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Report of the

FAO WORKING GROUP ON THE ASSESSMENT OF SMALL PELAGIC FISH OFF NORTHWEST AFRICA

Banjul, Gambia, 2–11 May 2006

Rapport du

GROUPE DE TRAVAIL DE LA FAO SUR L'ÉVALUATION DES PETITS PÉLAGIQUES AU LARGE DE L'AFRIQUE NORD-OCCIDENTALE

Banjul, Gambie, 2-11 mai 2006

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INTERNATIONAL COOPERATION WITH THE NANSEN PROGRAMME

COOPÉRATION INTERNATIONALE AVEC LE PROGRAMME NANSEN

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PREPARATION OF THIS DOCUMENT

A permanent FAO Working Group composed of scientists from the coastal States, and from countries or organizations that play an active role in Northwest African pelagic fisheries, was established in March 2001.

The overall objective of the Working Group is to assess the status of the small pelagic resources in Northwest Africa and recommend on fisheries management and exploitation options aimed at ensuring optimal and sustainable use of small pelagic fish resources for the benefit of coastal countries.

The sixth meeting of the FAO Working Group on the Assessment of Small Pelagic Fish off Northwest Africa was held in Banjul, Gambia, from 2 to 11 May 2006.

A first editing of the report was made by all the participants of the Working Group. Final technical editing was done by Ana Maria Caramelo and Merete Tandstad. We are grateful to Stephen Cofield, Marie-Thérèse Magnan, Sacha Lomnitz and Françoise Schatto for their assistance in the final editing of this document.

PRÉPARATION DE CE DOCUMENT

Un groupe de travail permanent de la FAO, composé de scientifiques des Etats côtiers et des pays ou organisations qui jouent un rôle actif dans les pêcheries pélagiques de l'Afrique nord-occidentale a été créé en mars 2001.

L'objectif général du Groupe de travail est de contribuer à l'amélioration de l'évaluation des ressources des petits pélagiques en Afrique nord-occidentale et d'analyser la gestion des pêches et les options d'exploitation afin d'assurer la meilleure utilisation durable des ressources de petits pélagiques pour le bénéfice des pays côtiers.

La sixième réunion du Groupe de travail de la FAO sur l'évaluation des petits pélagiques au large de l'Afrique nord-occidentale s'est réunie à Banjul, Gambie, du 2 au 11 mai 2006.

Une première édition du rapport a été faite par tous les participants du Groupe de travail. L'édition technique finale a été faite par Ana Maria Caramelo et Merete Tandstad. Nous sommes reconnaissants à Stephen Cofield, Marie-Thérèse Magnan, Sacha Lomnitz et Françoise Schatto pour l'assistance apportée à l'édition finale de ce document.

Distribution :
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ABSTRACT

The sixth meeting of the FAO Working Group on the Assessment of Small Pelagic Fish off Northwest Africa was held in Banjul, Gambia, from 2 to 11 May 2006. This year, the Working Group paid special attention to, and made decisions on, reference points for management of the pelagic stocks in the region. The Group also made predictions on the development of the status of the stocks and on future effort and catch levels. The advices for the stocks are given in relation to the reference points and on the basis of the predictions for the next five years.

The structure of the report is the same as that of the 2005 Working Group report (FAO, 2006), with the addition of a chapter on predictions. A separate section is devoted to each of the main groups of species (sardine, sardinella, horse mackerel, chub mackerel, bonga and anchovy). For each of these, standardized information is given on stock identity, fisheries, abundance indices, sampling, biological data, assessment, predictions, management recommendations and future research.

In the absence of reliable age compositions, the Working Group used dynamic production models for all stocks. Most stocks in the area are influenced by abnormal hydrographical conditions in certain years. An index of environmental quality has therefore been introduced in the production models. It should be noted that, for most of the stocks, the time series from the acoustic surveys with the R/V DR. FRIDTJOF NANSEN is used as the index of abundance in the assessments and future assessments would therefore depend on the continuation of the time series by the local research vessels as no survey is scheduled with the R/V DR. FRIDTJOF NANSEN in 2006.

The results of the assessments indicate that the stock of round sardinella is overexploited and consequently a decrease in effort in the total sardinella fishery was recommended (corresponding to a total of catch of 220 000 tonnes in 2007). The Atlantic horse mackerel was found to be probably fully exploited whereas the Cunene horse mackerel was found not to be fully exploited. Given that this is a mixed fishery, a decrease in the catches of horse mackerel was recommended (corresponding to a total of 260 000 tonnes in 2007). The mackerel was found not to be fully exploited, but given the mixed fishery with other species, it was recommended that the catches should not exceed 200 000 tonnes. The sardine stock in Zone A+B was found not fully exploited and the Working Group recommended not to increase catches above the average level of the last five years (600 000 tonnes). The stock of sardine in Zone C was found to be underexploited and it was noted that the total catch level may be progressively increased up to one million tonnes during a five-year period.

It was not possible to reach reliable conclusions from the assessment models applied to bonga and anchovy, but in the case of anchovy acoustic estimates show an increasing biomass in recent years. For bonga the catch rates are stable. For bonga the Working Group recommended as a precautionary measure that the catch level should not exceed the average over the five last years (42 000 tonnes) and for anchovy the catch level should not exceed the average over the three last years (135 000 tonnes).

The Working Group recommended that in 2006/2007 recruitment surveys covering the whole sub-region should be carried out regularly to provide an early estimate of year class strength. It also recommends to continue work on age reading of sardine and sardinella to improve the basis for stock assessment.

RÉSUMÉ

La sixième réunion du Groupe de travail de la FAO sur l'évaluation des petits pélagiques au large de l'Afrique nord-occidentale s'est tenue à Banjul, Gambie, du 2 au 11 mai 2006. Cette année, le Groupe de travail a été particulièrement attentif et a pris des décisions sur les points de référence pour l'aménagement des stocks de petits pélagiques dans la région. Le Groupe a aussi fait des prédictions sur le développement de l'état des stocks et sur l'effort futur et les niveaux de capture. Les conseils en matière de stocks sont donnés par rapport aux points de référence et sur la base des prévisions pour les cinq prochaines années.

La structure du rapport est la même que celui du Groupe de travail 2005 (FAO, 2006), avec l'addition d'un chapitre sur les prédictions. Une section séparée est consacrée à chacune des catégories principales d'espèces (sardine, sardinelle, chinchards, maquereaux, bonga et anchois). Pour chacune d'elles des informations standardisées sont données sur l'identité du stock, les pêcheries, les indices d'abondance, l'échantillonnage, les données biologiques, les prédictions, les recommandations d'aménagement et la recherche future.

En l'absence de compositions par âge fiables, le Groupe de travail a utilisé des modèles de production dynamique pour tous les stocks. La plupart des stocks dans la région sont influencés par les conditions anormales hydrographiques pour certaines années. Un indice de qualité de l'environnement a donc été introduit dans les modèles de production. Il faut cependant noter que pour la plupart des stocks la série chronologique des campagnes acoustiques avec le N/R DR. FRIDTJOF NANSEN est utilisée comme indice d'abondance dans les évaluations, les futures évaluations dépendraient donc de la continuation de la série chronologique par les bateaux de recherche locaux puisqu'aucune campagne n'est programmée avec le N/R DR. FRIDTJOF NANSEN en 2006.

Les résultats des évaluations indiquent que le stock de sardinelle ronde est surexploité et par conséquent une diminution de l'effort pour la pêche totale de la sardinelle a été recommandée (ce qui correspond à une capture totale de 220 000 tonnes en 2007). On a trouvé que le chinchard atlantique était probablement pleinement exploité tandis que le chinchard du Cunène n'était pas pleinement exploité. Comme il s'agit d'une pêcherie mixte, une baisse des captures de chinchards a été recommandée (correspondant à un total de 260 000 tonnes en 2007). On a trouvé que le maquereau n'était pas pleinement exploité, mais comme il s'agit d'une pêcherie mixte avec d'autres espèces, il a été recommandé que les captures ne dépassent pas 200 000 tonnes. On a trouvé que le stock de sardine dans la Zone A+B n'a pas été pleinement exploité et le Groupe de travail recommande de ne pas augmenter les captures au-dessus du niveau moyen des cinq dernières années (600 000 tonnes). On a trouvé que le stock de sardine dans la Zone C était sous-exploité et que le niveau total des captures pouvait être progressivement augmenté jusqu'à un million de tonnes pendant une période de cinq ans.

Il n'a pas été possible d'arriver à des conclusions fiables à partir des modèles d'évaluation appliqués à l'ethmalose et à l'anchois, mais les estimations acoustiques pour l'anchois montrent une biomasse en augmentation ces dernières années. Pour l'ethmalose les taux de capture sont stables. Pour l'ethmalose, le Groupe de travail a recommandé comme mesure de précaution que le niveau de capture ne dépasse pas la moyenne des cinq dernières années (42 000 tonnes) et pour l'anchois que le niveau de capture ne dépasse pas la moyenne des trois dernières années (135 000 tonnes).

Le Groupe de travail a recommandé qu'en 2006/2007 les campagnes de recrutement couvrant l'ensemble de la sous-région soient régulièrement conduites afin de fournir une première estimation de la fréquence annuelle des classes d'âge. Il a également recommandé de continuer le travail de lecture d'âge de la sardine et de la sardinelle pour améliorer la base de l'évaluation du stock.

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1. INTRODUCTION

The sixth meeting of the FAO Working Group on the Assessment of Small Pelagic Fish off Northwest Africa was held in Banjul, Gambia, from 2 to 11 May 2006. The overall objective of the Working Group was to assess the status of the small pelagic resources in Northwest Africa and recommend on fisheries management and exploitation options aimed at ensuring optimal and sustainable use of small pelagic fish resources for the benefit of coastal countries.

The species assessed by the group were: sardine (*Sardina pilchardus*), sardinella (*Sardinella aurita* and *Sardinella maderensis*), horse mackerel (*Trachurus trecae*, *Trachurus trachurus* and *Caranx rhonchus*), chub mackerel (*Scomber japonicus*), bonga (*Ethmalosa fimbriata*) and anchovy (*Engraulis encrasicolus*) in the region between the southern border of Senegal and the northern border of Morocco.

The meeting was funded by project GCP/INT/730/NOR: "International cooperation with the Nansen Programme. Fisheries Management and Marine Environment" and the Institute for Marine Resources and Ecosystem Studies (IMARES[1]) and organized by FAO and the Fisheries Department of the Gambia.

Altogether 17 scientists from seven countries and FAO participated. The chairman of the group was Reidar Toresen, Institute of Marine Research (IMR), Norway.

1.1 Terms of reference

The terms of reference of the Working Group were:

1. Presentation of new data on catch, effort, sampling intensity and biological data by country. Updating existing data base.
2. Presentation of working papers on research activities. Review of research activities carried out during 2005/2006 as recommended by the Small Pelagics Working Group in 2005.
3. Presentation of reports on R/V DR. FRIDTJOF NANSEN acoustic surveys Oct./Nov./Dec. 2005 and from the research vessels of the different countries.
4. Presentation of the report of the Planning Group for the coordination of acoustic surveys and the results of the Workshop to analyse parallel survey results.
5. Report on the progress made on age readings of sardine and sardinella in the region.
6. Analyses of catch, effort and biological data for the period 1990–2005, if possible also for the period before 1990.
7. Update stock assessments for sardine, sardinella, horse mackerel, chub mackerel, bonga and anchovy.
8. Advise on management for each resource/stock.
9. Coordination of small pelagic research projects.

1.2 Participants

Pedro Barros	FAO
Eduardo Balguerías (until 5 May)	Spain
Ana Maria Caramelo	FAO
Hamid Chfiri	Morocco
Ad Corten	The Netherlands

[1] Formerly the Netherlands Institute for Fisheries Research (RIVO)

Andrew Cooke (2 and 3 May)	FAO–CCLME
Hicham Gourich	Morocco
Ebaye Ould Mohamed Mahmoud	Mauritania
Asberr Mendy	Gambia
Azeddine Ramzi	Morocco
Birane Samb	Senegal
Abdoulaye Sarre (until 4 May)	Senegal
Ibrahima Sow	Senegal
Mahfoudh Ould Taleb	Mauritania
Merete Tandstad	FAO
Nikolay Timoshenko	Russian Federation
Pablo Tjoe-awie	The Netherlands
Reidar Toresen (chairman)	Norway

Names and full addresses of all participants are given in Appendix I.

1.3 Definition of working area

The working area for the Working Group is defined as the waters between the southern border of Senegal and the northern border of Morocco.

1.4 Structure of the report

The structure of the report is the same as that of the previous Working Group report (FAO, 2006), with the addition of one chapter on predictions. A separate section is devoted to each of the main groups of species (sardine, sardinella, horse mackerel, chub mackerel, bonga and anchovy). For each of these, standardized information is given on stock identity, the fisheries, abundance indices, sampling, biological data, assessment, predictions, management recommendations and future research.

1.5 Overview of landings

There was a marginal increase of 1.3 percent in total landings of the main small pelagic fish landed in the region from 1.94 million tonnes in 2004 to 1.95 million in 2005. The gradual upward trend observed since 1999 continued despite a small decrease in 2002 (Figure 1.5.1a). Total landings of small pelagic fish for the period 1990 to 2005 have been fluctuating around 1.6 million tonnes.

The sardine (*S. pilchardus*) dominated the total landings of the main pelagic fish species in the subregion constituting about 40 percent of overall landings in 2005. Landings of sardine between the period 1993 to 2000 were observed to have attained reasonable stability with slight fluctuations around an average of 612 000 tonnes. The average landings of sardine over the last five years was around 746 000 tonnes, with the highest landings in 2001 (790 000 tonnes). In 2005, landings were 773 000 tonnes representing an increase of 8.2 percent as compared with 2004 (Figure 1.5.1a).

The round sardinella (*S. aurita*) constituted nearly 16 percent of total landings of small pelagic fish, thus ranking the second most important small pelagic fish in the region. Total landings of round sardinella have been fluctuating slightly between 250 000 and 335 000 tonnes over the last five years with an average of about 296 000 tonnes. The overall trend is a relatively steady decrease in landings for this species since 1999, with the lowest total landings of about 250 000 tonnes in 2004 (Figure 1.5.1a).

The landings of flat sardinella (*S. maderensis*) in 2005 were 160 000 tonnes with a contribution to the total landings of the main small pelagic fish in the region of about 8 percent. Compared with the total landings of the round sardinella in 2005, flat sardinella is just over 50 percent lower. The average for the last five years for this species is 157 000 tonnes.

The Atlantic horse mackerel (*T. trachurus*) was this year the most important species of horse mackerel, constituting about 10 percent (approximately 197 000 tonnes) of the total landings of the main small pelagic fish in 2005. The average annual landings of the Atlantic horse mackerel over the last five years were estimated at about 108 000 tonnes. About 193 000 tonnes of Cunene horse mackerel (*T. trecae*) were landed in 2005. This represents a 5 percent increase in total landings of this species in the subregion. The average landings of Cunene horse mackerel in the last five years is 170 000 tonnes. The third species in this group is the false scad (*Caranx rhoncus*) with total landings of 21 000 tonnes in 2005 representing about a 50 percent decrease in landings as compared to 2004.

Landings of chub mackerel (*Scomber japonicus*) over the last five years fluctuated between 136 000 and 225 000 tonnes with the highest landings (225 000 tonnes) recorded in 2004. The landings in 2005 were around 180 000 tonnes and the average landing for this period was estimated at around 176 000 tonnes.

Anchovy (*Engraulis encrasicolus*) and bonga (*Ethmalosa fimbriata*) were included in the assessed small pelagic fish in 2004. The total landings of anchovy in 2005 were around 86 000 tonnes, declining by about 50 percent compared to 2004 (Figure 1.5.1a). An average of 144 000 tonnes of anchovy were recorded for the last five years. Landings of bonga in 2005 constitute about 2 percent of total landings of small pelagic fish in the subregion. Bonga, an estuarine species is mainly targeted by artisanal fishers operating in Senegal and Gambia. In Mauritania it is landed as a bycatch. Total landings of bonga in the subregion were 39 000 tonnes in 2005, which constitutes an increase of about 20 percent compared to the 2004 landings (33 000 tonnes).

