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Abstract

Ensuring the sustainable use of the small pelagic fish stocks and the sustainable management of the fisheries exploiting them is a significant challenge faced by countries in Northwest Africa. Small pelagic fish constitute the bulk of the landings in this region, with annual catches of the main species ranging from approximately 1.7 to 2.5 million tonnes over the last few decades. Many of the main pelagic stocks are distributed across the 200 nautical-mile boundaries of the sub-region, and are shared bilaterally or sub-regionally among countries of Western Africa. These resources, which migrate along the Northwest African coast, are exploited by local fleets of both the artisanal and industrial sectors, as well as distant water fishing vessels from Europe, Asia, and Central America. The transboundary nature of these fish stocks calls for joint action with respect to their monitoring and management. In 2001, the Food and Agriculture Organization of the United Nations created a permanent working group on the assessment of small pelagic fish off Northwest Africa, which today reports to the Fishery Committee for the Eastern Central Atlantic. As a result of this Working Group's efforts, more consistent series of catch and effort and annual abundance indices of the main small pelagic fish species are now available, and significant improvements in sampling intensity have been achieved. Furthermore, consolidated annual advice is provided at a regional scale on the state of these resources that complements the national assessment and management advice systems. This paper provides some reflections on the contributions of the Working Group to science-based fisheries management and possible future actions that could further strengthen the collaborative momentum gained through this type of regional collaboration.

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More than fifteen years of collaboration on the assessment of small pelagic fish off Northwest Africa: lessons learned and future perspectives.

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Abstract
Ensuring the sustainable use of the small pelagic fish stocks and the sustainable management of the fisheries exploiting them is a significant challenge faced by countries in Northwest Africa. Small pelagic fish constitute the bulk of the landings in this region, with annual catches of the main species ranging from approximately 1.7 to 2.5 million tonnes over the last few decades. Many of the main pelagic stocks are distributed across the 200 nautical-mile boundaries of the sub-region, and are shared bilaterally or sub-regionally among countries of Western Africa. These resources, which migrate along the Northwest African coast, are exploited by local fleets of both the artisanal and industrial sectors, as well as distant water fishing vessels from Europe, Asia, and Central America. The transboundary nature of these fish stocks calls for joint action with respect to their monitoring and management. In 2001, the Food and Agriculture Organization of the United Nations created a permanent working group on the assessment of small pelagic fish off Northwest Africa, which today reports to the Fishery Committee for the Eastern Central Atlantic. As a result of this Working Group's efforts, more consistent series of catch and effort and annual abundance indices of the main small pelagic fish species are now available, and significant improvements in sampling intensity have been achieved. Furthermore, consolidated annual advice is provided at a regional scale on the state of these resources that complements the national assessment and management advice systems. This paper provides some reflections on the contributions of the Working Group to science-based fisheries management and possible future actions that could further strengthen the collaborative momentum gained through this type of regional collaboration.

Key words: fishery resources, pelagic fisheries, Northwest Africa, acoustic surveys, fishery management

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1. Introduction

Ensuring the sustainable use of small pelagic fish stocks and the sustainable management of the fisheries exploiting them is a significant challenge faced by countries in Northwest Africa, in particular when considering their role in sustaining food security and securing economic and social benefit for the coastal countries. Fisheries in this region currently support an estimated one million jobs (FAO, 2009a), and form the basis of the livelihoods for around 150 000 artisanal fishers (CCLME Project, 2016). The contributions from fisheries to the national gross domestic products (GDPs) range from USD 3 460 million in The Gambia (3.9% of national GDP), USD 7 820 million in Mauritania (6.4% of national GDP), USD 27 000 million in Senegal (3.5% of national GDP), and USD 174 000 million in Morocco (3.0% of national GDP) (World Bank, 2013).

Fishery production in this region is supported by the active ocean upwelling that occurs at different intensities along the Northwest African coast, largely attributed to the Canary Current (Santos et al., 2005; Arístegui et al., 2009; Heileman and Tandstad, 2009; Garcia et al., 2012; Cropper et al., 2014). The Canary Current, together with the California and Humboldt currents in the northeastern Pacific Ocean and the Benguela current in the southern Atlantic Ocean, is known as one of the four main upwelling areas of the world (Gómez-Gesteira et al., 2008). These are supportive of high biological productivity and sustaining important fish resources, in particular small pelagic species (Bakun, 1996).

On average, small pelagic fish represent approximately 70% of the total marine fish landings in this region (Sambe *in* FAO, 2003a; Sambe et al., 2006; FAO, 2016a). The main commercial small pelagic species include sardine (*Sardina pilchardus*, Walbaum, 1792), round sardinella (*Sardinella aurita*, Valenciennes, 1847), flat sardinella (*S. maderensis*, Lowe, 1839), Cunene horse mackerel (*Trachurus trecae*, Cadenat, 1949), Atlantic horse mackerel (*T. trachurus*, Linnaeus, 1758), chub mackerel (*Scomber colias*, Houttuyn, 1782), bonga (*Ethmalosa fimbriata*, Bowdich, 1825), and anchovy (*Engraulis encrasicolus*, Linnaeus, 1758). These species constitute annual catches ranging from around 1.7 to 2.5 million tonnes over the last few decades (FAO, 2015).

Small pelagic species are part of plankton-based food chains, and typically are not uniformly distributed throughout the region; some show more temperate affinities and others more tropical affinities. Most of these species are highly mobile and migration patterns can be latitudinal or longitudinal. They are short-lived (3–7 years), highly fecund, and some can spawn all year round. These species are dependent on their recruitment success, which is linked to the state of their environment, and thus their abundance is variable (FAO, 1979).

The sardine (*Sardina pilchardus*) is distributed in the northern region of the Canary Current, commonly from the north of Morocco through Mauritania and occasionally down to Senegal (Parrish et al., 1989; FAO, 2005). Chub mackerel (*Scomber colias*) is distributed throughout the region, but this species also has more temperate affinities (Lorenzo and Pajuelo, 1996; Carvalho et al., 2002; Martins, et al., 2013). The main concentration of the two species of sardinella (*Sardinella aurita* and *S. maderensis*) is typically located further to the South as compared to sardine and chub mackerel, while its distribution ranges from the area around Cape Bojador (Morocco) to The Gambia and the southern area of Senegal. *Sardinella maderensis* is commonly believed to be distributed nearer to the coast (inshore), and *S. aurita* is found further offshore (Ettahiri et al., 2003; Zeeberg et al., 2008; Bacha et al., 2017). With respect to the two species of horse mackerel, the Atlantic horse mackerel *(Trachurus trachurus*) is mainly found north of Cape Blanc and while the Cunene horse mackerel (*T. trecae*) can also be found in this area, its distribution is more southern. The bonga (*Ethmalosa fimbriata*) is found inshore, close to creeks and estuaries, and the anchovy (*Engraulis encrasicolus*) is variably found in high concentrations in certain areas, such as in the area off Cape Blanc.

Fishing vessels that exploit small pelagic resources throughout the region are heterogeneous and typically composed of domestic canoes (*pirogues*), traditional purse seiners, and industrial pelagic and bottom trawlers, including distant water fleets from many nations (FAO, 2016a). However, the vessel composition in the area is variable and has shown changes over time. The gears used in the small-scale or artisanal fishery are purse seines, drift gillnets, encircling gillnets, and beach seine nets. The drift gillnets, previously used in a multi-species fishery for some coastal pelagic species, has gained importance in the fisheries for flat and round sardinella. The encircling gillnets were originally designed to capture the bonga (*Ethmalosa fimbriata*), but have since been used to catch flat sardinella as well. The most commonly used gears for the industrial fishing vessels are pelagic and midwater trawls, and purse seiners.

It has been widely recognized in the region that the transboundary nature of the resources, with many of the main pelagic stocks being distributed across the exclusive economic zones (EEZs) of the countries of the sub-region, requires shared actions with respect to monitoring and management to ensure their sustainable use (Garcia et al., 2012). The need for appropriate arrangements to be put in place for each shared fishery, for both governance and scientific advice, have been discussed in many fora throughout the years including under the auspices of the different regional fisheries bodies that exist in the region or through regional projects or programmes (FAO, 2002a; Owen, 2003).

