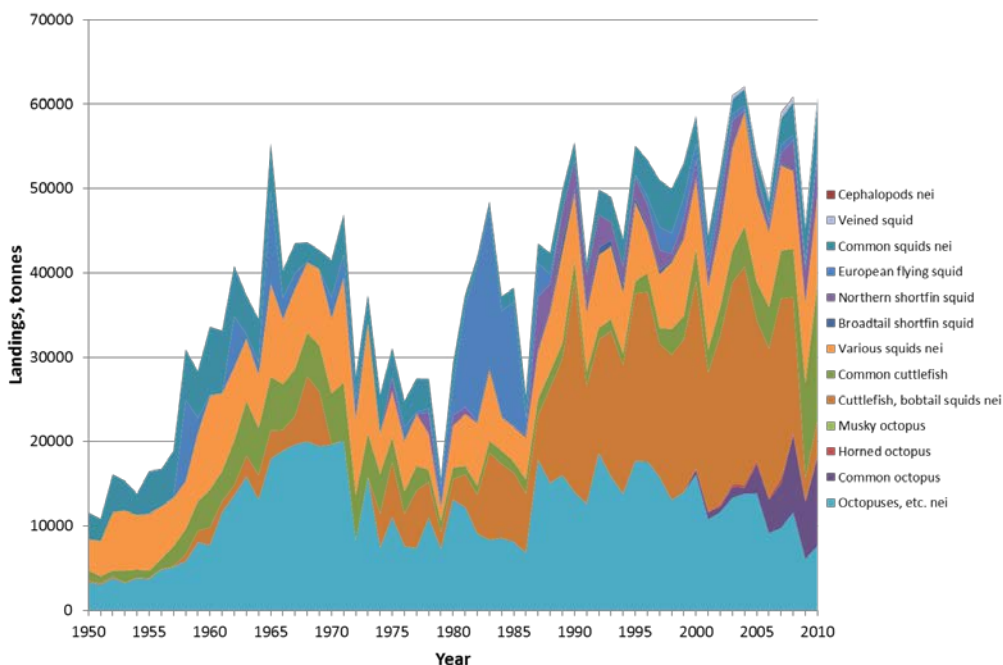


Figure 12. Landings in ton of cephalopods by species groups in the Northeastern Atlantic Area (based on FAO data (FAO FishstatJ, 2011)).

There may be opportunities to catch more oceanic squid in future but they are currently inaccessible, unpredictable and often unpalatable (unless, for example, ammonia can be removed from the flesh).

Cephalopod fisheries can be assessed and managed, as shown by many examples around the world (e.g. Japan, South Africa, West Africa, the eastern United States and the Falkland Islands) (see Caddy, 1989; Pierce and Guerra, 1994; Roa-Ureta, 2012). Evidently, controlled exploitation and management by fishing of natural populations depends upon sufficient information about the basic biological characteristics of the target species (Boyle, 1990) but it also depends on the context in which the fishery operates. A large proportion of European cephalopod landings are taken as bycatch of finfish fisheries, thus limiting management options, even if assessment would be possible. However, various directed fisheries are amenable to both assessment and management.

Octopus vulgaris in IXa north (Portugal)

Octopus vulgaris landings in Portuguese waters are recorded nationally since 1927 and by region and port since 1970s. Biological data collection started in 1990s.

When analysing octopus historical landings, a marked increase is observed from 1000 t, in the first years of dataseries (1920s) to a historical maximum in the mid-2000s of close to 13 000 t (Figure 13). When analysing the landing dataseries, more in detail, three stability periods divided by quick rises are observed. Within these periods, non-significant trends are detected. The increasing catch over the whole time period may be attributable to technical evolution of fishing methods.

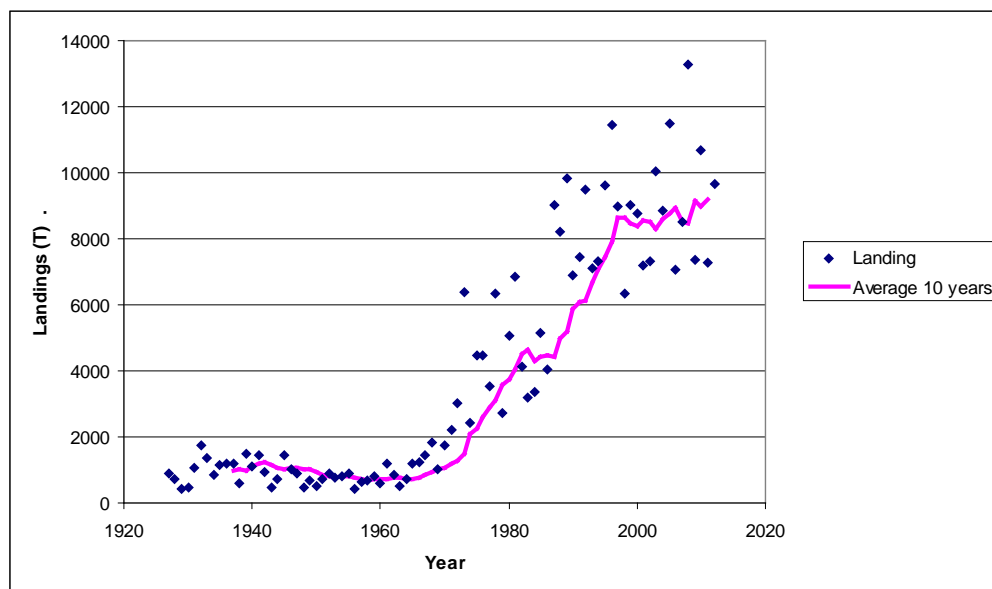


Figure 13. Historical landings series of *Octopus vulgaris* from Division IXa deployed by Portuguese fleets. Atlantic Area.

During the first period, so called “Historical” period before 1970s, average landings reached 953 t with a standard deviation of 376 t. In the second period, known as “Modern” period (1971–1984), the average landings were 4155 t with a standard deviation of 1524 t. In the latest period, from 1985 to the present, the average landings reached 8477 t with positive and negative oscillations of 1966 t. Thus, there is a 30% average change in landings from one year to the next. Although the trend over the

whole latest period is positive, it is non-significant. Whereas, the trend over the whole series (1920 onwards), is significant.

Case studies

Octopus fisheries include some directed trawling which contributes around 10% of the total trawl landings. The majority of the catches come from artisanal fleets. There is a substantial over-capacity deployed. The existence of black market landings of underweight octopus (recruits) is well known.

In the recent years there has been a decreasing average of total weight of landings of legal-sized octopus. The current legislation defines the number of licences in operation, minimum mesh size depending on gear, maximum number of traps (effort limitation) for artisanal catches and the minimum landing weight.

***Octopus vulgaris* in IXa south (Gulf of Cadiz)**

Detailed information on the fishery and management can be found in Annex 6 WD1.

Commercial landings of octopods (Fam. Octopodidae) comprise common octopus *Octopus vulgaris* and horned octopus *Eledone cirrhosa*, plus musky octopus *Eledone moschata* in Subdivision IXa-South. More than 87% of octopodidae caught along the Spanish coast (Divisions IXa and VIIIc), are common octopus *O. vulgaris*. In Subdivision IXa-north, most of the *O. vulgaris* is caught in the demersal multifleet and multi-gear fisheries.

The Bottom-otter trawl fleet (together with more than 50 target species) operating in Division IXa-South (Gulf of Cadiz), accounts for around 60% of total catch on average. The artisanal fleet, using mainly clay pots, traps and hand-jigs, accounted for the remaining 40% of the catches. Division IXa-South contributes to the total landings from the Division IXa with variable percentages that ranged between 29% (454 t) in 2004 and 80% (2871 t) in 2005, with a 46% on average through the time-series. In Figure 14, it can be observed these strong fluctuations in the octopus landing along the time-series, with the minimum values in 2011 (285 t) and maximum values in 2012 (3242 t). In 2012, the artisanal fleet accounted for the 70% of total octopus landings. Possibly, such oscillations may be related with environmental changes such as rainfall and discharges of rivers (Sobrino *et al.*, 2002).

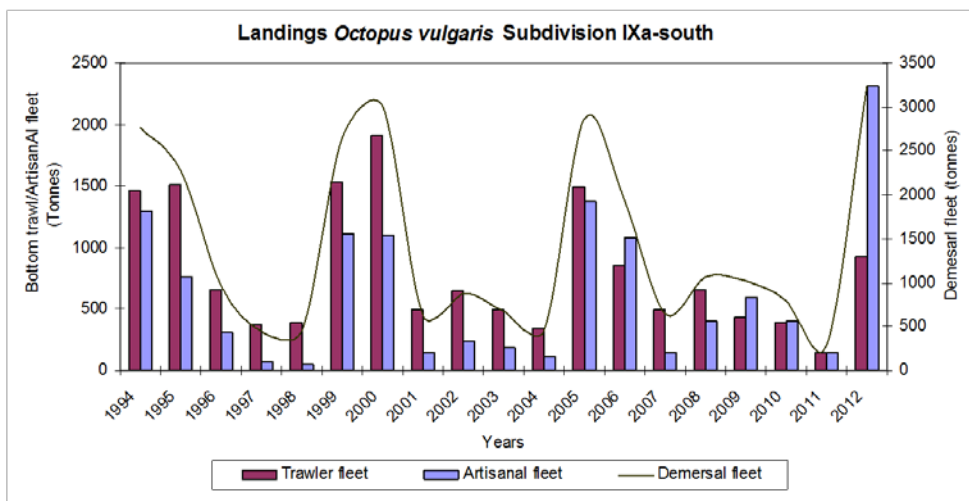


Figure 14. Historical landings series of *Octopus vulgaris* from Division IXa-south deployed by industrial and artisanal fleets.

Two different regulations are applied to Spanish waters: Central Administration regulations in external waters (CA) and the Regional Administration regulation in internal waters (RA).

Bottom-trawl activity is only regulated by Central Administration, which, in 1993 established a *Real Decreto 632/1993* including the main aspect to regulate this fishery, among others, vessel characteristics, fishing area outside six miles of coastline and fishing effort per week.

In 1996: the first important measure was established to manage and maintain the sustainability in the octopus fishery for all types of gears: minimum legal weight of 1 kg. (*Orden, 22 November 1996, BOE 290*). Fishing octopus was forbidden for recreational vessels.

Since 2004, consecutive Fishing Plans have been established in the Gulf of Cadiz with the aim to reduce the fishing effort of the bottom-trawl fleet (*ordenes APA/3423/2004, APA/2858/2005, APA/2883/2006, APA/2801/2007, ARM/2515/2009, ARM/58/2010, ARM/2457/2010*). The main aspect of these fishing plans was the closed fishing season implemented in autumn, with a gradual increase in the number of days (45, 60, and 90 days per year). Currently, the closed season lasts for 45 days in autumn when the recruitment peak is believed to occur in these fishing grounds. This measure is aimed to reduce the illegal landing of immature specimens, protecting small octopus until minimum legal weight is reached in these two months.