Morocco

The sardine (*Sardina pilchardus*) is the dominant species of the small pelagic fish landed in Morocco constituting about 68 percent of the total landings of small pelagic fish in 2005. From 2001 to 2004 a gradual decline in landings of sardine from around 770 000 tonnes to about 640 000 tonnes can be observed, followed by an increase to 700 000 tonnes in 2005 (Figure 1.5.1b). The average landings of sardine for the last five years (2001 and 2005) were about 690 000 tonnes.

The Atlantic horse mackerel (*T. trachurus)* was the second most important species landed in Morocco in 2005 constituting about 17 percent. The total landings of about 140 000 tonnes of the chub mackerel (*S. japonicus)* constituted about 13 percent of small pelagic fish landed in Morocco. The round sardinella, *S. aurita* was the fourth most important species in the series with about 1.4 percent. Despite the decreasing trend in landings of the sardinella species observed since the late 1990s followed by an apparent stability from 2002 to 2004, there was a sharp increase in total landings of this species from 1 600 tonnes in 2004 to 15 000 tonnes in 2005.

Landings of anchovy (*Engraulis encrasicolus*) in 2005 were around 6 000 tonnes, constituting around 0.6 percent of total landings of small pelagic fish in Morocco. A decrease in total landings of this species has been observed since 2001.

Mauritania

Landings of all the main small pelagic fish in Mauritania have shown important inter-annual fluctuations during the period from 1990 to 2005 with an overall increasing trend from 1994 until 2004, followed by a decrease of about 20 percent in 2005 (Figure 1.5.1c). Some of the species (*T. trachurus, C. rhoncus, S. japonicus* and *E. encrasicolus*) decreased drastically in 2005. The decrease in landings of these species ranges from about 50 to nearly 70 percent (Figure 1.5.1c).

The Cunene horse mackerel (*Trachurus trecae*) and the round sardinella (*Sardinella aurita*) dominated landings of the main small pelagic fish in Mauritania in 2005. The total landings of these species were around 190 000 tonnes (about 30 percent) and 175 000 (about 28 percent) tonnes respectively. These were followed by anchovy (*E. encrasicolus*) with about 80 000 tonnes (Figure 1.5.1c).

Senegal

Overall landings of the main small pelagic fish in Senegal showed periodic fluctuations from 1990 to 2005. A steady increase in the total landings of all small pelagic fish was observed from 2000 to 2003, followed by a decrease of 20 percent in 2004. A small increase in total landings was observed in 2005 from around 270 000 tonnes in 2004 to about 280 000 tonnes in 2005. The total landings of the main small pelagic fish in Senegal in 2005 were dominated by the two sardinella species constituting about 87 percent of the total. Landings of these species increased from about 237 000 tonnes in 2004 to around 243 000 tonnes in 2005, representing a 2.5 percent increase in landings of the two *Sardinella* spp. Over the last four years the flat sardinella (*S.maderensis*) has been the dominant species (Figure 1.5.1d).

Landings of bonga (*E.fimbriata*) consisted of about 4 percent of total landings of small pelagic fish in 2005, increasing by 13 percent as compared to 2004.

Horse mackerel and chub mackerel are taken as bycatch species by the Senegalese fishers.

Gambia

Bonga (*Ethmalosa fimbriata*) is the main target species and dominated landings of the main small pelagic fish in Gambia. Bonga landings constituted about 88 percent of total landings of all the main small pelagic fish in 2005. An average of about 21 000 tonnes of bonga was landed over the last five years. Despite fluctuations in the landings of bonga, the trend shows a gradual increase over the period, with a peak in 1997 to 1998. Landings of bonga in 2005 had increased from about 16 000 tonnes in 2004 to nearly 20 000 tonnes in 2005 (Figure 1.5.1e).

Until recently, landings of sardinella and other species of small pelagic fish were considered bycatch since there is no fishery targeting them. Purse seiners targeting sardinellas are beginning to fish in Gambian waters and this has led to some landings of *Sardinella* spp. constituting about 10 percent of total landings of the main small pelagic fish.

1.6 Overview of acoustic survey results by R/V DR. FRIDTJOF NANSEN

The Norwegian research vessel, R/V DR. FRIDTJOF NANSEN has surveyed the subregion from 1995 to 2005, carrying out acoustic surveys during the months October–December each year. In addition, between 2001 and 2003, the vessel carried out acoustic surveys covering the same area in May–July. The surveys aimed to map the distribution and estimate the abundance of the main small pelagic fish species, sardine (*Sardina pilchardus*), sardinella (*Sardinella aurita* and *Sardinella maderensis*), horse mackerel (*Trachurus trachurus* and *Trachurus trecae*) and chub mackerel (*Scomber japonicus*). The distribution of other pelagic resources (other carangids and anchovy) was also mapped and their abundance was estimated. The abundance estimates from the surveys are presented as numbers and biomass per length-group.

Figure 1.6.1a shows the estimated abundance for all the target species during the surveys in October–December, while Figure 1.6.1b shows the estimated abundance for the target species excluding sardine. For *S. pilchardus*, there has been an increase in the estimated biomass over the years 1997–2004, from a level of around 1 million tonnes to more than 7 million tonnes. In 2005 a record high biomass of some 8.0 million tonnes of sardine was estimated. In 2005, R/V DR. FRIDTJOF NANSEN had to stop the survey earlier than usual due to technical problems, leaving the northern parts of Morocco uncovered. This year's estimate of sardine is therefore an underestimate compared to earlier years. However, the major parts of the distribution area of sardine were covered by the vessel. For *Sardinella aurita*, there has been an overall decreasing trend in the acoustic estimates from 2.1 million tonnes in 1999 to 1.3 million tonnes in 2003. In 2004, a somewhat higher biomass of 1.5 million tonnes was estimated, while for 2005 a low estimate of 808 000 tonnes was obtained. For *S. maderensis*, the values have fluctuated between 1 and 1.5 million tonnes since 1989, and the 2003 estimate of 1.8 million tonnes was the highest on record. In 2004, an even further increase of *S. maderensis* biomass of 2.5 million tonnes was estimated. For 2005, the estimated biomass of *S. maderensis* decreased to 1.2 million tonnes.

Of the horse mackerels, *T. trecae* has been the dominating species in the acoustic estimates, and its abundance was estimated at 800 000 tonnes in 1998. Since then, its biomass, as estimated by the acoustic surveys, has decreased, and it was estimated at 390 000 tonnes in 2003. However, in 2004 the abundance was estimated at 730 000 tonnes, a considerable increase compared to 2003, and in 2005 the increase has continued to 1.2 million tonnes. The abundance of the other main horse mackerel species, *T. trachurus*, has fluctuated in the acoustic estimates, but its estimated biomass has shown an increasing trend from 2001 onwards, and was estimated at 320 000 tonnes in 2003. However, in 2004 the biomass of *T. trachurus* was lower, estimated at 179 000 tonnes. In 2005 a further decrease to 144 000 tonnes was observed. The estimated biomass of *Scomber japonicus* has shown an increasing trend, from the rather low level of 100 000 tonnes in 2000 to 550 000 tonnes in 2003. In 2004 it was estimated at 505 000 tonnes, while in 2005, the estimated biomass decreased to 239 000 tonnes.

Detailed estimates for the different species are given in the respective sections.

1.7 Quality of data and assessment methods

For the analysis of data, the group has the long-term aim to apply age-based analytical assessment methods to all the main stocks. However, to use such methods, it is a requirement that catch statistics can be age-disaggregated with a high degree of consistency in the series. These data series are however, not yet of sufficient quality to use analytical assessment methods. The reasons for this are problems with age reading, non representative sampling of the catch (fishing fleets by quarter) and uncertainty in stock definition. The group aims to enhance the quality of these data series, encouraging developments to be made in all these fields, like arranging otolith age reading workshops, studies on stock components. The quality of these data series could be improved in the future.

Although the amount of biological data available to the Working Group has seen a small increase in recent years, some deficiencies persist. The main deficiency remains reliable age data for most of the stocks. For sardine there are no age-length keys after 2003 and the same age-length key (ALK) is applied to annual length composition for 2004 and 2005. The study of age and growth, therefore, remains a priority for the Working Group. Other data deficiencies concern the species and length composition of the landings and discards of the industrial fleet in Mauritania and the length distribution of artisanal catches in Mauritania.

1.8 Methodology and software

After revision of the available data, the Working Group concluded that the only class of methods that could be applied to all stock groups were Production Models (Appendix II). In addition it was decided to investigate the application of Extended Survivors Analysis (XSA) (Shepherd, 1999) and an ISVPA (Vasiliev, 1998) on mackerel. Predictions were made for all stocks using an Excel spreadsheet (Appendix III).

1.9 Age reading

The 2005 Working Group recommended that an exchange of *Sardina pilchardus* and *Sardinella aurita* otoliths should be initiated after the 2005 Working Group. An otolith exchange was carried out in January–May 2006 with the following objectives:

- To estimate precision from the age readings of each individual age reader.
- To improve the quality of sardine age readings.
- To stimulate regional collaboration.

Sardina pilchardus

The *Sardina pilchardus* otoliths exchange was initiated with three sets of otoliths:

Two sets from the Moroccan Institut national de recherche halieutique (INRH):

- The Safi set with 393 otoliths from the 2004 landings at Safi port from January to August and October to December (length range 15.2–23.7 cm).
- The Laayounne set with 500 otoliths from 2004 landings at port (length range 10.0–26.0 cm), this set was not suitable for the exchange for various reasons (not well mounted, most of them broken and some inverted, etc. and then with very difficult interpretation) and it was decided not to include it in the exchange.

One set from the Atlantic Scientific Research Institute of Marine Fisheries and Oceanography (AtlantNIRO):

- The Russian set with 50 otoliths (length range 10.3–27.2 cm) all 2004 months represented except April, May and June.

The Safi set was circulated among 6 readers (two from Morocco, three from the Russian Federation and one from Spain) from countries involved in the sardine fisheries off Northwest Africa and with experience in otoliths readings. A preliminary analysis of the Safi set was made using a spreadsheet developed by Guus Eltink (Eltink *et al.*, 2000).

The total percentage of agreement was 78.0 percent with a coefficient of variation (CV) by age group (CV = standard deviation/mean age recorded) of 7.3 percent. A small improvement in the percentage of agreement could be seen if compared with the last exchange of sardine otoliths carried out in 2002. However, some readers present a tendency to overestimate ages 0 and 1 and underestimate ages older than 3. A more complete analysis will be performed before the workshop on age readings of sardine that will be held in July 2006 in Casablanca.

Sardinella aurita

The *Sardinella aurita* otolith exchange was initiated with three sets of otoliths.

- The Mauritania set consisted of 485 otoliths from commercial catches from January to August and a total length range from 20.4 to 39.5 cm.
- The Senegalese set consisted of 258 otoliths from commercial catches from January and April to October 2004 with a total length range from 11.2 to 39.7 cm.
- The Russian set contained 14 otoliths with a range from 10.4 to 47.5 cm.

Before the Working Group meeting FAO received the readings from four readers but from different sets. The analysis will be carried out when the exchange has been completed. A workshop should be held in Tenerife in December 2006.

1.10 Planning Group for acoustic surveys

The Planning Group for the coordination of acoustic surveys off Northwest Africa was held in Dakar, Senegal, 27–29 October 2005. The general objective of the Planning Group is to discuss acoustic difficulties met by countries of the region, organise parallel surveys of each country’s research vessel (R/V) with the Norwegian R/V DR. FRIDTJOF NANSEN and act as a forum for discussion on issues important to acoustic surveys such as standardization of methods, acoustic research and training (age reading, trawl sampling, scrutinizing, data storage, target strength (TS) measurements, etc.).

The main conclusions of the Planning Group were as follows:

The local research vessels conducted acoustic surveys in 2005. The plan from 2004 had in general been respected and major improvements have been made. As recommended, local vessels began conducting regional acoustic surveys in 2005 and the R/V ITAF DEME is now carrying out surveys in Gambia. The ability to run acoustic surveys in the subregion has been further improved and focus in the future should continue to be on development of human capacity and the resolution of recurrent technical problems of trawl performance, noise discrimination and data storage. The report of the Planning Group will be published in the FAO Fisheries Report Series.

The results from the parallel surveys and intercalibrations conducted between the vessels in the region and the R/V DR. FRIDTJOF NANSEN were analysed at a Workshop held in Saly, Senegal, 27 March – 1 April 2006. The comparisons of acoustic response between local vessels and the R/V DR. FRIDTJOF have not been completed due to some technical problems encountered, mainly a bug in the version of BI60 used during this survey, but comparison of total allocations shows that although some variability in the allocation of recorded acoustic energy is observed between the local vessels and R/V DR. FRIDTJOF NANSEN, generally the variability is within acceptable limits. However, effort should be maintained to harmonise the interpretation of echograms and trawling and sampling procedures.

The Working Group expressed its satisfaction with the work of the Planning Group and the development of the general competence of running acoustic surveys in the region.

1.11 Reference points for management advice

In formulating the results of the assessments, the 2005 Working Group noted that it lacked a set of uniform reference points and management objectives for all stocks in the area. The Group therefore decided that appropriate reference points should be addressed at the 2006 Working Group meeting.

Given that current assessment procedures are based on the application of a dynamic version of the Schaefer logistic production model, the reference points (RPs) to adopt should be those that can be calculated from those models. Since it was not possible, during this meeting, to explore adequately the properties of alternative RPs the Working Group decided to use RPs already investigated by other authors.

Production models include, in a single stock growth rate constant, all the processes leading to stock growth, recruitment, natural mortality and individual growth. These models do not allow separate estimates of these processes, and thus the fine-tuning that structural models may provide (at least in theory). However, these models do have the potential for providing reference points that include the recruitment dynamics of the stocks, based on far less detailed data.

Caddy and Mahon (1995) define a Reference Point as a conventional value, derived from technical analysis, which represents a state of the fishery or population, and whose characteristics are believed to be useful for the management of the stock.

Two main types of reference points (RP) are usually defined:

- Limit Reference Points (LRP)
- Target Reference Points (TRP)

Both LRPs and TRPs may be defined in terms of stock biomass or fishing mortality indicators, or other indicators of the state of the stocks or fisheries.

For practical purposes of management, the TRP is often converted, directly or indirectly, into values of fishing effort.

Limit Reference Points, LRPs are maximum values of fishing mortality or minimum values of the biomass, which must not be exceeded, otherwise it is considered that it might endanger the capacity of self-renewal of the stock. The most commonly used Limit Reference Points are the Maximum Sustainable Yield (MSY) and the respective Biomass (B_{MSY}) and Fishing Mortality (F_{MSY}), these are to be considered as limit conditions for fishery management. B_{MSY} is the biomass level at which the natural production of the stock (in Biomass) is at a maximum, and F_{MSY} is the fishing mortality level that will, if applied over a long term, and in average conditions, lead the stock to B_{MSY}. Hence, if stock biomass is assessed below B_{MSY}, the advice would be to reduce the fishery to let the stock biomass increase. If the fishing mortality is estimated above F_{MSY}, the advice would be to reduce fishing in order to bring fishing mortality to the desired level.

Accordingly, the Working Group decided to adopt B_{MSY} and F_{MSY} as the Limit Reference Points for the stocks of small pelagic fish assessed by the Working Group.