The importance that the region places on regional collaboration is also reflected in the number of regional organizations that aim to promote collaboration on fisheries issues. The Fishery Committee for the Eastern Central Atlantic (CECAF) was established in 1967 under the auspices of the Food and Agriculture Organization of the United Nations (FAO), and advises on the living marine resources of the eastern central Atlantic region, including Northwest Africa (Figure 1). Members of CECAF include Morocco, Portugal and Spain (on behalf of the Madeira and Canary Islands, respectively) in the north and down to Angola in the South, including the fishing countries from more than 21 countries[2]. Other regional fisheries bodies include the Sub-Regional Fisheries Commission (SRFC) in 1985, and the Ministerial Conference on Fisheries Cooperation among African States bordering the Atlantic Ocean (ATLAFCO/COMHAFAT) in 1989. These organizations operate at different scales and aim to, among others, improve the governance and management of shared fishery resources off Northwestern Africa.

Recognizing the importance of a collaborative and holistic approach for the provision of scientific advice specifically for the management of small pelagic species off Northwest Africa, the FAO established the Working Group for the assessment of small pelagic fish off Northwest Africa in 2001. The general objective of the Working Group is to contribute to the improved management of small pelagic resources in West Africa through the assessment of the state of the stocks and fisheries in order to ensure sustainable use of these resources for the benefit of coastal countries.

Since its establishment, the Working Group has met annually. The results and recommendations of the Working Group are discussed at the Scientific Sub-Committee of CECAF, where the information is reviewed and recommendations made that are presented to the Committee for endorsement (Figure 2). Member countries are responsible for acting on these recommendations.

This paper highlights some key results and achievements, and discusses technical and institutional challenges for regional collaboration. In this study all relevant CECAF Working Group reports are reviewed to examine how total catch, catch composition, and the state of resources have evolved through time. Finally, this paper provides some reflections on the contributions of the Working Group to science-based fisheries management and possible future actions that could further strengthen the collaborative momentum gained through this type of regional collaboration.

[2] http://www.fao.org/fishery/rfb/cecaf/en

2. Materials and Methods

2.1 Data sources and organization

The data used to perform the analyses summarized in this paper stem mainly from the published reports of the Working Group (FAO, 2001; 2002b; 2003b; 2004; 2006a; 2006b; 2007b; 2008; 2009b; 2011; 2013a; 2013b; 2015a; 2015b). The Working Group uses and manages several types of data provided by its members and includes both fishery dependent and fishery independent data: i) catch and effort for the assessed species and fishing area, by fishing fleet when possible, provided by national scientific institutes; ii) FAO catch statistics (FAO, 2016b); iii) national and regional surveys (for example, the Norwegian R/V *Dr Fridtjof Nansen* and vessels from AtlantNiro[3]); iv) information on biological parameters; and v) information on environmental parameters obtained from various sources (e.g. surveys, global datasets, national databases, among others) that are adapted for use by the Working Group.

2.2 Working Group Assessment models and analytical approach

The main assessment model used by the Working Group to assess the current state of the small pelagic stocks is a dynamic surplus production model using the Schaefer (1954) logistic equation. This model was routinely applied to all species where total catch information and a continuous abundance index was available. To estimate the model parameters, a spreadsheet implemented in Microsoft Excel was developed to run the model with the observation error estimator method (Haddon, 2001). The model is fitted to the observed data using the non-linear optimizer of Excel (Solver; FAO, 2006a). To account for external influences leading to fluctuations in abundance indices that cannot be explained by the fisheries data alone, a qualitative environmental index was introduced to the model in 2007 (FAO, 2007b). Simple medium-term projections of future yields and stock development were made using the Schaefer model fitted to the historical data with a time horizon of three to five years. All projections took as their departure point the estimated stock status in the last year of data available (FAO, 2006b).

Length Cohort Analyses (LCA; Jones, 1984) are used for species were length data are available. For the purpose of the Working Group, the LCA is provides an estimation of the current F-level, and the relative exploitation pattern of the fishery. A length-based Yield-per-Recruit analysis (Beverton and Holt, 1957) is then run with Excel, based on the length-based model outputs to estimate the biological reference points F_{MAX} and $F_{0.1}$ (FAO, 2005). These models are routinely used for the assessment of anchovy, bonga, and, in later years, sardinella.

Age-based methods, Extended Survivors Analysis (XSA; Shepherd, 1999) and Independent Component Analysis (ICA; Patterson and Melvin, 1996), were also applied to the chub mackerel stocks, the only species for which reliable age data have been available for most of the period.

CECAF, based on the work made by the small pelagic working group, adapted $B_{0.1}$ and $F_{0.1}$ as target biological reference points and B_{MSY} and F_{MSY} as limit reference points (Figure 3; FAO, 2005; FAO, 2007c). The stocks are categorized as non-fully exploited[4], fully exploited[5], or overexploited[6]

[3] https://atlantniro.ru/

[4] The stock is in good condition and fishing pressure can be increased without affecting the sustainability (all increases must be seen in the context of the general environmental situation).

[5] The fishery operates within the limits of sustainability. Current fishing pressure seems sustainable and can be maintained.

[6] The fishery is in an undesired state in terms of biomass and/or fishing mortality. Fishing pressure should be reduced to allow the stock to grow.

depending on the relationship between the estimated current biomass (B) and fishing mortality (F) and the target reference point values ($B_{CUR}/B_{0.1}$ and $F_{CUR}/F_{0.1}$), or if assessments are not possible, based on other evidence that can provide information on fisheries status. The target reference points indicate the desired situation of the stock in terms of biomass and fishing mortality. For this region, $B_{0.1}$ and $F_{0.1}$ have been chosen as target reference points, rather than B_{MSY} and $F_{MSY,}$ as a precautionary measure given the many data challenges the CECAF region faces.

Plots illustrating the proportion of stocks within ecologically sustainable limits through time have been prepared based on the final status allocation from the respective Working Group meetings. Kobe-type plots showing the evolution of $F_{CUR}/F_{0.1}$ and $B_{CUR}/B_{0.1}$ for all the main stocks have been prepared to analyze the different stock status trajectories since the Working Group adopted the systematic use of reference points in 2006 (FAO, 2006b). A descriptive approach was taken, based on the authors' knowledge, to describe how the recommendations of the Working Group strengthened the standardization of methods in the fields of acoustics and age-reading, for example, using these as illustrations of the challenges in ensuring long-term research and data collection for small pelagic fisheries at an institutional level in the CECAF region.

3 Results

3.1. Trends in catch

The earliest catch data recorded at the pre-Working Group meeting in Casablanca, Morocco, in 2000, dates back to 1974 for Senegal, 1979 for Mauritania, 1983 for Morocco, and 1985 for The Gambia. However, the consolidated time series that the Working Group developed begins in 1990. Figure 4 shows the global trend of the catch of small pelagic resources in Northwest Africa, with the average catch analysed for the last few decades. Total catch of small pelagic fish off Northwest Africa from 1990–2015 has been fluctuating, while showing an overall increasing trend. The average catch for the period is around 1.9 million tonnes, while the average for the last five years was around 2.3 million tonnes. Total catch for 2015 was just under 2.4 million tonnes. The average catch composition for the last five years, similarly to the whole period, shows that sardine (*Sardina pilchardus)* is the dominant species, followed by the round sardinella (*Sardinella aurita)*. The proportion of chub mackerel (*Scomber colias)* has increased in the total catch in the recent years.

Figure 5 shows the catch trends of the four main species in volume of catches from 1990–2015 (FAO, *in press*2), and Figure 6 shows the catch composition for 2015. Sardine (*Sardina pilchardus*) is the dominant species and approximately 820 000 tonnes were caught in 2015, around 35% of the total catch. The round sardinella (*Sardinella aurita*) is the second most important species in terms of catch and, despite some fluctuations, the species catch has shown a general increasing trend since 2006 with around 550 000 tonnes caught in 2015, which constitutes around 24% of the total catch. The catch of chub mackerel (*Scomber colias*) from 1990–2015 has shown a general increasing trend, with around 304 000 tonnes in 2015 (13% of total catch), the highest catch of the time series. Cunene horse mackerel (*Trachurus trecae*) is the most important species of horse mackerel reported in the catches, constituting about 9% (approximately 200 000 tonnes) of the total catch of the main small pelagic fish in 2015. The catch of flat sardinella (*Sardinella maderensis*) was around 190 000 tonnes in 2015 (around 8% of total catch; FAO, *in press*1).

