FAO Fisheries Report No. 785
FAO, Rapport sur les pêches n° 785 FIRM/R785 (Bi)
ISSN 0429-9337

Report of the

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

**Nouadhibou, Mauritania, 26 April–5 May 2005**

Rapport du

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

**Nouadhibou, Mauritanie, 26 avril-5 mai 2005**

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
ORGANISATION DES NATIONS UNIES POUR L'ALIMENTATION ET L'AGRICULTURE
Rome, 2006

ISBN 978-92-5-005608-1

## 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 fifth meeting of the FAO Working Group on the Assessment of Small Pelagic Fish off Northwest Africa was held in Nouadhibou, Mauritania, from 26 April to 5 May 2005.

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, Luigia Sforza 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 cinquième 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 Nouadhibou, Mauritanie, du 26 avril au 5 mai 2005.

Une première édition du rapport a été faite par tous les participants au 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, Luigia Sforza et Françoise Schatto pour l'assistance apportée à l'édition finale de ce document.

**Distribution :**
Participants in the Working Group/Participants au Groupe de travail
FAO Regional Fishery Officers/Fonctionnaires des pêches régionaux de la FAO
FAO Fisheries Department/Département des pêches de la FAO
NORAD
IMR
Ministry of Agriculture of the Netherlands
RIVO (the Netherlands Institute for Fisheries Research)

FAO.
Report of the FAO Working Group on the Assessment of Small Pelagic Fish off Northwest Africa. Nouadhibou, Mauritania, 26 April–5 May 2005.
Rapport du Groupe de travail de la FAO sur l'évaluation des petits pélagiques au large de l'Afrique nord-occidentale. Nouadhibou, Mauritanie, 25 avril-5 mai 2005.
*FAO Fisheries Report/FAO Rapport sur les pêches*. No. 785. Rome, FAO. 2006. 180p.

**ABSTRACT**

The fifth meeting of the FAO Working Group on the Assessment of Small Pelagic Fish off Northwest Africa was held in Nouadhibou, Mauritania, from 26 April to 5 May 2005. The meeting continued to focus on data quality and on the analysis of trends in the basic data (landings, catch, effort, abundance, length and age distribution) and trends in the fishery independent survey data.

The structure of the report is the same as that of the previous Working Group report (FAO, 2004), with the addition of two chapters, one on bonga (*Ethmalosa fimbriata*) and one on anchovy (*Engraulis encrasicolus*). 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, management recommendations and future research.

In the absence of reliable length and/or age compositions, the Working Group used production models for all stocks.

The results of the assessments indicate that the sardine stock in Zone C is not fully exploited and the Working Group hence noted that the total catch level may be temporarily increased but should be adjusted to natural changes in the stock. A constant monitoring of the stock abundance and structure, by scientific surveys, independent from catch data, should be ensured, to detect unanticipated changes that may require urgent management measures. As regards the central stock of sardine (Zones A+ B), it is recommended not to increase catches above the average level of the last five years (600 000 tonnes). The stock of round sardinella was found to be fully exploited and it was hence recommended not to increase catches of sardinella above the current level of 400 000 tonnes (2004). As a precautionary approach, the Working Group recommended not to increase catches above the average level of the last five years for the horse mackerels (80 000 tonnes for *Trachurus trachurus* and 170 000 tonnes for *T. trecae*) and not to increase catches above the 2004 level for chub mackerel (220 000 tonnes). For bonga the Working Group recommended as a precautionary measure that the catch level should not exceed the average over the last five years (42 000 tonnes) and for anchovy the catch level should not exceed the average over the last three years (160 000 tonnes).

In formulating the results of the assessments, the Working Group noted that it lacked a set of uniform reference points and management objectives for all stocks in the area. The Group noted that the selection of appropriate reference points required more time than was available during the meeting. It was therefore decided that some members will look further into this problem, working by correspondence, and present a working paper at the 2006 meeting. At that meeting the Working Group will attempt to agree on a common policy concerning the way it presents its management advice for the various stocks.

**RÉSUMÉ**

La cinquième 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 Nouadhibou, Mauritanie, du 26 avril au 5 mai 2005. La réunion a encore insisté sur la qualité des données et l’analyse des tendances des données de base (débarquements, capture, effort, abondance, distribution de tailles et d’âges) et tendances des données de campagne.

La structure du rapport est la même que celle du rapport précédent (FAO, 2004) avec l’addition des deux chapitre, un sur le bonga (*Ethmalosa fimbriata*) et un autre sur l’anchois (*Engraulis encrasicolus*). Une section séparée est consacrée à chacune des catégories principales d'espèces (sardines, sardinelles, 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, l’évaluation, les recommandations d’aménagement et la recherche future.

En l’absence de compositions de tailles et/ou d’âges fiables, le Groupe de travail a utilisé des modèles de production pour tous les stocks.