Target Reference Points, TRPs, are defined as the level of fishing mortality or of the biomass, which is preferable from a management point of view. One commonly used TRP is $F_{0.1}$. $F_{0.1}$ corresponds to a level of fishing mortality at which the increase in long-term yield from a small increase in F is 10 percent of the increase in long-term yield obtained by the same small increase in F on a virgin stock (e.g. at $F_{0.1}$ the increase in yield obtained by adding one unit of fishing effort to the fishery corresponds to 10 percent of the increase in yield obtained by adding the same unit of fishing effort to a non-exploited fishery). The concept of this reference point arises from similar considerations in economic theory. For the Schaefer logistic production model, this value is 90 percent of MSY, and the corresponding Yield is 99 percent of MSY. Thus, fishing at $F_{0.1}$ will allow the fishery to catch almost MSY, with 10 percent less effort and costs.

The Working Group decided to adopt $F_{0.1}$ as TRP.

The estimation of the absolute (current or reference) values of fishing mortality and/or biomass is often very difficult, due to uncertainties in the data used, or in the parameters used in the modelling process. It is thus often not possible to define accurate values of the RPs, nor the absolute current status of the stocks. In many cases however, it is possible to estimate quantities that are proportional to these values, even if the proportionality constant is not known. In these cases, it will be possible to evaluate the current status of the stocks relative to the RPs defined.

Given the uncertainties associated with estimating absolute values of B and/or F, it is proposed that the SPWG keeps presenting the results of its assessment as current levels relative to the target reference points ($F_{0.1}$ and $B_{0.1}$). Additionally, the estimated current catch relative to the catch that would keep the stock at the current biomass level should also be presented. In addition the ratios B_{cur}/B_{MSY} and F_{cur}/F_{MSY} are also presented.

If the stock biomass is assessed below a level of 30 percent of B_{MSY}, the Working Group decided to issue a special warning on the status of the stock.

1.12 Predictions

The Working Group decided to continue making recommendations in terms of catch limitations but also to include some simple medium term predictions according to predefined scenarios.

The estimated status of the stock and the exploitation level, based on the assessments are described for each of the stocks. The management advice is based on the current status and on the deviation from the management target reference point for the specific stock (see Section 1.11).

Medium term predictions (predictions for five years) were done for each of the stocks assessed.

For the predictions, Excel spreadsheets were used. The spreadsheets are described in Annex III. The basis for the predictions were the assessments of the different stocks. The input for the predictions is described in the chapters dealing with the different stocks.

For each stock, two scenarios where made, the first giving the development of the stock if the current fishing effort in the fishery is continued. The second scenario presented the sustainable fishery level and the corresponding total allowable catch per year (TAC) leading to the targeted stock level $B_{0.1}$. It also indicated when this stock level would be reached.

1.13 Canary Current Large Marine Ecosystem Project (CCLME)

The sixth session of the FAO Working Group on Assessment of Small Pelagic Fish off Northwest Africa had received a request from the Coordinator of the Canary Current Large Marine Ecosystem (CCLME) to consider issues that are transboundary in nature with regard to small pelagic fish. The CCLME project is hosted at the Permanent Secretariat of the Subregional Fisheries Commission (SRFC) and will be implemented in the member countries of the CCLME region, namely; Cape Verde, Guinea, Guinea-Bissau, Mauritania, Morocco, Senegal and Gambia. The Working Group is therefore an important forum to discuss matters that concern these important shared stocks in the subregion as it has invaluable knowledge of the small pelagic fish in the subregion.

The small pelagic fish studied by the Working Group are presently the most abundant fish stocks in the subregion and are also extensively shared by countries within which they are distributed. They contribute immensely to socio-economic development of Morocco, Mauritania, Gambia and Senegal.

The Working Group was requested to discuss issues of concern which affect one or more countries which share the small pelagic fish to contribute to the Transboundary Diagnostic Analysis (TDA) process and to propose demonstration projects that will address those concerns for possible funding.

After a lengthy brain-storming session the Working Group proposed the following projects which they deemed appropriate to enhance the assessment and sustainable management of the small pelagic fish.

1. Factors influencing abundance, migration and geographical distribution of the small pelagic fish.
    - Study environmental influence (upwelling, shift in thermal front, time series of environmental indices).
    - Recruitment surveys (acoustic, trawling).
    - Stock identity (genetics, morphology, parasitology).
    - Migration (tagging, acoustic survey, trawling).
2. Reinforce capacities for the sustainable management of shared stocks.
    - Improve biological and ecological data collection systems.
    - Improve monitoring, control and surveillance (MCS) mechanisms.
    - Study mechanisms for putting in place a catch quota system in the subregion.
    - Develop a common database for the shared stocks (fisheries statistics).
    - Organize meetings between scientists and fisheries managers.

2. SARDINE

2.1 Stock identity

As the results on the genetic study of the sardine stocks was not provided this year, the Working Group decided to use the same stocks as in previous Working Groups for the northern stock (35°45'–32°N), the central stock, zones A+B (32°N – 26°N), and the southern stock, zone C (26°N – the southern extent of the distribution of the species) (Figure 2.1.1).

2.2 Fisheries

Catch

Catch and effort data were updated for the three zones with data from 2005 (Tables 2.2.1a and 2.2.1b).

Recent developments

Recent changes in the different economic zones are described below:

In Morocco, in 2005, the sardine stock in zone A+B was exploited exclusively by the Moroccan fleet, made up of 350 coastal purse seiners, operating close to the ports at depths not exceeding 100 metres, with an average trip length of seven hours.

Catch of sardine in zone A fell drastically this year, going from 60 000 tonnes in 2004 to 25 000 tonnes in 2005. This zone saw a heavy decline in the nineties registering a particular low in 1996, 3 500 tonnes. This decrease in catch was due to a strong decline in the availability of sardine. Equally, the northern zone saw a reduction in sardine catch, going from 21 000 tonnes in 2004 to 17 000 tonnes in 2005. On the other hand, in zone B catches increased, going from around 475 000 tonnes in 2004 to around 530 000 tonnes in 2005. In zone C, total sardine catch reached around 190 000 tonnes in 2005 (Table 2.2.1a and Figure 2.2.1a).

In 2005, the zone between Cape Boujdor and Cape Blanc was exploited by Moroccan coastal purse seiners operating from the port of Dakhla, by three Moroccan refrigerated sea water (RSW) vessels, by pelagic trawlers operating under the fishing agreement signed between Morocco and the Russian Federation on 15 October 2002 and by boats chartered by Moroccan operators.

The Russian pelagic trawlers (numbering a maximum of 12 units) operate in the zone beyond 15 miles from the coast for a period of three years with effect from 2004, targeting sardine, mackerel, horse mackerel, sardinella, hairtail and anchovy, with an authorized bycatch of 3 percent.

The chartered boats are authorized to follow the same exploitation patterns as the Russian pelagic trawlers for a period of four years as from 2004, with a maximum number of 20 units.

Sardine catch in the Mauritanian zone has fallen from 80 000 tonnes in 2004 to 65 000 tonnes in 2005, with 45 tonnes being landed by the artisanal Mauritanian fishery.

Catches are seasonal for both the European Union (EU) and Russian pelagic trawlers. A reduction in effort on sardine was observed during 2005 in Mauritania.

This reduction in effort in the Mauritanian industrial fishery is connected in part to the transfer of effort towards Europe (for the EU fleet) and in part to the problems of maintaining the old eastern European trawlers. The reduction has caused, amongst other things, the decrease in catch of sardine which is a seasonal target species for the different fleets and in particular for the EU fleet.

In Senegal, occasional catches of sardine have been reported over the last few years. This is an unusual situation which was last observed in 1994. The catch this year of the combined Senegalese artisanal and industrial fisheries was around 1 900 tonnes.

2.3 Abundance indices

2.3.1 Catch per unit of effort

The CPUEs in tonnes per positive trip, have been updated for 2005. In general, in zone A+B, they show fluctuations from one year to the next, with a maximum being registered in 2001 (Figure 2.3.1a).

In zone C, fishing effort is expressed in number of fishing days for the Moroccan RSW vessels, the Russian vessels, the boats chartered by the Moroccans and the industrial vessels operating in the Mauritanian zone (Figure 2.3.1b).

Figure 2.3.1b shows CPUE trend for sardine in zone C. The highest yields were obtained in the nineties by the Spanish coastal purse seiners. The yield of the EU fleet in the Mauritanian zone has decreased from 22 tonnes per day in 2004 to 20 tonnes in 2005 whereas the yields of the Ukrainian and Russian fleets have increased respectively by 1 and 2 tonnes per day to 4 and 7 tonnes.

2.3.2 Acoustic surveys

R/V DR. FRIDTJOF NANSEN

The results from the survey by R/V DR. FRIDTJOF NANSEN in November–December 2005 showed a large increase in sardine biomass in respect to the estimated biomass of the same period in 2004. The total estimated biomass for the zone between Cape Boujdor and Saint-Louis was in the order of 8 million tonnes.

The trend in estimated biomass in zone A+B shows a continual increase from a low value of 255 000 tonnes in 1996 to a value of around 900 000 tonnes in 2002. There was a decrease in 2003 (660 000 tonnes) before it increased again to around 950 000 tonnes in 2004 (Figure 2.3.2).

In the zone south of Cape Boujdor, the estimated biomasses of sardine show fluctuations between 1995 and 2005. The sharp decline in 1997 (870 000 tonnes) was followed by a steady increase in the stock which reached a value of 8.12 million tonnes in 2005 (the exception being 2003 when a small decrease was registered) (Figure 2.3.2).

R/V ATLANTIDA

Between November 2005 and January 2006, a survey to study the recruitment of small pelagics was carried out in the EEZs of Morocco and Mauritania. This was the third survey of a series that began in 2003.

Over the whole zone, sardine individuals aged 1 showed much higher concentrations than those aged 0. The distribution and density of the sardine population is similar to that of the previous two years.

Since 2003, the abundance indices at ages 0 and 1 have shown a continual decrease.

National surveys

Morocco

The Moroccan research vessel R/V AL-AMIR MY ABDALLAH carried out four acoustic surveys in 2005. One of these was an intercalibration survey with the Norwegian vessel R/V DR. FRIDTJOF NANSEN carried out between November–December 2005 in the zone between Cape Boujdor and Cape Blanc. The intercalibration coefficient between the estimated biomasses of the two vessels was 0.79. The trawl survey in the zone situated between Cape Cantin and Cape Boujdor gave a biomass estimate of around 750 000 tonnes. Applying the biomass ratio between the two vessels gives a biomass of around 950 000 tonnes for this zone.

Mauritania

The Mauritanian research vessel R/V AL-AWAM carried out two acoustic surveys in November 2005 and March 2006. The first survey was carried out in conjunction with the R/V DR. FRIDTJOF NANSEN. The sardine biomass estimation was 510 000 tonnes of which 409 000 tonnes were to the south of Cape Timiris and 101 000 tonnes to the north. Two modes were observed, a main one of 25 cm and a secondary one of 14 cm.

2.4 Sampling of commercial fisheries

The number of samples and individuals measured by fishing zone is given in Table 2.4.1.

Morocco

The biological sampling programme continued throughout 2005 in all of the fishing ports south of Cape Cantin: Safi (zone A), Agadir (zone A), Sidi Ifni (zone B), Tantan (zone B), Tarfaya (zone B) and Dakhla (zone C). On board the Russian fleet, sampling was continued but not over the whole year. Sampling intensity in 2005 was considerably lower than that of 2004.

Mauritania

In Mauritania, sampling is carried out on board the EU fleet (by IMROP scientists) and the Russian fleet. Sampling on board these two fleets does not cover the whole year.

Senegal

In Senegal, sampling was undertaken this year on the landings of sardine by the industrial and artisanal fisheries.

2.5 Biological data

Moroccan biological data for zones A, B and C concerning the demographic structure are available for 2005. These data include length measurement and the length–weight relationship. The lengths are measured in total length (TL) to the nearest ½ cm below.

The length distribution of sardine caught in zone A+B shows a main mode of 19 cm and two secondary modes of 11.5 cm and 23 cm (Figure 2.5.1a).

In zone C, the length distribution shows a predominance of individuals with a length of 24 cm (Figure 2.5.1b).

Age reading of the landings of the Moroccan fishery in 2005 in zones B and C is underway. Age-length keys based on Moroccan data from 2003 were used to establish the age composition in 2005 for both zones A+B and C (Tables 2.5.1a and b). An age-length key for sardine in zone C was prepared by the Russians for the second half of 2005.

Age composition as well as average weight-at-age were brought up to date for the two zones (A+B and C) for 2005 (Tables 2.5.2a,b,c and d). The average lengths by age, however, show a difference in growth rate from one age to another (Table 2.5.2e).

Table 2.5.2e: Average lengths by age in 2003, 2004 and 2005 in zones A+B and C

Age class	0	1	2	3	4	5	6
Zone A+B							
Average length (cm) 2003	15.2	16.9	19.9	22.4	24.0	25.0	25.7
Average length (cm) 2004	15.3	17.6	19.5	22.3	23.9	25.0	25.8
Average length (cm) 2005	14.5	18.4	20.1	22.2	24.2	25.2	26.1
Zone C							
Average length (cm) 2003	-	18.3	20.6	22.8	24.2	25.0	26.4
Average length (cm) 2004	-	18.5	21.6	22.7	24.1	25.0	26.5
Average length (cm) 2005	-	19.2	22.1	23.4	24.6	25.3	26.7

The length–weight relationships used in the average weight by age calculation are obtained from samples carried out in the Moroccan ports during 2005.

The length distribution observed in the R/V DR. FRIDTJOF NANSEN survey in November–December 2005 shows a main mode at 23 cm in the region south of Cape Boujdor (Figure 2.5.2b). Furthermore, the length distribution observed during the Moroccan research vessel survey is dominated by individuals of a length of 19 cm in the area between Cape Boujdor and Cape Cantin (Figure 2.5.2a).

Length composition for both vessels together is dominated by fish of a length of 23 cm (Figure 2.5.2c).

2.6 Assessment

Data quality

To gauge the quality of the data available for the assessment, the Working Group carried out a statistical exploration of the data and calculated the correlation between the different age groups and the number corresponding to the class from the same year and the following year. The results show (Figure 2.6.1) that for zone A+B there is no correlation between the different cohorts as the age structure shows anomalies from one age to the next. For zone C, the correlations are less weak than those of zone A+B, except for ages 0–1, 1–2 and 2–3 (Figure 2.6.2).

This lack of correlation shows that the cohorts cannot be rigorously followed which could be the result of several factors such as poor age estimation, a change in the exploitation pattern (alternating of several fleets), non-representative sampling, targeting of certain lengths more in demand by the canning industry or even poor stock identification. The result of this is that the data cannot be relied upon for an analytical age-based assessment.

Thus the Working Group decided not to use analytical models based on age for stock assessment.

Methods

The Schaefer logistic production model was adapted from an Excel spreadsheet (the model is described in Annex II) to assess the two stocks, A+B and C. This year the Working Group carried out abundance and catch projections for five years following different management scenarios using the same model (Annex III).

Data

The time series of sardine landings for zones A+B and C from 1995 to 2005 were used for the production model.

The abundance indices from the R/V DR. FRIDTJOF NANSEN surveys in November–December of the same years were used to estimate the model parameters. Until 2003 the abundance indices of

R/V DR. FRIDTJOF NANSEN were calculated from the entire zone between Cape Juby and Cape Blanc. The separation of the abundance indices carried out during the R/V DR. FRIDTJOF NANSEN survey of 2004 was used to separate the abundance indices of the previous surveys into the two zones (Cape Juby – Cape Boujdor and Cape Boujdor – Cape Blanc).

The estimated sardine biomass index of the Moroccan vessel in December 2005 was corrected by the sardine intercalibration coefficient (0.79) and used for the year 2005 to complete the abundance index series in zone A+B.

The year 1997 was marked by a very sharp decline in sardine biomass. In order to incorporate this situation into the estimations, a negative environmental index was introduced for 1996.

Results

After introducing the environmental index, the fit of the model improved and was judged to be satisfactory.

For zone A+B the results show that the current stock biomass is well above that producing maximum sustainable yield. The level of exploitation is below the natural production of the stock, and therefore it is expected that the stock will continue to grow. For zone C the results also show that the current stock biomass is well above that producing maximum sustainable yield and that the level of exploitation is largely below the sustainable level, and therefore it is expected that the stock will continue to grow.