Other species caught in the region include: the Atlantic horse mackerel (*Trachurus trachurus*) with 86 000 tonnes landed in 2015 (4% of the total catch); the false scad (*Caranx rhonchus*), with a total catch around 19 000 tonnes in 2015 (1% of total catch); the anchovy (*Engraulis encrasicolus*) was around 70 000 tonnes in 2015, constituting about 3% of the total catch; and the bonga (*Ethmalosa fimbriata*) with a catch of around 76 000 tonnes in 2015 (3.3% of the total catch).

Overall, the general catch trend for all species has been increasing since the 1990s, with round sardinella catch showing the largest relative increase.

3.2 Analysis of assessment results

Figure 7 illustrates the proportion of the assessed stocks that are within biologically sustainable limits, according to the status allocation by the Working Group. Stocks classified as U or F are considered within biologically sustainable limits (U corresponds to the status category non-fully exploited of CECAF and F to fully exploited), and stocks classified as O are considered overexploited and not within biologically sustainable limits. In the early days of the Working Group, no specific status was indicated for any of the stocks (category NR), but as the assessment framework was further developed, the Working Group has strived to provide an indication of stock status based on evidence available to the group, even if assessments could not be conducted or when assessments results were not reliable. Until 2004, anchovy and bonga were not assessed. From 2004 to 2009, these two species were assessed but the results did not allow for a status to be allocated. It should be noted that Figure 7 uses the latest year of catch data available, and not the assessment year (i.e. year 2000 = assessment year 2001). In 2015, 63% of the stocks were considered within biologically sustainable levels.

Figure 8 provides a summary of the stock assessment results, illustrating the estimated current biomass (B_{CUR}) and fishing mortality (F_{CUR}) to the reference points $B_{0.1}$ and $F_{0.1}$, respectively, over time for the main species of the Working Group since 2006. In the Working Group, sardine is assessed as three stocks in zones as follows: Zone North, Zone A+B, and Zone C. In general, the biomass of sardine (*Sardina pilchardus*) from Zone A+B has mostly been in a "good" state, with a mid-to-high biomass that exceeds the target reference point $B_{0.1}$, with the exception of year 2006. The fishing mortality has occasionally been exceeding the reference value. In 2010 and 2011, no results were obtained from the assessment however this stock was considered overexploited. In 2014, this stock improved and was considered non-fully exploited. Sardine from Zone C has been in a good state throughout the time series assessed, with a biomass only occasionally below the target value (2010 and 2011) and with low to moderate fishing mortality. According to the assessment results, round sardinella and Cunene horse mackerel, however, have been in a relatively unhealthy position throughout the time series. With respect to sardinella species, no reference point values are available from the production models since 2010. Both Atlantic horse mackerel and Chub mackerel show trajectories that move between ecologically unsustainable to sustainable. Since 2011, Atlantic horse mackerel has been considered fully exploited.

3.3.1 Development of regional standards

<u>Acoustic surveys</u>

The importance of acoustic surveys for the assessment of small-pelagic species have long been recognized. In the Northwest Africa region, discussions on how to coordinate methodologies between countries and the need to join efforts to ensure a complete coverage of the small pelagic stocks led to several workshops at the end of the 1990s that focused on addressing questions in relation to the standardization of, and joint planning of, surveys (Caramelo et al., 2001). These meetings were the precursors to the establishment of the Working Group. One of the principle outcomes of these meetings were the Guidelines for acoustic surveys (FAO, 2009c), which set standards and approaches for acoustic surveys in the Northwest African region. The Norwegian R/V *Dr Fridtjof Nansen*, funded by the EAF-Nansen Programme[7], conducted surveys in the region regularly from 1995-2006, and this series was the backbone for small pelagic assessments in the early days of the Working Group. The

[7] http://www.fao.org/in-action/eaf-nansen/en

intention was that national research vessels should maintain this time series once the R/V *Dr Fridtjof Nansen* surveys were completed for the region.

The Guidelines were used to ensure that the methodologies applied by the three national research vessels in the region (Figure 9) were the same, in order for the results of the acoustic surveys to be comparable and input in the assessment models. The R/V *Dr Fridtjof Nansen* was used as a reference vessel, which the national vessels were calibrated against.

Figure 10 shows the acoustic biomass data from the R/V *Dr Fridtjof Nansen* time series for the main species studied in the Working group. Unfortunately, due to different constraints, principally financial for some countries in the region and, to some extent, technical, the joint regional survey coverage was only upheld for a few years and the abundance indices are available only for a fraction of the stocks, such as for the north of the region (e.g. Morocco).

The impact of the non-continuation of the acoustic survey series can be seen in the assessments of the Working Group, which had to search for other alternative abundance indices for the production models. This has, in particular, impacted the quality of assessments for sardinella.

In the early 2000s, a group was established for the planning and coordination of acoustic surveys in the Northwest African region, with the chair of this group reporting to the small pelagics Working Group to provide inputs to the assessments and to discuss research priorities. This group was active from 2002-2007, however when the joint surveys were no longer feasible in the region it became difficult to maintain the groups' activities, and has only met periodically since then. Nevertheless, the work of the group resulted in the development of scientific capacity in the Northwest African region, as identified by the Working Group, to address key challenges in conducting surveys in the sub-region, and overcame technical constraints such as recurrent technical problems with trawl performance, noise discrimination, and data storage issues, amongst others.

Age reading

The working group pursues the use of age-based methods, such as XSA and ICA assessment methods, that require age-disaggregated catch statistics with a high degree of consistency in the series. While these age-disaggregated data were available for some stocks (sardine, horse mackerel and chub mackerel), they were not found to be of sufficient quality to effectively perform the assessments. This was due to issues with age-reading and an insufficient sampling of the catch and uncertainty in the stock definition. To improve this, the Working Group undertook efforts to enhance the quality of these age-data series with training in otolith reading through otolith exchange and otolith-reading workshops. One such workshop was conducted for sardine in 2001, two were conducted for sardinella in 2003, and one was conducted for both species in 2006 (FAO, 2002d; FAO, 2007d). The objectives of the workshops were to describe the age-reading method of each individual age reader, to estimate the precision from age-readings of each individual age reader, to investigate whether problems occurring concerning the interpretation of the edge, and to evaluate the results of the exchange. The workshops resulted in agreed regional criteria for age interpretation for the two species (Sylla et al., 2012). However, despite this effort it is still difficult to obtain accurate age-disaggregated data. The Working Group thus decided that it should focus on continued improvement in basic data, and the further development of the production models and the length-based models.

4. Discussion

The efforts of the Working Group to collect and manage data for small pelagic fisheries of the northern CECAF region has resulted in a comprehensive database, managed by the Working Group, of annual data since the 1980s. Over time, the quality and type of data available to the Working Group

has generally improved, as evidenced by the reported sampling intensity section in the Working Group reports (FAO 2002 to 2016).

However, the Working Group continues to face challenges to maintain and improve the basic data and to ensure continuity of the various data series that have been developed by the group as input to analysis and assessments. There were several challenges to estimating total catch for some of the Northwest African countries, which led to the Working Group combining catches of different species (e.g. for *Trachurus* spp.), and in some cases no official statistics were available for some fleets (e.g. the artisanal fishery), however, this has improved in recent years. There were also discrepancies in assigning ages for the species assessed due to a lack of standardized criteria for age-reading methdologies to ensure consistent interpretation, however, challenges still remain to obtain accurate data throughout the region. Thus, there remains the need to improve the collection of basic data with biological sampling for length and age-estimates.

