ICES WGCEPH REPORT 2018

ECOSYSTEM PROCESSES AND DYNAMICS STEERING GROUP

ICES CM 2018/EPDSG:12

REF. SCICOM

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

5-8 June 2018

Pasaia, San Sebastian, Spain

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

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

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

Recommended format for purposes of citation:

ICES. 2019. Interim Report of the Working Group on Cephalopod Fisheries and Life History (WGCEPH), 5–8 June 2018, Pasaia, San Sebastian, Spain. ICES CM 2018/EPDSG:12. 100 pp.

Contents

Executive summary

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

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

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

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

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

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

1 Administrative details

Working Group name

Working Group on Cephalopod Fisheries and Life History (WGCEPH)

Year of Appointment within current cycle

2018

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

2

Chair(s)

Graham J. Pierce, Spain

Jean-Paul Robin, France

Meeting dates

5–8 June 2018

Meeting venue

Pasaia, San Sebastian, Spain

2 Terms of Reference

a) Report on cephalopod stock status and trends: Update, quality check and analyse relevant data on European fishery statistics (landings, directed effort, discards and survey.

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

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

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

e) Recommend tools for identification cephalopod species and update best practices for data collection.

3 Summary of Work plan

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

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

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

The main outcomes of the work of WGCEPH in 2018:

- Annual summaries for cephalopod fishery production in the ICES area plus a brief review of the use of morphometric and trace element data for stock identification (ToR A);
- Outlines of two manuscripts, one on stock trends and the other on assessment and management of cephalopods, plus a short review of stock assessment of cephalopods in Russia (ToR B);
- An updated version of the review of relevant new research on cephalopods, plus short reviews of cephalopod stock identification and Russian cephalopod studies (ToR C);
- A brief review of the socioeconomic importance of large-scale cephalopod fisheries. A manuscript on small-scale fisheries is almost complete (ToR D);
- Proposals for the structure of the identification guide, an evaluation of current use of nationally collected monitoring data on cephalopods, and draft recommendations for future monitoring (ToR E).

5 Progress report on ToRs and workplan

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

5.1.1 Stock identification

While WGCEPH has carried out various preliminary assessments of cephalopods and has discussed fishery management options, for most cephalopods in European waters, no stocks have been formally designated. Historical molecular genetic (and allozyme) studies suggest that, in European Atlantic waters, the high mobility of squids means that it is unlikely that more than one stock of each species is present (at least if we exclude the isolated population of *Loligo forbesii* in the Azores). In practice, smaller management units may be defined for convenience. For cuttlefish, which lack a planktonic paralarval stage, and octopus, which show little movement as adults, it is more likely that multiple stocks exist. In 2019, WGCEPH reviewed evidence available from non-genetic approaches to stock identification, including morphological studies, in particular considering the advances possible due to applying geometric morphometric analysis, and trace element analysis. The text of this section is adapted from a short review prepared by Jessica Jones and Fedor Lishchenko (Annex 3).

5.1.1.1 Morphological analysis

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

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

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

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

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

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

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

5.1.1.2 Trace Elemental analysis

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

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

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

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

Combining different population discrimination techniques is a promising area for future research. High resolution ICP-MS and statolith Fourier shape data were used to study temporal and spatial variation in *Nototodarus gouldi* (Green *et al.* 2015). Although shape analysis indicated the existence of two separate stocks, elemental analysis showed hatching of individuals from both stocks occurred throughout their distribution range. There was evidence that adults in Victoria were contributing more to the Great Australian Bight stock than vice versa, with implications for stock management (Green *et al.* 2015). Trace element analysis and morphometric measurements combined revealed the existence of three discrete cuttlefish populations in Algerian coastal waters (Kennouche and Nouar 2017). Another technique which can be combined with trace element and morphometric analyses is stable isotope analysis – which was used to elucidate migration and trophic patterns in *Ommastrephes bartramii* (Kato *et al.* 2016).