Table 2.6.1 summarizes the results from the fit of the logistic production model to the sardine catch environmental variables and the abundance index of the data. Figures 2.6.3a and b show the observed and predicted indices and their diagnostics.

Table 2.6.1: Summary of the results from the fit of the logistic production model

Stock/abundance index	$B_{cur}/B_{0.1}$	F_{cur}/F_{SYcur}	F_{cur}/F_{MSY}	$F_{cur}/F_{0.1}$
Sardine, zone A+B/Nansen	128%	96 %	57 %	63 %
Sardine, zone C/Nansen	177%	113 %	5.8 %	6.4 %

$B_{cur}/B_{0.1}$: Relationship between the estimated biomass for the last year and the corresponding biomass at $F_{0.1}$.
F_{cur}/F_{SYcur}: Relationship between the fishing mortality coefficient observed over the last year of the series and the coefficient that would provide a sustainable yield at the current biomass level.
F_{cur}/F_{MSY}: Relationship between the fishing mortality coefficient observed over the last year of the series and the coefficient that would provide a sustainable yield over the long term.
$F_{cur}/F_{0.1}$: Relationship between the fishing mortality coefficient observed over the last year of the series $F_{0.1}$.

Discussion

For zone A+B, the fit of the model is acceptable (Figure 2.6.3a). The $B_{cur}/B_{0.1}$ relationship shows that the stock is not fully exploited and that the biomass trend estimated by the model is increasing.

For zone C, the fit is also acceptable. The biomass has an increasing trend levelling out over the last two years. The considerable increase in biomass in 2005 cannot be explained by the average parameters estimated for the time period analysed. If this increase corresponds to real growth in the biomass it must be due to more favourable environmental conditions for stock growth. Additionally, the fit of the model shows that stock C is very weakly exploited (Figure 2.6.3b).

The sharp decline in biomass registered in 1997 cannot be solely due to fishing pressure. It could be due, amongst other things, to a regional environmental change which would have had a strong influence on survival, recruitment and movement of sardine. The increase in estimated global biomass by R/V DR. FRIDTJOF NANSEN in 2005 coincides with a strong movement of sardine as far as Senegal.

Due to the sensitivity of this species to changes in environmental conditions and the instability of the environment in the whole Canary Current region, the sardine stock could undergo periods of increased production and others where the level is weak for natural reasons. This change in stock abundance can be either gradual or very rapid.

2.7 Predictions

In order to study the behaviour over time of the results produced by the model, the Working Group opted for a projection of the results over the next five years. Two management scenarios were chosen in order to analyse the results for each of the stocks.

- 1^{st} scenario: Maintain fishing effort at its current level.
- 2^{nd} scenario: Change the current level of effort to produce a better yield over the long term.

For zone A+B, the first scenario shows little change in catch and stock abundance trends (Figure 2.7.1a). The second scenario shows that with a slight increase (10 percent) of the current effort, a slight increase in catch is projection with respect to that of 2005 as well as a reduction in abundance to an acceptable level with respect to $B_{0.1}$ taking into account the fragility of the stock when considering the environmental conditions (Figure 2.7.1b).

For zone C, the first scenario shows that the catch will be very weak and the abundance will stabilize at a very high level (Figure 2.7.2a). The second scenario shows that with a considerable increase in current effort (700 percent), a large increase in catch is forecast with a decrease in abundance to a level greater than $B_{0.1}$ taking into account environmental impact on the abundance and the stock dynamic (Figure 2.7.2b).

Analysis of historical data of the sardine fishery in zones A+B and C shows that the stock can undergo very large variations in abundance without affecting the fishery. Because of this the projections should be considered with precaution and as being solely indicative. They need to be frequently updated.

2.8 Management recommendations

Stock A+B

The results show that the stock is not fully exploited. Due to the fluctuations that this stock has undergone, sardine catch in this zone should not exceed 600 000 tonnes over the coming years.

Stock C

The results clearly demonstrate that the stock is weakly exploited and that catch can be increased. As a precaution, this should be done gradually over a period of five years until reaching a level of one million tonnes.

Taking into account the instability of the stock (which is particularly highlighted by the sharp drop in 1997), continuous monitoring of the structure and abundance of the stock should be guaranteed by the scientific surveys independently from the data on commercial catches in order to detect any unforeseen changes which could demand urgent management measures.

2.9 Future research

The Working Group recommends that research in the following areas be intensified:

1. Improvement in the sampling programme for the different fisheries and all of the stocks.
2. Carrying out a workshop on age reading of sardine otoliths.

3. Measurement of total length of sardine to the nearest ½ cm below for the different fisheries.
4. Presentation of quarterly length frequency data for the whole time series for zones A+B and C to the next Working Group meeting.
5. Continuation of the research on stock identity (working document).
6. Recalculation of the biomass indices from the R/V DR. FRIDTJOF NANSEN by zone (A+B and C) for the whole time series (working document).

3. SARDINELLA

3.1 Stock identity

The Working Group considered a single stock for both sardinella species due to the lack of any new study on stock identity. Refer to the Working Group report of 2001 (FAO, 2001) for further information on stock identity.

3.2 Fisheries

The main exploitation of sardinella is carried out by the Mauritanian industrial fishery (EU fleet, Russian fleet and other fleets of Eastern European origin) and the Senegalese artisanal fishery.

Catch

Catch by fleet and country is given in Table 3.2.1a for *Sardinella aurita* and in Table 3.2.1b for *Sardinella maderensis*. Total catch for the whole of the region is shown in Figures 3.2.1a and 3.2.1b.

Total catch of *S. aurita* shows a decreasing trend since 1998 despite peaks in 2003 (335 000 tonnes) and 2005 (around 305 000 tonnes).

For *S. maderensis*, the catch shows an increasing trend from 110 000 tonnes in 2000 to around 210 000 tonnes in 2003, then a heavy drop in 2004 with only 145 000 tonnes. In 2005, the catch increased slightly, reaching around 165 000 tonnes.

Effort

Effort data for each zone are given in Table 3.2.2 and Figures 3.2.2a, 3.2.2b and 3.2.2c. In Mauritania, the effort of the non-EU fleet (Russian Federation, Ukraine and others) saw strong growth between 2003 and 2004 before decreasing in 2005. The effort of the EU fleet tends to increase (with a slight decrease in 2005).

In Senegal, the effort of the industrial fishery has been practically stable since 2001. The artisanal fishery shows an increasing trend between 2000 and 2003 then a decrease between 2003 and 2004. In 2005, the effort remains at the 2004 level.

Recent developments

Recent changes in the various economic zones are described in the following paragraphs.

In zone C, sardinella is fished by a fleet of Russian trawlers (with a maximum number of 12 units) and a fleet of chartered pelagic trawlers (20 at most). These vessels are licensed to fish for all pelagic species, including sardinella.

Sardinella catch in zone C has increased from 1 600 tonnes in 2004 to 15 000 tonnes in 2005 following a recommencement of activity.

In Mauritania, sardinella catch increased from 157 000 tonnes in 2004 to around 210 000 tonnes in 2005. This increase is related to a higher CPUE in 2005 than in 2004. Fishing effort fell drastically in 2005 by 27 percent for the EU fleet and 38 percent for the non-EU fleet.

The amount landed by the artisanal fishers in Nouakchott has decreased. This catch has gone from 23 000 tonnes in 2004 to 18 000 tonnes in 2005.

In Senegal the exploitation of coastal pelagic resources is still heavily influenced by the artisanal fishery which is concentrated south of Dakar, and in particular at Mbour and Joal. However an increasing number is beginning to operate in the large northern fishing centres such as Hann (Dakar), Kayar and Saint-Louis. Sardinella catch remains stable with a slightly increasing trend, going from around 235 000 tonnes in 2004 to 240 000 tonnes in 2005.

A census of the canoes in Senegal was carried out in August–September 2005. The results are ready for publishing. There is nothing to indicate that there has been a change in the number of purse seines since 2002.

Self-regulatory measures regarding fishing effort adopted by the Senegalese artisanal pelagic fishery continue and appear to be satisfactory. These measures consist in limiting the number of trips of purse seines at certain landing sites like Kayar to avoid saturating the market.

In 2005, Mauritania granted Senegal 270 free artisanal fishery licences, targeting solely pelagic species, excluding mullet, for a duration of six months (from July to December). The Senegalese artisanal fleet that received these licences operates in the southern part of Mauritania and lands its catch at Saint-Louis.

The industrial fleet is composed of four small sardine boats from Dakar. Fish are preserved using sea water cooled by ice. For several years, this fleet has only exploited around 10 percent of the continental shelf off the Petite Côte near Dakar, which is still its landing port. Only depths of between 10 and 50 metres are fished. This can be explained in part by the old age of the vessels which cannot endure the poor sea conditions marked by a relatively strong swell to the north of Cape Verde, and in part by their poor cruising autonomy which does not enable them to go and fish in the south.

In Gambia, sardinella landings were until recently bycatch of the artisanal and industrial fleets. It should be underlined that now there are some artisanal fisheries purse seines targeting sardinella. This led to a catch figure of 2 300 tonnes of sardinella in 2005 which represents about 11 percent of total small pelagic catch.

3.3 Abundance indices

3.3.1 Catch per unit of effort

Two CPUE series are presented for Mauritania in Figure 3.3.1a: the first is for the EU fleet and the second is for the rest of the industrial fleet (Russian Federation, Ukraine and others). The two series refer to the combined catch of *S. aurita* and *S. maderensis* as no distinction could be made between the effort aimed at one or the other species individually. In actual fact, around 90 percent of the catch of the EU trawlers is composed of *S. aurita*. The calculated CPUE based on effort therefore refers mainly to *S. aurita*.

In Mauritania, the EU fleet mainly targets sardinella and catches other species when there are no sardinellas available in the area. The CPUE of sardinella for this fleet can therefore be considered as an indication of the availability of sardinella in Mauritania, particularly of *S. aurita*. Effort data for the EU fleet do not include that of the two Irish vessels as none was available for these. For the rest of the EU fleet, effort has been adjusted to the engine power of the vessel using the factors given in the 2003 report, and is expressed in standard fishing days of a 10 000 HP trawler.

For the EU fleet, the series shows a declining trend over the course of the years 1999–2004, then an increase in 2005. For the non-EU fleet (Russian Federation, Ukraine and others), the series shows a similar trend. The trend is therefore of a heavy reduction in the two series for the whole of the 1997–2004 period.

In Senegal, CPUE trend of the artisanal sardinella fishery is given in Figure 3.3.1b. Yields are expressed in tonnes per number of trips.

The yields of *S. aurita* are relatively stable over the last few years with an average of around 1.3 tonnes per trip over the last four years. On the other hand, for *S maderensis*, the CPUEs fall from 1.8 tonnes per trip in 2003 to 1.5 tonnes in 2004 and 2005.

3.3.2 Acoustic surveys

R/V DR. FRIDTJOF NANSEN

In the zone between the south of Cape Boujdor and Cape Blanc, the estimated sardinella biomasses show strong fluctuations between 1995 and 2004 (Figure 3.3.2a). Two peaks in 1996 and 2001 are followed by decreases of 78 percent in 1997 and 53 percent in 2002. In 2003, the biomass witnessed a slight decline followed by an increase in 2004 and an estimated sharp decrease in 2005.

The round sardinella biomass (*S. aurita*) is always greater than that of the flat sardinella (*S. maderensis*). During the 2004 and 2005 surveys, the round sardinella represented respectively 67 and 75 percent of the total estimated sardinella biomass.

The decreasing trend in sardinella observed up until 2001 in Mauritania is followed by an increase for the period 2002–2004. In 2005, a decrease in abundance was measured (Figure 3.3.2b).

In Senegal and the Gambia strong fluctuations in the biomass are seen from one year to the next (Figure 3.3.2c). The years of greater abundance are 1995, 1999, 2002 and the last two years.

The whole subregion

The estimated trend in biomass for *S. aurita* and *S. maderensis* over the whole subregion shows fluctuations between 1995 and 2005 (Figure 3.3.2d). In 2005, the biomass declined by 50 percent with respect to that of 2004.

The lowest biomass of *S. aurita* was recorded in November–December 1998, whereas a peak of two million tonnes was observed in 1999. Thereafter the biomass declined gradually to 1.2 million tonnes in November–December 2003 before increasing slightly to 1.6 million tonnes in 2004 and decreasing once again to around 810 000 tonnes in 2005. In contrast to the round sardinella, the flat sardinella stock shows a more regular trend over the last few years, with however an increasing trend up to 2004. A decrease in flat sardinella biomass is recorded in 2005.

National surveys

Senegal

Two surveys were carried out by the R/V ITAF DEME in 2005. The first, during the cold season, took place between 14 and 25 May 2005. This survey was characterized by a strong presence of sardinella of which the total biomass (780 000 tonnes) represents 65 percent of the total pelagic biomass in the area of the continental shelf surveyed (1.2 million tonnes). The round sardinella, present in the north from Sangomar to Saint-Louis, was estimated at around 400 000 tonnes, whereas the flat sardinella, present in the south from Dakar and southwards, was estimated at about 380 000 tonnes.

The second survey took place between 30 October and 9 November 2005, in parallel with the Norwegian research vessel R/V DR. FRIDTJOF NANSEN. It revealed a very strong presence of flat sardinella on the Senegalese and Gambian continental shelf during the warm season. Effectively of a total pelagic biomass estimated at 1.2 million tonnes, the flat sardinella made up more than 620 000 tonnes, that is over half of the total biomass. The relatively weak biomass of the round sardinella was also highlighted by this survey. It was estimated at only 95 000 tonnes and concentrated mainly in the area of the Petite Côte.

Mauritania

In Mauritania, the Mauritanian research vessel R/V AL-AWAM carried out two surveys in the interval between Working Groups, the first in November 2005 and the second in March 2006. The results are only available for the first survey. A strong recruitment of *S. aurita* was observed with length classes varying between 8 and 16 cm. The biomass was estimated at 66 000 tonnes, 44 000 tonnes to the south of Cape Timiris and 22 000 tonnes to the north. This is corroborated by the recruitment survey carried out by the R/V ATLANTIDA in January 2005 in the Mauritanian EEZ.

The estimated biomass of *S. maderensis* is 225 000 tonnes, 155 000 tonnes to the south of Cape Timiris and 70 000 tonnes to the north. The main mode is 26 cm with a second mode of around 8 cm also being observed.

Morocco

The Moroccan research vessel R/V AL-AMIR MY ABDALLAH carried out four acoustic surveys in 2005. One of these was an intercalibration survey with the R/V DR. FRIDTJOF NANSEN in November–December 2005 which took place in the zone located between Cape Boujdor and Cape Blanc.

The estimated biomass of the two sardinella species by the Moroccan vessel is in the order of 410 000 tonnes which represents 68 percent of that estimated by R/V DR. FRIDTJOF NANSEN.

3.4 Sampling of commercial fisheries

Tables 3.4.1 and 3.4.2 show the sampling intensity of *S. aurita* and *S. maderensis* in 2005.

Mauritania

The number of length frequency samples for *S. aurita* for the EU fleet (The Netherlands) is 125 on a catch of 78 000 tonnes (1.6 samples per 1 000 tonnes). This represents a decrease in comparison to 2004, when the frequency was 2.5 samples per 1 000 tonnes.

For the non-EU fleet (Russian Federation, Ukraine and others), 83 samples of *S. aurita* were taken for a catch of around 80 000 tonnes (1 sample per 1 000 tonnes). This was an improvement on 2004 (0.43 sample per 1 000 tonnes).

For *S. maderensis*, the level of sampling was of 2.6 samples per 1 000 tonnes for the EU fleet and 4.2 samples per 1 000 tonnes for the non-EU fleet (Russian Federation, Ukraine and others).

Even though the catch level of the Mauritanian artisanal fishery passed 20 000 tonnes in 2005, no sampling was carried out.