The improvement of the regional data has allowed for more accurate assessments of the stocks, and improved the quality and consistency of advice produced by the Working Group. With regards to assessments, the round sardinella has been a particular challenge to assess by the Working Group, and the approach to the assessment for this species has changed over time. Until 2008, this species was assessed with production models using the acoustic abundance index from the surveys of the R/V *Dr Fridtjof Nansen* (until 2006), and the combined index by the coordinated surveys of the national research vessels from Morocco (R/V *Amir My Abdellah*), Mauritania (R/V *Al-Awam*), and Senegal (R/V *Itaf Deme*) as input for the dynamic version of the Schaefer model. While the diagnostics with these data were satisfactory, the catches remained high, exceeded the recommended level, and were considered overexploited. When the acoustic survey series was discontinued, the sardinella catch per unit of effort series using the pelagic trawlers vessels from the European Union (EU) (mainly from the Netherlands, which were the main fleet operating in the region) was used as input to the model. However, since the departure of most of the fleet in 2014, when the EU vessels only operated for a short period in the region, this series could no longer be continued. No results have been obtained from the dynamic production model since 2011, due to inconsistencies in the data series. After the improvement of biological sampling in the region, the length composition for sardinella was available and a length-based model was used in 2014 and 2015, although still with many constraints due to the variability of growth parameters or the lack of basic biological data. The R/V *Dr Fridjof Nansen* returned to the region in 2015, and this survey showed the lowest biomass indices of round sardinella in the entire series. The Working Group therefore put emphasis on supporting the development and implementation of common scientific survey standards and routines for Northwest Africa region, including the capacity building for use of these methodologies.

Recommendations from the Working Group are taken up in various national processes and incorporated into national planning and management policies. Of the countries in the Northwest African region, Morocco has an operational management plan for small pelagic species, and Mauritania has a plan in the development stage. In Senegal and The Gambia, plans are also being initiated. Regional commitments also exist for improved management, through the work of the Sub-Regional Fisheries Commission (SRFC/CRSP; from Mauritania to Sierra Leone) and also through a draft framework for a regional management plan (Canary Current Large Marine Ecosystem Project with the Sub-Regional Fisheries Commission and CECAF). These bodies all require scientific advice and thus create opportunities for the Working Group to collaborate with other relevant institutions to improve science-based management for the region.

The results of the CECAF Working Group on small pelagic species and the subsequent advice formulated by the Committee reflect the sub-regional cooperation and commitment among Northwest African countries to work towards the sustainable management of small pelagic fisheries in the region. Key issues that have been identified by the Working Group that requires further research

include: improved understanding of stock units, and recruitment processes, and how to improve consistency in assessments and predictions with shifts in basic data. Furthermore, improved understanding of linkages between environmental variables and pelagic fish fluctuations at relevant spatial and temporal scales, to be incorporated in assessments, in order to propose appropriate environmental indices that can be used to support improved management advice has been highlighted. CECAF, based on the work of the Working Group has adopted a precautionary decision framework with $F_{0.1}$ and $B_{0.1}$ as the main target reference points, and using production modeling as the principle model reference. There is a need to review this framework, including status descriptions, allocations and reference points to adapt to regional developments and current global standards and requirements which principally refer to F and B at MSY.

5. Conclusions

Collaboration between scientists of different countries in the Northwest African region has resulted in strengthened scientific advice supporting improved science-based fisheries management, and has also led to collaborative recommendations for improved data collection and research priorities to address key gaps in knowledge for fisheries management in the region. The small pelagic working group has an important role to play to promote and support collaboration in science, building on the experiences made from over 15 years of collaboration.

The continued national, regional and international support for the work of CECAF and its Working Groups is imperative to ensure continued scientific advice in support of the sustainable utilization of small pelagic resources in the Northwest African region.

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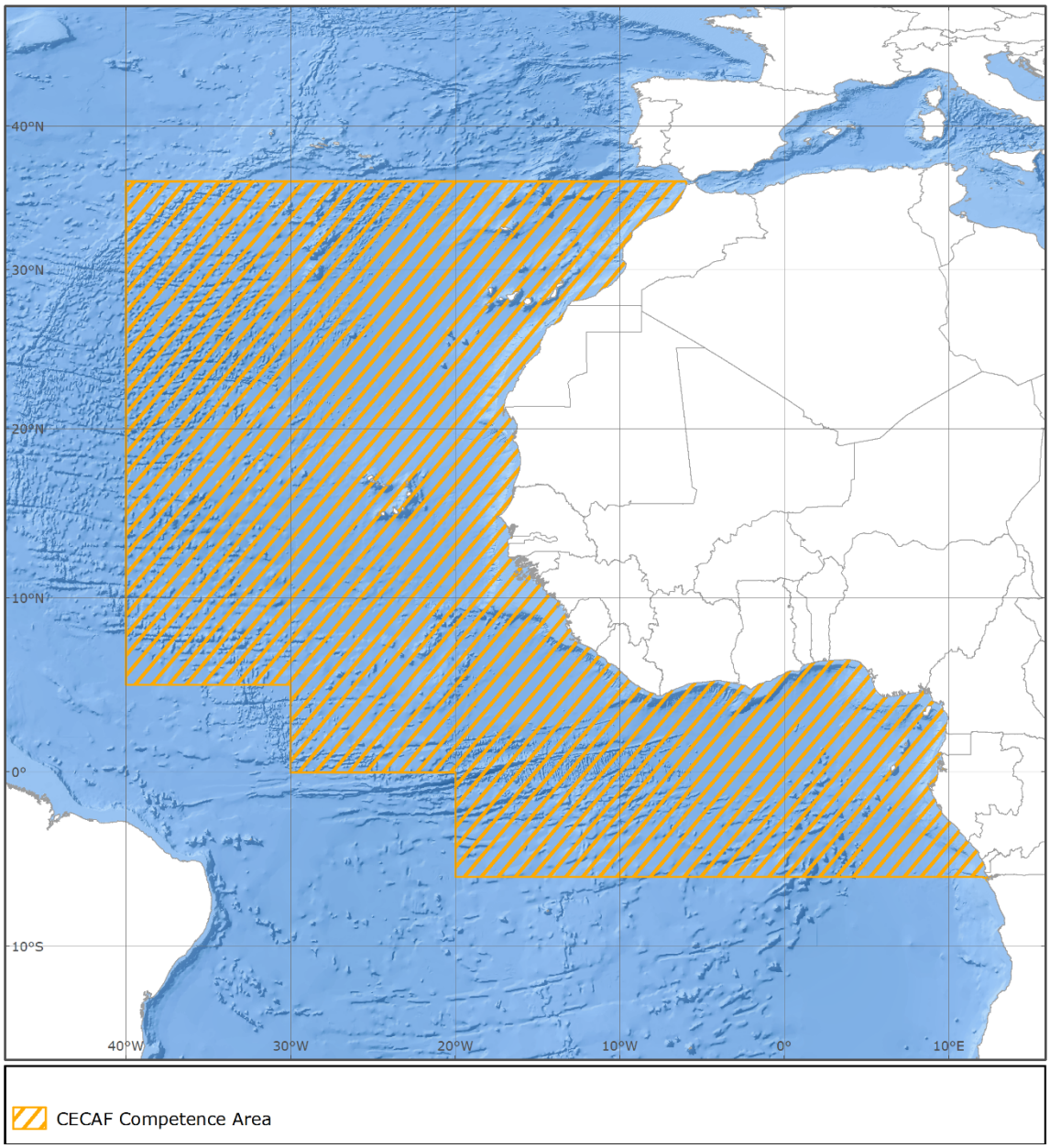


Figure 1: competence area of CECAF (FAO, 2016b).