All the artisanal fisheries, including the octopus fishery, are regulated under *Real Decreto 1428/1997* established in 1997 by the central administration. This regulation set up the rules related to effort, this is, number of trap or clay-pots per vessel, among others aspects.

In 2005, in order to maintain a sustainable fishery for octopus, both Administrations established a specific fishing plan for the conservation and sustainable management of octopus fishery in the fishing grounds of the Gulf of Cádiz. These regulations, CA: ORDEN 2438/2005, 20th July and RA: RESOLUCION on 19th September 2005 (BOJA 189) had, as distinguishing features, the following closed seasons:

- 1) Spring–summer from 1 June to 15 July; only targeted at artisanal fisheries (Fishing plan of CA).
- 2) Autumn from 15 September to 31 October; targeted at all demersal fleet (Fishing Plan of both CA and RE).

The spring closed season was intended to protect spawners during the main peak of the reproduction period. The octopus laid the eggs in shallow waters in spring-summer, and for this reason only affect to artisanal fleet. The autumn closed season is established in order to protect the recruitment occurring in this period.

For the definition of these measures, biological information was taken into account. There are others measures included in the fishing plan such as specific fishing licences for octopus, restriction of fishing to the first six miles from coast and the constrain of the use of clay-pots and trap to the most western area of the Gulf. As an example, in summer 2013 and in the eastern area of the Gulf, only five vessels were allowed to catch octopus. These measures appear to be based more on the distribution of space in the marine area between fleets and gears to avoid conflicts than on real scientific knowledge of the stock.

Sepia officinalis in Subarea VII d and e (English Channel)

Detailed information about this case study can be found in WD2. In the NE Atlantic, the English Channel cuttlefish (*Sepia officinalis*) is the most important cephalopod resource. Cuttlefish is part of the main English Channel demersal resources (Cuttlefish, Scallop, Squid). Catches are mainly shared between French and UK fishermen who annually landed 11 000 t in the period 2000–2010 for an annual average income of 20 M € (Royer *et al.*, 2006; Portail CHARM III - Interreg IV, 2012). France contributes in 70% of the catches, while United Kingdom accounts for the remaining 30% (Figure 15).

The English Channel cuttlefish stock is managed only with local measures and no European management is carried out (Pierce *et al.*, 2010).

Annual yields (t) 2000-2008 average

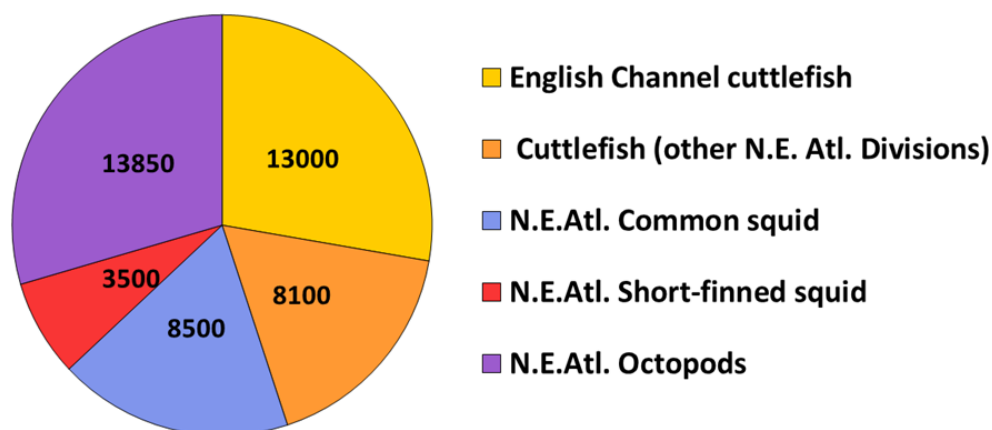


Figure 15. Average annual yields for cephalopods in the English Channel (Division VII d, e) for the period 2000 to 2008.

Cuttlefish landings increased from 1992 to 2004 while for the last years of the period (2004 to 2008) landings followed a decreasing trend (Figure 16).

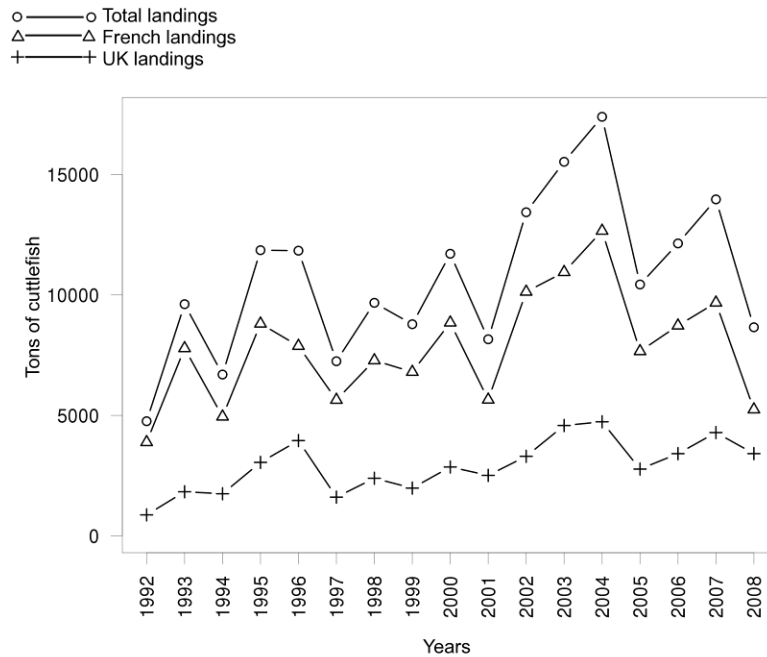


Figure 16. Historical Cuttlefish landing deployed by France and United Kingdom in the English Channel.

In the Northeastern Atlantic and for the period 2000 to 2008, total Cuttlefish landings reached 30 000 t, one third of these landings (11 000 t) came from the English Channel.

Cuttlefish in the English Channel is a multi-métiers fishery in which more than 28 métiers are involved (Royer *et al.*, 2006). The most important ones are:

- Inshore trawling (within the 3 miles limit from the shore);
- Offshore trawling during autumn and winter;
- Inshore trapping and trawling during spring.

At European scale, no output or input management measures (neither Total Allowable Catch nor effort limitation) are applied to the cuttlefish resource in the English Channel. This resource benefits from the general trawling regulation in which a minimum mesh size is established at 80 mm. Also, there is an exclusion of trawling in the 3 nautical miles zone.

At local level, management is regulated by the Lower Normandy body. Under this local body, inshore fishing effort of traps and trawling is monitored by licensing. In the inner 3 miles zone, shallower waters, exemption from trawling occurs during six weeks in spring and another two weeks in summer.

***Loligo spp.* in the Bay of Biscay**

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

becoming more important in relation to the species composition of the catch and for some trips, nowadays, they are target species.

Currently, in Division VIIIa, b, d, the largest landings of squids are recorded during October and November. In 2012, squid landings reached 317 t in November. Ninety-six percent of the squid landed in Basque ports came from Division VIIIa, b, d.

Historical cephalopod landings by Basque vessels show an important decreasing trend from 1994 to 2001 (Figure 17). From 2002 onwards, the total landings of cephalopods remain quite stable but with interannual fluctuations. From 2009 and increasing trend is observed and in year 2012 landings are close to the maximum level of the time-series at the same level than the peak in 1994. Focusing on fishing effort, it shows a decreasing trend from 1996 to 2012 which is caused by the disappearance of some Basque vessels in the last few years due to regulation implementation and other different factors. From 2009, fishing effort of the Basque fleet has remained mostly stable at low levels (Figure 18).

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

OTB_DEF_ \geq 70 (otter trawlers targeting demersal fish with 70 mm mesh size).

OTB_MCF_ \geq 70 (otter trawlers targeting mixed cephalopod and demersal fish with 70 mm mesh size).

OTB_MPD_ \geq 70 (otter trawlers targeting mixed pelagic and demersal with 70 mm mesh size).

From 2009, the métier targeting cephalopods, OTB_MCF, has increased in number of trips and in cephalopods catches. The increase in the OTB_MCF métier seems to be related to the decrease in OTB_DEF métier targeting demersal species like hake, megrim or anglerfish.

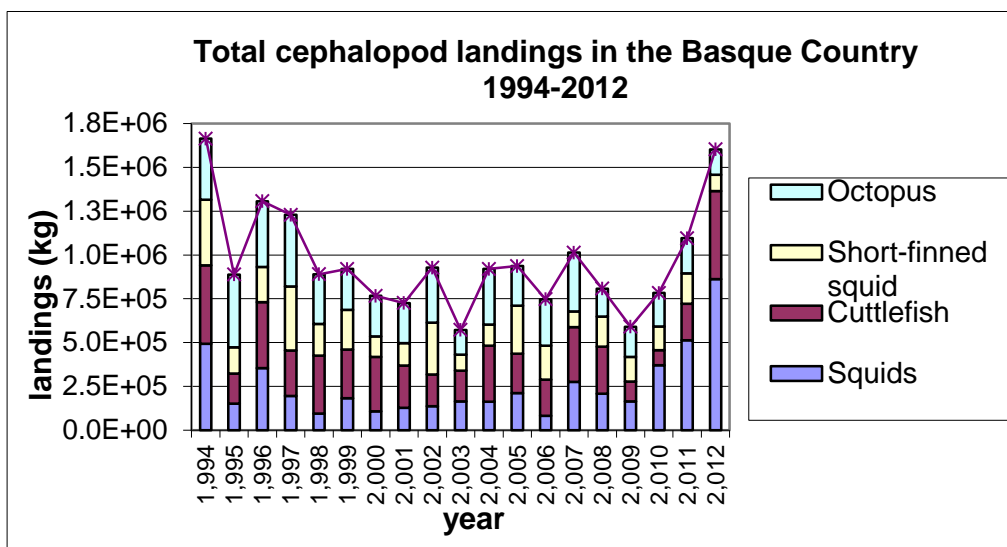


Figure 17. Historical cephalopod catches by the Basque fleet in all ICES areas (Subarea VI, VII and Divisions VIIIabd & VIIIc) from 1994 onwards.

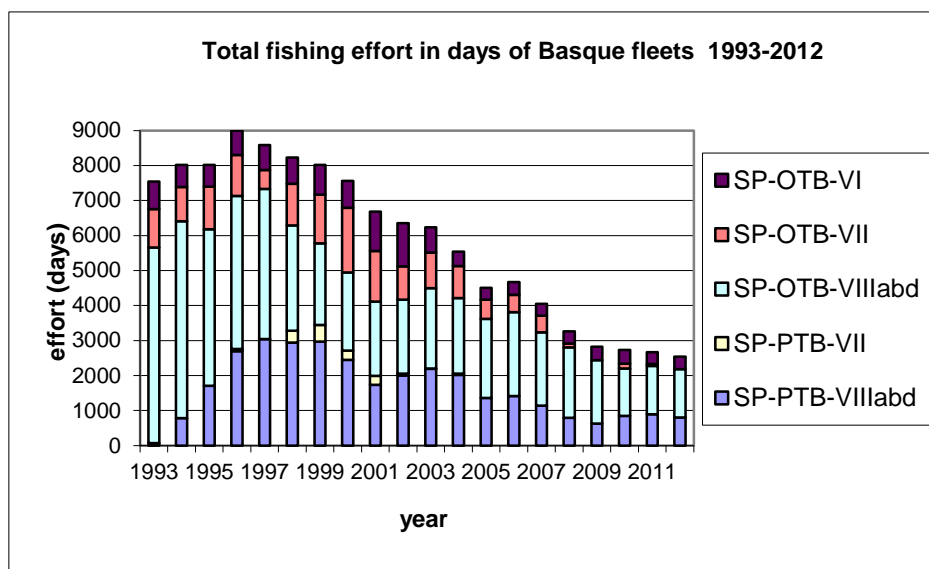


Figure 18. Total fishing effort of the Basque fleets from 1993 to 2012.