Senegal

In 2005, the lack of balance in the artisanal fishery sampling, noted the previous year, was rectified (Table 3.4.1). The number of samples passed from 43 to 374 for *S. aurita*, which represents 3 samples per 1 000 tonnes compared with 0.39 in 2004. For Pour *S. maderensis*, 180 samples were taken compared to the 60 in 2004.

Gambia

In the Gambia, sampling of pelagic fish has not yet begun.

3.5 Biological data

In 2005, the ratio of the two species of sardinella in the catches of the Russian vessels differs from that of the preceding year (Figure 3.5.1a). The proportion of *S. aurita* declined heavily during the months of July to September both in Morocco and Mauritania.

The high abundance distribution of round sardinella observed around Cape Blanc was exceptional and reproduction which normally stops in August, continued until October. Abnormal positive temperatures were observed during the third quarter of 2005.

Small sardinellas (11–26 cm) were found in the north as far as Dakhla, at depths of up to 100 m. These young individuals remained there until January–March, whereas their usual habitat in this season is in the shallower depths. This was corroborated by the catches of the recruitment survey of the R/VATLANTNIRO. Their index was 40 percent greater than that obtained during the last cold season survey of the same research vessel. This increase can be partly explained by the distribution described earlier.

Following the decision taken by the Working Group in 2004, all length measurements are expressed in total length (TL). For the years before 2004, the length frequencies of *S. aurita* expressed in fork length (FL) were transformed into total length using the equation TL = 1.21FL – 0.857.

Figure 3.5.1b shows the length frequencies of *S. aurita* in the Dutch catches in Mauritania for the period 1999–2005. One can see a predominance of fish with a length of around 35 cm during the early years (1999–2002). From 2003, fish of a length greater than 35 cm disappear from the catches and the modal length moves towards a length of 30–32 cm. These changes in length frequency are relatively consistent and show the probable effect of the Dutch industrial fishery on the demographic structure of *S. aurita* in Mauritania with a reduction in lengths of the round sardinella over a period of time.

The results of the R/V DR. FRIDTJOF NANSEN acoustic survey (Figure 3.5.2) in December 2005 highlight a weak abundance of *S. aurita* adults in Mauritania and Senegal. The greatest lengths are observed in Morocco, between Cape Boujdor and Cape Blanc, with modes of 9 and 32 cm for *S. aurita*.

3.6 Assessment

Method

The Schaefer logistic production model adapted for an Excel spreadsheet was used. This model is described in detail in Annex II. The same model, also used on an Excel spreadsheet, allowed catch and abundance projections to be made for a period of five years (Annex III).

Data

The model requires a time series of total catch as well as stock abundance indices.

Total catch estimates obtained by adding the catches of the different national fleets were used as the catch series.

The production model was applied to the *S. aurita* data and the two species grouped using abundance indices from the R/V DR. FRIDTJOF NANSEN acoustic surveys (Table 3.2.1a,b and Figure 3.3.2d).

In the data series, 1999 represents an exceptional year, with stock growth conditions that can only be explained by the dynamic parameters of the stock. Research has revealed that 1999 showed strong upwelling activity. An environmental index taking into account the peculiarity of 1999 has therefore been incorporated into the model.

Results

Results from fitting the model are shown in Figures 3.6.1 and 3.6.2.

Sardinella aurita

For *S. aurita*, the results from the 2006 model are compared with those of 2005 in Table 3.6.1. They show a quite different perspective than those of the previous year. The model does in fact show a worrying situation with a biomass below that necessary to produce the maximum sustainable yield. Actual effort is 303 percent of the F_{MSY} level and 340 percent of the $F_{0.1}$ level.

***Sardinella* spp.**

Combining the data for the two sardinella species also shows a more worrying situation than that of the previous year. Present biomass is below that necessary to extract maximum sustainable yield and fishing effort is 165 percent of the MSY biomass level. With respect to the $F_{0.1}$ level, current effort is 212 percent of the target level.

Table 3.6.1: Summary of the results of fitting the model using the abundance indices of R/V DR. FRIDTJOF NANSEN. The results from last year are between brackets.

Stock/abundance index	$B_{cur}/B_{0.1}$	F_{cur}/F_{SYcur}	F_{cur}/F_{MSY}	$F_{cur}/F_{0.1}$
Sardinella aurita/Nansen	46 % (58 %)	205 % (80 %)	303 % (110 %)	340 % (122 %)
Sardinella spp./Nansen	77 % (85 %)	165 % (91 %)	192 % (96 %)	212 % (107 %)

$B_{cur}/B_{0.1}$: Relationship between the estimated biomass for the last year and the corresponding biomass at $F_{0.1}$.
F_{cur}/F_{SYcur}: Relationship between the fishing mortality coefficient observed over the last year of the series and the coefficient that would provide a sustainable yield at the current biomass level.
F_{cur}/F_{MSY}: Relationship between the fishing mortality coefficient observed over the last year of the series and the coefficient that would provide a sustainable yield over the long term.
$F_{cur}/F_{0.1}$: Relationship between the fishing mortality coefficient observed over the last year of the series $F_{0.1}$.

Discussion

The differences between the 2006 and 2005 results are related to a heavy decline in the acoustic index (a reduction of 50 percent between 2004 and 2005).

The results of the current modelling are very different from those of the previous year. Last year, the Working Group concluded that the two species together showed a slight increase in Biomass and that effort was close to the MSY level. The situation was more critical for *S. aurita*. The results now show a decrease in biomass and a level of effort two to three times higher than the MSY level. This situation is even more severe for the round sardinella.

The current analysis, although showing fluctuations in abundance from one year to the next, appears to confirm the decreasing trend in abundance of the round sardinella mentioned above. The reduction in stock of the round sardinella is additionally confirmed by the decrease in length of this species in the Mauritanian industrial fishery and the disappearance of individuals of a length greater than 35 cm in the catches of the EU fleet. It should also be underlined that the proportion of *S. aurita* in the Russian fleet sardinella catches decreased drastically between the months of July and September both in Morocco and in Mauritania.

3.7 Predictions

Using the outcomes from the models, a projection of catch and abundance for the two sardinella species was carried out for a period of five years. Two scenarios were considered, one with a constant effort and the other with a reduction in effort of 50 percent.

In the scenario where effort was maintained at its current level, a continual decrease in catch is indicated. Abundance falls drastically over the course of time (Figure 3.7.1).

In the case of a 50 percent reduction in effort, catches increase and so does the abundance index, reaching a level above that of the biomass in equilibrium (Figure 3.7.2).

Applying this measure should allow sardinella biomass to recover to the level extracting maximum sustainable yield.

3.8 Management recommendations

The results indicate that the sardinella stock is overexploited (especially the round sardinella). In order for the stock to recover to the MSY level of catch, a 50 percent reduction in effort is recommended as shown by the projection, which corresponds to a catch of 220 000 tonnes in 2007.

As the pelagic fishery is multispecific, it is urgent that management measures be taken with an aim to decreasing effort on the round sardinella with a regulation which takes into consideration the following proposals:

- To fix the quotas between countries.
- To divide the pelagic licences into two categories (one licence for clupeids and one for carangids and other species).
- To encourage a reduction of selected fishing gears towards the round sardinella (mainly for the artisanal fishery).

3.9 Future research

The Working Group recommends that research be undertaken in the following domains:

1. Continue the programme of otolith exchange for sardinella age reading.
2. Create a study group between Senegal, Mauritania and Morocco in 2006 to analyse the length-distribution of sardinella in depth.
3. Begin sardinella sampling in the artisanal fishery of the Gambia.

4. HORSE MACKEREL

The two main species considered for the assessment are the Atlantic horse mackerel (*Trachurus trachurus*) and the Cunene horse mackerel (*Trachurus trecae*). For the false scad (*Caranx rhonchus*), only catch data are given.

4.1 Stock identity

This section was described in the previous Working Groups (FAO, 2001 and 2002). Supplementary studies are however necessary for a better assessment of the results already obtained.

4.2 Fisheries

The exploitation of this resource is mainly carried out by foreign industrial fleets.

Catch

Catches of the species under consideration have seen large variations, going from around 200 000 tonnes in 2003, to 400 000 in 2004 and 360 000 in 2005 (Figure 4.2.1). The artisanal share of the catches remains very low: 1.2 percent in 2004 and 1.6 percent in 2005.

The Cunene horse mackerel (*T. trecae*) is the most important species, with a catch of around 220 000 tonnes in 2005, followed by the Atlantic horse mackerel (*T. trachurus*) with around 120 000 tonnes and the false scad (*Caranx rhonchus*) with 20 000 tonnes. The annual trends in catch of the three horse mackerel species are given in Figure 4.2.1. The catch data series for the three horse mackerel species is given by country and for the whole of the subregion in Tables 4.2.1a, b and c for the period 1990–2005.

Total catch of *T. trecae* has seen a significant increase from more or less 180 000 tonnes in 2004 to around 220 000 in 2005. Despite the partial effort reduction of the Russian fleet in the Mauritanian zone, almost all the catch of this species comes from this zone. Catch of *T. trachurus* saw a sharp decline in 2005 but remains high in respect to the whole of the series (with the exception of 2004). As for *Caranx rhonchus*, landings have halved, going from 45 000 tonnes in 2004 to 20 000 in 2005.

Effort

In 2005, a marked withdrawal of the Russian fleet from the Mauritanian zone can be seen. This translates into a 50 percent reduction in the fishing effort of this fleet in respect to 2004 (Figure 4.2.2). This decrease in Russian effort is partly compensated by the commencement of activity of two South African vessels and of vessels flying the Mauritanian flag as well as an increase in the activity of the Russian and Ukrainian fleets in the Moroccan zone.

In the south of Morocco, the industrial fleets (Russian Federation, Ukraine and others) carried out 3 200 fishing days, divided equally between the Russian and Ukrainian fleets. In this zone there are also purse seiners (RSW) which catch horse mackerel as bycatch and which carried out 2 000 fishing days in 2005.

In Senegal horse mackerel fishing is carried out both by an industrial fishery which is in decline and an artisanal fishery which catches them as bycatch. Fishing effort remains weak and proves to be negligible in the Gambia with respect to that of the northwest African region.

Recent developments

As well as the Russian fleet which recommenced activity in this zone in 2004, Moroccan operators continued to charter pelagic trawlers in 2005.

In Mauritania, two South African vessels are authorised to fish as well as chartered national vessels. This has partially compensated for the withdrawal of several vessels from the Russian fleet.

4.3 Abundance indices

4.3.1 Catch per unit of effort

The fishing effort of the Russian fleet was used to obtain a CPUE series for the two horse mackerel species. The CPUE index was calculated on the base of average daily catch of the Russian fleet during the months when the species is considered to be dominant in the catches (November–April for *T. trachurus* and May–October for *T. trecae*). The results are shown in Figures 4.3.1a and 4.3.1b. For *T. trecae* the series is relatively stable over almost the whole period. Even taking into consideration that the industrial fleet follows this species, it is hard to explain such stability over such a long period. This probably translates into the use of a standardisation of the Russian effort which is not appropriate for this species.

4.3.2 Acoustic surveys

Acoustic surveys aim to estimate the biomass and abundance of the stocks, the distribution of the fish and the length composition of the different small pelagic stocks (including horse mackerel) in the northwest African zone.

R/V DR. FRIDTJOF NANSEN

Abundance assessments by R/V DR. FRIDTJOF NANSEN highlight the fluctuating nature of the two Trachurus species (*T. trachurus* and *T trecae*) over their whole distribution zone (Figures 4.3.2a, b, c and d). In 2004, the biomasses of the two horse mackerel species were corrected. The values that should be taken into consideration are 730 000 tonnes for *T. trecae* (instead of 315 000) and 180 000 tonnes for *T. trachurus* (instead of 575 000).

The only recorded concentration of *T. trachurus* in 2005 is located between Cape Juby and Cape Blanc. It reaches 145 000 tonnes. In 2005, the global biomass of *T. trecae* is greater than 1.2 million tonnes. It is detected less and less from the north to the south. In respect to 2004, the year in which concentrations of this species were distributed over the whole region, in 2005, the species is found solely to the south of Morocco. This is surprising insofar as this species is considered to be a tropical species. It can be explained in part by the difficulty in separating the echoes of this species from those of *T. trachurus*, a more temperate species which has the same morphology and is more abundant in the sector. However, taking into account the survey period (October–December), a similar distribution can be expected.

False scad (*Caranx rhonchus*) are distributed from Cape Timiris to the south of Senegal. Amounts of around 50 000 tonnes have been detected in the Mauritanian zone, and 35 000 tonnes in Senegal.

R/V ATLANTIDA

This vessel did not carry out an acoustic survey in the region in 2005. However, for the third consecutive year, a horse mackerel recruitment survey was carried out between November 2005 and January 2006 in Morocco and Mauritania. It is not currently possible to provide recruitment predictions on the basis of these surveys.

National surveys

R/V AL AWAM

In Mauritania, the research vessel R/V AL AWAM carried out a survey in November 2005. The biomass of *T trecae*, the only horse mackerel species found, was estimated at 435 000 tonnes, of which 180 000 tonnes to the south of Cape Timiris and 255 000 tonnes to the north.

R/V ITAF DÈME

The research vessel R/V ITAF DÈME carried out a survey in November 2005 in Senegal and the Gambia. Horse mackerel were found almost exclusively to the south of Cape Vert and their biomass was estimated at around 205 000 tonnes of which more than half was in the Gambian zone.

R/V AL AMIR MY ABDELLAH

The Moroccan research vessel R/V AL AMIR MY ABDELLAH carried out an acoustic assessment survey between Cape Catin and Cape Blanc in November–December 2005. The zone between Cape Blanc and Cape Boujdor was surveyed jointly with the R/V DR. FRIDTJOF NANSEN. During this mission, the Moroccan vessel estimated the biomass at 370 000 tonnes for both horse mackerel species. Between Cape Boujdor and Cape Catin, the R/V AL AMIR MY ABDELLAH estimated a biomass of 16 000 tonnes.

4.4 Sampling of commercial fisheries

In Mauritania, biological sampling on board Russian and Dutch vessels is carried out by IMROP scientists and Russian researchers. In 2005, IMROP sampling effort extended to other industrial pelagic fleets. The sampling also covers population dynamic parameters (age reading, growth, reproduction, food, etc.). From 2006, this effort will be stepped up by involving observers from the delegation surveillance and control at sea.

In Morocco, sampling is concentrated on the Russian fleet operating in zone C and the Moroccan fleet of purse seiners.

As regards the Senegalese fleets, horse mackerel sampling improved in 2005.

As in the past, sampling intensity has been presented by quarter for the two main fleets (Russian and EU), incorporating the results from the other Mauritanian industrial fleets and the Senegalese artisanal fleets (Tables 4.4.1, 4.4.2 and 4.4.3).

During 2005, all three horse mackerel species were sampled. For the Russian fleet operating in Moroccan waters, sampling was carried out in the second half of the year, with 124 samples for the two *Trachurus* species, and in the third quarter for *Caranx rhonchus*.

In Mauritania, *T. trachurus* sampling was carried out throughout the year for the Russian and Ukrainian fleets, but only in the first half of the year for the EU fleet. In total, 79 samples were collected.

In Senegal sampling of *T. trecae* was done throughout the year for the artisanal fishery and during the first quarter for the industrial fishery.

Sampling intensity

Trachurus trachurus

Overall, in Morocco, sampling intensity improved in 2005 compared to 2004. The Moroccan fleet operating in zone A was sampled with an intensity of 2 per 1 000 tonnes in 2005. On the other hand, the Moroccan fleets operating in the northern zones, B and C (north of Cape Blanc) are still not being sampled.

For the Russian fleet operating in zone C (north of Cape Blanc), sampling intensity has strongly decreased, from 42 per 1 000 tonnes in 2004 to 3 in 2005. The number of individuals measured has also greatly decreased, falling from 114 920 tonnes in 2004 to 38 700 tonnes in 2005.