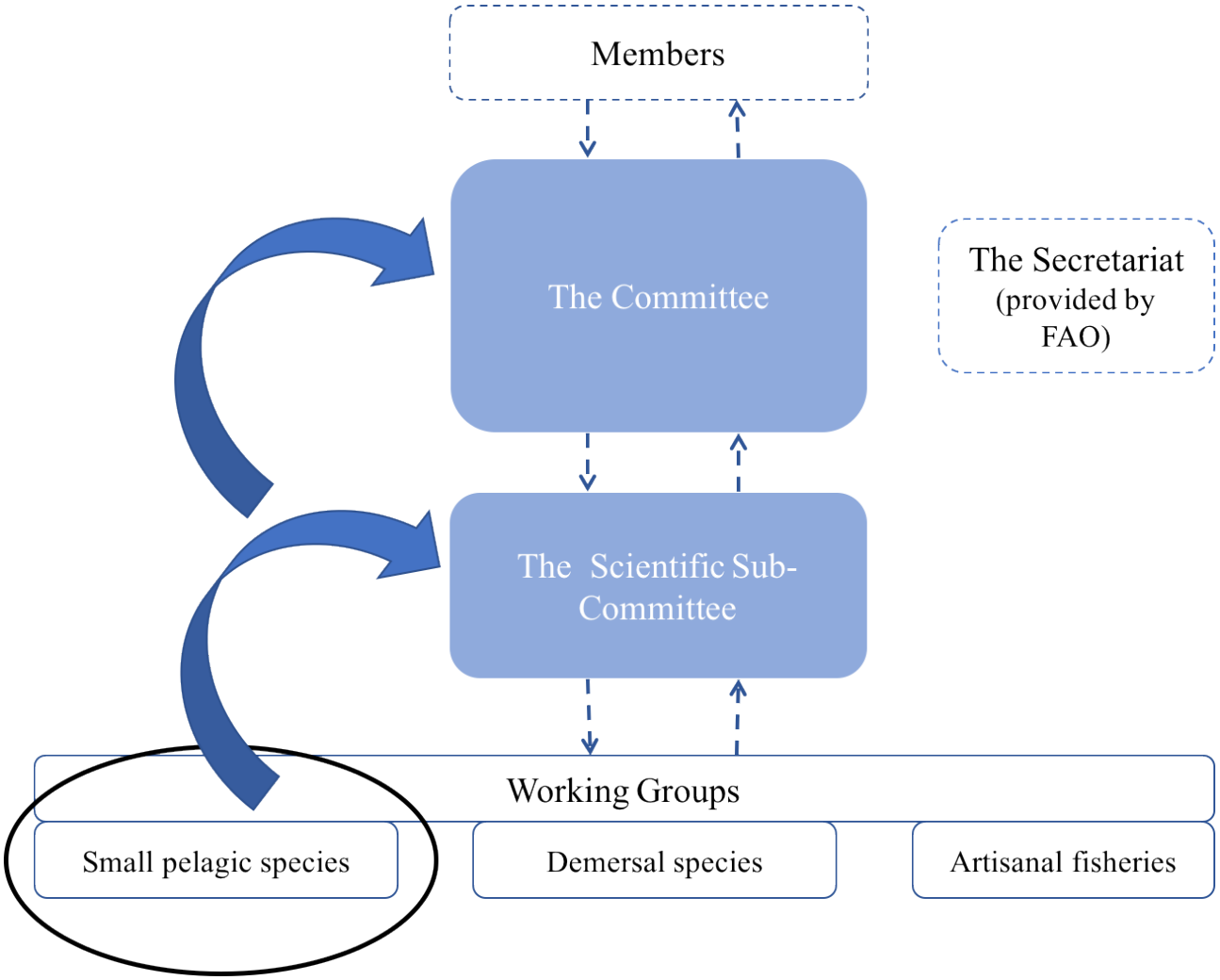


Figure 2: Management advice process for CECAF.

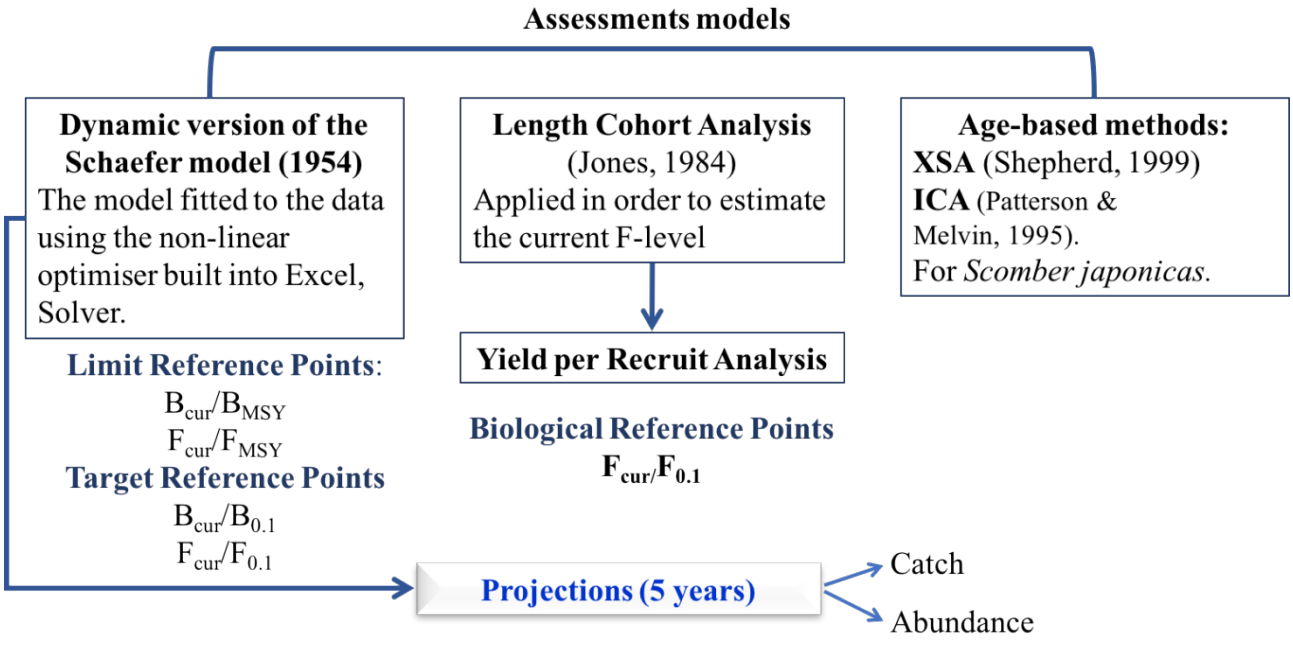


Figure 3. Assessment framework and models for the FAO Working Group (source: Tandstad, pers. com.)

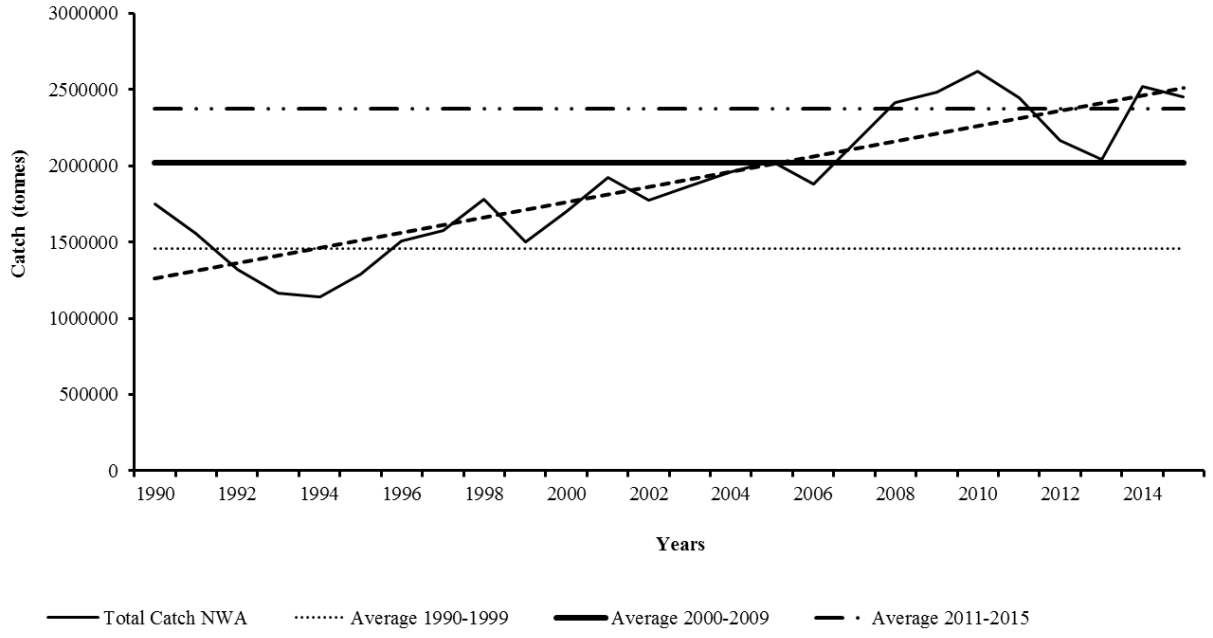


Figure 4. Small pelagic species (tonnes) for the Northwest African sub-region of CECAF: total catch from 1990-2015 with trendline, average catch from 1990-1999, average catch from 2000-2009, and average catch from 2011-2015 (adapted from FAO, *in press*1).