The figure below (Figure 19) shows a stable situation in lpuue of squid from 1995 till 2005. Some fluctuations with high and low abundances are observed in the dataser-ies. From 2007, the last period of the series, and in relation to Division VIIIabd, lpuues for squid have markedly increased, reaching almost 400 kg of squid by day of fishing.

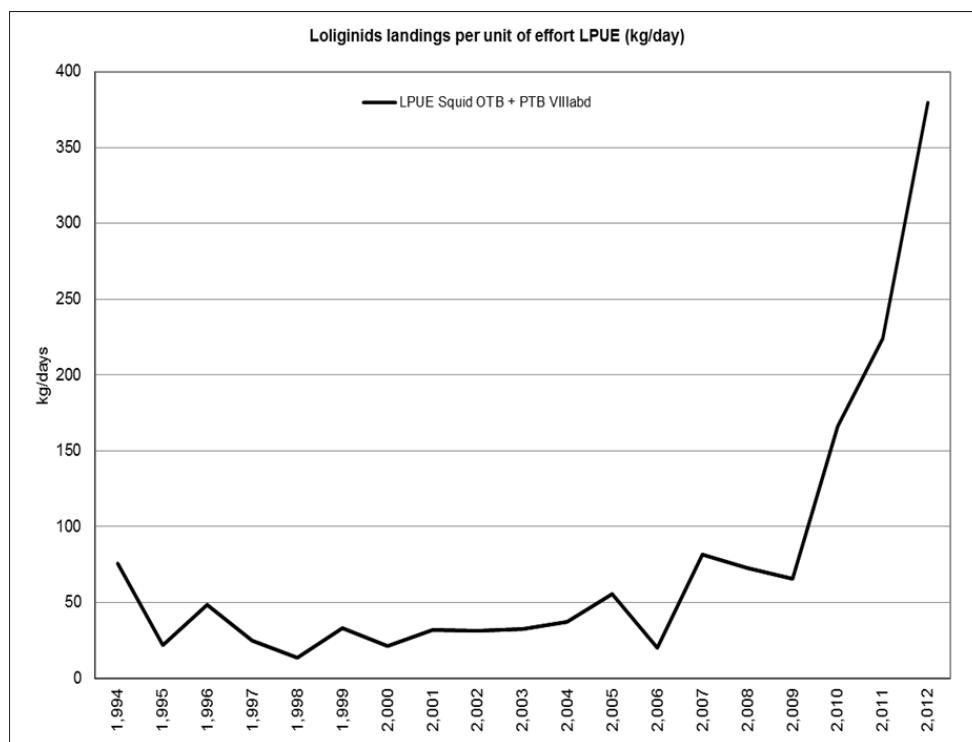


Figure 19. Cephalopod landings per unit of effort (kg/day) of the Basque trawling fleet (otter and pair trawls) from 1994 to 2012.

Since 2001, a discard sampling program has been carried out by the AZTI-Tecnalia on the Basque fleet (North Spain). Traditionally, short-finned squid mainly and, to a lesser extent, curled octopus (*Eledone cirrhosa*) were the most frequently discarded species because of their low price in market. During year 2012 an important change in the exploitation pattern of cephalopods was observed. Discards in all fleets of the Basque fleets were reduced to 0%, which is explained by the change in target species for these fleets. In this case, cephalopods are now the target species, and now represent the most important catches, while traditional demersal target species are now bycatches of the cephalopod métier.

No specific management measures are defined for *Loligo* spp. in Division VIIIabd. *Loligo* spp. being caught in trawl fisheries benefits from the general technical measures applied to these gears in relation to mesh sizes, days at sea, and any other trawl technical measures applicable in Division VIIIabd.

4.1.3 Further Information on the stocks or case studies

While there have been genetic studies for several species (Pierce *et al.*, 2000) in general there is a lack of such studies on a European scale, with the purpose of identifying populations for assessment.

Knowledge of main population features included in this report as case studies is still scarce. As an example, there is only a weak stock–recruitment relationship for *Octopus vulgaris* in the Gulf of Cadiz based partially on the observation that the lowest observed stock levels in 1998, 2004 and 2011 were sufficient to rebuild the stock by the next year. If a very weak stock–recruit relationship is expected in cephalopods, the possibility of recruitment overfishing is reduced, although the possibility of poor recruitment remains.

However, there seem to be indications for growth overfishing for *Octopus vulgaris* in Portugal. A real recruitment index is, so far, not available as no scientific surveys are conducted neither during the peak of adult abundance nor during the important egg carrying period. Additionally, cephalopod paralarval abundance (for those species which have paralarvae) is not monitored.

4.2 (Other) data availability and quality

Data available and scientific knowledge to be used in assessment of the above-mentioned species is summarized in the tables included in Annex 5.

4.3 Advice on the need for management of Cephalopods (ToR a)

4.3.1 Role of Cephalopods in the foodweb

The cephalopods occur regularly in the diets of various well-known predator species, e.g. cetaceans (Clarke, 1996; Clarke and Pascoe, 1997; Santos *et al.*, 2001), seabirds (e.g. Furness, 1994) and large epipelagic fish - e.g. sharks (Clarke *et al.*, 1996; Ebert *et al.*, 1992), tuna (Rancurel, 1976; Okutani and Tsukada, 1988) and swordfish (Bello, 1991; Clarke *et al.*, 1995; Hernández-García, 1995), as well as smaller demersal fish (e.g. Daly *et al.*, 2001).

Also, there are numerous publications on cephalopod diets. They are extremely voracious predators, and their carnivorous diet situates them at a relatively high trophic level compared with other molluscs (Boyle, 1987). See Pierce *et al.* (2010) for brief reviews on the main European cephalopod species and Jereb *et al.* (in press) for detailed accounts.

Their ecological importance and impact on fishing could be high, since they are part of the diet of marine mammals. As explained above, their contribution to marine animals' diets is known but not much is known about their possible impact on the ecosystem, although Gasalla *et al.* (2012) suggest that squid can be keystone species in relation to their trophic role. Little quantification of these diets in relation to the effects on prey and predators abundance is found. Thus, not many studies are available on the quantification of the importance of cephalopod role in ecosystems.

Literature also includes studies in which cephalopods trophic importance is evaluated, providing data on their distribution and abundance (Torres *et al.*, 2013).

Coll *et al.* (in press) studied the role of squid in the ecosystems. In this study is presented the synthesized available information on squid from ecological models at local and regional scales to obtain a global picture of their trophic position and ecological role in marine ecosystems. Their results showed that squid occupied a large range of trophic levels in marine foodwebs, reflecting the versatility in their feeding behaviours and trophic connections with the foodweb. Results also showed that squid can have a large trophic impact on other elements of the foodweb, and top-down control from squid to their prey can be high.

Navarro *et al.* (in press) synthesized the available information for two intrinsic markers ($\delta^{15}\text{N}$ and $\delta^{13}\text{C}$ isotopic values) in squid for all oceans and several types of ecosystems to obtain a global view of the trophic niches of squid in marine ecosystems. To correctly compare among systems and oceans, they adjusted squid $\delta^{15}\text{N}$ values for the isotopic variability of phytoplankton at the base of the foodweb in the same locations. This paper is the first of its kind to use model-generated baseline $\delta^{15}\text{N}$ values to provide direct comparisons among consumers worldwide. The study

showed the importance of considering the natural variation in isotopic values among ecosystems.

Arkhipkin (in press) determined population parameters including individual growth rates, duration of ontogenetic phases and mortalities of three abundant nektonic squid species from the Southwest Atlantic. He found that squid were major nutrient vectors and played a key role as transient 'biological pumps' linking spatially distinct marine ecosystems. *Illex argentinus* had the greatest ecosystem impact due to its high abundance and productivity. He concluded that the variable nature of squid populations increased their vulnerability to overfishing and environmental change.

In order to determine cephalopods' true importance in the marine food chain and ecosystem role, data must be collected on different areas regarding their trophic relationships with both their prey and their predators. It is also worth to mention that although publications on non-pelagic predators are scarce, that cephalopods could make up an important percentage of the diet of groundfish off South Africa (Lipinski *et al.*, 1992).

In summary

- There is a general lack of knowledge of the role of cephalopods in the ecosystem, especially in Europe. Methodologies for quantifying this role as predators and prey are needed. For example, ecosystem models such as Ecopath have assumed increased importance in the context of the Ecosystem Approach to Fisheries and the Marine Strategy Framework Directive (MSFD); while models exist for various European seas, cephalopods have usually not been specifically investigated.
- Cephalopods are potentially significant components, but their importance tends to be underestimated if emphasis is given to biomass rather than to energy flows, due to their high P/B ratio.
- The high sensitivity of cephalopods to environmental changes means they can be useful indicators. It appears that some countries have shown interest in including cephalopods in the Trophic descriptor (4th descriptor of the GES) under MSFD. The question remains about how the species will be taken into account.

4.3.2 The impact of the cephalopod fishery on other commercially exploited fish stocks in relation to multispecies and mixed fisheries considerations

Directed cephalopod fisheries, particularly bottom-trawl fisheries, tend to use small-mesh codends which could result in high incidental catch rates of other commercially exploited invertebrate and finfish stocks. Examples of direct cephalopod fisheries and their impact on other commercial species are summarized.

Bottom-trawl fisheries targeting longfin squid in the Northeast Atlantic

One of the reasons to manage cephalopod stocks in the Northeast Atlantic is due to the use small-mesh codends in some cephalopod fisheries, particularly directed bottom-trawl fisheries, which tend to result in high incidental catches of other commercially exploited invertebrate and finfish stocks. As a result of their cylindrical body shape and unique ability to perform forward and reverse escape jetting in trawls, the exploitation of squid species requires the use of high-opening bottom trawls with small-mesh with diamond codends (generally less than 60 mm inside stretched mesh) which are very efficient at retaining most species that enter the trawl. For example, in

the Northwest Atlantic, approximately 26% by weight of the total catch in the *Doryteuthis (Amerigo) pealeii* (longfin inshore squid) fishery is discarded (Glass *et al.*, 1999). Some of the commercially fished species which are discarded include: *Merluccius bilinearis* (silver hake); *Illex illecebrosus* (Northern shortfin squid); *Urophycis chuss* (red hake) and *Peprilus triacanthus* (Atlantic butterfish, MAFMC 2009). Butterfish co-occurs with longfin squid throughout the year and discarding in the longfin squid fishery is the primary source of fishing mortality on the butterfish stock (NEFSC 2010). However, for the longfin squid fishery it would have been difficult to select an appropriate codend mesh size which maximizes bycatch reduction for multiple species while concurrently minimizing the catch loss of the target species during the months when the latter is of a smaller size than the bycatch species (Hendrickson, 2011). Consequently, fishery managers have implemented an incidental catch cap on the longfin squid fisheries during quarter 1 and 3. The catch cap is monitored on a weekly basis and has resulted in closures of the directed fishery when the catch cap buffer was reached.