As regards age reading, only the Russian Federation carried out any otolith readings. In 2004, 1 991 individuals were aged and 1 131 in 2005.

In Mauritania, sampling intensity on board the EU fleet has severely declined, going from 19 per 1 000 tonnes in 2004 to 3 in 2005. This is partly due to the transfer of sampling effort by the IMROP scientists to other fleets (mainly ex-USSR). Thus sampling effort by Russian observers and IMROP scientists on board the non-EU fleet increased in 2005 from 1 per 1 000 in 2004 to 10 in 2005.

Trachurus trecae

Sampling effort improved in 2005. In addition to sampling the Russian fleet operating in zone C and the EU and non-EU fleets in Mauritania in 2004, the industrial and artisanal fisheries of Senegal were sampled in 2005 with a respective intensity of 3 and 32 per 1 000 tonnes, which represents 220 and 2 966 individuals measured. Sampling effort of the Russian fleet operating in zone C north of Cape Blanc fell dramatically in 2005 from 108 per 1 000 tonnes to 6. This decrease is of the same order (108 per 1 000 tonnes to 7 between 2004 and 2005) of that of the EU fleet operating in Mauritania following the transfer of sampling to other pelagic fisheries. This decrease translates into a number of individuals measured which has fallen from more than 100 000 in 2004 to less than 20 000 in 2005. As with *T. trachurus*, the Russian scientists also carried out age readings of this species in 2004 (1 613 individuals in zone C and 1 988 in Mauritania) and in 2005 (1 225 individuals in zone C and 1 350 in Mauritania).

Caranx rhonchus

Sampling only took place in the Mauritanian zone. Sampling effort by the EU fleet increased from 8 per 1 000 tonnes to 10, and from 1 418 individuals measured to 2 497. For the non-EU fleet, sampling intensity increased from 0.5 per 1 000 tonnes (4 435 individuals measured and 496 of these age read) to 2 (7 638 individuals measured and 1 060 of these age read).

4.5 Biological data

Analysis of the horse mackerel length frequencies obtained during the trawl surveys allows the length composition of the stocks to be studied.

R/V DR. FRIDTJOF NANSEN

For *T. trecae*, length frequencies from the acoustic survey carried out in 2005 show the presence of a group of young individuals of 12 cm in the zone from Cape Juby to Cape Blanc. A second group of individuals, less important and relating to older fish (23 cm) was observed in the same sector. Two other smaller modes are present in the sector between Cape Blanc and Saint-Louis (11 and 13 cm). Another small group of individuals with a mode of 24 cm was observed to the south of Senegal (Figure 4.5.1a).

The only recorded concentration of *T. trachurus* in 2005 was that situated between Cape Juby and Cape Blanc. Two groups of individuals were present. The first corresponds to young individuals (a mode of 12 cm) and the second, smaller group, to a mode of 20 cm (Figure 4.5.1b).

Length frequencies of false scad, which is distributed between Cape Timiris and the south of Senegal, show numerous modes from 13 to 27 cm.

R/V ITAF DEME

The length composition of *T. trecae*, highlighted by the research vessel in November 2005, shows the presence of a main mode of 26 cm and a secondary one of 11 cm (Figure 4.5.2).

R/V AL-AWAM

During the November 2005 survey, only the mackerel (Cunene or African horse mackerel) was found. The main mode was 26 cm and the secondary mode, 8 cm (Figure 4.5.3).

4.6 Assessment

As already mentioned, the Working Group concentrated the assessment on the two main horse mackerel species (*T. trachurus* and *T trecae*) using a production model.

Data quality

Catch data are judged to be acceptable but not complete due to under-reporting (probable transformation of young individuals into fishmeal) and discards (especially in the case of the demersal fleets).

An exploratory analysis of total catch by age for each of the two horse mackerel species from 1990 to 2005 was carried out by calculating a correlation coefficient between the two following years. The raw data used are shown in Table 4.6.1 for *T. Trachurus* and in Table 4.6.2 for *T. Trecae*. The results (Table 4.6.3, Figures 4.6.1 and 4.6.2) show a weak correlation between catches of the same cohort over the life cycle.

Table 4.6.3: Values of R^2 between the estimated catches of horse mackerel by consecutive age of the same cohorts

Species/age	1–2	2–3	3–4	4–5	5–6	6–7
Trachurus trachurus	0.10	0.23	0.10	0.21	0.28	0.53
Trachurus trecae	0.04	0.12	0.04	0.12	0.002	0.016

The lack of correlation between the ages could be due, amongst other things, to the lack of data covering the whole of the distribution zone of the stocks and to the difficulty in age reading this species. Catch of most of the vessels is not regularly followed and the scientific on board observer programme does not cover the whole year. What further complicates the situation is that the catches are not split into species level.

Methods

The Schaefer logistic production model adapted for an Excel spreadsheet was used for the assessment (the model is described in Annex II). This year the Working Group produced a medium term projection (over five years) of the abundance and catch following the application of different management scenarios using the same model in another spreadsheet (Annex III).

Input data

The Working Group prepared the data for the two species for the dynamic production model. For both, two types of abundance index are available: the CPUEs provided by the Russian scientists (1991–2005) and the biomasses obtained by the R/V DR. FRIDTJOF NANSEN (1995–2005).

The model was run using both of these and the total catch estimated by the Working Group for 1990–2005.

Run 1: Standardized catch per unit of effort using the Russian BATA vessels operating in the Mauritanian zone in May–July from 1991 to 2005 for *T. trachurus* and *T. trecae*.

Run 2: Abundance index from the R/V DR. FRIDTJOF NANSEN in November–December from 1995 to 2005, for *T. trachurus* and *T. trecae*.

Run 3: Abundance index from the R/V DR. FRIDTJOF NANSEN in November–December from 1995 to 2005, for the two combined horse mackerel species.

An environmental effect was introduced into the model in order to take into account the anomalies observed in the series for certain years.

Results

Trachurus trachurus

The model was run using the abundance index series of the R/V DR. FRIDTJOF NANSEN. For reasons of comparison, the standardized Russian CPUE series was also used (Table 4.6.5 and Figures 4.6.3 and 4.6.4). The Pearson correlation coefficients are respectively 0.92 and 0.70.

The current biomass is close to the level of $B_{0.1}$ but the level of fishing clearly exceeds that which would keep exploitation at an acceptable level.

Table 4.6.5: Summary of the current state of the *T. trachurus* stock and fishery using the R/V DR. FRITDJOF NANSEN indices. The results obtained using the standardized Russian CPUEs are given for comparison.

Stock /abundance index	**$B/B_{0.1}$**	**F_{cur}/F_{SYcur}**	**F_{cur}/F_{MSY}**	**$F_{cur}/F_{0.1}$**
*T. trachurus/*R/V DR. FRIDTJOF NANSEN	108 %	132%	136%	151%
*T. trachurus/*Russian standardized CPUEs	126%	155%	134%	160%

$B_{cur}/B_{0.1}$: Relationship between the estimated biomass for the last year and the corresponding biomass at $F_{0.1}$.
F_{cur}/F_{SYcur}: Relationship between the fishing mortality coefficient observed over the last year of the series and the coefficient that would provide a sustainable yield at the current biomass level.
F_{cur}/F_{MSY}: Relationship between the fishing mortality coefficient observed over the last year of the series and the coefficient that would provide a sustainable yield over the long term.
$F_{cur}/F_{0.1}$: Relationship between the fishing mortality coefficient observed over the last year of the series $F_{0.1}$.

Trachurus trecae

The fit of the model with the estimated biomass indices from R/V DR. FRIDTJOF NANSEN is shown in Figure 4.6.5. For comparison, the model was run again with the standardized Russian CPUEs. The fit of both models is relatively satisfactory as for both the Pearson correlation coefficient is above 0.73. Given the high stability, as already mentioned, of the CPUEs (which is difficult to explain), the Working Group decided to adopt the run using the Nansen index as the best description of the state of the stock.

The results show that the current biomass is above the biomass level $B_{0.1}$, on average, and that current fishing mortality is considerably less than the level of fishing mortality $F_{0.1}$ (Table 4.6.6). The stock is not fully exploited.

Table 4.6.6: Summary of the current state of the stock and fishery of the *T. trecae*

Stock /abundance index	**$B/B_{0.1}$**	**F_{cur}/F_{SYcur}**	**F_{cur}/F_{MSY}**	**$F_{cur}/F_{0.1}$**
*T. trecae/*R/V DR. FRIDTJOF NANSEN	159 %	116 %	66 %	73 %

$B_{cur}/B_{0.1}$: Ratio between estimated biomass for the last year of the series and the biomass corresponding to $F_{0.1}$.
F_{cur}/F_{SYcur}: Ratio between the observed fishing mortality coefficient from the last year of the series and that which would produce a sustainable catch at the current biomass level.
F_{cur}/F_{MSY}: Ratio between the observed fishing mortality coefficient from the last year of the series and that which would extract maximum sustainable yield over the long term.
$F_{cur}/F_{0.1}$: Ratio between the observed fishing mortality coefficient from the last year of the series and $F_{0.1}$.

Discussion

For *T. trachurus*, the results of the model show that very similar outcomes can be obtained using different indices, even if the length of the acoustic survey time series is 30 percent shorter than that of the catch per unit of effort series. This is particularly important if one takes into account the number of unknown parameters in the model and the existence of uncontrollable variations in the two indices due to the multispecific nature of the fisheries and the catch of only large individuals in the case of the commercial Russian fleets. The fit of the model shows that the total current biomass of this species is close to the level $B_{0.1}$, but that current fishing mortality is above that corresponding to $F_{0.1}$.

For *T. trecae*, the Russian CPUEs obtained for the Mauritanian zone are probably not proportional to those of other fisheries in other sectors (Morocco and Senegal).

In multispecific fisheries, as is our case, a major problem in applying the production model rests in the estimation of the effective effort that corresponds to the fishing mortality exercised on the different populations that make up a composite stock exploited by several artisanal and industrial fleets. Fishing vessels look for the most widely available species and this tends to accentuate the natural variations in availability. Estimation of effort data is therefore one of the most important and delicate aspects of the global approach and greatly conditions its effectiveness. The biological characteristics of the resource, the nature of the fisheries and the quality of the available data effectively impose a delicate and progressive shaping of the effort, catch and estimated yield values.

The horse mackerel fisheries in the northwest African zone have seen very strong changes over the course of the last few years: partial or total withdrawal from one zone then redeployment in another zone. These large variations in the system of exploitation make stock assessment difficult and the conclusions often risk being uncertain.

4.7 Predictions

In order to have more information on which to base a decision, the Working Group decided to carry out a projection of the next five years. Two management scenarios were adopted to analyse the results for each stock.

1st scenario: Keep fishing effort at its current level (status quo).

2nd scenario: Change the current level of effort to obtain a better long term yield (decrease by 20 percent).

The projection was carried out for the next five years.

Trachurus trachurus

If fishing effort is maintained at its current level, catch and biomass (Figure 4.7.1a) will continue to decrease in respect to current catches and the target $B_{0.1}$ value over the next five years.

To bring catches to their current level and the biomass to the target biomass (Figure 4.7.1b), a decrease of 20 percent in effort is necessary, this corresponds to a catch level of 90 000 tonnes. This decrease in fishing effort would bring about the best medium term yield.

Trachurus trecae

Using the first scenario (status quo) catches decrease slightly before rapidly stabilising from 2007 onwards (Figure 4.7.2a). Biomass remains stable at 130 percent of the target $B_{0.1}$ value over the next five years (Figure 4.7.2a).

If a 20 percent decrease in fishing effort is introduced, the catch stabilises from the first year of the projection at 70 percent of the MSY value (Figure 4.7.2b) and biomass remains at 140 percent of the target value (Figure 4.7.2b).

4.8 Management recommendations

Analysis of these stocks indicates that their biomass is close to the $B_{0.1}$ level. For *T. trachurus*, the fishing level does not exceed the target fishing level $F_{0.1}$. For *T. trecae*, the stock is not fully exploited. However, given the multispecific nature of the horse mackerel fisheries and the high level of exploitation of *T. trachurus*, the Working Group recommends a 20 percent reduction in fishing effort in 2007, which corresponds to a catch level of 260 000 tonnes.

This recommendation is also justified by the current exploitation level of sardinella for which a reduction of 50 percent is proposed.

4.9 Future research

To reduce uncertainties in the assessment and to be able to apply analytical models, the Working Group recommends the following:

1. Improvement in the sampling of all catches in all segments of the fleet. This improvement in biological sampling should be carried out by putting scientists from both national and fishing countries on board the fishing vessels to ensure a satisfactory coverage of all segments of the fleet operating in the zone so as to better understand the specific composition of the landings and the discards and to carry out detailed biological studies (reproduction, growth, feeding, etc.).

2. Provide a series of standardized CPUEs for the region based on generalized linear methods which use fisheries statistics from different sources (Working document).

3. Encourage the use of polymodal decomposition techniques of length frequencies to be able to evaluate these. The importance of the available length frequency data, currently used for illustration purposes, shows a lack of thorough processing of these data where stock assessment by structured models is concerned.

4. Follow the recruitment surveys closely and produce a detailed working document on these for the next session.

5. MACKEREL

5. 1 Stock identity

The distribution of mackerel (*Scomber japonicus*, Houttuyn 1782) has been described during previous Working Groups (FAO 2001, 2002, 2003 and 2004).

Two mackerel stocks have been identified in the northwest African region. The northern stock is situated between Cape Boujdor and the north of Morocco. The southern stock is situated between Cape Boujdor and the south of Senegal. The Working Group has not yet been provided with any update on stock identity.

Since the 2003 meeting, due to migration and uncertainties in identification of the two stocks and the migration of mackerel, the Working Group has decided to assess the two stocks jointly over the whole distribution area.

5.2 Fisheries

In the northern zone (Tangiers–Cape Boujdor), the mackerel fishery is carried out solely by the Moroccan fleet. This fleet comprises coastal purse seiners that mainly target sardine but also mackerel when these are available.

The zone between Cape Boujdor and Cape Blanc is exploited not only by Moroccan coastal purse seiners but also by vessels chartered by Moroccan operators and by pelagic trawlers that operate under the fishing agreement signed between Morocco and the Russian Federation.

Several pelagic trawlers from different countries (Russian Federation, Ukraine, European Union and others) operate in the Mauritanian zone, targeting mackerel seasonally.

In Senegal and the Gambia, mackerel is considered as bycatch by the artisanal Senegalese fishery.

Catch

Annual catch by country of *Scomber japonicus* for the period 1990–2005 is given in Table 5.2.1 and Figure 5.2.1.

Catch of the northern fishery (north of Cape Boujdor) varied between 11 000 and 62 000 tonnes during 1990–2005. Landings continually increased from 2002 to 2005 going from around 22 000 tonnes in 2002 to a record catch of 62 000 tonnes in 2005. This catch was mainly from zone A where the catch was the highest of the series, 45 000 tonnes (Table 5.2.1 and Figure 5.2.1). Catches between Cape Cantin and Cape Spartel have seen an increase of 72 percent whereas those of zones A and B have only witnessed a slight variation.

Catches in zone C (between Cape Boujdor and Cape Blanc), carried out under fishing agreements with the Russian Federation and by chartered vessels, progressively increased during 1993–1998, reaching a maximum of about 150 000 tonnes in 1998. Since then, there has been a continual decrease in catch due to the end of the above mentioned agreements, the departure of the Russian vessels in 1999 and of the Ukrainian and other chartered vessels in 2001. During 2005, catches in zone C reached 76 000 tonnes, an increase of 15 percent over the year 2004. These catches were recorded by Russian, Ukrainian and other vessels (70 percent) and by the Moroccan fleet (30 percent).

In Mauritania, total mackerel catch shows an increasing trend between 1990 and 1996. In 1996, the catch reached around 100 000 tonnes. After that the catch decreased progressively, reaching its lowest level of about 20 000 tonnes in 1999 before improving again and registering a new record in 2003, for the 1990–2005 period, of around 135 000 tonnes. Since 2003, catches have declined. In 2005, mackerel catch in Mauritania dropped by 60 percent with respect to 2004 (Table 5.2.1 and Figure 5.2.1).