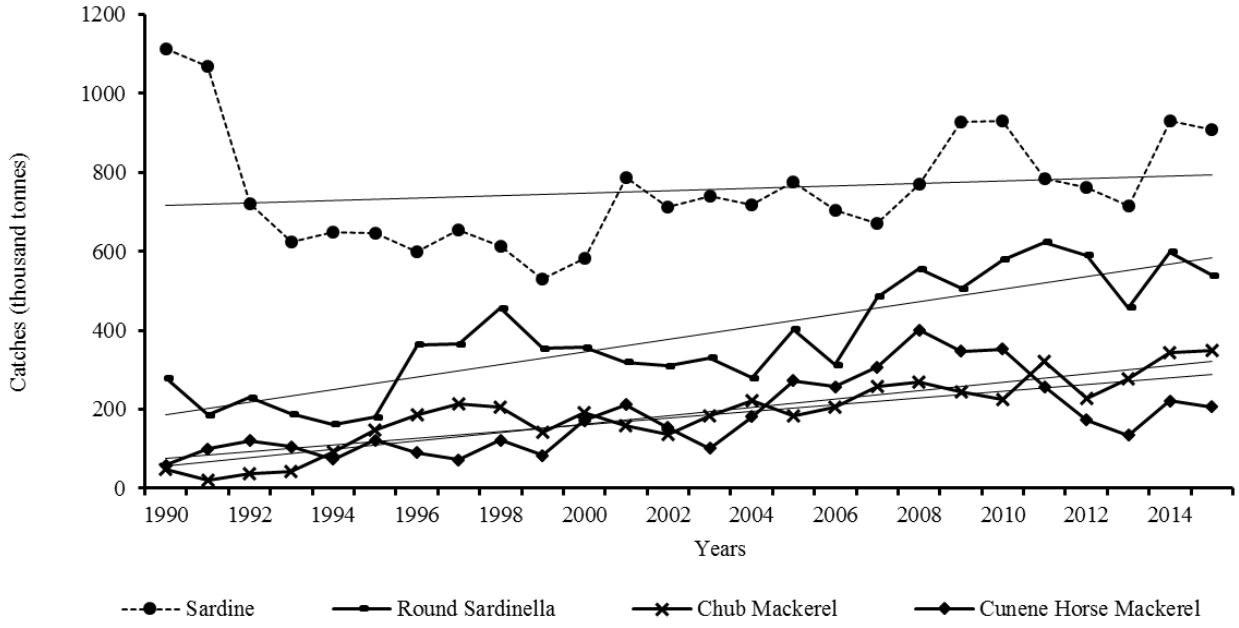


Figure 5: Small pelagic catch (tonnes) trends for four main species studied by the small pelagic species Working Group for the northern sub-region (adapted from FAO, *in press*1).

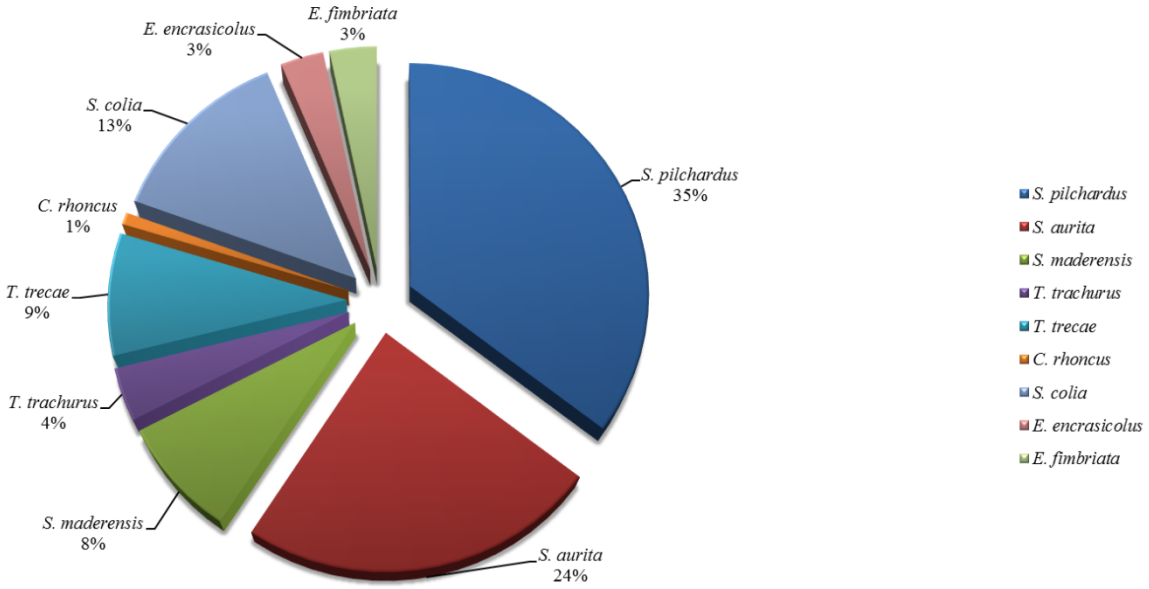
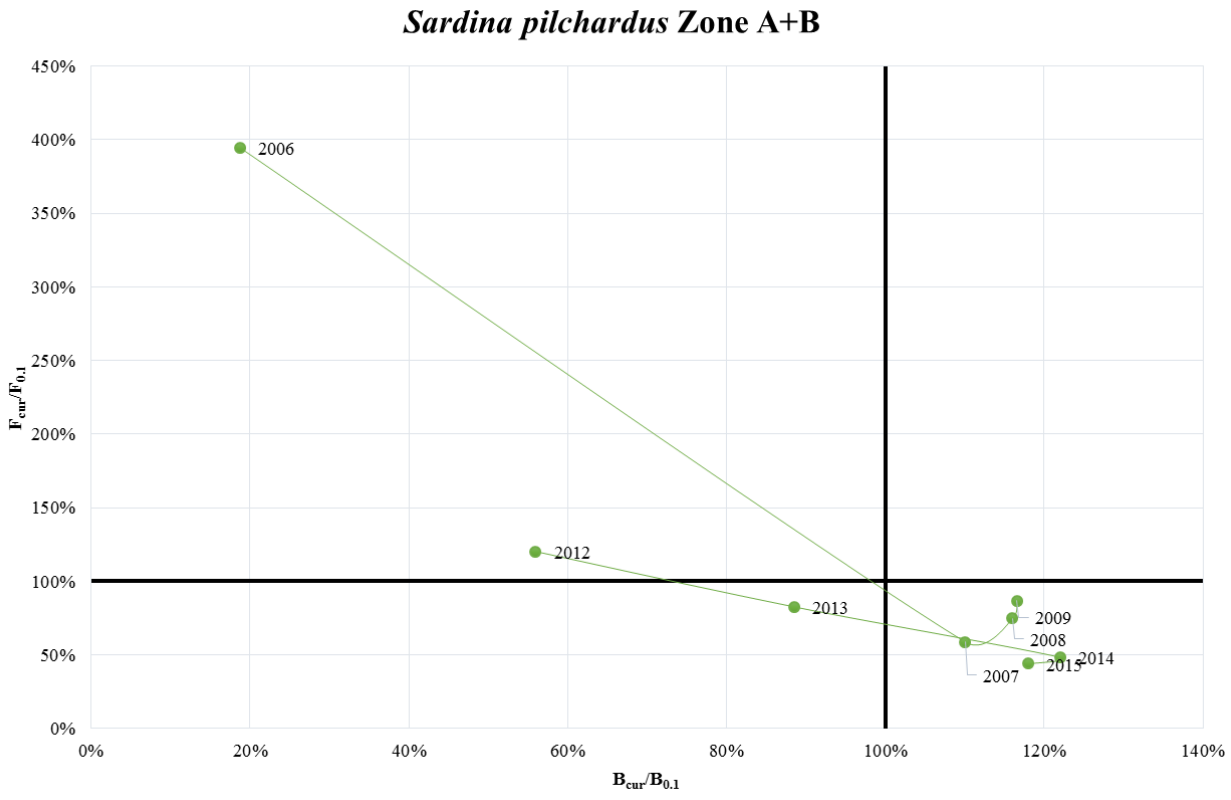
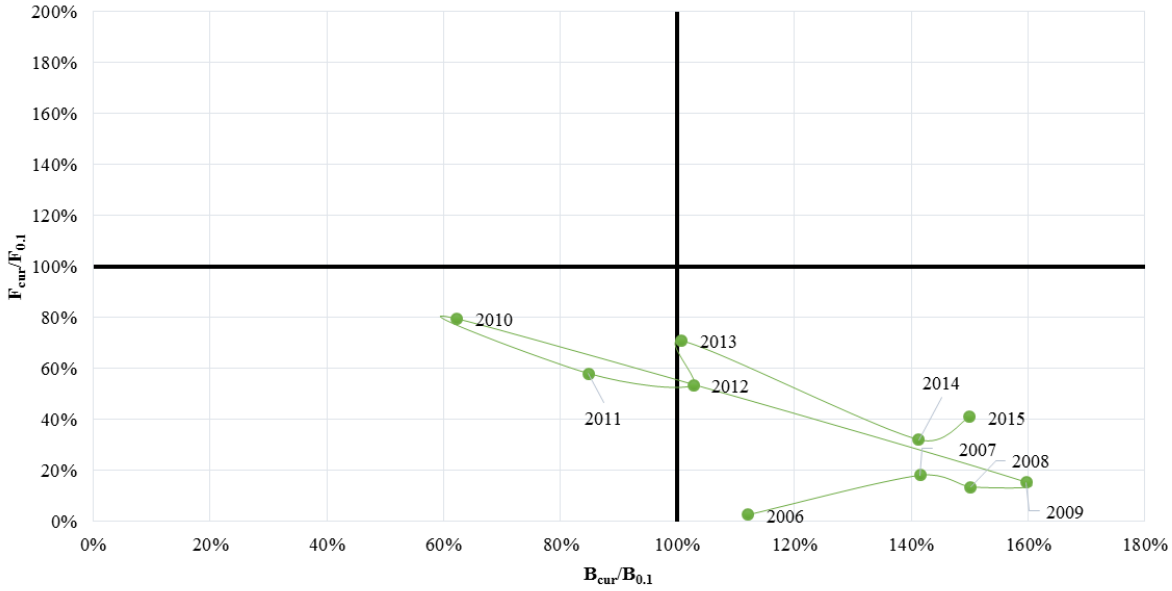