Recently, the longfin squid bottom-trawl fishery was also identified as the third highest source of incidental catches of four anadromous fish species for which some of the riverine stocks were deemed depleted (MAFMC 2013). As a result, the longfin squid fishery is also subject to an incidental catch cap for the four combined anadromous species. Both of these examples demonstrate the importance of monitoring directed and mixed-species cephalopod fisheries in order to quantify the discards of other commercially important species for inclusion in stock assessments.

Squid directed fisheries in Moray Firth (Subarea VI)

The percentage of commercial species caught together with squid in the small directed squid fishery was comparatively low. The most abundant one was whiting reaching 25% of the catch (see the table below, Table 6 from Hastie *et al.*, 2009). Most of the whiting was discarded as they were undersized individuals; since the squid fishery was allowed to use a smaller mesh size than the standard trawlers targeting demersal fin species (Hastie *et al.*, 2009, their Table 6, here Table 1).

Table 1. From Hastie *et al.* (2009, Table 6). Recorded fish and shellfish species bycaught and discarded during directed squid-fishing operations (pooled data, 2007).

Species	Prevalence /25 tows(%)	Proportion of catch wt (%)
Fish		
Whiting (<i>Merlangius merlangus</i>)	18 (72)	25.7
Haddock (<i>Melanogrammus aeglefinus</i>)	7 (28)	2.8
Dab (<i>Limanda limanda</i>)	12(48)	3.3
Flounder (<i>Platichthys flesus</i>)	9 (36)	2.0
Plaice (<i>Pleuronectes platessa</i>)	7 (28)	0.3
Mackerel (<i>Scomber scombrus</i>)	14 (56)	4.8
Sandeel (<i>Ammodytes marinus</i>)	5 (20)	0.3
Sprat (<i>Sprattus sprattus</i>)	3 (12)	0.4
Gumard (<i>Trigla lucerna</i>)	10 (40)	0.2
Scad (<i>Trachurus trachurus</i>)	8 (32)	0.4
Bib (<i>Trisopterus luscus</i>)	2 (8)	<0.1
Megrim (<i>Lepidorhombus whiffiagonis</i>)	1 (4)	<0.1
Scorpion (<i>Myoxocephalus scorpius</i>)	3 (12)	<0.1
Sole (<i>Solea solea</i>)	2 (8)	<0.1
Weaver (<i>Trachinus draco</i>)	2 (8)	<0.1
Dragonet (<i>Callionymus lyra</i>)	2 (8)	<0.1
Pipefish (<i>Syngnathus acus</i>)	3 (12)	<0.1
Monkfish (<i>Lophius piscatorius</i>)	1 (4)	<0.1
Herring (<i>Clupea harengus</i>)	1 (4)	<0.1
Butterfish (<i>Pholis gunnellus</i>)	1 (4)	<0.1
Cod (<i>Gadus morhua</i>)	3 (12)	<0.1
John Dory (<i>Zeus faber</i>)	2 (8)	<0.1
Coley (<i>Pollachius virens</i>)	1 (4)	<0.1
Cuckoo Ray (<i>Raja naevus</i>)	1 (4)	<0.1
Shellfish		
Velvet crab (<i>Necora puber</i>)	6 (24)	ND
Prawn (<i>Nephrops norvegicus</i>)	1 (4)	ND
Lobster (<i>Homarus gammarus</i>)	3 (12)	ND

Baka Otter trawlers catching cephalopods in the Bay of Biscay

From 2009 to 2012, the métier named as mixed cephalopods and demersal has increased its number of trips and its cephalopods catches. This increase seems to be related to the decrease in otter trawl targeting demersal species such as hake, megrim or anglerfish. There has been a change in fishing tactics in which number of trips dedicated to cephalopods (especially during the last quarter of the year) are being increased. This new tactic does not cause higher discards in other target species (finfish species) as these ones are not as abundant as cephalopods in the inshore areas where the fishery has moved, and also finfish bycatches are still part of the multi-specific fishery.

Direct trawling for squid in Portuguese waters

Together with squid there are other targeted species that are also quantified and are important part of the multispecies fishery. As the number of targeted species is large and all of them are commercial species, it can be said that no increasing discards are produced due to the direct fishery to cephalopod.

Multispecies trawling fishery in the Gulf of in Cadiz

Octopus is part of the multispecies composition of the catch as many other commercial species. It does not appear that there is any direct consequence of targeting octopus, jointly with other species, on the rest of commercial species.

Traps and pots targeting octopus in Portugal

Traps and pots are very selective gears. Very few species can be found caught jointly with Octopus. Bycatches of moray eels, conger and crustaceans occur. However all these accompanying species are commercial ones, so no discards are caused.

Other general fishery issues affecting multispecies fisheries

Trawling for cuttlefish in the English Channel

Under the licence and permit system for vessels deploying cuttlefish catches in which large trawlers are not allowed to enter the 3 mile limits, there are some exceptions. That is, some vessels are allowed to enter and thus, trawl in areas within the 3 miles from the French coast to catch juveniles, not only of cuttlefish but also of other species (e.g. flatfish). In general, protecting essential habitats or dedicated areas for cephalopods recruitment or spawning could be also a good benefit for other resources (inshore areas).

Some positive effects are also indicated in lost fishing traps in relation to the generation of artificial reefs and the use of these devices as structures or obstacles from trawling in habitats to protect.

OBSMER programme of observers on board French vessels, IEO and AZTI program on board Basque vessels and IPMAR observers' programme

The dedicated observer on board programme from Fisheries Institutions collect data on catches for all important métiers being deployed by French, Spanish and Portuguese vessels. In this way also catch data on métiers targeting squid can be investigated in relation to other accompanying and/or bycatch species.

In summary: Key points of the effect of cephalopod fisheries on other species

- A direct effect on bycatches of other fish species is detected for industrial cephalopod fisheries having squid as first direct target species. Bycatches and discards of certain fish species are known to be high in some fisheries, although results from other fisheries suggest relatively “clean” catches.
- No direct effect on bycatches is observed in those fisheries where squid are part of the multispecific and mixed fisheries, as technical measures are designed for the finfish species that are assessed and managed.
- Artisanal fisheries targeting cephalopods are known to be highly selective and with low rates of bycatch.
- In general, protecting essential habitats from trawling is a precautionary measure that can help recruitment and spawning success not only for cephalopods, but also for finfish species.

4.3.3 The impact of the cephalopod fisheries on cephalopods

Directed cephalopod fisheries can impact negatively on cephalopod species preventing them from reaching population and fisheries sustainability. Examples of direct cephalopod fisheries and their impact cephalopod species are presented.

Negative impact effect

Cuttlefish fishery in the English Channel

Results of the stock assessment exercise presented at this WK point out that this stock is fully exploited or even overexploited. We are not aware of anything similar assessment trials done in European waters for cuttlefish. On the other hand, other assessment exercises of sepia fisheries and its affection to sepia populations have been deployed using depletion methods to calculate initial biomass but, no values for fishing mortality (and thus level of fishing pressures) has been calculated.

The impact of cuttlefish trap fisheries on the resource could also be caused by the fact that cuttlefish eggs are attached to the traps and when these ones are retrieved, eggs are lost at the end of the fishing season. It is known that the amount of eggs lost is important but no relationship or at least, the relationship of these losses in future recruitment is unknown. There is no knowledge of how many spawners are needed to assure population. The monitoring of the spawners and recruit is needed to be assured.

No clear or neutral impact effect

Octopus fishery in Portugal

There appears not to be a negative effect of octopus fisheries on the octopus populations at current fishing pressure. Fisheries appear to just be taking a good part of the population that probably are not needed for sustaining the populations. However, there is a decrease in the mean size of the individuals but also; the average of landing is smaller which appears to confirm that even smaller octopus is enough to maintain the recruitment for sustaining the population.

In the case of Portuguese octopus fisheries, the increasing number of traps is not creating socio-and economic troubles or disputes for spatial areas.

The Spanish Octopus fisheries in the Gulf of Cadiz

These are an example of how different gears are regulated in different areas. The new regulation (see Section 4.1.6) about spatial distribution and use of the different gears tries to solve the problem of spatial competences. So, in this way, conflicts are managed but not the species.

Some studies have been carried about the selectivity of clay pots on octopus specially related to the fact that this gear could be used by female octopus as substratum to lay eggs. The risk could be that when gear is retrieved, eggs will be lost with the consequent possible affection to octopus recruitment. However a recent study (Sobrino *et al.*, 2011) has confirmed that commercial clay pots are not used for laying eggs as the instability of the gear produced by the movement of the rope in which these ones are placed, is disliked by octopus as substratum. So the possible impact on octopus recruits is negligible.

General concern about mixed cephalopod fisheries impacting on cephalopods

In cephalopod fisheries in which several gears and métiers interact, it is important to develop decision tools to take management decision in relation to sustainable exploitation levels of populations. This is important when thinking about management strategies in which, for instance, industrial and artisanal fisheries are included. Assessment for the whole English Channel is an example of how first a monospecific

model can be constructed but still a step ahead need to be taken to take into consideration spatial distribution of métiers and population distribution so that a management strategy evaluation framework can be presented and provided to managers.

In summary: Key points on the effect of cephalopod fisheries on cephalopod species

- **Negative effects:** concerns about *Sepia officinalis* status in the English Channel as it appears to be a fully exploited or even, overexploited stock. However, updating of assessment since 2008 is needed and the uncertainty remain about the actual stock status.
- **Unclear effect:** Octopus fishery in Portugal appears to exploit the part of the population that exceeds the minimum biomass to assure sustainability of the populations. However, weight of octopus has suffered a decrease in the last years as landings do.
- **No data:** for the majority of cephalopod fisheries, exploitation rates have not been measured.
- Artisanal gears, pots and clays for octopus in the Gulf of Cadiz, appear to have no effect (or negligible one) on octopus population. Environmental variables seem affect octopus abundances stronger than fishing activity.
- To really assess the impact of cephalopod fisheries in cephalopod population, assessment and decision management tools will be desired.

4.3.4 The impact of other fisheries on cephalopods

Fisheries, in general, can impact negatively in cephalopod species preventing this from reaching population and fisheries sustainability. Examples of positive and negative effects of fisheries on cephalopod fisheries are presented.

Positive effect

Missing discarded gears, while they are not retrieved, can be used as substrata for laying eggs or as artificial reefs for protecting essential habitats.