For Senegal and the Gambia, the species is only bycatch and is not targeted. In Senegal, catches reached a value of 14 000 tonnes in 2003 but have declined over the last two years.

Between 1991 and 2001, total mackerel catch for the whole subregion shows a continual increase, reaching a maximum value in excess of 200 000 tonnes in 1997. Following this, total catch fluctuated around 175 000 tonnes on average with, in 2004, a record catch in excess of 224 000 tonnes. In 2005, catch fell by 20 percent with respect to the previous year (Table 5.2.1 and Figure 5.2.1).

Effort

Effort for mackerel is considered to be the same as that for sardine and sardinella.

In zone C, fishing effort showed an increasing trend from 1993 reaching a maximum in 1998 of 7 400 days at sea. After that it progressively decreased due to the end of the fishing agreement with the Russian

Federation (1999) and with the chartered vessels (2001). Since the signing of new agreements and chartering in 2004, fishing effort in Zone C has begun to increase.

In Mauritania, as the fishery is multispecific, fishing effort of the industrial fleet, expressed in days at sea, is the same as that of the sardinella and horse mackerel fishery.

Recent developments

Mackerel catches to the north of Cape Blanc have increased in a remarkable way since 2004. This increase is due in part to the recommencement of fishing in zone C under the Morocco–Russian Federation fishing agreement and to chartering (in addition to a few Moroccan purse seiners that operate in this zone) and, in part, to the availability of mackerel to the northern fishery (north of Cape Boujdor) which allowed the Moroccan purse seiners to obtain record catches of around 60 000 tonnes in 2005. Catch in zone C (north of Cape Blanc) reached about 75 000 tonnes in 2005.

5.3 Abundance indices

5.3.1 Catch per unit of effort

CPUEs were calculated according to the method described in the 2004 Working Group report. In 2005 it can be seen that the CPUEs in tonnes RTMS/day registered a considerable decrease (Table 5.3.1 and Figure 5.3.1).

5.3.2 Acoustic surveys

R/V DR. FRIDTJOF NANSEN

Since 1999 the biomass of this species has been estimated by a series of acoustic surveys carried out by the R/V DR. FRIDTJOF NANSEN. The series of mackerel biomass between Cape Blanc and Cape Cantin shows an increasing trend (Figure 5.3.2). In 2005, the biomass was estimated jointly by the R/V DR. FRIDTJOF NANSEN and the R/V AL AMIR MY ABDELLAH at 850 000 tonnes. It should be noted that the R/V DR. FRIDTJOF NANSEN did not cover the zone between Cape Boujdor and Cape Cantin and that the biomass in this zone was estimated by the R/V AL AMIR MY ABDELLAH.

R/V ATLANTNIRO and R/V ATLANTIDA

Between 1994 and 2004, mackerel biomass in Moroccan waters and to the north of Mauritania was estimated between 100 000 and 900 000 tonnes (FAO, 2005) during the acoustic surveys carried out by the R/V ATLANTNIRO (Figure 5.3.3).

During the recruitment survey carried out by the R/V ATLANTNIRO in autumn 2003, covering the zone between 16 °N and 32 °N, 214 pelagic trawls were carried out. The highest concentrations of mackerel juveniles were found between Cape Juby and Cape Barbas. Another recruitment survey was carried out between December 2004 and January 2005 by the R/V ATLANTIDA which detected high concentrations of mackerel juveniles in the same zones. The abundance indices of the 0+ and 1+ age classes were similar to those of 2003. During the same season, the R/V ATLANTNIRO carried out a third recruitment survey, concluded in January 2006. Juveniles were found in the same zones with very high abundance indices for the 0+ and 1+ age classes.

Table 5.3.2: Abundance indices of mackerel juveniles from the recruitment surveys in the center–east Atlantic region (expressed in thousands)

Years	Age classes	
	0+	1+
2003	4 537 947	1 023 515
2004	3 527 663	915 899
2005	4 344 558	1 402 984

National surveys

Morocco

The Moroccan research vessel R/V AL-AMIR MY ABDALLAH carried out four acoustic surveys in 2005 of which one during the intercalibration with the Norwegian vessel R/V DR. FRIDTJOF NANSEN in November–December 2005 in the zone situated between Cape Boujdor and Cape Blanc. During this survey mackerel biomass to the north of Cape Boujdor was estimated by the R/V AL-AMIR MY ABDALLAH at 613 000 tonnes. It should be noted that a conversion factor of 0.79 was used for the biomass between R/V AL-AMIR MY ABDALLAH and the R/V DR. FRIDTJOF NANSEN.

Mauritania

The Mauritanian research vessel R/V AL-AWAM carried out two acoustic surveys one in November 2005 and one in March 2006. The first survey was carried out jointly with the R/V DR. FRIDTJOF NANSEN. There is still no acoustic biomass estimation of mackerel in Mauritania.

5.4 Sampling of commercial fisheries

Sampling intensity of mackerel lengths for the year 2005 in the northwest African zone is given in Table 5.4.1.

Morocco

For the northern fishery exploited by the Moroccan coastal purse seiners, a total of 130 samples were taken in 2004 in zone A+B, for a total of 6 319 individuals (50 individuals per sample). In 2005, sampling took place the whole year, and 144 samples were taken with a total number of individuals of 7 123 (50 individuals per sample). Sampling intensity was slightly lower in zone A, going from 2.7 per 1 000 tonnes in 2004 to 2.4 in 2005. On the other hand, it increased in zone B, going from 1.8 per thousand tonnes to 8.4 between 2004 and 2005.

For the southern fishery (north of Cape Blanc) a total of 284 samples were taken composed of 75 416 individuals by the Russian fleet in 2004 (on average 265 individuals per sample). Sampling took place the whole year and age reading was carried out on 1 722 individuals. In 2005, 126 samples were taken for a total of 42 312 individuals (335 individuals per sample). Age reading was carried out on 1 623 individuals. Sampling however only took place in the second half of the year and the sampling intensity decreased from 4.9 per 1 000 tonnes in 2004 to 3.1 in 2005.

Mauritania

For the Mauritanian fishery, length sampling was carried out on board pelagic trawlers by IMROP scientists and Russian observers. 287 samples were taken in 2004. Composed of more than 65 118 individuals (70 individuals per sample), the majority came from the non-EU fleet (172 samples). In 2005, 254 samples were taken for a total of 12 097 individuals (on average 48 individuals per sample). Sampling intensity increased greatly for the two main fleets, going from 13.8 per 1 000 tonnes in 2004 to 39.6 in 2005 for the EU fleet, whereas for the non-EU fleet it went from 1.9 per 1 000 tonnes in 2004 to more than 4.3 in 2005.

Senegal

In 2005, Senegal submitted a sampling of mackerel landings for the artisanal fishery. In total 10 samples, comprising 916 individuals were taken (on average 92 individuals per sample). Effectively covering the first quarter of the year when this species is present in the fishery, sampling intensity was 1.3 per 1 000 tonnes.

5.5 Biological data

The length frequency distributions of mackerel were analysed for both the northern and southern stocks. The length distributions obtained in 2005 were compared with those of 2004 (Figure 5.5.1).

Landings of the Moroccan purse seiners in the northern fishery (zone A+B) in 2004 had a unimodal structure and showed an accentuated mode of adults (20 cm) and a weak presence of adults of a length greater than 27 cm. Landings in 2005 show a unimodal structure of mode 21 cm which is comparable with 2004. In 2005, in contrast to the 2004 observations, a weak presence of individuals of a length between 10 and 12 cm can be seen as well as the absence of any adults of a length greater than 27 cm.

For the southern fishery, length frequencies of the landings in 2004 were dominated by individuals of a length between 24 and 25 cm, whereas those of 2005 were relatively flat with no pronounced mode distinguishable. It can be seen however, that 2005 contained adults of a large length, reaching up to 46 cm even though individuals of a length between 27 and 31 cm are more prevalent.

The length frequency distribution of mackerel from the acoustic surveys carried out by the R/V DR. FRIDTJOF NANSEN in November–December 2005 on the northern and southern stocks is shown in Figure 5.5.2. Only data for the zone north of Cape Blanc are available.

In 2005, the length frequencies show two pronounced modes (18 and 23 cm) for the southern stock. The length structure is a similarly bimodal with a pronounced mode of between 12 and 13 cm and another between 17 and 20 cm.

5.6 Assessment

Data quality

In order to test the quality of the available data for the assessment, the Working Group carried out an exploratory analysis of the data by calculating the linear correlation between the estimated catches of each age group and the corresponding number of the same age class the following year. The results are given in Table 5.6.1. The correlations are considered to be too weak to assess the data using an analytical model. Nonetheless the Working Group decided to try an exploratory application of the “Extended Survivors Analysis” (Darby et Flatman, 1994).

Table 5.6.1: Values of the linear correlation coefficient between estimated catches of consecutive ages from the same mackerel cohorts

Age group	1–2	2–3	3–4	4–5	5–6
Correlation coefficient	0.59	0.33	0.34	0.60	0.71

The Schaefer logistic production model adapted for an Excel spreadsheet was used for the assessment (the model is described in Annex II). This year the Working Group produced a medium term projection (over five years) of the abundance and catch following the application of different management scenarios using the same model in another spreadsheet (Annex III).

Input data

As catch data, the Working Group used a time series of total landings in the subregion from 1992 to 2005 (Table 5.2.1).

The abundance index used was the series of commercial standardized CPUEs in tonnes/RTMS days (FAO, 2001). It was necessary to use the commercial CPUE series, despite the limitations of this for pelagic fish stocks, as the abundance indices series from the R/V DR. FRIDTJOF NANSEN acoustic surveys only began in 1999 and is therefore considered to be to short to use in the model.

Results

The fit of the model to the data was considered to be acceptable (Figure 5.6.2). The model reproduces the main trends in the abundance indices even though the time series of these does not show many fluctuations, which reduces its reliability.

The results from the model indicate that current biomass is clearly above that of the sustainable production $B_{0.1}$. Current fishing mortality, F_{cur}, is practically at the level of the fishing mortality that is necessary to maintain the current biomass level of the stock B_{cur}. It represents furthermore, around 50 percent of the level of target fishing mortality $F_{0.1}$ (Table 5.6.2).

Table 5.6.2: Summary of the current state of the stock and fishery of the mackerel *Scomber japonicus*

Stock/Abundance index	$B_{cur}/B_{0.1}$	F_{cur}/F_{SYcur}	F_{cur}/F_{MSY}	$F_{cur}/F_{0.1}$
Scomber japonicus/Russian standardized CPUE	140%	101%	46%	51 %

$B_{cur}/B_{0.1}$: Ratio between estimated biomass for the last year of the series and the biomass corresponding to $F_{0.1}$.
F_{cur}/F_{SYcur}: Ratio between the observed fishing mortality coefficient from the last year of the series and that which would produce a sustainable catch at the current biomass level.
F_{cur}/F_{MSY}: Ratio between the observed fishing mortality coefficient from the last year of the series and that which would extract maximum sustainable yield over the long term.
$F_{cur}/F_{0.1}$: Ratio between the observed fishing mortality coefficient from the last year of the series and $F_{0.1}$.

Exploratory assessment using an analytical model (XSA)

The XSA (Shepherd, 1999) allows estimates to be made of stock abundance by number of individuals, as well as for fishing mortality by age class. As input data it uses the catch-at-age matrix for the period under consideration, by number of individuals, and estimates of the natural mortality of each of these age classes. The algorithm used by the XSA for the calibration is based on the relationship between the population abundance and the CPUE.

Input data

To assess the mackerel stock, the following hypotheses were made:

i. Catchability of age classes of less than three years depends on abundance.

ii. Estimates of survivors have been limited to the average population of ages less than three years (shrinkage).

iii. Catchability is independent of age for all age classes greater than or equal to four years.

For the period 1992–2005, the catch-at-age matrix used in the model was prepared using annual mackerel catches of all the fleets fishing in the region during this period and applying the age–length keys of the Russian fleet in zone C (Table 5.6.3). The Russian age–length keys from zone C were applied to the whole stock due to the lack of age–length key data for the northern zone. All individuals of an age greater than or equal to 6 were included in the 6+ group.

Average weights of the catches by age class and by year are given in Table 5.6.4. The proportion of mature individuals (maturity ogive) is given in Table 5.6.6. The annual natural mortality used in the model was a constant, equal to 0.4, for all years and all age classes of the series.

Annual effort of all the fleets (Table 5.3.1), standardized using the Russian fleet CPUE, was used to calibrate the model. For the juvenile age classes, the model was adjusted using a type C calibration (Darby et Flatman, 1994).

Results

The Working Group did not have time to assess the quality of the analyses this year as an error was found in the age composition table and corrected (Table 5.6.3).

Discussion

The lack of contrast in the catch and abundance indices time series makes the results of the BioDyn modelling unreliable. This lack of reliability is also affected by the use of commercial CPUE data in the fit, as it is well known the CPUEs of the pelagic fish fisheries rarely reflect the abundance of the target stocks. Consequently these results should be interpreted with caution. The modelling results indicate that the stock is not fully exploited.

5.7 Predictions

For the first time the Working Group carried out medium term projections (over five years) using the Schaeffer model. These projections were used as a basis for the recommendations on small pelagic stock management. Two scenarios were put forward.

1st scenario: Maintain fishing mortality at its current level over the next five years.

2nd scenario: Increase fishing mortality by 25 percent to bring the stock to a level approaching the target biomass $B_{0.1}$.

Two figures summarize the current state of the stock and the projections based on the two scenarios (Figures 5.7.1a and 5.7.1b).

Maintaining fishing mortality at its current level, the abundance index of the catches remains relatively constant over the next five years. This scenario does not reflect an optimum fishing strategy.

If increasing fishing mortality by 25 percent, the biomass would remain stable at a level of 130 percent of the $B_{0.1}$ target value and catches would stabilise at around 200 000 tonnes.

5.8 Management recommendations

Considering the assessment results, the mackerel stock, taken as a separate stock in management terms, is not fully exploited. However, given the uncertainties surrounding the data and taking into account the fact that this stock forms part of a mixed fishery with the horse mackerel stocks for which a reduction in effort is recommended, the Working Group recommends cautiously that the level of catch does not exceed 200 000 tonnes.

5.9 Future research

1. Adopt total length (TL) to the centimetre below as the reference measurement.

2. Define a standard common method for fishing effort (Working document).

3. Continue the studies into growth and reproduction for a better understanding of the mackerel biological cycle.

4. Encourage the collection and reading of otoliths in order to prepare age–length keys for each fishing zone

5. Propose age structure analysis models (XSA, etc.) (Working document).

6. ANCHOVY

6.1 Stock identity

Anchovy (*Engraulis encrasicolus*) are distributed over the whole of the east Atlantic from the coast of Norway to South Africa. During the 1981–1982 surveys of the R/V DR. FRIDTJOF NANSEN in the subregion, the anchovy stock was found to stretch from Morocco to Sierra Leone, with a seemingly constant presence between Cape Blanc and Cape Timiris (Mauritania) and off Cape Roxo (Senegal).

The Working Group considers only one stock in the entire subregion.

6.2 Fisheries

In the subregion the anchovy is mostly fished in Mauritania and Morocco. It is not known to what extent anchovy is targeted. But presumably large quantities are caught as bycatch of certain target species of the industrial pelagic fishery in Mauritania and by Moroccan coastal purse seiners.

Catch

Catch data are given in Table 6.2.1 and Figure 6.2.1. They refer essentially to Mauritania and Morocco for the years 1990–2005. Catches increased steadily from 1996 to 2003 from around 20 000 tonnes to 180 000 tonnes in 2003. In 2004 the total anchovy catches for the subregion fell by 20 percent compared to the previous year, and in 2005 this downward trend continued and catches fell by another 40 percent compared to the previous year (Figure 6.2.1).