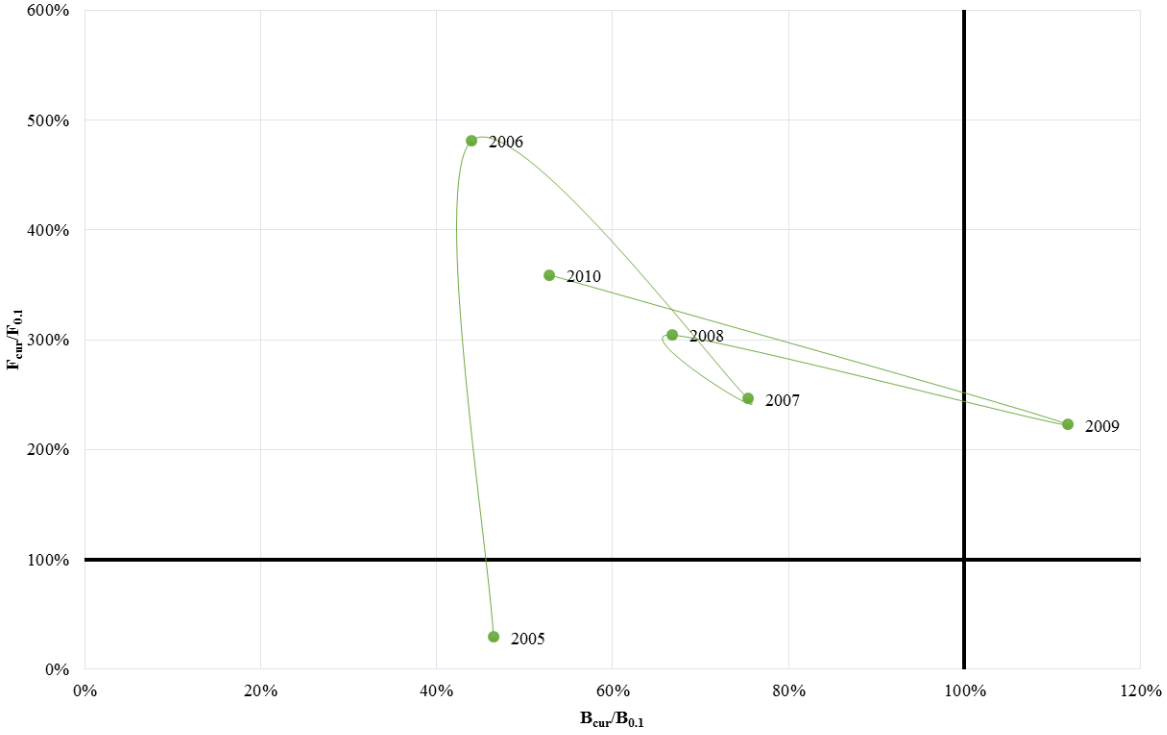
Figure 6: Percentage of small pelagic catches relative to the total catch for 2015 (Source: FAO, *in press*1).