Les résultats des évaluations indiquent que le stock de sardine dans la Zone C n’est pas pleinement exploité et le Groupe a donc noté que l'effort de pêche actuel peut être provisoirement accru, mais qu’il devrait être ajusté aux changements naturels du stock. Une surveillance constante de l’abondance des stocks et de leur structure, par des campagnes scientifiques, indépendantes des données de captures, devrait être assurée, afin de détecter les changements non anticipés que pourraient exiger des mesures urgentes d’aménagement. En ce qui concerne le stock central de sardine (Zone A+B), il est recommandé de ne pas augmenter les captures au-dessus du niveau moyen des cinq dernières années (600 000 tonnes). Le stock de sardinelle ronde a été pleinement exploité et il a donc été recommandé de ne pas intensifier les prises des sardinelles au-dessus du niveau actuel de 400 000 tonnes (2004). Par mesure de précaution, le Groupe de travail a recommandé de ne pas augmenter l’effort de pêche au-dessus du niveau moyen de ces cinq dernières années pour les chinchards (80 000 tonnes pour *Trachurus trachurus* et 170 000 tonnes pour *T. trecae*) et de ne pas augmenter l’effort de pêche au-dessus du niveau 2004 pour le maquereau (220 000 tonnes). Pour le bonga, le Groupe de travail à recommandé, à titre 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 (160 000 tonnes).

Au moment de la formulation des résultats des évaluations, le Groupe de travail a noté qu’il manquait une série uniforme de points de référence et d’objectifs d’aménagement pour tous les stocks de la région. Le Groupe de travail a remarqué que la sélection des points de référence appropriés demandait plus de temps que celui à disposition pendant la réunion. En conséquence, il a été décidé que quelques membres du Groupe seront chargés d’analyser ce problème, en travaillant par correspondance, et de présenter un document de travail à la réunion de 2006. Durant cette réunion, le Groupe de travail tentera de trouver un accord sur une politique commune concernant la façon de présenter les recommandations pour l’aménagement des différents stocks.

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# 1. INTRODUCTION

The fifth meeting of the FAO Working Group on the Assessment of Small Pelagic Fish off Northwest Africa was held in Nouadhibou, Mauritania, from 26 April to 5 May 2005. 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 Netherlands Institute for Fisheries Research (RIVO) and organized by FAO and the "Institut mauritanien de recherches océanographiques et des pêches" (IMROP).

Altogether 20 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 and sampling intensity by country. Updating existing data base.
2. Presentation of working papers on research activities. Review of research activities carried out during 2004/2005 as recommended by the Small Pelagics Working Group in 2004.
3. Presentation of reports on R/V DR. FRIDTJOF NANSEN acoustic surveys Oct/Nov/Dec 2004 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 1990-2004, 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 short and long term management for each resource/stock.
9. Coordination of small pelagic research projects.

## 1.2 Participants

| | |
|---|---|
| Pedro Barros | FAO |
| Eduardo Balguerías | Spain |
| Ana María Caramelo | FAO |
| Hamid Chfiri | Morocco |
| Ad Corten | The Netherlands |
| Pavel Gasyukov | Russian Federation |
| Cheikh Inejih | Mauritania |
| Ebaye Mahmoud | Mauritania |
| Asberr Mendy | Gambia |
| Ahmedou Moustapha | Mauritania |
| Azeddine Ramzi | Morocco |
| Birane Samb | Senegal |
| María Teresa García Santamaria | Spain |
| Abdoulaye Sarre | Senegal |
| Mor Sylla | Senegal |
| Merete Tandstad | FAO |
| Nikolay Timoshenko | Russian Federation |
| Pablo Tjoe-awie | The Netherlands |
| Reidar Toresen (chairman) | Norway |
| Abdoulaye Wagué | Mauritania |

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, 2004), with the addition of two chapters on bonga and anchovy. 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, management recommendations and future research.

## 1.5 Overview of landings

The total landings of the main small pelagic fish landed in the region in 2004 increased by 4.6 percent from around 1.8 million tonnes in 2003 to about 1.9 million tonnes. Despite a small decrease in 2002, a gradual upward trend continued as observed since 2000 (Figure 1.5.1a). Overall, total landings of small pelagic fish for the period 1990 to 2004 have fluctuated around 1.6 million tonnes.

Total landings of the main pelagic fish species in the subregion were dominated by sardine (*S. pilchardus*) constituting about 37 percent of overall landings in 2004. 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. Total landings of sardine over the last five years ranged from about 580 000 to nearly 710 000 tonnes with an average of about 708 000 tonnes (Figure 1.5.1a).

The round sardinella (*S. aurita*) is the second most important small pelagic fish in the region, constituting nearly 13 percent of total landings of small pelagic fish in the region. Total catches of round sardinella have been fluctuating slightly between 250 000 and 340 000 tonnes over the last five years with an average of about 300 000 tonnes. The overall trend is a relatively steady decrease in landings for this species since 1999 (Figure 1.5.1a) with the lowest total landings of about 250 000 tonnes in 2004. Total annual landings of flat sardinella (*S. maderensis*) constitute about 8 percent of total landings of the main pelagic fish in the subregion. The landings of flat sardinella have been significantly lower (70 percent) than those of round sardinella with an average of about 146 000 tonnes for the last five years.

The Cunene horse mackerel (*T. trecae*) is the most important species in the horse mackerel sub-group constituting about 9 percent of the total landings of the main small pelagic fish in 2004. The average annual landings of Cunene horse mackerel over the last five years were estimated at about 164 000 tonnes while average landings of Atlantic horse mackerel (*T. trachurus*) were around 83 000 tonnes. A 164 percent increase in landings of the Atlantic horse mackerel in 2004 over the preceding year was observed. Average landings of false scad (*Caranx rhoncus*) (2000–2004) were about 44 000 tonnes.

Landings of chub mackerel (*Scomber japonicus*) fluctuated between 136 000 and 225 000 tonnes with an estimated average of about 180 000 tonnes over the last five years.