5.1.2 Trends in abundance

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

5.1.2.1 Cuttlefish and bobtail squids (Sepioidea)

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

5.1.2.2 Octopuses (Octopodidae)

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

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

5.1.2.3 Loliginid squids (Loliginidae)

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

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

5.1.2.4 Ommastrephid squids (Ommastrephidae)

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

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

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

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

5.2.1 Assessments

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

5.2.2 Assessment and management in Russian fisheries

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

Fishery management for aquatic biological resources in Russia is required to be consistent with the Code of Conduct for Responsible Fisheries (FAO, 1995), and the ecosystem approach and precautionary approaches to fisheries management. In practice, this means that assessments consider the impact of exploitation not only on the target species, but also on the *biocenosis* with which the target species is associated. Compliance of management with the principles of precautionary exploitation and sustainable development is monitored (Babayan, 2000).

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

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

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

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

Level 1. information support includes historical data series on age structure, growth and maturation, yearly and age-specific natural mortality rates, catches, and catches per unit of fishing effort. In such cases, structured stock assessment models are used, e.g. cohort models, stock-replenishment models, etc. Due to the short lifespan (about 1 year) of cephalopods, wide fluctuations in abundance and natural mortality, and the fact that the knowledge on their biology is limited in comparison with finfish, structured models are not used in their fishery management.

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

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

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

5.2.3 Manuscripts

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

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

5.3.1 Life history review

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

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

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

5.3.2 Russian studies

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

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

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

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

Nesis (1965) provides information on biology, distribution and migratory routes of juveniles and adults of *G. fabricii*. Subsequent studies on this species have described variability of morphological and biological traits, temperature preferences and possible impacts of climate change, and abundance in the eastern part of the species' range (Lubin & Sabirov, 2007; Golikov *et al.*, 2012, 2015; Golikov, 2014).

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

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

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

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

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

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

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

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

5.5.1 Identification guide

As mentioned in the last year's report (ICES 2017), the background of this ToR is the need to identify cephalopods to species level in commercial catches and research surveys, to increase the quality of data available for assessing the status of cephalopod stocks. The main idea is to produce a cephalopod identification guide suitable for use on-board research and commercial vessels for different regions, to help with identification of the main commercial species in the survey or fishing area. The guide should be quick and easy to use without a large amount of text. The focus will be on easily used identification criteria, shown by pictures and drawings.

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

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

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

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

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

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

5.5.2 Data collection recommendations

5.5.2.1 Current fishery data collection and use of these data

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

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

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

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

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

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

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

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

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

United Kingdom: currently most of the use of the data for the UK cephalopods has been for academic studies of biology and ecology (e.g. on distribution and abundance and impact of climate change, Kooji *et al.*, 2016). Various studies on patterns and trends in distribution and abundance (e.g. Pierce *et al.*, 1994, 1998; Waluda *et al.*, 1998; Bellido *et al.*, 2001; Pierce & Boyle 2003; Wang *et al.*, 2003; Zuur & Pierce 2004) and some preliminary stock assessment exercises have been carried out, e.g. a PhD thesis on Sepia by Matthew Dunn in 1999, papers by Young *et al.* (2004, 2006).

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

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

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

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

5.5.2.2 Revised Data Collection guidelines

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

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

WGCEPH proposes the following changes to cephalopod fishery data collection:

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

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

3) Focus of the most intensive sampling (i.e. weekly or monthly) during periods of higher catches in order to ensure adequate characterizations of the length compositions of the multiple microcohorts that are often present, while avoiding unproductive sampling effort at times of low abundance.

4) Collection of maturity data for the most important cephalopod fisheries, to facilitate comparison of trends in maturity and length composition data by cohort, from research surveys vs. the fishery, to assess trends in recruitment and length at 50% maturity (L50).

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

References

Aksyutina, Z.M., 1968 Elements of mathematical estimation on the observation results in biological and fishery studies. Moscow, Food industry, 288 pp.

Alexeyev, D.O., Lishchenko, F.V., Kivva, K.K. New method of schoolmaster squid, Berryteuthis magister biomass assessment. (2017). Problems of fisheries. vol. 18, No. 2, pp. 216–230.

Anon., 2005. Planning, organization and support of fisheries research in the Far Eastern seas of Russia and the north-western parts of the Pacific Ocean. Vladivostok, TINRO-Center, 231 pp.

Arbuckle, N.S.M. and Wormuth, J.H., 2014. Trace elemental patterns in Humboldt squid statoliths from three geographic regions. Hydrobiologia, 725(1), pp.115–123.

Arkhipkin, A.I., 2005. Statoliths as 'black boxes'(life recorders) in squid. *Marine and Freshwater Research*, *56*(5), pp.573–583.