Negative effect

Static (e.g. trammelnets, traps) and mobile gears can destroy significant amount of squid eggs: Eggs are laid on static gear and lost when it is hauled; mobile gear can catch or damage eggs on the substratum. However, at the moment no idea on the impact on future recruits is available. There is a general desirability of protecting spawning areas. At the moment there is no measurable effect on the effect of active gear.

Other human activities in the marine ecosystem

Some human marine activities could have a negative impact on some cephalopod species, for instance the installation of wind farms on traditional trawling fishing grounds or in essential cephalopod habitats. Maybe in those areas, passive gears could be incentivized.

Species replacement

There seems to be no evidences for species replacement in relation to cephalopods. That is, cephalopods do not appear to replace other species which are overfished and reduced in abundance. Caddy and Rodhouse (1998) found little or no evidence of this issue. Balguerias *et al.* (2000) studied possible species replacement in the Sahara Bank

as octopus appeared to increase in abundance when sparids disappeared. The explanation appears to be just a regular ecological relationship between a decrease in prey and an increase in predator as a simple response to the operating fleets, as well as a change in the fleet behaviour.

General concern about mixed cephalopod fisheries impacting on cephalopods

Taking as an example squid, as part of multispecific fisheries, if population status is known to be threatened, how should multispecies fisheries be managed? Fishing for squid should be stopped and consequently, for the rest of the target species? This is a common problem of all multispecies and mixed fisheries exploiting different species at different MSY target levels.

In summary: Key points on the impact of other fisheries on cephalopods

- **Negative effect:** some gears can impact negatively by means of indirect or direct effects. For instance, some gears can destroy essential habitats for cephalopod recruitment and spawning, while direct effect can be identified as the loss of eggs when static gears are removed from the sea. No quantification of these effects is available.
- **Unclear effect:** based on the general concern about how to manage multi-specific and mixed fisheries, it is necessary to look for optimization of trajectories of MSY target of simultaneously exploited commercial species.

4.3.5 Conclusion: do we need management?

There is evidence that cephalopod management is needed. In the few cases where there is assessment, populations are considered to be fully exploited or overexploited (e.g. *Sepia officinalis* in the English Channel). Also, some evidence of growth overfishing could be detected in octopus in Portugal. In other cases, an increase in fishing efficiency and/or effort is detected. As for example, *Loligo* spp. in Bay of Biscay, where effort is being increased by increasing the number of trips shifting traditional métiers targeting demersal species towards métiers targeting cephalopods (*Loligo* spp.). Thus, there is a significant risk that if no management is implemented something could happen in both cephalopod populations and marine ecosystems. The precautionary approach and the ecosystem aspects contemplated under Natura 2000 and UNESCO lead us to identify this management need.

In the event of lack of sound scientific information for moving into management right away, there is still a need to monitor cephalopods by means of assessment, even if this assessment is not analytical. Monitoring would allow formulating measures and have them readily available in the event that populations reach unexpected low levels jeopardizing sustainability.

The need for management is also supported by the relatively high importance of cephalopod fisheries in some areas. Thus, there is a need of maintain sustainable fisheries based on adequate (*ad hoc*) management of the target species and regions. Consequently, the first measures to be taken, could be those that assure the protection of spawning grounds and recruits and also, for some populations, to restrict and avoid increase of effort. Interactions between fleets are a point to be taken into account when managing populations exploited by mixed fisheries. Thus, all gears exploiting cephalopods should be taken into account (e.g. in the case of a need to compensate one gear vs. another one under different population status). This should be done, again, on the basis of sound scientific advice.

As an example of *ad hoc* management requirements, in the 2000s in the Moray Firth a new directed fishery on squid was developed. Stakeholders had great interest for exploiting the stock, however through the years; industry realized that, although being very profitable fisheries in some years, they were not reliable because of the unpredictability of catches. The fishery was considered unproductive in 2006. At that time, stakeholders propose to incorporate some technical measures (i.e. deter entry in the fishery to large boats) and include some protection for recruitment. Fishing effort was unregulated but it should have been controlled during the good years of the resource status. Nothing was done, and so yields decreased. This fact, the need of protection of the squid fisheries while the resource is at good status, is also described by Roa (2012) in relation to *Loligo gahi* in the Falklands. This example of a fishery collapse (and various other examples could be cited) can be used as a basis for having management tools readily available to assess different strategies of, for instance increasing effort on recruits, or on the contrary, being more conservative and restricting effort from increasing.

In summary: Key conclusion on the need of management

- There is evidence that cephalopod management is needed, as some stocks are considered to be fully exploited or overexploited (e.g. *Sepia officinalis* in VIIe). There is a significant risk that if no management is implemented negative impact on both cephalopod populations and marine ecosystems could occur. Although evidence is not conclusive it is suspected that some past stock crashes were at least partially fishery induced.
- In the event of lack of sound scientific information for moving into management, there is a need of monitoring cephalopods, for example by means of assessment. Monitoring would allow formulating measures to be readily available in the event that populations reach unexpected low levels jeopardizing sustainability.
- The need for management is also supported by the relatively high importance of cephalopod fisheries in some areas and the likelihood that pressure on these stocks will increase in future; there is a need of maintain sustainable fisheries based on adequate management for the target species and regions.

ToR b. Develop a strategy and road map for the inclusion of cephalopod fisheries data to be included in ICES multispecies and mixed fisheries assessments (where relevant)

The strategy

Multispecies and mixed species fisheries obviously appear to have an impact on cephalopods. The use of monospecific MSY targets and the overall lack of an ecosystem based approach to management is a major weakness to undertake practical measures at a time when the stocks could be overexploited and the situation could be worsening.

The strategy will be to include cephalopods under other working groups dealing with multispecies assessment and mixed fisheries advice. This possibility is reviewed under the operational focus of: knowledge required, model availability, and existence of expertise.

WGSAM

The knowledge needed: when considering multispecies assessment, variability of cephalopod populations should be incorporated as is done in monospecific fisheries.

The models required: there is no information about models that could incorporate such a high variability. Also, concerns are raised about how to include cephalopods in multispecies models as time-scales are different: cephalopods time-scales do not fit with those from finfish (in general they are much shorter).

The expertise needed: it has to be pointed out that many experts in cephalopods regularly attending the ICES WGCEPH are, in general, focused on biological and ecological issues rather than on assessment. So it appears necessary to i) train biological and ecological experts in multispecies models and/or ii) create multidisciplinary teams of modellers and biologist/ecologist, at country and ICES WG level, to overcome this challenge.

WGMIXFISH:

The knowledge needed: further knowledge of stock/population identification and assessment of stock status is required. The method used in this WG, F_{cube} , is already defined. Input needed is, basically, stock assessment status and métier/fleet effort. At this moment, there is no cephalopod analytical assessment to deliver such data.

The experts needed: could be those already attending the WGMIXFISH.

The possibility that **WGCEPH** takes on the assessment task: we should be cautious as **WGCEPH** does not have the capacity, at present, to incorporate more ToRs due to small membership and lack of assessment experts in the group due to the more biological and ecological nature of the expert group (under SCICOM). However, as noted above there is a need to make more progress on assessment methods appropriate to European stocks as well as to evaluate the feasibility of including cephalopods in multispecies assessment. **WGCEPH** could participate in this task; a further workshop may also be necessary, to assemble expertise in cephalopods and in assessment.

Participation in multidisciplinary projects which could, in future, incorporate their knowledge development into the ICES system of WGs

In some multidisciplinary European projects cephalopods are already included for their assessment and future management advice. As an example, in the SOCIOEC project (FP7), Ifremer models the dynamics of the French fisheries in the Eastern Channel using the simulation model ISIS-Fish. There is an interest in the economic and ecological impact of new management measures on the fisheries and in the development of harvest control rules for data-limited species. Ifremer included squid in the modelling with a twofold objective: assess the ecological impact of the management of others species on squid and assess the potential of new HCRs for squid.

The challenge here is how to translate this knowledge to the ICES WG. A first step could be to derive results to traditional mono-specific assessment WG which are taken more and more a holistic approaches of, at least, all commercial species exploited by all fleets in their area of competence (the new WGBIE, WGCS, WGNS...)

Road map for the three year period of WGCEPH multi-ToRs

- 1) Cephalopods in mixed fisheries

2014–2016. To assure assessment (analytical or non-analytical) of cephalopods in the context of the WGCEPH. Starting by well identified CSs (see next section).

2014–2016. Delivery of assessment exercises for cephalopods at the mono-specific assessment WGs for their consideration and feedback in methods, raising concern about the importance of these species in the ecoregion under the scope of these WG.

2014–2016. Close contact with WGSAM for model identification that can cope with cephalopod variability and short-living life histories. Close contact with WGMIXFISH for identification of parameters needed for the inclusion of cephalopods in VIIIc & IXa in the F_{cube} model already deployed.

2016. As a result of the assessment exercises in WGCEPH and peer review by assessment WGs, go for a step ahead and start feeding multispecies models and mixed fisheries models.

2) Artisanal fisheries

2014–2016: In the numerous small-scale directed fisheries a radically different approach will be needed. In most such fisheries, interactions with other stocks will be biological rather than fishery-related as gears to catch cephalopods are often very specific to their targets. The challenge is to devise suitable monitoring and management that involves the stakeholders and supports the important social and economic role of these fisheries while retaining sustainability. This work could more easily be accommodated within WGCEPH, with the addition of some social science and assessment expertise.

At the end of the complete period 2014–2016, the goal is to have included (at different levels of implication) cephalopods in ICES WG other than WGCEPH.

4.4 Potential steps towards cephalopod management

Preliminary exercises of cephalopods stock assessment: to start getting ready for management. However, we should be cautious as WGCEPH does not have the capacity, at present, to incorporate more ToRs due to small membership and lack of assessment experts in the group due to the more biological and ecological nature of the own expert group (under SCICOM).

Due to the last three years of data call launched by ICES, and required from WGCEPH, there are **some suitable assessment models to be explored** for the data already available, both for the small-scale and large-scale fisheries:

Cpue trends and survey trends: As a first approach, cpue trends and surveys trends can be offered.

Production models: seem to work very well for cephalopods and could be tried with the existing data. (e.g. Sahara Bank octopus (Balguerias *et al.*, 2000)). In these models, survey data can be used together with dataserie of lpues and/or cpues.

A two-step biomass model, stochastic or deterministic: In case of quarterly data, assessment models to be used are the same ones as those presented for *Sepia officinalis* in the English Channel or the currently assessment model used for anchovy in VIIIabdc.

Catch dynamic model or generalized depletion models (Roa-Ureta, 2012): in case of higher temporal resolution data or long dataserie of catches, can be

tried. This exercise of assessment has been proposed to be carried out for *Octopus vulgaris* in Gulf of Cadiz (Division IXa).