Considering total landings of anchovy (*Engraulis encrasicolus*) and bonga (*Ethmalosa fimbriata*) in some countries in the subregion, the Working Group decided in 2003 to include these species in the small pelagic fish being assessed. Total landings of anchovy ranged from 126 000 tonnes in 2000 to 170 000 tonnes in 2004. An average of 150 000 tonnes were recorded for the last five years. Landings of bonga in 2004 constitute about 2 percent of total landings of small pelagic fish in the subregion. This species is mainly targeted in Senegal and The Gambia. Landings of bonga ranged from 31 000 tonnes to 43 000 tonnes in the last five years, with an average of 35 000 tonnes.

**Morocco**

The dominant species of the small pelagic fish landed in Morocco is sardine (*Sardina pilchardus)* which constitutes about 74 percent of the total landings of small pelagic fish in 2004. There has been a gradual decline in landings of sardine from around 770 000 tonnes in 2001 to about 640 000 tonnes in 2004 (Figure 1.5.1b). The average landings of sardine between 2001 and 2004 were about 680 000 tonnes. In the overall series, the second most important species for at least the last five years, was the chub mackerel (*S. japonicus),* constituting about 10 percent of total landings of small pelagic fish in Morocco. The Atlantic horse mackerel, *T. trachurus* and round sardinella, *S. aurita,* were the third and fourth most important species in the series. These species have been observed to decline steeply since the late 1990s, and have kept approximately stable, at very low levels, from 2002 to 2003. However, there have been significant increases in landings of *S. japonicus* and *T. trachurus* in 2004.

Landings of anchovy (*Engraulis encrasicolus*) in 2004 were around 7 100 tonnes, constituting around 8 percent of total landings of small pelagic fish in Morocco. In 2003 total landings of this species were 17 000 tonnes, e.g. a decrease of approximately 50 percent from 2003 to 2004.

**Mauritania**

The overall series of landings of the main small pelagic fish in Mauritania have shown important inter-annual fluctuations during the period from 1990 to 2003 (Figure 1.5.1c). However, the overall tendency has been an upward one since 1994.

In 2004, landings of small pelagic fish in Mauritania were dominated by *Trachurus trecae* and *Engraulis encrasicolus*. The total landings of these species were around 180 000 and 160 000 tonnes respectively. These were followed by *Sardinella aurita* with 140 000 tonnes (Figure 1.5.1c).

Compared to 2003 landings, there was an increase in landings of *Trachurus trachurus* and *Engraulis encrasicolus* (53 and 15 percent, respectively) in 2004. While landings of sardine (*Sardina pilchardus)* and chub mackerel *(Scomber japonicus*) decreased in the same year. A continued decrease of landings of the two sardinella species (*S. aurita* and *S. maderensis*) was observed. Landings of *Trachurus trecae* nearly doubled (80 percent) from about 99 000 tonnes in 2003 to around 180 000 in 2004. A 22 percent increase in landings of *Caranx rhonchus* was observed in 2004.

**Senegal**

Overall, the series of landings of small pelagic fish in Senegal showed periodic fluctuations from 1990 to 2004. A steady increase in the total landings of all small pelagic fish was observed from 2000 to 2003 after which a downward trend can be observed, from around 330 000 tonnes in 2003 to about 270 000 tonnes in 2004 (Figure 1.5.1d).

Up to 1998, round sardinella was dominant in the landings, but since then flat sardinella has been the main species reported. Horse mackerel and chub mackerel are always by-catch species.

Total landings of *Sardinella* spp. dropped from about 300 000 tonnes in 2003 to around 240 000 tonnes in 2004. This represented a 20 percent decrease in landings of *Sardinella* spp. However, *Sardinella* spp. constitutes about 89 percent of total landings of the main small pelagic fish landed in Senegal in 2004. Landings of bonga are on average about 6 percent of total landings of small pelagic fish, and the rest of the species, 5 percent.

**The Gambia**

The trend of total landings of the main small pelagic fish landed in The Gambia is dependent on bonga (*Ethmalosa fimbriata*) as it is the main target species. Bonga constituted about 87 percent of total landings of all the main small pelagic fish landed in The Gambia (Figure 1.5.1e) in 2004. An annual average of about 19 000 tonnes of bonga was landed over the last five years. Despite fluctuations in the landings of bonga, the trend shows a gradual increase. Landings of bonga declined by 16 percent from about 19 000 tonnes in 2003 to around 16 000 tonnes in 2004.

Until recently, landings of sardinella and other species of small pelagic fish were considered by-catch since there is no fishery targeting them. Total landings of these species constitute only 13 percent. Of the 13 percent, about 1 700 tonnes (70 percent) were *Sardinella* spp.

## 1.6 Sampling of the European Union fleet landing at the port of Las Palmas de Gran Canaria

European Union (EU) Regulations numbers 1543/2000, 1639/2001 and 1581/2004 respectively establish i) a EU framework for the collection and management of the data needed to conduct the common fisheries policy, ii) provide detailed rules for the application of Regulation1543/2000, and iii) specify the minimum and extended EU programmes for the collection of data in the fisheries sector.

In order to conform to the above mentioned Regulations, the "Centro Oceanográfico de Canarias", belonging to the "Instituto Español de Oceanografía" (IEO), started, in May 2004, a sampling programme for the following species caught in the Eastern Central Atlantic (CECAF region) by the EU fleet landing at the port of Las Palmas de Gran Canaria (Canary Islands, Spain): *Sardina pilchardus*, *Sardinella aurita*, *Sardinella maderensis* and *Scomber japonicus*.