Arkhipkin, A.I. and Bizikov, V.A., 1997. Statolith shape and microstructure in studies of systematics, age and growth in planktonic paralarvae of gonatid squids (Cephalopoda, Oegopsida) from the western Bering Sea. *Journal of plankton research*, *19*(12), pp.1993–2030.

Arkhipkin, A.I., Campana, S.E., FitzGerald, J. and Thorrold, S.R., 2004. Spatial and temporal variation in elemental signatures of statoliths from the Patagonian longfin squid (*Loligo gahi*). *Canadian Journal of Fisheries and Aquatic Sciences*, *61*(7), pp.1212–1224.

Babayan, V.K., 2000. Precautionary Approach to Assessment of Total Allowable Catch (TAC): Analysis and practical recommendations. Moscow, VNIRO publishing, 192 pp.

Barón, P.J. and Ré, M.E., 2002. Reproductive cycle and population structure of *Loligo sanpaulensis* of the northeastern coast of Patagonia. *Bulletin of Marine Science*, 71(1), pp.175–186.

Bekker, V.E., Belyanina, T.N., Kashkin, N.I., Nesis, K.N., 1982. Mesopelagic fishes and cephalopods of four areas of northern Atlantic (based on data of 31-th cruise of "Academic Kurchatov"). Problems of Ichthyology. vol. 22, No. 4, pp. 548–554.

Bellido, J.M., Pierce, G.J. & Wang, J., 2001. Modelling intra-annual variation in abundance of squid *Loligo forbesi* in Scottish waters using generalised additive models. Fisheries Research 52, 23–39.

Bonnaud, L., Rodhouse, P.G. and Boucher-Rodoni, R., 1998. A phylogenetic study of the squid family Onychoteuthidae (Cephalopoda: Oegopsida). *Proceedings of the Royal Society of London B: Biological Sciences*, *265*(1407), pp.1761–1770.

Borges, T.C., 1995. Discriminant analysis of geographic variation in hard structures of *Todarodes sagittatus* from the North Atlantic. In *ICES Marine Science Symposia* (Vol. 199, pp. 433–440). Copenhagen, Denmark: International Council for the Exploration of the Sea, 1991-.

Braga, R., Crespi-Abril, A.C., Van der Molen, S., Bainy, M.C.R.S. and Ortiz, N., 2017. Analysis of the morphological variation of *Doryteuthis sanpaulensis* (Cephalopoda: Loliginidae) in Argentinian and Brazilian coastal waters using geometric morphometrics techniques. *Marine Biodiversity*, *47*(3), pp.755–762.

Campana, S.E., 1999. Chemistry and composition of fish otoliths: pathways, mechanisms and applications. *Marine Ecology Progress Series*, *188*, pp.263–297.

Chembian, A.J. and Mathew, S., 2014. Population structure of the purpleback squid *Sthenoteuthis oualaniensis* (Lesson, 1830) along the south-west coast of India. *Indian Journal of Fisheries*, *61*(3), pp.20–28.

Chen, X., Lu, H., Liu, B., Chen, Y., Li, S. and Jin, M., 2012. Species identification of *Ommastrephes bartramii*, *Dosidicus gigas*, *Sthenoteuthis oualaniensis* and *Illex argentinus* (Ommastrephidae) using beak morphological variables. *Scientia Marina*, *76*(3), pp.473–481.

Ching, T.Y., Chen, C.S. and Wang, C.H., 2017. Spatiotemporal variations in life-history traits and statolith trace elements of *Sepioteuthis lessoniana* populations around northern Taiwan. *Journal of the Marine Biological Association of the United Kingdom*, pp.1–11.

Clarke, M.R., 1978. The cephalopod statolithan-introduction to its form. *Journal of the Marine Biological Association of the United Kingdom*, *58*(3), pp.701–712.

Crespi-Abril, A.C., Morsan, E.M. and Barón, P.J., 2010. Analysis of the ontogenetic variation in body and beak shape of the *Illex argentinus* inner shelf spawning groups by geometric morphometrics. *Journal of the Marine Biological Association of the United Kingdom*, *90*(3), pp.547–553.

Díaz-Santana-Iturríos, M., Salinas-Zavala, C.A. and Granados-Amores, J., 2017. Description of the statolith shape of two sympatric ommastrephids in the Mexican Pacific obtained from geometric morphometrics as a tool for identification at the species level. *Marine Biodiversity*, pp.1–5.