Sardina pilchardus Zone C

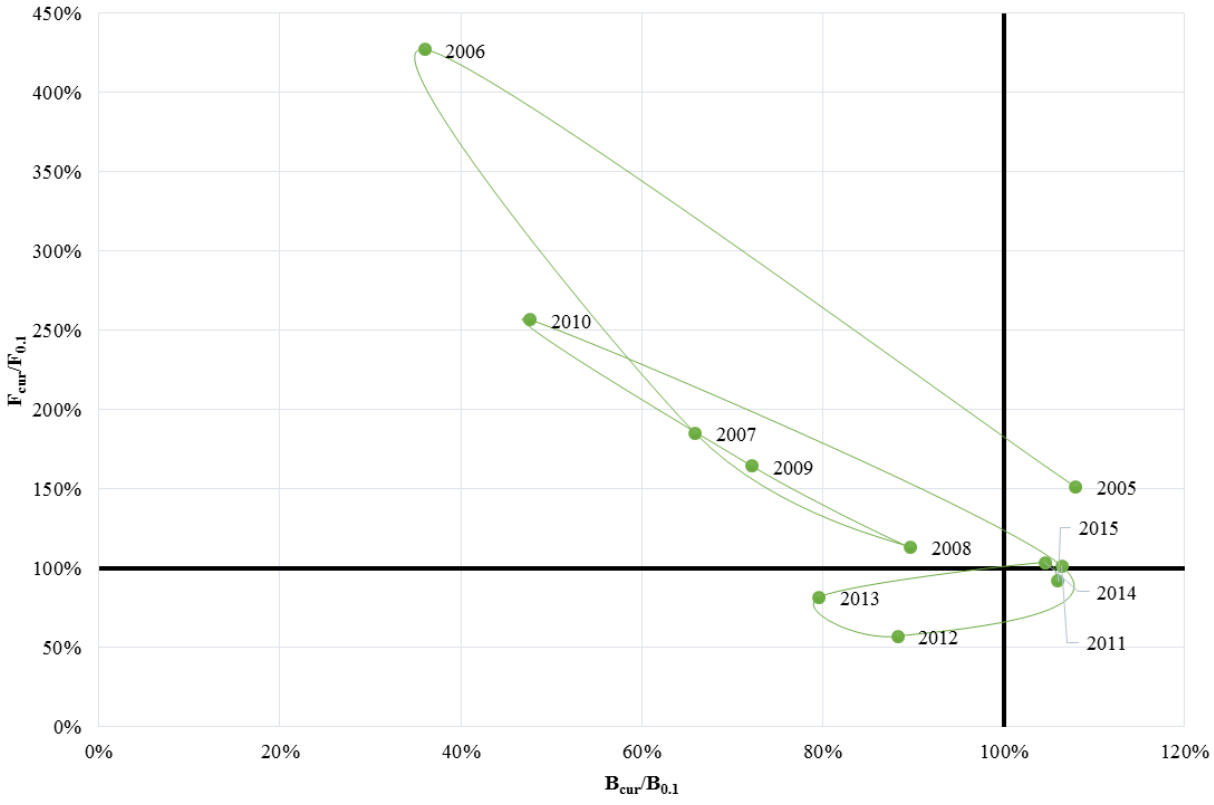


Sardinella aurita



Trachurus trecae

Trachurus trachurus



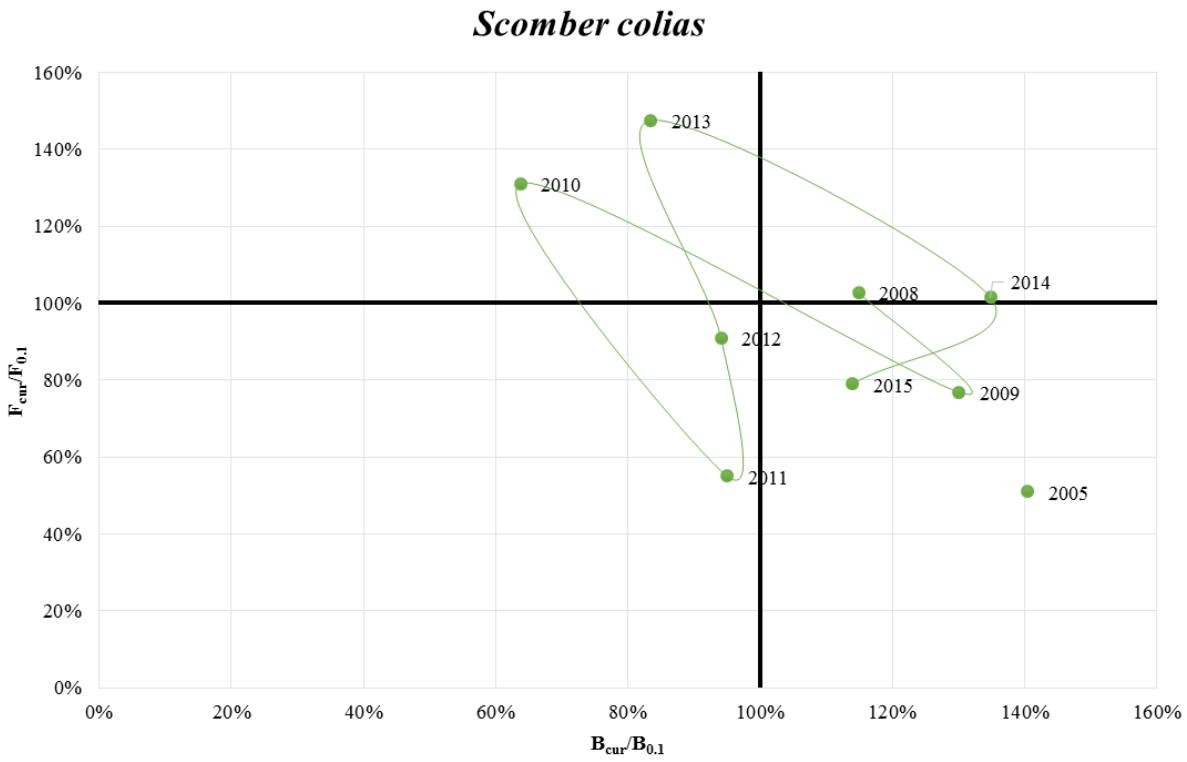


Figure 8. Summary of stock assessment results for sardine in Zone A+B and Zone C, round sardinella, Cunene horse mackerel, Atlantic horse mackerel, and Chub mackerel[8].

Figure 9. Clockwise from top left: the R/V *Dr Fridtjof Nansen*; the R/V *Amir My Abdellah*; the R/V *Itaf Deme*; and the R/V *Al-Awam*. Clockwise from top left, images courtesy of the EAF-Nansen Programme, *Institut National de Recherche Halieutique* (INRH, Morocco), *Centre de Recherches*

[8] It should be noted that the graphs reflect data from years that do not always correspond to the year of the assessment.

Océanographiques de Dakar-Thiaroye (CRODT, Senegal), and *Institut Mauritanien de Recherches Océanographiques et de Pêches* (IMROP, Mauritania).

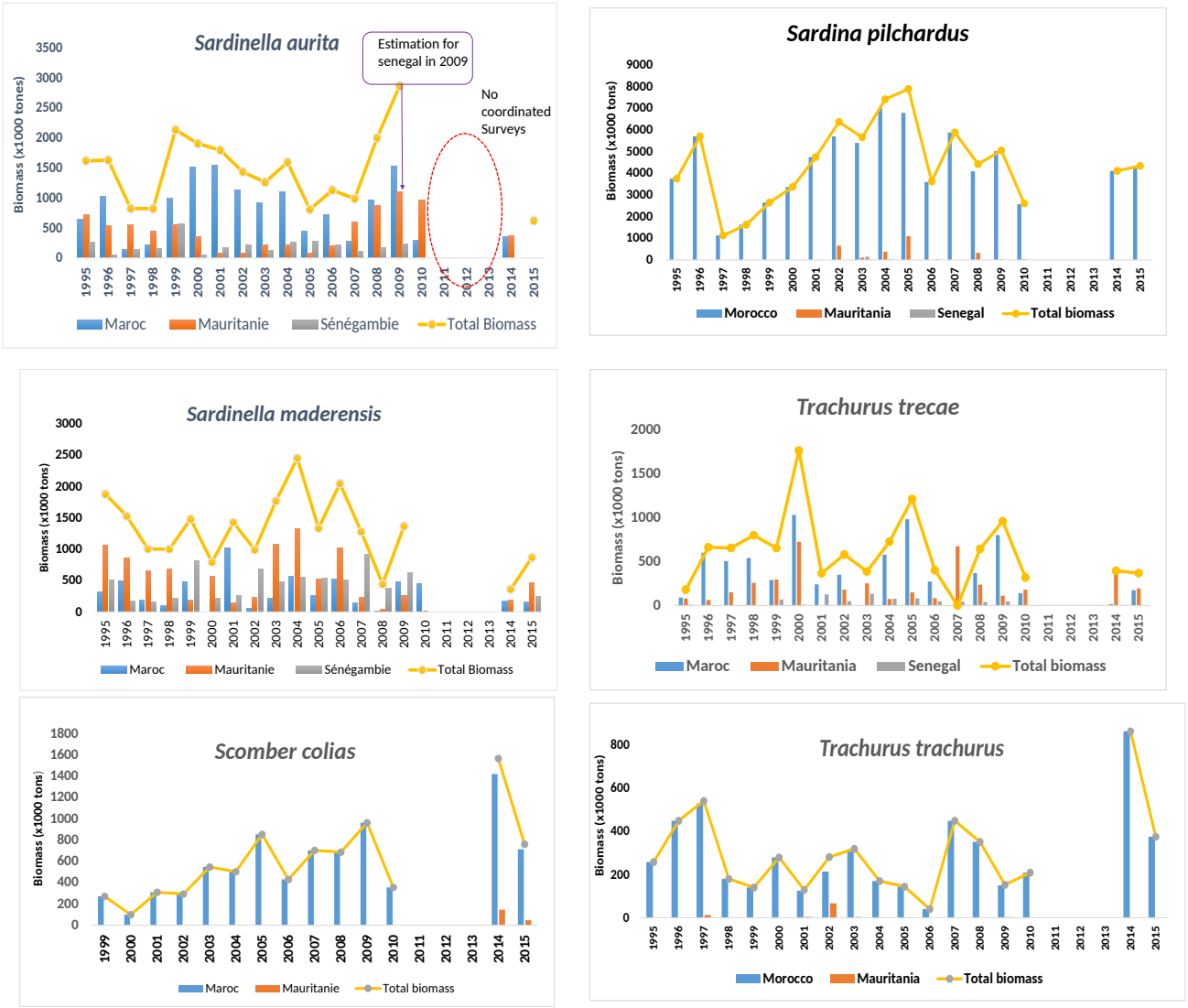


Figure 10. Acoustic biomass data for the R/V *Dr Fridtjof Nansen* time series from 1999-2015.