Sampling consists of i) length measurements of all species concerned to obtain quarterly length frequency distributions of the catches and ii) biological observations on *Sardina pilchardus* to estimate the following information, to be reported on a 3 years basis: growth parameters, length at first maturity and sex ratio by length and age.

## 1.7 Overview of acoustic surveys' results by R/V DR. FRIDTJOF NANSEN

The Norwegian research vessel, R/V DR. FRIDTJOF NANSEN has surveyed the subregion during the period 1995–2004, carrying out acoustic surveys during the months October–December each year. In addition, between 2001–2003, 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 1.7.1a shows the estimated abundance for all the target species during the surveys in October–December, while Figure 1.7.1b 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 1997–2002, from a level of around 1 million tonnes to more than 6 million tonnes, with a relatively small decrease from 2002 to 2003. In 2004 a record high biomass of 7.4 million tonnes of sardine was estimated in the survey. 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. 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 was estimated, to a level of 2.5 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. 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 estimated at 179 000 tonnes. 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.

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

## 1.8 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. These are the Virtual Population Analysis (VPA) based methods like Integrated Catch Analysis (ICA), Extended Survivor Analysis (XSA) and others. 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, and that it is possible to follow the different year-classes age by age and year by year through the time series of catch data. For the main stocks to be analysed by the group, there are age-disaggregated data 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, etc. The quality of these data series may therefore change for the better in the future.

The quality of the age-disaggregated data series can be controlled by simple methods, such as the correlation between the number of fish in the catch at a certain age and the corresponding number of the same year-class the following year (the numbers at age 0 versus the numbers of the corresponding year-classes at age 1, and so on for all age groups). If the data series is consistent the correlation coefficient (r) should be high. Data sets showing low values of the correlation coefficients should not be used in the analysis. If the data are of poor quality, methods not requiring age-disaggregated catch data, such as surplus production models or length based models should be used.

## 1.9 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 apply a Length based Cohort Analysis (LCA) (Jones, 1981) on sardine in Zones A+B and Zone C and an XSA on mackerel (Shepherd, 1999). For trial calculations by VPA for *Trachurus* spp. ICA (Patterson and Melvin, 1996) was used.

## 1.10 Age reading

One of the objectives during the survey carried out on board the R/V DR. FRIDTJOF NANSEN between 13 and 27 November, 2004 from Cap Blanc to Cape Juby was the preparation of otoliths and the interpretation of rings for sardine (*Sardina pilchardus*), round sardinella (*Sardinella aurita*) and flat sardinella (*Sardinella maderensis*), and to set up an age-length key for sardine. A summary of the findings for the different species from that survey together with other work on otolith interpretation in the region is provided below.

*Sardinella*

Round sardinella (*Sardinella aurita*)

A total of 190 pairs of otoliths were extracted from the fish and mounted during the 2004 survey with the R/V DR. FRIDTJOF NANSEN. The age interpretation for this species was difficult and had low reliability. However, the results of the readings may be considered to contribute to the drawing up of a future length-age key once the size ranges have been covered with a certain degree of reliability. One of the most positive aspects of the analysis of these samples on board the R/V Dr. Fridtjof Nansen was the chance to obtain otoliths from very small individuals and to be able to examine the first ring more closely.

A Workshop on the age-reading of round sardinella was held in Mauritania from 2-10 December, 2004, where otolith readers from Senegal and Mauritania met to harmonize their age readings. The results of that Workshop showed that there are still discrepancies in the way *Sardinella aurita* otoliths are interpreted by the different readers. Otoliths (749 pairs of otoliths in 2004) are also collected by observers on board Russian commercial vessels and age is determined.

The Working Group recommends that an exchange of *Sardinella aurita* otoliths should be initiated in June 2005. The exchange should consist of samples from all the countries in the region covering the entire year. If possible the otoliths should be from 2004.

Flat sardinella (*Sardinella maderensis*)

Given the difficulties in determining the age of *Sardinella aurita*, for which age interpretation has not yet been standardized, and in the face of the difficulties of age interpretation on board, *Sardinella maderensis* otoliths were not read during the survey of the R/V DR. FRIDTJOF NANSEN. However, given that biological information had also been collected from the flat sardinella, 127 pairs of otoliths were chosen to start a collection that would allow the exchange of otoliths to standardize age interpretation for this species in the future.

For both species of sardinella it is strongly recommended to extract and mount a number of otoliths for each size range that is ample enough, at least 20–40 otoliths for each cm group. It is also recommended that sampling from commercial catches should take place throughout the year.

*Sardine*

Of a total of 459 otoliths mounted during the R/V DR. FRIDTJOF NANSEN survey, a total of 89 (20 percent) were rejected due to: otolith not calcified, incorrectly prepared, rings not very clear and difficult interpretation.

Except in some very particular cases, the otoliths presented hyaline edge. Finally, 370 readings were used to draw up the age-length key and to determine the growth parameters.

The Working Group recommends that an exchange of *Sardina pilchardus* otoliths should be initiated immediately after the Working Group.