Doubleday, Z.A., Pecl, G.T., Semmens, J.M. and Danyushevsky, L., 2008b. Using stylet elemental signatures to determine the population structure of *Octopus maorum*. *Marine Ecology Progress Series*, *360*, pp.125–133.

Doubleday, Z.A., Pecl, G.T., Semmens, J.M. and Danyushevsky, L., 2008a. Stylet elemental signatures indicate population structure in a holobenthic octopus species, *Octopus pallidus*. *Marine Ecology Progress Series*, *371*, pp.1–10.

Fang, Z. and Chen, X., 2017, October. Statolith-based species identification methods for ommastrephidae species. In *Image and Signal Processing, BioMedical Engineering and Informatics (CISP-BMEI), 2017 10th International Congress on* (pp. 1–6). IEEE.

Fang, Z., Chen, X., Su, H., Thompson, K. and Chen, Y., 2017. Evaluation of stock variation and sexual dimorphism of beak shape of neon flying squid, *Ommastrephes bartramii*, based on geometric morphometrics. *Hydrobiologia*, *784*(1), pp.367–380.

Froerman, Y.M., 1981. Approach to stock assessment of nerito-oceanic squids of the family Ommastrephidae in the Atlantic Ocean on the example of North-Western Atlantic shortfin squid *Illex illecebrosus* (Lesueur, 1821). Status of resources and basis of rational fishery in the Atlantic Ocean. Kaliningrad, AtlantNIRO publishing. pp. 60–69.

Golenkevich, A.V., 1999. Estimation of the number of octopuses by trap catches. Fisheries. No. 4, pp. 34–35.

Golikov, A.V., 2014. Distribution and reproductive biology of the decapod cephalopods (Sepiolida, Teuthida) in the Barents Sea and adjacent areas. PhD Thesis. Kazan. 236 p.

Golikov, A.V., Sabirov, R.M., Lubin, P.A., 2012. New data on *Gonatus fabricii* (Cephalopoda, Teuthida) distribution and reproductive biology in the Western Sector of Russian Arctic. Proceedings of Kazan University, Natural Sciences series 154: pp.118–128.

Golikov, A.V., Sabirov, R.M., Lubin, P.A., 2015. Analysis of the quantitative distribution of two abundant cephalopod species in the Barents Sea. Proceedings of the 8th All-Russian Conference on Commercial Invertebrates. Kaliningrad, KSTU publishing. pp. 190–191.

Golikov, A.V., Sabirov, R.M., Lubin, P.A., Zakharov, D.V., Zimina, O.L., 2016. Features of the modern distribution of cephalopods in the western part of the Arctic. Proceedings of the XIII International Scientific Conference "Integrated Research of the Nature of Spitsbergen and the Adjacent Shelf". UNSC RAS publishing. pp. 72–75.

Granados-Amores, J., García-Rodríguez, F.J., Hochberg, F.G. and Salinas-Zavala, C.A., 2014. The taxonomy and morphometry of squids in the family Loliginidae (Cephalopoda: Myopsida) from the Pacific coast of Mexico. *American Malacological Bulletin*, *32*(2), pp.198–208.

Green, C.P., Robertson, S.G., Hamer, P.A., Virtue, P., Jackson, G.D. and Moltschaniwskyj, N.A., 2015. Combining statolith element composition and Fourier shape data allows discrimination of spatial and temporal stock structure of arrow squid (*Nototodarus gouldi*). *Canadian journal of fisheries and aquatic sciences*, *72*(11), pp.1609–1618.

Haefner, P.A., 1964. Morphometry of the common Atlantic squid, *Loligo pealei*, and the brief squid, *Lolliguncula brevis* in Delaware Bay. *Chesapeake Science*, *5*(3), pp.138–144.

Hu, G., Fang, Z., Liu, B., Chen, X., Staples, K. and Chen, Y., 2018. Using Different Standardized Methods for Species Identification: A Case Study Using Beaks from Three Ommastrephid Species. *Journal of Ocean University of China*, *17*(2), pp.355–362.

Ikeda, Y., Arai, N., Kidokoro, H. and Sakamoto, W., 2003. Strontium: calcium ratios in statoliths of Japanese common squid *Todarodes pacificus* (Cephalopoda: Ommastrephidae) as indicators of migratory behavior. *Marine Ecology Progress Series*, *251*, pp.169–179.