From 1995 onwards there was a steady increase of the Mauritanian share in the total catches, from 8 percent of the total anchovy catch in 1995 to 92 percent in 2005, while the Moroccan share showed the opposite trend in the same period. This shift in share in total catch between the two countries might be explained by the closure of the fisheries in Zone C in 2000.

Since 92 percent of the total anchovy catches in the subregion are taken in Mauritania, the Russian/Ukrainian fleet in Mauritania (with 70 percent of the Mauritanian total) plays an important role in the total catches of anchovy in the subregion. Over the past years the number of operating vessels of this fleet in Mauritania has been reduced due to technical and financial problems, which can be seen in the catch data for this fleet. Table 6.2.1 shows in 2005 a 50 percent reduction (compared to the previous year) in the anchovy catch for the Russian/Ukrainian fleet in Mauritania, and a 20 percent reduction for all other fleets combined fishing in Mauritania.

From this it can be concluded that the reduction in anchovy catch may partly be explained by the reduction of Russian/Ukrainian effort over the past years.

Effort

Since effort by the industrial pelagic fleet is mainly directed towards the *Sardinella* spp. and the *Trachurus* spp., this effort cannot be used for *Engraulis encrasicolus*, which is mainly reported as a bycatch species in this type of fisheries.

6.3 Abundance indices

6.3.1 Catch per unit of effort

These could not be calculated due to a lack of effort data.

6.3.2 Acoustic surveys

R/V DR. FRIDTJOF NANSEN

Even though catches of *Engraulis encrasicolus* show a decrease over the last two years in the subregion (Figure 6.2.1), the biomass estimates of the R/V DR. FRIDTJOF NANSEN show for the same period a small increase in biomass for anchovy in Mauritania (Figure 6.3.1).

R/V ATLANTNIRO

For the R/V ATLANTNIRO there is data available from 1994 till 2004 for anchovy in the Mauritanian zone and the zone north of Cape Blanc. Biomass estimates were always made in the summer for both zones. Data points are very scattered over the period, and therefore it is impossible to establish any trend in this dataset. Because of this, the dataset from the R/V ATLANTNIRO was not used in the assessment of *Engraulis encrasicolus*.

National surveys

Mauritania

The Mauritanian research vessel, R/V AL AWAM, carried out two surveys during 2005 (March and November). The biomass estimate for November 2005 was around 65 000 tonnes. The data set of this vessel is very short, and was not used in the assessment.

Morocco

In the autumn of 2005 the R/V AL AMIR estimated a biomass of 35 000 tonnes in the zone north of Cape Blanc. Historical biomass estimates made by this vessel were not available to the Working Group. Therefore data from the R/V AL AMIR were not used in the assessment of anchovy in 2005.

Table 6.3.1: Biomass estimates (tonnes) for *Engraulis encrasicolus* in NW Africa (2005)

	Zone A AL AMIR	**Zone B AL AMIR**	**Zone C FRIDTJOF NANSEN**	**Mauritania FRIDTJOF NANSEN**	**Mauritania AL AWAM**
Biomass estimate (tonnes)	5 000	5 000	9 763	97 967	64 000
Season of survey	Autumn	Autumn	Autumn	Autumn	Autumn

From Table 6.3.1 it can be seen that 99 percent of the anchovy biomass in the subregion was found in zone C and Mauritania (northern part of Mauritania).

6.4 Sampling of commercial fisheries

Sampling intensity of *Engraulis encrasicolus* off Northwest Africa over the course of the years 2004 and 2005 is given in Table 6.4.1.

For the northern fishery (zone A+B) which is exploited by Moroccan purse seiners, a total of 38 samples of anchovy containing 5 828 individuals were taken in 2005. For the year 2004, no sampling data was given. Otoliths of 70 individuals were collected in Zone A, and only in the first half of 2005.

In 2004 and 2005, no samples were taken North of Cape Blanc.

For the Mauritanian fishery, only length sampling was carried out on board Russian and European Union (the Netherlands) pelagic trawlers by scientific observers. For 2004 there is no data on sampling intensity in the Mauritanian industrial fishery. In 2005, 3 samples containing anchovy were taken, comprising 200 individuals.

6.5 Biological data

Length composition for Morocco and Mauritania are presented in Figure 6.5.1 (autumn 2005). Data for zone A+B are corrected with a factor of 3.3 (R/V AMIR/R/V DR. F.NANSEN). The data from the R/V AL AWAM could not be corrected, as the correction factor was not known.

For zone C the range of lengths of individuals varies from 5 to 9 cm in total length, with a peak around 6 cm total length. For Mauritania the total lengths varied between 6 and 13 cm, with a peak around 11 cm.

Compared to the southern part of the region (zone C), the total lengths of zone A and B were larger, with respectively peaks around 14 and 13 cm total length, but the numbers of individuals found in these zones were lower than those found North of Cape Blanc and Mauritania (Figure 6.5.1).

6.6 Assessment

This year the Working Group carried out an exploratory assessment by using the Schaefer logistic production model. This model is described in Annex II.

Input data

For the catch data the Working Group used an updated time series of total landings in Mauritania from 2000–2005. The abundance index used was the series of abundance indices from the R/V DR. FRIDTJOF NANSEN for Mauritania.

The r–value in the model is an indication of the rate at which the biomass can multiply within a year. In this simulation the Working Group found an r–value of 7.27. This high r–value is in line with what can be expected for as highly a productive, short lived species as anchovy. The consequence of this high r–value is that the model becomes very sensitive, small changes in any parameter will lead to a complete lack of fit of the model, which increases the uncertainty of the model.

Another point which raises the uncertainty of the model for this species is the R–Pearson value of –0.37. This negative correlation between the observed abundance index and the predicted abundance index is caused by the first survey year on anchovy. This first year was an experimental year and the biomass estimate may be considered as not reliable. When leaving out this first survey year the R–Pearson value increases to 0.91, which is a much better correlation between the observed and the predicted abundance index.

Even though the negative R–Pearson value can be fixed, the Working Group decided not to use the results of this model in the assessment of anchovy, because of the high sensitivity of the model.

Results

Even though it was decided by the Working Group not to use the results of the production model for anchovy, the model seems to show a trend of increasing biomass for the last 5 years. The catches, on the other hand, show a decrease over the last 3 years. These observed trends in the model strengthen the hypothesis mentioned before that the observed decline in anchovy catches (Figure 6.2.1) in the subregion were most probably caused by a reduction in fishing effort by the industrial pelagic fleet.

6.7 Predictions

The Working Group was not in a position to make projections for anchovy.

6.8 Management recommendations

As a precautionary approach the Working Group recommends not increasing catch above the average level of the last three years (135 000 tonnes).

6.9 Future research

1. Look for effort data in the historical time series for stock assessment.
2. Investigate the species and length composition of the Mauritanian industrial pelagic catch.

7. BONGA

7.1 Stock identity

Bonga (*Ethmalosa fimbriata),* one of the four shad species found in Africa are mainly concentrated in Senegal, Gambia and Mauritania. Interested readers are referred to the previous report of this Working Group (FAO, 2006) for more information on the species.

7.2 Fisheries

The bonga fishery has a long history in the subregion but exploitation has been especially intense in Gambia and Senegal as described in the overview of landings (chapter 1). As a coastal and estuarine species, bonga is exploited by artisanal fisheries.

Catch

Total annual landings of bonga by country (Gambia, Senegal and Mauritania) are presented in Table 7.2.1. and Figure 7.2.1. There have been interannual fluctuations in landings of bonga in Gambia and Senegal since 1990 but the tendency is a gradual upward trend. This species is landed as bycatch by artisanal fishers operating around Nouakchott, Mauritania.

Effort

Effort data for Senegal are presented in Table 7.2.2 as number of trips. The effort is the total number of trips fishers using surround gillnet made during the year. No effort data were provided by the Gambia and Mauritania for bonga.

Recent developments

Gambia and Senegal registered an overall increase in landings in 2005 from about 16 000 tonnes in 2004 to nearly 20 000 tonnes in 2005 in the Gambia and from nearly 17 000 tonnes to about 19 000 tonnes, in Senegal.

Total landings recorded in Mauritania for 2005 were very low, 136 tonnes as opposed to 1 700 tonnes in 2004 (Table 7.2.1). Catch data for Bonga landings in Mauritania were available for the period 2000 to 2005. With data only available for six years, it was difficult to say much about the trend (Figure 7.2.1).

7.3 Abundance indices

7.3.1 Catch per unit of effort

The CPUEs were calculated from the catch and effort data provided by Senegal. The CPUEs were stable between 1990 to 1998, then increasing annually before peaking in 2001 and decreasing drastically in 2002 then taking an upward trend in 2003 (Figure 7.3.1).

7.3.2 Acoustic surveys

Surveys of small pelagic fish in Northwest Africa conducted under the Nansen programme and subregional research vessels do not estimate the abundance of Bonga as they are found inshore and in estuaries. Therefore fisheries independent data were not available to the Working Group.

7.4 Sampling of commercial fisheries

At present, there are no sampling schemes in place for bonga in the countries in which the species is caught.

7.5 Biological data

The length composition for 2004 and 2005 of bonga caught by the Senegalese artisanal fisheries available to the Working Group shows one main mode in 2005 of 21 cm (FL) with some small fish and one of 26 cm (FL) in 2004 (Figure 7.5.1).

7.6 Assessment

The CPUEs calculated from the catch and effort data of the Senegalese artisanal fleet targeting bonga were used with the total landings of bonga in the subregion to carry out an exploratory assessment. A modified Excel spreadsheet of the Schaefer Logistics model (Annex II) was used for the assessment. The results obtained from this trial were not satisfactory and the Working Group therefore recommended that the results be disregarded until further information on the species is available.

7.7 Predictions

The Working Group was not in a position to make stock projections for bonga.

7.8 Management recommendations

As a precautionary measure, catch level should not exceed the average of the last five years (42 000 tonnes).

7.9 Future research

1. The Gambia to collect effort data for *E. fimbriata*.

2. As biological sampling schemes do not exist for bonga, member countries in the subregion are urged to collect biological data on *E. fimbriata* to enable better analysis of the status of the stock and the effect of the fishery on the stock.

3. It is proposed that countries targeting bonga carry out a search for data/information on the bonga fishery.

8. GENERAL CONCLUSIONS

A summary of the assessments and management recommendations by the Working Group is presented below:

Stock	Last year catch in 000 t (5 year average)	$B/B_{0.1}$	$F_{cur}/F_{0.1}$	Assessment	Management recommendations
Sardine *S. pilchardus* Zone A+B	550 (600)	128%	63%	Stock is not fully exploited	Do not increase catches above average level of last 5 years (600 000 tonnes).
Sardine *S. pilchardus* Zone C	190 (115)	177%	6%	Stock is under-exploited	The total catch level may be progressively increased up to 1 000 000 tonnes during a 5 year period.
Sardinellas *S. aurita* and *S.maderensis* Whole subregion	470 (460)	77%	212%	Stock of *S. aurita* probably overexploited No reliable results for *S. maderensis*	Decrease effort in total sardinella fishery by 50% corresponding to a total catch of sardinellas of not more than 220 000 tonnes (2007).
Horse mackerel *T. trachurus* *T. trecae* Whole subregion	120 (90) 220 (180)	108% 159%	151% 73%	Stock of *T. trachurus* probably fully exploited Stock of *T. trecae* not fully exploited	Because of mixed horse mackerel fishery, decrease effort by 20%, corresponding to a total catch of horse mackerel of 260 000 tonnes (2007).
Mackerel *Scomber japonicus* Whole subregion	185 (180)	140%	51%	Stock not fully exploited	Because of mixed fishery with the other stocks, the catch should not exceed 200 000 tonnes (2007).
Anchovy *Engraulis encrasicolus* Whole subregion	84 (143)	NA	NA	NA, acoustic estimates showed an increase in biomass in recent years	As a precautionary measure, catch level should not exceed the average over the three last years (135 000 tonnes).
Bonga *Ethmalosa fimbriata* Whole subregion	39 (42)	NA	NA	NA, but catch rates are stable	As a precautionary measure, catch level should not exceed the average over the five last years (42 000 tonnes).

For assessment of the pelagic fish stocks mentioned in this report in the Northwest African region, there is a variety of information available. The information can be divided into two main groups, – fishery dependent and – fishery independent information. Fishery dependent information is based on fishery statistics, effort data, and the samples that are taken of fish in the various fisheries, such as length measurements, age readings etc. From these data it is possible to obtain information relevant to fish stock assessments such as, total catch, length groups harvested and quantity thereof, what age groups (year classes) are harvested, catch per unit of effort etc. The Working Group appreciates the effort made to obtain all these data, which are of the utmost importance for fish stock assessment and management. The fishery independent data, on the other hand, are data derived from sources other than the fishery, and can be various abundance estimates made during surveys with research vessels (for example the acoustic estimates of stock size obtained by R/V DR. FRIDTJOF NANSEN, and other research vessels). Such estimates can be length based or age disaggregated. Currently, the abundance indices estimated on the basis of the activity of the research vessels are numbers and biomass of the target species by length group and they are not age disaggregated. However, they are very valuable and in many cases they represent the most important information on the status and development of the fish stocks.

In the absence of reliable length and/or age compositions, the Working Group used dynamic production models for all stocks. The disadvantage of the dynamic production models is that they cannot follow individual age groups, and thus cannot simulate the effect of changes in relative exploitation patterns on the stock. In previous years, the Working Group used the models assuming average stock growth parameters for all years. It has been realized that most stocks in the area are influenced by abnormal hydrographical conditions in certain years. The fit of the production models has been significantly improved by specifically including an index of environmental quality. However, the values used for this index have been defined on a rather subjective basis, and a more objective procedure with the application of a series of environmental data has to be developed in the future. For this purpose, more research on hydrographical variability in the region and its effects on stock dynamics should be encouraged and the results made available to the Group. The long-term objective of the Working Group is to use analytical models for assessment of all the stocks.

This year, the Working Group made decisions on reference points for management of the pelagic stocks in the region. The Group also made predictions on the development of the status of the stocks and on future effort and catch levels. The advices for the stocks are given in relation to the reference points and on the basis of the predictions. The advice for each stock gives guidelines for managers in the management of the pelagic stocks on how to make them develop in a direction where each stock is exploited at an optimum level. The advice for each stock is given both in terms of effort and catch levels.

Although the amount of catch, effort and biological data available to the Working Group has increased in recent years, some deficiencies persist. The main deficiency remains reliable age data for most of the stocks. The study of age and growth, therefore, remains a priority for the Working Group. Other data deficiencies concern the species and length composition of the landings and discards of the industrial fleet in Mauritania and the length distribution of catches in Morocco, Gambia, Senegal and Mauritania.

9. FUTURE RESEARCH

The Working Group recommended that the following research areas be pursued in 2006/2007:

1. All data for the next Working Group must be prepared and sent to group focal points and FAO at the latest 2 weeks before the next meeting in Morocco in March/April 2007.

2. Acoustic surveys and related activities such as coordination between countries and intercalibration, should be continued to maintain and improve the time series; when possible, acoustic abundance estimates should be split by zones and age groups. The assessment work is critically dependent on the quality of the acoustic estimates. It is therefore strongly recommended that the participating vessels in the region coordinate and make intercalibrations.

3. Recruitment surveys covering the whole subregion should be carried out regularly to provide an early estimate of year class strength and to improve the basis for stock assessment.

4. Research activities aiming at a better understanding of the effect of environmental changes on the dynamics of pelagic stocks should be encouraged. One or more working papers should be presented to show the relevant results of projects on this issue.

5. Continue to develop and improve the assessment methods. Further develop the version of the production model used by the group including other versions of the production functions, multiple abundance indices and uncertainty estimates.

6. Continue to improve sampling by increasing the numbers of individuals in each sample covering all size ranges. All fleet segments and all quarters of the year should be covered. Special attention must be given to the fisheries in the Gambia and the artisanal fishery in Mauritania.

7. Continue work on age reading of sardine and sardinella.