*Horse mackerel and mackerel*

In 2004 the Working Group recommended that an exchange of horse mackerel and chub mackerel otoliths should be carried out in early 2005. Given the continued difficulties with the reading of sardine and sardinella otoliths it is however unlikely that such an exchange will be carried out this year. Otoliths of *Trachurus trachurus*, *Trachurus trecae* and *Caranx rhonchus* are collected both by observers on board the Russian commercial vessels operating in Morocco and Mauritania and on board the Russian research vessel Atlantida that carried out two surveys in the area in 2004; one pelagic survey in August 2004 and one recruitment survey in December 2004-January 2005. These otoliths are read by Russian scientists. The Working Group suggests that 1-2 age readers from the region be invited to Atlantniro, Kaliningrad to be trained in horse mackerel and chub mackerel otolith preparation and interpretation as soon as possible.

### 1.11 Planning Group for acoustic surveys

The Planning Group for the coordination of acoustic surveys off Northwest Africa was held in Dakar, Senegal, 22–23 October, 2004. The meeting was the third of its kind, following two meetings in Dakar, Senegal, 26–28 October, 2002 and 28–29 October, 2003. The general objective of the Planning Group is to discuss acoustic difficulties met by countries of the region, organize 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, scrutinising, data storage, target strength (TS) measurements, etc).

The main conclusion of the Planning Group was as follows:

The local research vessels conducted acoustic surveys in 2004. The plan from 2003 had in general been respected and major improvements have been made in the standardisation of procedures and the processing of data since the vessels have been using the same acoustic equipment. The ability to run acoustic surveys in the subregion has developed to a good level and focus in the future should be on the development of human capacity and the resolution of recurrent technical problems of trawl performance, noise discrimination and data storage. The reports of the Planning Group will be published in the FAO Fisheries Report Series.

The results from the parallel surveys and inter-calibrations conducted between the vessels in the region and the R/V DR. FRIDTJOF NANSEN were analysed at a Workshop held in Casablanca, Morocco, January 2005. The results showed a more or less similar acoustic response between local vessels and the R/V DR. FRIDTJOF NANSEN but an effort should be made to harmonize 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. With respect to the recommendation made, the Working Group supported the need for standardisation of scrutinising procedures for the echograms. The Working Group also supported the idea of organising a meeting after the surveys for analysing data with the members of the Planning Group.

### 1.12 Technical workshop on shared stocks

The results of the Technical Workshop on the analysis of data relevant to the management of shared stocks in Banjul, The Gambia from 14-17 March, 2005 were presented to the Working Group. The objective of that workshop was to review principles for national allocations of shared fish stocks. During the meeting a model for 'zonal attachment' was demonstrated and the suitability of the model for shared stocks of small pelagic fish in Northwest Africa was tested. The results of the meeting were promising. However, it was noted that although data on stock distribution, abundance and age-structure are available, the longest data series available on stock distribution (acoustic data series from the R/V DR. FRIDTJOF NANSEN in November–December) was considered not to be representative of the whole year.

Some information was available from other times of the year, but this was not sufficient to provide the overall annual picture. It was therefore recommended to obtain more information on species distribution in the periods where information was lacking, including the organisation of surveys to take place in these periods, and to continue the work on age reading.

The Working Group recommended that the work carried out at the Workshop should be continued with the participation of members of the Working Group when new information is available.

### 1.13 Reference points for management advice

In formulating management recommendations, the Working Group should as far as possible be consistent from one year to another, and from stock to stock. For this purpose, it needs a standard method for presenting the results of its assessments, and for the formulation of the management recommendations based on these assessments.

Management recommendations are often based on the ratio between current stock size or fishing mortality, and certain biological reference points. These reference points may be the fishing mortality or stock size corresponding to Maximum Sustainable Yield (MSY), the minimum stock size for the production of average recruitment, or some intermediate stock level or fishing mortality that is considered optimal from a management point of view. Another basis for management recommendations may be short- and medium-term predictions of catch and stock size.

The Group decided that the selection of appropriate reference points required more time than was available during the meeting. It was therefore decided that some members will look into this problem further, working by correspondence, and present a working paper at the 2006 meeting. At that meeting the Working Group will attempt to agree on a common policy concerning the way it presents its management advice for the various stocks. One person from each country was appointed by the Working Group to participate and the names are indicated in Appendix I.

As an interim measure for the present meeting, the Group will present for each stock estimates of:

| | |
|---|---|
| $F_{cur}/F_{MSY}$ | (ratio between current fishing mortality and fishing mortality corresponding to MSY) |
| $F_{cur}/F_{SYCur}$ | (ratio between current fishing mortality and fishing mortality required to keep yield at its current level) |
| $B_{cur}/B_{MSY}$ | (ratio between current stock size and stock size corresponding to MSY) |

### 1.14 Management advice for small pelagic fish stocks

During earlier meetings, the Working Group has sometimes recommended catch limitations, and sometimes effort limitations for the various stocks concerned. In order to be consistent from year to year and from stock to stock, it is preferable to advise only one type of management measure for all stocks concerned. In this section, we shall consider briefly which of the two main management methods, catch limitation or effort limitation, is most appropriate for small pelagics in West Africa.

In pelagic fisheries, effort limitation is not considered to be a reliable method of reducing fishing mortality to a desired level. There is no simple relationship between effort and fishing mortality, due to variations in availability of the fish, and also the ability of vessels to locate fish with electronic aids. With decreasing stock size, the fleet will concentrate on the remaining fish, and fishing mortality may increase while effort remains constant. Therefore, in most pelagic fisheries of the world, the desired level of fishing mortality is achieved by regulating catches rather than fishing effort.

The regulation of catches is achieved by setting Total Allowable Catches (TACs) that apply to the entire fish stock. If the stock is distributed over different countries, the TAC has to be divided into national quotas. Within a country, the national quota may be further divided into fleet quotas, company quotas, or even individual vessel quotas.