Jin, Y., Liu, B., Li, J. and Chen, X., 2017. Identification of three common Loliginidae squid species in the South China Sea by analyzing hard tissues with geometric outline method. *Journal of Ocean University of China*, *16*(5), pp.840–846.

Jones, J.B., Arkhipkin, A.I., Marriott, A.L. and Pierce, G.J., 2018. Using statolith elemental signatures to confirm ontogenetic migrations of the squid *Doryteuthis gahi* around the Falkland Islands (Southwest Atlantic). *Chemical Geology*, *481*, pp.85–94.

Kato, Y., Sakai, M., Nishikawa, H., Igarashi, H., Ishikawa, Y., Vijai, D., Sakurai, Y., Wakabayshi, T. and Awaji, T., 2016. Stable isotope analysis of the gladius to investigate migration and trophic patterns of the neon flying squid (*Ommastrephes bartramii*). *Fisheries Research*, *173*, pp.169–174.

Kennouche, H. and Nouar, A., 2017. First population identification of common cuttlefish (*Sepia officinalis,* L.1758) by body morphometry and cuttlebone chemistry along the Algerian coast (South-western Mediterranean Sea). [Poster] Exhibited at: International symposium on ecology and environmental problems. Çanakkale, Turkey.

Lishchenko, F., Lishchenko, A. and Bizikov, V., 2017. Statolith shape variability of *Berryteuthis magister.* [Poster] Exhibited at: CephsInAction and Cephalopod International Advisory Council joint meeting. Haraklion, Crete, Greece.

Liu, B., Chen, X., Chen, Y., Lu, H. and Qian, W., 2011. Trace elements in the statoliths of jumbo flying squid off the Exclusive Economic Zones of Chile and Peru. *Marine Ecology Progress Series*, *429*, pp.93–101.

Liu, B., Chen, X., Chen, Y. and Tian, S., 2013. Geographic variation in statolith trace elements of the Humboldt squid, *Dosidicus gigas*, in high seas of Eastern Pacific Ocean. *Marine biology*, *160*(11), pp.2853–2862.

Liu, B.L., Chen, Y. and Chen, X.J., 2015. Spatial difference in elemental signatures within early ontogenetic statolith for identifying Jumbo flying squid natal origins. *Fisheries oceanography*, *24*(4), pp.335–346.

Liu, B., Fang, Z., Chen, X. and Chen, Y., 2015. Spatial variations in beak structure to identify potentially geographic populations of *Dosidicus gigas* in the Eastern Pacific Ocean. *Fisheries Research*, *164*, pp.185–192.

Lubin, P.A., Sabirov, R.M., 2007. Cephalopod fauna (Mollusca, Cephalopoda) of the Spitsbergen archipelago. Materials IX International Scientific Conference "Integrated research of nature Spitsbergen" Murmansk: MMBI KSC RAS. pp. 300–306.

Nesis, K.N., 1965. Distribution and nutrition of juvenile squid *Gonatus fabricii* (Licht.) In the Labrador and Norwegian Seas. Oceanology. vol. 5, No. 1, pp. 134–141.

Nesis, K.N., 1985. Biomass of pelagic cephalopods and its distribution in the World Ocean. Biological resources of the Ocean. Moscow. pp. 145–153.

Nigmatullin, Ch.M., Vovk, A.N., 1972. Biology of shortfin squid *Illex coindetii* (Vérany, 1839) in the Angolean waters.. Researches of AtlantNIRO. vol. 42, pp. 162–166.

Pecl, G.T., Tracey, S.R., Danyushevsky, L., Wotherspoon, S. and Moltschaniwskyj, N.A., 2011. Elemental fingerprints of southern calamary (*Sepioteuthis australis*) reveal local recruitment sources and allow assessment of the importance of closed areas. *Canadian Journal of Fisheries and Aquatic Sciences*, *68*(8), pp.1351–1360.

Pierce, G.J., Bailey, N., Stratoudakis, Y. & Newton, A., 1998. Distribution and abundance of the fished population of *Loligo forbesi* in Scottish waters: analysis of research cruise data. ICES Journal of Marine Science 55, 14–33.