More sophisticated assessment models: these ones should be able to incorporate environmental variables so important for short-living species. In this way, the predictive variables to be included in the model could be the environmental variables. As commented above, abundances of *Octopus vulgaris* are highly related to the rainfall detected one year in advance (Sobrino *et al.*, 2002). Also, for *Sepia officinalis* the success of the recruitment can be related to other environmental variables. Abundances of *Octopus vulgaris* in the Northwest of Spain (Division VIIIc, Galicia) is also related to the wind strength inducing a local upwelling event. In this study the windstress structure during spring–summer (prior to the *Octopus vulgaris* hatching peak) and autumn–winter (during the *Octopus vulgaris* planktonic stage) was found to affect the early life phase of this species, and explains up to 85% of the total variance of the year-to-year variability of the adult catch (Otero *et al.*, 2008).

Forecasting cephalopods abundances: the use of pre-seasonal surveys could be assessed for forecasting abundances for the next season. A possible exploratory exercise could be based on the revision of the existing surveys and their possible forecasting use. If abundances of cephalopods could be forecasted management could be focused on the awarding of licences or quota with the aim of limit fishing power in each good or bad year or season. Also, this forecasting capacity could be increased by the use of environmental relationships.

Reference points: their calculation appears to be limited by the difficulty of having estimates of initial biomass or recruitment when there is so much variability. In these situations, reference points could be variable ones or better, these ones could be based on rules of escapement. $B_{\text{escapement}}$ is a possible reference point to be calculated for short-living species with no stock–recruitment relationship. The idea behind this reference point is to leave in the system, or let escape from the fishery, certain population quantity that could assure next season abundances.

The methodology on how to calculate this $B_{\text{escapement}}$ is problematic. Some proxies can be tried but always if an estimate of biomass is available. In this way, some proxies can be defined as $B_{\text{escapement}}$ vs. initial biomass. Estimates of biomass for several seasons are needed by means of checking historical catches from where to derive a proxy that can be used as a threshold.

An exercise is proposed under this $B_{\text{escapement}}$ calculation matter. *Loligo forbesii* in Moray Firth (Rockall, Subarea VI) dataserries of catches could be checked and analysed for inferring some kind of threshold. For instance, a question to be stated could be whether there is any evidence that heavy fishing led to low catches in the next year/seasons.

Harvest control rules to be applied to cephalopods: Protection of essential habitats as spawning grounds, protection of recruitments and establishing catch limits at levels defined by thresholds ($B_{\text{escapement}}$).

Revision of technical measures: Already in place based on scientific knowledge of the populations: Minimum weight size defined as 1 kg for octopus in the Gulf of Cadiz based on 50% of the population mature weight.

Already in applied but appear not to be related to any biological reason: 10 cm minimum landing sizes for squids in Galician waters (western part of ICES Division VIIIc).

The traditional TACs and Quotas (output control measures) could be also proposed but always based on sound scientific knowledge, which at stage is not applicable due to the uncertainties mentioned above and the lack of use of assessment models.

Other alternative ideas for managing cephalopod

For instance the minimum ideal landing weight (1100 gr.) for *Octopus vulgaris* in Portuguese waters (Division IXa (north) is based on the minimum production in relation to the weights (Figure 20).

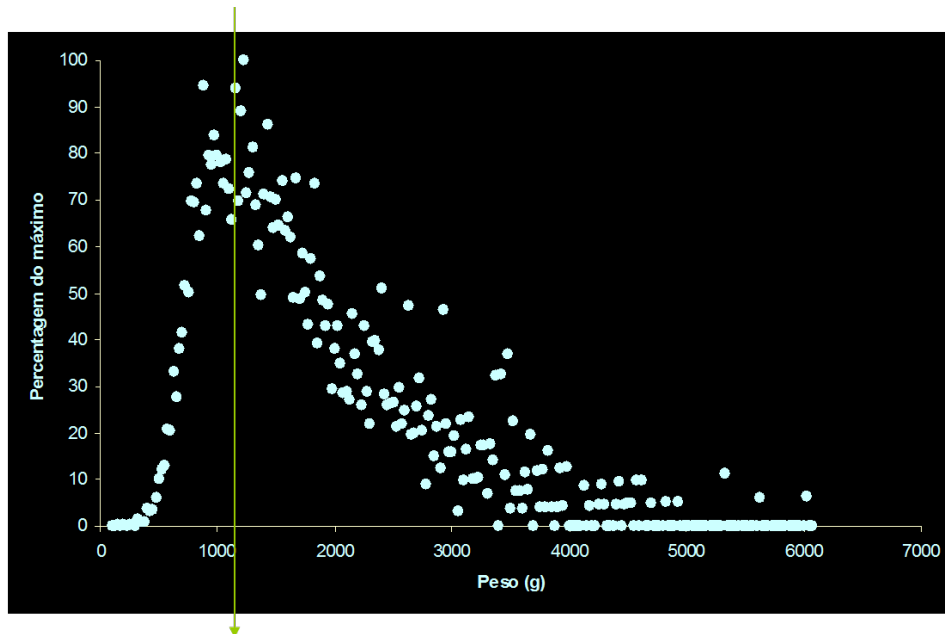


Figure 20. Percentage of production by weight of octopus is presented. The weight where the maximum percentage of production is obtained will be chosen as the ideal landing minimum weight. In this case this corresponds to 1 100 gr.

Considerations of research and monitoring needs

There is still a need of research and monitoring in the following key topics:

- Recruitment relationship with environmental variables.
- How to include these relationships into assessment models (e.g. Production models).
- Quantification of trophic importance and role of cephalopods in ecosystem.
- It appears to be useful to have the highest temporal resolution on effort and catches as catches are very responsive to effort, so, from this relationship, evidence of abundance could be found.
- There is a problem with detailed data in relation to availability: in general, data owners aggregate data to deliver them to data users.
- There is a need of monitor variables or parameters accommodating the periodicity and seasonality of the monitoring to these short-living species and life histories.
- Also, stakeholder feedback is required as the idea will be to bring their knowledge to establish thresholds in cephalopods exploitation. Stakeholders have the historical view, capacity and know very well the market. So in

this way, if thresholds are jointly defined could be easier assumed by stakeholders as their own limits. Thus, industry could commit to them and, mainly, accomplish with them.

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Annex 1: List of participants

NAME	ADDRESS	PHONE/FAX	E-MAIL
Firmin, Chris	Cefas UK		chris.firmin@cefas.co.uk
Figueiredo Pereira, João By WebEx	Portuguese Institute for the Sea and the Atmosphere (IPMA) Avenida de Brasilia 1449-006 Lisbon Portugal	Phone +351 213027044 Fax +351 213015948	jpereira@ipma.pt
Hufnagl, Marc Chair	University of Hamburg Institute of Hydrobiology and Fishery Science Olbersweg 24 D-22767 Hamburg Germany	Phone +49 (0)40428386625 Fax +49 (0)40428386618	marc.hufnagl@uni-hamburg.de
Miller, David	Wageningen IMARES PO Box 68 1970 AB IJmuiden Netherlands	Phone +31 3174 853 69 Fax +31	david.miller@wur.nl
Neudecker, Thomas	Johann-Heinrich von Thünen- Institute Federal Research Institute for Rural Areas, Forestry and Fisheries Institute for Sea Fisheries Palmaille 9 22767 Hamburg Germany		thomas.neudecker@ti.bund.de
Nooitgedagt, Johan K.	Dutch Fishery Organisation Vissersbond PO 64 8300 AB Emmeloord Netherlands	Phone +31 Fax +31	nooitgedagt@euronet.nl
Oberdoerffer, Philipp	Erzeugergemeinschaft der Deutschen Krabbenfischer GmbH Niedersachsenstr. 9 27472 Cuxhaven Germany	Phone +49 Fax +49	p.oberdoerffer@ezdk.de
Parker- Humphreys, Matthew	Cefas UK		Matthew.parker- humphreys@cefas.co.uk
Pierce, Graham	University of Aberdeen Oceanlab Main Street AB41 6FL Newburgh, Ellon Aberdeenshire, Scotland United Kingdom	Phone +44 1224 272459 Fax +44	g.j.pierce@abdn.ac.uk

NAME	ADDRESS	PHONE/FAX	E-MAIL
Roa-Ureta, Rubén	King Fahd University of Petroleum and Minerals Center for Environment and Water, Research Institute KFUPM Box 1927 31261 Dhahran Saudi Arabia	Phone +966 3 860 7850 mobile. +34- 680308541 Fax +966 3 860 1205	ruben@kfupm.edu.sa
Robin, Jean- Paul	Université de Caen Basse- Normandie PO 5186 14032 Caen Cedex France		jean-paul.robin@unicaen.fr
Santurtún, Marina Co-chair	AZTI-Tecnalia AZTI Sukarrieta Txatxarramendi ugarte a z/g E-48395 Sukarrieta (Bizkaia) Spain	Phone +34 946 029 400 Fax +34 946 870 006	msanturtun@azti.es msanturtun@suk.azti.es
Schoute, Barbara	ICES H.C.Andersen's Blvd 44-46 1558 Copenhagen V Denmark		barbara@ices.dk
Schulte, Katharina	Johann-Heinrich von Thünen- Institute Federal Research Institute for Rural Areas, Forestry and Fisheries Institute for Sea Fisheries Palmaille 9 22767 Hamburg Germany		katharina.schulte@ti.bund.de
Silva, Luis	Instituto Español de Oceanografía Centro Oceanografico de Cádiz Puerto Pesquero Muelle de Levante s/n E-11006 Cádiz Spain	Phone +34 956 3601 6290 Fax +34 956 3601 6415	Luis.silva@cd.ieo.es
Steenbergen, Josien Chair	Wageningen IMARES PO Box 68 1970 AB IJmuiden Netherlands	Phone +31 Fax +31	josien.steenbergen@wur.nl
Temming, Axel	University of Hamburg Institute of Hydrobiology and Fishery Science Olbersweg 24 D-22767 Hamburg Germany	Phone +49 40 28 38 6620 Fax +49 40 428 38 6618	atemming@uni-hamburg.de
Torrelee, Els By WebEx	Institute for Agricultural and Fisheries Research (ILVO) Ankerstraat 1 8400 Oostende Belgium	Phone +32 59569833 Fax +32	els.Torrelee@ilvo.vlaanderen.be

NAME	ADDRESS	PHONE/FAX	E-MAIL
Tulp, Ingrid	Wageningen IMARES PO Box 68 1970 AB IJmuiden Netherlands		Ingrid.tulp@wur.nl
van de Water, Monique	The North Sea Foundation Drieharingstraat 25 3511 Utrecht Netherlands	Phone +31 Fax +31	m.vandewater@noordzee.nl
van Kooten, Tobias	Wageningen IMARES P.O. Box 68 1970 AB IJmuiden Netherlands	Phone +31 Fax +31	Tobias.vankooten@wur.nl

Annex 2: Agenda

Tuesday morning 8 October

09:00	Housekeeping, welcome and introduction
09:30–10:00	ACOMs view of the world (Barbara)
10:00–10:30	Crash course Cephalopods + Case studies (Marina, Graham, Joao, Jean Paul & Luis)
10:30–10:45	Discussion
10:45–11:00	<i>Coffee break</i>
11:00–11:30	Crash course Crangon (Marc, Josien)
11:30–11:45	Discussion
11:45–12:30	ToRs and how to proceed, formation of break out groups
12:30	<i>Lunch break</i>