The use of a quota system requires accurate monitoring of catches, and a strict regulation on the discarding of low value fish. Although these requirements involve some extra administration, the application of a quota system in pelagic fisheries generally poses less technical problems than effort limitation. It should be noted however that the use of TACs and quotas does not exclude the need for regulating fishing capacity of the fleet.

# 2. SARDINE

## 2.1 Stock identity

As the results of the study into genetic characteristics (molecular biology) of the sardine stocks are still preliminary, the Working Group decided to use the same stocks as during the previous assessment: 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 species) – Figure 2.1.1.

## 2.2 Fisheries

*Catch*

Catch and effort data were updated for the three zones with those of 2004 (Table 2.2.1a,b).

*Recent developments*

Recent changes in the different economic zones are described below.

In Morocco in 2004 the sardine stock in Zone A+B was exploited solely by the Moroccan fleet, made up of over 350 vessels of between 40 and 60 gross registered tonnage.

Sardine catch in Zone A fell from 74 000 tonnes in 2003 to 60 000 tonnes in 2004. A slight increase was recorded in the Northern Zone with a catch of 21 000 tonnes. On the other hand in Zone B the catches decreased slightly in 2004. However, total sardine catch in Zone C reached 160 000 tonnes in 2004 (Table 2.2.1a and Figure 2.2.1a).

In 2004 the zone between Cape Boujdor and Cape Blanc was exploited by Moroccan coastal purse seiners based in the port of Dakhla, by three Moroccan RSW vessels, by pelagic trawlers operating under the Morocco–Russian Federation fishing agreement signed on 15 October 2002 and by boats chartered by Moroccan operators who had left the octopus fishery due to over-capacity of fishing.

Beginning in 2004, the Russian pelagic trawlers (a maximum number of 12 vessels) were autohrized to operate outside the 15 mile zone from the coast for a period of three years, targeting sardine, chub mackerel, horse mackerel, sardinella, hairtail and anchovy with 3 percent rejects authorized.

The chartered vessels follow the same exploitation procedures as the Russian pelagic trawlers but for a duration of four years beginning in 2004 with a maximum number of 20 vessels.

In Mauritania sardine catch off Cape Blanc has increased despite the fact that sardine is not the target species of the fleets fishing in Mauritanian waters. Catch of sardine in the Mauritanian zone has steadily increased going from 37 000 tonnes in 2002 to more than 80 000 tonnes in 2003 and 2004.

Catches are carried out seasonally by the EU and Russian pelagic trawlers. An increase in fishing effort on sardine has been seen over the last few years due both to an increase in its abundance, as shown in the acoustic surveys, and to the decrease in traditionally targeted species (sardinella and horse mackerel).

Occasional catches of sardine have also been registered in Senegal over the last few years, an unusual situation which was last recorded in 1994.

## 2.3 Abundance indices

### 2.3.1 Catch per unit of effort

The CPUE series have been updated for 2004. In general, in Zone A+B, they show fluctuations from one year to the next (Figure 2.3.1a).

In Zone C fishing effort is defined in terms of number of fishing days for the Moroccan RSW vessels, the Russian vessels, the boats chartered by Moroccans and the industrial vessels operating in the Mauritanian zone. For the Moroccan coastal fleet, fishing effort is defined as the number of positive trips (Figure 2.3.1b).

### 2.3.2 Acoustic surveys

*R/V DR. FRIDTJOF NANSEN*

The results of the R/V DR. FRIDTJOF NANSEN surveys in December 2004 showed a large increase in sardine biomass compared to December 2003. The total estimated biomass for the Cape Cantin–Cape Timiris zone was in the order of 7.4 million tonnes (Figure 2.3.2a).

*R/V ATLANTIDA*

The acoustic survey on board the R/V ATLANTIDA carried out between the 16 ºN–28 ºN parallels from June–August 2004 detected a heavy concentration of sardine (4 831 000 tonnes). This biomass is the highest registered value for the last ten years. In Mauritania only 17 000 tonnes of sardine was estimated (Figure 2.3.2b).

Between November–December 2004 a survey to study the recruitment of small pelagics was carried out in the Moroccan EEZ. This was the second survey of an envisaged series that began in 2003.

Over the whole zone sardine individuals aged 1 formed denser and more extensive concentrations than those individuals aged 0. The distribution and the density of the sardine population are similar to those of 2003. The displacement towards the south can be explained by seasonal migration.

Comparison of sardine spawning periods during the 2002/2003 and 2003/2004 seasons, shows that at the beginning of 2004 positive temperature anomalies, unfavourable to spawning, were recorded. In comparison to the previous season, spawning was stronger before the appearance of these anomalies. This is why Group 0 proved to be more numerous during the second survey and not only because of the shifting of the survey period.

The abundance indices of age 0 and 1+ were the same as during the last survey.

*National surveys*

**Morocco**

An intercalibration survey was carried out in November–December 2004 between the Moroccan R/V AL-AMIR MY ABDALLAH and the Norwegian R/V DR. FRIDTJOF NANSEN. No sardine biomass estimate was carried out in the Moroccan zone by R/V AL-AMIR MY ABDALLAH in 2004.