Pierce, G.J. & Boyle, P.R., 2003. Empirical modelling of interannual trends in abundance of squid (*Loligo forbesi*) in Scottish waters. Fisheries Research 59, 305–326.

Pierce, G.J., Boyle, P.R., Hastie, L.C. & Shanks, A., 1994. Distribution and abundance of the fished population of *Loligo forbesi* in UK waters: analysis of fishery data. Fisheries Research 21, 193–216.

Pierce, G.J., Hastie, L.C., Guerra, A., Thorpe, R.S., Howard, F.G. and Boyle, P.R., 1994a. Morphometric variation in *Loligo forbesi* and *Loligo vulgaris*: regional, seasonal, sex, maturity and worker differences. *Fisheries Research*, *21*(1–2), pp.127–148.

Pierce, G.J., Hastie, L.C., El Shanawany, N., Fernandez, J., Valavanis, V., Robin, J.-P., Arkhipkin, A., Santos, M.B., Ellis, J., Roel, B., Burns, F. & Greenstreet, S.P.R., 2015. Cephalopods and the MSFD. Final Report to Defra on contract ME5311.

Pierce, G.J., Thorpe, R.S., Hastie, L.C., Brierley, A.S., Guerra, A., Boyle, P.R., Jamieson, R. and Avila, P., 1994b. Geographic variation in *Loligo forbesi* in the Northeast Atlantic Ocean: analysis of morphometric data and tests of causal hypotheses. *Marine Biology*, *119*(4), pp.541–547.

Pineda, S.E., Hernandez, D.R., Brunetti, N.E. and Jerez, B.E.A.T.R.Í.Z., 2002. Morphological identification of two southwest Atlantic loliginid squids: *Loligo gahi* and *Loligo sanpaulensis*. *Revista de Investigacion y Desarrollo Pesquero*, *15*, pp.67–84.

Sabirov, R.M., Golikov, A.V., Nigmatullin, C.M. and Lubin, P.A., 2012. Structure of the reproductive system and hectocotylus in males of lesser flying squid *Todaropsis eblanae* (Cephalopoda: Ommastrephidae). *Journal of natural history*, *46*(29–30), pp.1761–1778.

Sabirov, R.M., Lubin, P.A., Golikov, A.V., 2009a. Occurence of the lesser flying squid *Todaropsis eblanae* (Oegopsida, Ommastrephidae) in the Barents Sea. Zoological Journal. vol. 88, No. 8, pp. 1010–1012.

Sabirov, R.M., Lubin, P.A., Golikov, A.V., 2009b. The lesser flying squid *Todaropsis eblanae* (Oegopsida: Ommasrephidae) - a new bioinvasion in the Barents Sea. Abstracts of the reports of the 10th Congress of the Hydrobiological Society RAS. Vladivostok, Dal'nauka publishing. p. 344.

Schaefer, M.B., 1954. Some aspects of the dynamics of populations important to the management of commercial marine fisheries. Bulletin of the Inter-American tropical tuna commission, vol. 1, No. 2, pp. 25–56.

Schroeder, R., Schwarz, R., Crespi-Abril, A.C. and Alvarez Perez, J.A., 2017. Analysis of shape variability and life history strategies of *Illex argentinus* in the northern extreme of species distribution as a tool to differentiate spawning groups. *Journal of Natural History*, *51*(43–44), pp.2585–2605.

Sin, Y.W., Yau, C. and Chu, K.H., 2009. Morphological and genetic differentiation of two loliginid squids, *Uroteuthis* (Photololigo) *chinensis* and *Uroteuthis* (Photololigo) *edulis* (Cephalopoda: Loliginidae), in Asia. *Journal of Experimental Marine Biology and Ecology*, *369*(1), pp.22–30.

Slobodsky, E.V., 1986. Methods for density estimation of the pelagic squid aggregations. Resources and exploitation prospects of the world Ocean squids. Moscow, VNIRO publishing, pp. 85–93.

Sushin, V.A., 1996. Main fields and outcomes of fishery-biological studies of AtlantNIRO in 1994–1995. Collection of researches of AtlantNIRO. Kaliningrad, AtlantNIRO publishing. 184 pp.

Thorpe, R.S., 1985 a. The effect of insignificant characters on the multivariate analysis of simple patterns of geographic variation. *Biological Journal of the Linnaean Society*, 26, pp. 215–223.