Tuesday afternoon

13:30–open end	<p>Break-out groups to deal with ToR A</p> <p>Why do we need a management! (Is there a threat to the population the environment other species?)</p> <p>Generally:</p> <ul style="list-style-type: none"> - Is it a lower trophic level species - Role of the species in the foodweb and ecosystem (predator and prey) - Necessity to manage the species - ToR b.) Mixed fisheries + Multispecies - Options for management
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Wednesday morning

09:00–10:00	Summary of break-out sessions (ToR b) more discussion later if needed)
10:00–10:20	Comparison with other stock managements (David)
10:20–10:40	A method to assess data-poor species (Ruben)
10:40–11:00	<i>Coffee break</i>
11:00–12:30	Finish ToR b), Start on ToR c)
12:30	<i>Lunch break</i>

Wednesday afternoon

13:30–15:00	<p>ToR c) Develop steps to manage the species</p> <p>Data needs</p> <p>Legislation steps</p> <p>Crangon: Evaluation of an HCR (Katharina)</p>
15:00–16:00	Wrap up and summary

Annex 3: Recommendations

RECOMMENDATION	ADRESSED TO
1. With regards to Crangon management it has been recommended to give a Pro Bono advice in support of the need for management of the fisheries of <i>C. Crangon</i> .	ACOM
2. Organization of a WK to evaluate the management plan for <i>C. crangon</i> fisheries.	ICES Secretariat, ACOM
3. Back to back meeting of the WGCRAN and WGCEPH with a joint session on management and assessment developments in 2015	ICES secretariat, WGCRAN WGCEPH
4. Cephalopod: There is a clear need to evaluate the feasibility of including very short-lived species in multispecies assessments	ICES WGSAM
5. Cephalopods: a workshop or workshops to advance with devising appropriate methodologies for assessment in the commercial multispecific and mixed fisheries and artisanal fisheries.	WGMET, WGCEPH,
6. Cephalopods: revision of WGCEPH proposed ToRs to permit this expert group to make a greater contribution on the assessment and management process.	WGCEPH

Annex 4: Data summary per species/fisheries

	CRANGON CRANGON	<i>Crangon crangon</i> IVb,c (North Sea, UK, Denmark, Germany, Netherlands, Belgium, France; inshore areas)
Current Knowledge	Life cycle	Good knowledge of life cycle. General life cycle information is available (e.g. maximum size, mean asymptotic size, total mortality of adult shrimp, size at maturity, length and temperature dependent growth rates, sex ratios, seasonal variation in juvenile and adult abundance, migration patterns, preferred temperatures, etc.)
	Ecology	Several studies analysed gut contents of <i>C. crangon</i> and its predators. Brown shrimp are omnivorous feeding mainly on benthic and pelagic crustaceans, bivalves, polychaetes, detritus and cannibalistic on its conspecifics. Main predators of adult brown shrimp (mainly derived from the year of the stomach data 1981/91) are cod and whiting. Juvenile and larval shrimp are consumed by a large variety of species mainly limited by the occurrence of predator and prey in the same habitat and the predator-prey size relation. Enumeration of predation rates (and therefore natural mortality M) on adult shrimps is possible while for juveniles its so far not.
	Fishery	Bottom trawls with stretched mesh opening of approximately 20 mm. Studies on gear selectivity are available and more data are currently risen on different mesh types and widths. Efficiency of sievenets and bycatch reduction devices has partly been examined. There are clear indications that catch efficiency depends on gear, vessel, age of the ship and captain but knowledge is limited due to a lack of available data from all nations.
Current data	Captures	Monthly landings are for all nations available for more than 25 years (besides France: 12 years). Larger vessels are equipped with a vessel monitoring system (VMS) and electronic logbooks are soon mandatory for the whole fleet. So far landings and effort data are reported to WGCAN via the delegates from the different nations, however not all data are made available or are available to the delegates.
	Effort	Monthly effort data are available for at least ten years but not all nations report in the same format (some days at sea, some hours outside the harbour) but effort is undertaken to standardize all series to hours outside the harbour. This standardization step is an ongoing process since several years but is complicated due to problems with manpower, responsibility and data availability.
	Discards/Bycatch	Bycatch and discards mainly consist of undersized shrimps, juvenile flatfish and smaller or juvenile demersal fish. Undersized shrimps discarded after the first sieving and before the cooking have a high chance of surviving whereas fish discards are mainly dead. Bycatch is monitored regularly by observers but trips are very limited (approx .1:2000).
	Market sampling and sampling aboard	Shrimp sizes are monitored during some observer trips. Data on landings and selling price are reported. Sieving sizes and price per size fraction are not standardized and are not available. In Belgium and France, larger fractions of the catch are sold directly and are therefore not monitored and recorded during the auctions.

	Survey	Ongoing surveys are conducted in autumn and are the German Demersal Young Fish Survey (DYFS; since 1974) and the Dutch Demersal Fish Survey (DFS; 1970). In the past monthly data from commercial catches have been monitored in the German Bycatch series. Additionally a winter and a spring survey have been conducted irregularly in the past but have now been stopped.
Current management	Licences	The maximum number of shrimpers is limited through a licence system in Germany, the Netherlands and Denmark.
	Minimum landing sizes	Minimum sieving width (carapace width) according to marketing standard ⁷ is for consumption shrimps 6.5 mm. Depending on the market situation larger sieves can be and are used.
	Gears (mesh)	Minimum mesh size (stretched mesh) is 16 mm in the codend ⁸ .
	Area-based management	Natura 2000 areas are closed for the fisheries in the Netherlands. In Germany closing these areas is under discussion, a small area is closed according to National Park Regulation. No detailed information for the other Countries
	Effort limitation	Within the 12 miles zone no vessels > 221 kw engine power are allowed. Within the plaice box no beam and otter trawlers with >300 kW engine power are allowed to operate.
	Stakeholder involvement	The industry started a MSC initiative that also involved a management plan including among other measures a standardized sieving on land and a harvest control rule based on regularly monitored lpue.
	Recreational fishing	Not relevant
Assessment(s)	Lpue based harvest control rule	A harvest control rule based on the reported landings and hours outside the harbour or hours fishing has been suggested by the industry. As soon as lpue fall below a predefined threshold effort is reduced. Thresholds and necessary effort reductions have been evaluated scientifically based on German logbook data and reported effort in combination with a yield-per-recruit model.
	Yield-per-recruit model	A yield-per-recruit model that takes into account sex, stage and seasonal variations in mortality and growth and reproduction and that also includes individual growth variation has been parameterized and published. The model can be used for scenario testing and effort management. Analysis using the model in combination with historical reconstructions of fishing and natural mortality indicate growth overfishing. From the model $F_{0.1}$ and F_{MAX} can be estimated that help to harvest the population efficiently and economically. These analyses are only possible retrospectively (as cod and whiting abundance and shrimp landings data are necessary) and they should therefore not be used as stand-alone tool. Additionally the model only indicates the most efficient way to harvest the stock which is not always the most sustainable one. The model gives valuable information on the impact of the fishery on the stock and economic yield.

⁷ EU 2406/96.

⁸ EU 850/98.

	Swept-area estimate	Based on the Dutch and German scientific autumn surveys shrimp biomass (only adults due to mesh widths used) based on the swept-area and the cpue can be calculated. The estimate has limitations due to uncertainties in catchability, area and season coverage, however the biomass and production estimates are reasonable and with respect to the order of magnitude and interannual variability. Due to the high P/B ratio (approximately 5 for adult shrimps) of the stock the shrimp biomass is about half of the annual landings but the production is comparable to the landings. This biomass and production estimate is, comparable to the Y/R model analysis, only possible at the end of the season. This is with respect to the annual life cycle too late for a management advice but gives valuable information to adjust for example a harvest control rule and to ground-truth fishery based lpue.
	Biomass model used for MSY	Recent examinations show that a biomass model does not provide a reliable biomass estimate nor reference points, even if the most reliable series (DFS survey series) is used. This is mainly based in the fact that the interannual variation in lpue and landings is too low and is not covering many bad years.
	General Depletion Model	A new General Depletion Model was introduced during the workshop that is stock independent and uses only fisheries data. The model needs to be evaluated and tested concerning the applicability for the brown shrimp stock and might be used for assessment.
Summary advice for the (near) future	Future management	<p>Due to the short lifespan of brown shrimp a classical age based management base on stock–recruitment relations is not possible. The most suitable solution seems to be an lpue based harvest control rule with regular ground-truthing through standardized survey data in combination with retrospective analysis on fishing and natural mortality as well as interannual variation of the stock status. In general the management plan should guarantee a sustainable fishery e.g. by an in time effort reduction in the case of reduced stock sizes (e.g. due to reduced recruitment, increased natural mortality, etc.)</p> <p>encourage effort reductions in situations of growth overfishing to optimize the use of the resource while reducing the impact on the ecosystem.</p> <p>encourage to use fishing gears that minimize the catch of undersized shrimps, the fish bycatch and the bottom impact.</p> <p>minimize adverse effects on the environment.</p>

Data needs	<p>A sound analysis of the relation between effort and landings is only possible if enough data on the fleet structure (fleet inventory) is available. This will prevent from unforeseen effort creeps and should contain specific gear information (TBB), ship type data and operation times/modes.</p> <p>At the moment sieving on board and land is not standardized besides the EU minimum width of 6.5 mm. However, a very large fraction of the landings is sieved ashore on 6.8 mm sieves according to voluntary market agreements and in view of the MSC process. Clear and holistic reporting of all sieving and processing steps is therefore highly recommended.</p> <p>Given the seasonal and spatial variation in bycatch present in Brown Shrimp fisheries there is a need for additional data on the composition of the catch. Monitoring programmes should be implemented for the whole (European) fleet and include evaluation of possible measures to avoid, or at least reduce bycatch.</p> <p>Natural mortality especially of undersized shrimps is an important but so far not determinable variable influencing the productivity of the stock. For a more sound determination updated stomach content data are required.</p>
Research needs	<p>In line with the previous argument the role of Crangon, especially of the undersized shrimps, in the foodweb is needed to get a better handle on the early life mortality rates.</p> <p>Effort creep will falsify results and advice given on an Ipue based monitoring. Especially new gears like the pulse beam trawl need to be tested very thoroughly and their introduction needs to be carefully tested, discussed and overthought before introduction.</p> <p>Survival rates of catch rates of undersized shrimps and fish bycatch needs to be investigated.</p> <p>The effect of using different gear and mesh types and their effect on the catchability and the stock productivity needs to be tested – as well as the effect on the catch-ability of other bycatch of these measures.</p> <p>The scientific surveys need to be evaluated concerning their setup and spatial and seasonal coverage. Additionally the comparability between the German and the Dutch survey needs to be evaluated.</p> <p>Methods to monitor juvenile abundance are needed. The data are needed to perform stock–recruitment and recruitment strength analyses.</p>
Future monitoring (extra)	<p>Regular evaluation of the management is recommended. This includes a regular ground-truthing of Ipue and recommended effort (HCR or short-term TAC). Possible ways could be extended scientific surveys or additional surveys that are for example conducted by the fisherman with standardized gears in a standardized fashion. An additional survey in late spring that can be used to identify the recruitment strength of the incoming cohort is highly recommended.</p>