**Mauritania**

The Mauritanian research vessel AL-AWAM carried out three acoustic surveys in April 2004, November 2004 and March 2005. Estimated sardine biomass was 2 428 000 tonnes, 95 000 tonnes and 461 000 tonnes respectively. The length distributions were similar in April 2004 and March 2005 having four modes (7, 10, 14 and 23 cm). In November 2004 two modes of 14 and 25 cm were observed. The marked variability in estimated sardine biomass is probably due to seasonal variability and the fact that the Mauritanian EEZ represents the southern limit of its distribution.

## 2.4 Sampling of commercial fisheries

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

**Morocco**

The programme of biological sampling was continued in 2004 in the three new fishing ports: Sidi Ifni (Zone B), Tarfaya (Zone B) and Dakhla (Zone C).

**Mauritania**

In Mauritania sampling is carried out on board the EU fleet by scientists from IMROP and on board the Russian fleet. Sampling on board the two fleets does not take place all year round.

## 2.5 Biological data

Moroccan biological data relating to the demographic structure for Zones A, B and C are available for 2004. These data include length measurement and the length–weight relationship. Lengths are total length (TL) to the nearest half centimetre below.

The length distribution of sardine caught in Zone A+B shows three modes (15.5 cm, 18 cm and 22.5 cm) (Figure 2.5.1a).

In Zone C annual length composition of the Russian catch in Mauritania are also available for 2004. For this fleet the average length is in the order of 23 cm (Figure 2.5.1b). Sardine is measured by total length to the ½ cm below (TL, 0.5 cm). The length composition of the EU fleet is not used by the Group (fork length measured to the centimetre below)

Age reading for Moroccan fishery landings in 2004 in Zone B and C is not yet finalized. The age–length keys based on Moroccan data for the year 2003 were used to prepare the age compositions for 2004, both for Zone A+B and for Zone C (Tables 2.5.1a,b). There is a sardine age–length key for Zone C landings by the Russian fleet for the second half of 2004 and there is also an age–length key from the R/V DR. FRIDTJOF NANSEN survey of November–December 2004 (Table 2.5.1c)

Age composition as well as average weight by age were brought up to date for both zones (A+B and C) for 2004 (Tables 2.5.2a,b). However average lengths by age show differences in the growth rate from one age to the next (Table 2.5.2c).

**Table 2.5.2c:** Average lengths by age for 2003 and 2004 for Zones A+B and C

| Age classes | 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 |
| **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 |

The coefficients of the length–weight relationship used to calculate the average weight by age also came from sampling done in the Moroccan ports.

The length distribution observed during the R/V DR. FRIDTJOF NANSEN survey in December 2004 is bimodal in Zone A+B (Cape Cantin–Cape Juby), with one mode at 15 cm and the other at 18 cm. In Zone C however, the length distribution is trimodal, dominated by the adults (mode at 23 cm) in the Cape Juby–Cape Timiris region (Figures 2.5.2a,b,c)

## 2.6 Assessment

*Data quality*

To study the quality of the available data, the Working Group carried out a statistical investigation into the data and calculated the correlation between the different age groups and the corresponding class number for the same year and the following year. The results obtained (Figure 2.6.1) show that for Zone A+B there was no correlation between the different cohorts as the age structure showed anomalies from one age to the next. For Zone C the correlations were relatively less weak than for 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, this could be the result of several factors, notably, poor age estimation, a change in the exploitation pattern (alternation of several fleets), sampling not being representative, targeting certain lengths which are more in demand in the canning factories and poor stock identification. The result of all this being that it is impossible to count on these data for an analytical age-structured assessment.

At this point the Working Group decided against using analytical models based on age for the stock assessment.

*Methods*

The Schaefer logistic production model was used to assess the two stocks, A+B and C (the model is described in Annex II). The Working Group proceeded to attempt a Length based Cohort Analysis (LCA) for the A+B stock (the average by length of the 2000–2004 catches was used).

*Data*

Time series of sardine landing data for Zones A+B and C from 1995 to 2004 were used for the production model.

The abundance indices from the R/V DR. FRIDTJOF NANSEN November–December surveys from the same years were used to estimate the model parameters. They were moved forward a year as the surveys take place at the end of the year. Using the results of the last survey (December 2004) by fishing zone, the abundance indices were calculated for the whole series for Zones A+B and C.

Most of the series for the region highlight large differences in relation to the average values estimated by the model, which cannot be explained either by the fishery or by the parameters of the average stock dynamic. There is cause to believe that these changes are due to climatic variations. Consequently an environmental index was incorporated into the model which allows the stock to grow more or less on average depending on the state of the environment each year. In spite of the complete data series, only exceptional years were marked by an environmental situation different to the average. Thus, 1997 should be considered an exceptionally unfavourable year for sardine growth and survival.

The values used in the Length based Cohort Analysis (LCA) were: Linf (26.5 cm), K (0.4), M (0.4), a (0.0057) and b (3.1261).

*Results*

**Production model**

The model managed to follow the main dynamics of the sardine stock in Zones A+B and C, with the introduction of a negative environmental effect in 1996, even with large variations in the abundance indices.

The results obtained indicate that the current stock biomass is well above that producing maximum sustainable yield and the current fishing mortality is below the level of sustainable fishing mortality at the current level of biomass. Table 2.6.1 summarizes the results from the fit of the logistic production model with the environmental co-variables of sardine catch and abundance index of the data. Between brackets, the variation coefficient of the estimate as obtained by Bootstrap (1 000 replications).