Thorpe, R.S., 1985 b. Character number and the multivariate analysis of simple patterns of geographic variation: categorical or "stepped clinal" variation. *Systematic Zoology*, 34, pp.127- 139.

Thorpe, R.S., 1987 a. Geographic variation: a synthesis of cause, data, pattern and congruence in relation to subspecies, multivariate analysis and phylogenesis. Boll Zool, 54, pp. 3 – 11.

Thorpe, R.S. 1987 b. Complex clines: the predictivity of complicated patterns of geographic variation portrayed by multivariate analysis. *Biological Journal of the Linnaean Society*, 31, pp. 75 – 88.

Van Der Vyver, J.S.F., Sauer, W.H.H., McKeown, N.J., Yemane, D., Shaw, P.W. and Lipinski, M.R., 2016. Phenotypic divergence despite high gene flow in chokka squid *Loligo reynaudii* (Cephalopoda: Loliginidae): implications for fishery management. *Journal of the Marine Biological Association of the United Kingdom*, *96*(7), pp.1507–1525.

Vega, M.A., Rocha, F.J., Guerra, A. and Osorio, C., 2002. Morphological differences between the Patagonian squid *Loligo gahi* populations from the Pacific and Atlantic Oceans. *Bulletin of Marine Science*, *71*(2), pp.903–913.

Vovk, A.N., 1969. Prospects of fishery development on longfin squid. Fisheries. vol. 10, pp. 7–9.

Vovk, A.N., 1972a. Maturity determination method for gonads of *Loligo pealei*. Zoological journal. vol. 51, No. 1, pp. 127–132.

Vovk, A.N., 1972b. Fecundity of North-American squid *Loligo pealei* (Lesueur, 1821). Researches of AtlantNIRO. vol. 42, pp. 133–140.

Vovk, A.N., Nigmatullin, Ch.M., 1972. Biology and fisheries on mass cephalopods of Atlantic. Researches of AtlantNIRO. vol. 42, pp. 22–56.

Waluda, C.M. & Pierce, G.J., 1998. Temporal and spatial patterns in the distribution of squid *Loligo* spp. in United Kingdom waters. South African Journal of Marine Science 20, 323–336.

Wang, C.H., Geffen, A.J. and Nash, R.D., 2012. Geographical variations in the chemical compositions of veined squid *Loligo forbesi* statoliths. *Zoological Studies*, *51*(6), pp.755–761.

Wang, J., Pierce, G.J., Boyle, P.R., Denis, V., Robin, J.P. & Bellido, J.M., 2003. Spatial and temporal patterns of cuttlefish (*Sepia officinalis*) abundance and environmental influences – a case study using trawl fishery data in French Atlantic coastal, English Channel and adjacent waters. ICES Journal of Marine Science 60, 1149–1158.

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

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

Zuur, A.F. & Pierce, G.J., 2004. Common trends in Northeast Atlantic squid time series. Journal of Sea Research 52, 57–72.

6 Revisions to the work plan and justification

No specific revisions to the working plan are envisaged.

7 Next meetings

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

8 Recommendations

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

9 List of annexes and working documents

Annex 1: List of participants

Annex 2: Agenda

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

Annex 4: ToR A. Tables_WGCEPH_2018

Annex 5: ToR A. Section Sepiida 2018

Annex 6: ToR A. Section Loliginidae 2018

Annex 7: ToR A. Section Ommastraephidae 2018

Annex 8: ToR A. Section Octopodidae 2018

Annex 9: ToR B. Trends manuscript outline 2018

Annex 10: ToR B. Assessment manuscript outline 2018

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

Annex 12: ToR D. Socioeconomic report

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

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

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

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

Annex 1: List of participants

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

Sebastian Villasante (by correspondence)	Universidad de Santiago de Compostela	Spain	sebastian.villasante@usc.es
Sonia Seixas (by skype and by correspondence)	Universidade Aberta	Portugal	Sonia.Seixas@uab.pt
Vladimir Laptikhovsky (by correspondence)	Centre for Environment, Fisheries and Aquaculture Science (Cefas)	UK	vladimir.laptikhovsky@cefas.co.uk

Annex 2: Agenda

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

Tuesday, 5 June 2018

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

Wednesday, 6 June 2018

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

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

Thursday, 7 June 2018

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

Friday, 8 June 2018

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