	<i>OCTOPUS VULGARIS</i>	VIIIc IXa (Spain)
Current Knowledge	Life cycle	Good knowledge of life cycle, e.g. size at maturity, seasonality, fecundity
	Ecology	Trophic model Gulf of Cadiz
	Fishery	Selectivity of clay pots (south)
Current data	Captures	VIII: boat, market and logbook data XIa Capture by boat, per day Trawler logbooks (with ICES rectangle) (not artisanal) <i>Octopus vulgaris</i> is separated (at least since mid-1990s in the south). Possibly some mixing with <i>Eledone</i>
	Effort	Logbook data Number of trips (artisanal) Fleet composition data (better in north)
	Discards	Trawl fleet – observers aboard (since 1994 in the north, and since 2005 in the south) (South: 0.1%, North 0.4%) (Projects? Teresa Borges project)
	Market sampling and sampling aboard	Some market sampling (Xunta de Galicia, artisanal?) Trawlers: since 2009 (north), 1996 (south)
	Survey	Demersal: since 1990s (north) ARSA: since 1993 (south) Yield, biological sampling since 1996 in south
Current management	Licences	Trawlers (licence to fish, multispecies) Artisanal: licence to fish for octopus, since 2005 in south (in north?)
	Minimum landing sizes	North, South: 1 kg (?)
	Gears (mesh, number of traps)	Trawls: normal mesh limits (55 mm in south; north ??) South: 1000 clay pot or 250 traps (maximum number per vessel), Hand jig (?) North: numerous regulations about gears
	Area-based management	South: no trawling inside 6 mile limit, no artisanal beyond 6 miles
	Effort limitation	Compulsory rest of 48 hours continuous per week two closed seasons: 45 days June–July (artisanal), 50 days October–November (all fleets)
	Stakeholder involvement	?
	Recreational fishing	South: no capture or sale of octopus North ?
Assessment	Project-based assessment	Environmental links with recruitment (CSIC IIM in Galicia, IEO in Cadiz)
	WGCEPH work	Trends in commercial and survey cpue, also landings
The future	Future assessment	
	Future management	Control of pots/traps per boat Gear out of water at least 48 hours (with enforcement) Minimum weight control (with enforcement)

	Benchmarking	
	Research needs	Recruitment and paralarvae. Age. Trophic role. More on quantifying variability of life-history parameters
	Future monitoring	Weekly data (size, captures, effort)
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	<i>SEPIA OFFICINALIS</i>	VIIIc IXa (Spain)
Current Knowledge	Life cycle	Good knowledge of life cycle, e.g. size at maturity, seasonality, fecundity
	Ecology	Data on prey and predators
	Fishery	
Current data	Captures	VIII: boat, market and logbook data XIa Capture by boat, per day Trawler logbooks (with ICES rectangle) (not artisanal) <i>Sepia officinalis</i> is distinguished from other <i>Sepia</i> spp.
	Effort	Logbook data Number of trips (artisanal) Fleet composition data (better in north)
	Discards	Trawl fleet – observers aboard (since 1994 in the north, and since 2005 in the south) (South: 0.1%, North 0.4%) (Projects? Teresa Borges project)
	Market sampling and sampling aboard	Market sampling by Xunta de Galicia, artisanal???? Trawlers: since 2009 (north), since 2003, every 3 years there were monthly samples; monthly since 2009 (south)
	Survey	Demersal: since 1990s (north) ARSA: since 1993 (south) Yield, biological sampling since 1996 in south
	Current management	Licences
Minimum landing sizes		Galicia(?)
Gears (mesh, number of traps)		Trawls: normal mesh limits (55 mm in south; north ??) Trammelnet: 50–59 mm mesh, maximum length: 4.5 km (south) In 2002, new fishing reserve (Guadalquivir) with new regulation for trammelnet (mesh 40 mm, length ≤3 km)
Area-based management		South: no trawling inside 6 mile limit, no artisanal beyond 6 miles Fishing reserve (Guadalquivir)
Effort limitation		Compulsory rest of 48 hours continuous per week (must be weekends in the fishing reserve) 50 days October–November (trawl)
Stakeholder involvement		?
Recreational fishing		South: no limitation on <i>Sepia</i> (?) North?
Assessment	Project-based assessment	No environmental links with recruitment (IEO in Cadiz)

	WGCEPH work	Trends in commercial and survey cpue, also landings
The future	Future assessment	A Two-stage biomass model (similar to the one developed in the English Channel Stock) can be implemented to assess Bay of Biscay cuttlefish (using EVHOE survey and Spain and France commercial data)
	Future management	Control of trammelnets (mesh, length) Gear out of water at least 48 hours (with enforcement) Establish minimum weight
	Benchmarking	
	Research needs	Recruitment. Age. Trophic role. More on quantifying variability of life-history parameters
	Future monitoring	Weekly data (size, captures, effort)
	<i>LOLIGO VULGARIAS</i> and <i>LOLIGO FORBESI</i>	VIIIabd (Spain and France)
Current Knowledge	Life cycle	Good knowledge of life cycle, e.g. size at maturity, seasonality, fecundity
	Ecology	Data on prey and predators can be derived from studies in the southern part of the distribution
	Fishery	
Current data	Captures	VIII: vessel, market and logbook data Capture by vessel, per day Trawler logbooks (with ICES rectangle) (not artisanal) <i>Loligo vulgaris</i> is not distinguished from <i>Loligo forbesi</i> .
	Effort	Logbook data + observers data (France inshore fisheries) Number of trips (industrial), Number of hours fishing (demersal trawlers) Fleet composition data
	Discards	Trawl fleet; observers onboard (since 1999 in Spain and since 2003 in France) (Spain: 0% in the last five years, France: no estimations) (Projects: DCP & DCF)
	Market sampling and sampling aboard	Market sampling: sampled as part of the DCF métier sampling, artisanal: in Spain reduced to the most southern part (VIIIb,c). Trawlers: , at métier level (1–2 samplings per year)since 2005 (Spain) French Trawlers may have been sampled since 2009 (about 1500 specimens in 2011) but species identification is poor before 2012)
	Survey	Demersal EVHOE: since 1990s (France) Yield, Abundances
Current management	Licences	Trawlers (licence to fish, multispecies) Artisanal: general licence to fish using artisanal gears. Permit to use light in internal and external waters.
	Minimum landing sizes	No existence in VIIIabd.(the lower boundary of the smallest UE commercial category - 100 g- is not a compulsory rule)
	Gears (mesh, number of traps)	Trawls: normal mesh limits (70 mm Spanish trawlers for square mesh pannels) Pair trawls use 100 mm.

	Area-based management	France: Trawl fishing is banned within 3 miles off the coastal zone (but there are exemptions) Spain: no specific area based management apart from 100 m isobate establish the limit where artisanal fisheries can operate.
	Effort limitation	Spain: Artisanal fisheries: compulsory rest of 48 hours continuous per week (must be weekends in the fishing reserve) Industrial fisheries is limited by number of fishing days that can operate in the area.
	Stakeholder involvement	SWWRAC Involvement for other commercial species
	Recreational fishing	Spain: 5 kg of squid by licence and day.
Assessment	Project-based assessment	
	WGCEPH work	Trends in commercial and survey (EVHOF just three years, can be extended but there are species identification problems before 1996) cpue, also landings
The future	Future assessment	Two step biomass model to be tried based on data availability
	Future management	To decide when assessment could be produce
	Benchmarking	
	Research needs	Species differentiation in the catch. Recruitment. Trophic role. More on quantifying variability of life-history parameters
	Future monitoring	Weekly data (size, captures, effort) this is especially required if generalized depletion models were to be tried.
	<i>SEPIA OFFICINALIS</i>	English Channel (VIIe) (France and United kingdom)
Current Knowledge	Life cycle	Good knowledge of life cycle, e.g. size at maturity, seasonality, fecundity
	Ecology	Data on prey and predators (grey literature but some knowledge, mainly from VIIId division)
	Fishery	Both countries have extended data collection systems
Current data	Captures	Logbooks (complemented by port observations in artisanal métiers) (data per ICES rectangle/ fishing operation or fishing trip / aggregated or made anonymous) <i>Sepia officinalis</i> is not distinguished from other <i>Sepia</i> spp. (<i>Sepia elegans</i> occurs in the West deepest fishing ground)
	Effort	Logbook data (complemented by port observations in artisanal métiers) (data per ICES rectangle/ fishing operation or fishing trip / aggregated or made anonymous) Fleet composition (gear type / vessel length / power)
	Discards	France : national on board observers programme "Obsmer" (mostly on board of trawlers) since 2004 (discarding rate <5% of catches ; observed catches 2.5–8.5 tons per year)
	Market sampling and sampling aboard	France: Monthly market sampling of trawlers landings at the Port-en-Bessin fish market (France) Comparative exercises carried out (once a year in the period 2002–2008) Obsmer programme records number and weights (the origin of length data in COST extractions should be checked) UK: Cephalopods not sampled on a regular basis. Project based observations collected in Brixham (MBA + Devon&Severn IFCA) Cefas has made preliminary observations of discards survival rates (<20%)

Current management	Survey	Only carried out in the eastern part of the Channel (ICES Division VIIId) Cefas BTS survey (using a beam trawl) in July Ifremer CGFS survey (using a GOV trawl) in October
	Licences	Licences only implemented in some coastal areas (mostly along the French coast) Concern trap fishing (although the number of trawlers operating within the 3 miles limit is also known via the exemption they have to apply for)
	Minimum landing sizes	None
	Gears (mesh, number of traps)	France: Trawls: normal mesh limits (80 mm related to multispecies or finfish rules) Maximum number of traps/ size of boats (<12 m) / spatial boundaries (to avoid interactions with trawlers)
	Area-based management	In French waters: Trawling within the 3 miles limit is only allowed during limited periods of time (in spring and late summer)
	Effort limitation	Temporal limitations (week-end rests) but no limitation in the number of boats
	Stakeholder involvement	French Coastal Waters: Fishermen and "Comité Régional des Pêches" interact about spatial conflicts (trawlers and traps)
	Recreational fishing	France : limitation of the number of traps that can be used for recreational fishing
Assessment	Project-based assessment	A series of exercises (assessment trials) published (Dunn, 1999 ; Royer <i>et al.</i> , 2006; Gras, 2013)
	WGCEPH work	Assessment exercises communicated to WGCEPH (the last exercise -2 stage biomass model- transformed in a "routine assessment tool" whose results will be passed on to WGCEPH
The future	Future assessment	The biomass model will be improved with Bayesian estimates of uncertainty and the next step is a spatial version in order to take into account interactions between fishing fleets
	Future management	Effective inshore trawling ban Establish minimum weight Mitigation of egg losses related to trap fishing?
	Benchmarking	
	Research needs	Recruitment. Age. Trophic role. More on quantifying variability of life-history parameters
	Future monitoring	Concerted sampling programmes in both French and UK fishing fleets Surveys are needed in the Western part of the Channel (VIIe)