**Table 2.6.1:** Summary of the results of fitting the logistic production model

| Stock/abundance index | $B/B_{MSY}$ | $F_{cur}/F_{SYcur}$ | $F_{cur}/F_{MSY}$ |
|---|---|---|---|
| Sardine, Zone A+B/Nansen | 149 % (5%) | 88 % (5%) | 45 % (10%) |
| Sardine, Zone C/Nansen | 192 % (1%) | 94 % (11%) | 7 % (8%) |

$B/B_{MSY}$: Ratio between current stock size and stock size corresponding to MSY.
$F_{cur}/F_{SYcur}$: Ratio between current fishing mortality and fishing mortality required to keep yield at its current level.
$F_{cur}/F_{MSY}$: Ratio between current fishing mortality and fishing mortality corresponding to MSY.

Figures 2.6.3a,b show the observed and predicted indices and their diagnostics.

**LCA (Length based cohort analysis)**

Results of the LCA analysis showed heavy exploitation of the length classes between 18–21 cm and 23–25 cm. The heavy exploitation of the first classes can be explained by the demand of the canning industry. The other classes are exploited towards the end of each year according to their availability in the area of operation of the coastal purse seiners.

***Discussion***

For Zone A+B the estimates showed an increasing trend over the study period beginning in 1998. The estimate for 2004 is the highest since 1996.

For Zone C the estimates showed an increase beginning in 1998 even though the abundance indices from the R/V DR. FRIDTJOF NANSEN surveys showed a slight decrease in biomass in 2003 (4 525 000 tonnes) followed by a recovery in 2004 (6 144 000 tonnes).

The drastic drop in 1997 cannot only be due to fishing pressure.  It could be due, amongst other things, to a change in the environment occurring at a regional level which would have grave consequences for sardine survival, recruitment and movement. This effect has also been seen in the sea surface temperature values in the whole region, which has an effect on other pelagic species such as sardinella and horse mackerel. On the other hand, the increase in global biomass reported in 2004 (7 408 000 tonnes) has been accompanied by a large movement of sardine as far as Senegal.

Due to the sensitivity of this species to changes in environmental conditions and to the instability of the environment in the Canary current region, the sardine stock can go from periods of high production to periods of very weak production for natural reasons. This change in stock abundance can be gradual or it can be marked.

The average value of F given by the LCA for Zone A+B is 0.61 per year. This is very close to the average value for F estimated by the production model for the last five years using independent fishery indices estimated by the R/V DR. FRIDTJOF NANSEN. Production estimates by recruit indicate that the stock is moderately exploited with values of F between $F_{max}$ and $F_{0.1.}$ As the production curve by recruit is a "flat top", $F_{0.1}$ instead of $F_{max}$ should be considered the reference point.

## 2.7 Management recommendations

Despite the promising results from the Working Group's assessment as far as the central stock is concerned (A+B), due to the fluctuations that this stock has seen and to be on the safe side, sardine catch in this zone should not exceed the average catch of the last five years (600 000 tonnes).

The results of the model, even though they should be treated with caution, have given consistent indications as to the state of the sardine stock in Zone C. These results show that with the current level of biomass, catch could be increased in comparison to previous years. Taking into account the instability of the stock which is very evident by the fall observed in 1997, continued monitoring of the structure and abundance of the stock through scientific surveys, and independent of the data from commercial catches, should be guaranteed in order to detect unforeseen changes which could require urgent intervention.

## 2.8 Future research

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

1. Otolith exchange in the region (which should begin before the end of June 2005) to improve sardine age reading.

2. Length measurement and age reading on board the research vessels during the acoustic surveys so as to obtain disaggregated abundance indices by age and zone.

3. Presentation of the quarterly length frequency distributions for the whole historical series for Zones A, B and C at the next Working Group (working paper).

4. Continue research into stock identity (working paper).

5. Recalculate all the R/V DR. FRIDTJOF NANSEN indices by Zone (A, B and C) for the whole historical series (working paper).

# 3. SARDINELLA

## 3.1 Stock identity

No new study of sardinella stock identity has been undertaken since the last Working Group meeting. As in previous years, the Working Group agreed upon a single stock for both sardinella species. For more detailed information on the stock identity refer to the Working Group report 2001 (FAO, 2001).

## 3.2 Fisheries

The greatest exploitation of sardinella is carried out by the EU industrial fishery (Netherlands, Ireland and others) in Mauritania, the non-EU industrial fishery (Russian Federation, Ukraine and others) in Mauritania and the artisanal fishery in Senegal.

*Catch*

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

Readjusting the catch in 2003 gives 335 000 tonnes. The total catches of *S. aurita* seem to have increased from 2002 to 2003. An increase can be seen in 2003 followed by a decrease in 2004. The decreasing trend which began in 1999 continued until 2002.

For *S. maderensis*, the catch series shows an increase from 106 694 tonnes in 2000 to 212 250 tonnes in 2003, then a drastic reduction in 2004 to 145 916 tonnes.

Sardinella catches from 1997 to 2004 by the Mauritanian artisanal fishery are shown in Tables 3.2.1a and 3.2.1b. These catches are composed mostly of round sardinella with an average catch of about 20 000 tonnes for *S. aurita* and only 1 000 tonnes for *S. maderensis.*

*Effort*

Effort data for each zone are given in Table 3.2.2 and Figures 3.2.2a, b and c. In Mauritania the effort of the non-EU fleet (Russian Federation, Ukraine and others) saw considerable growth from 2003 to 2004, however a slight decrease in effort can be seen for the Dutch fleet.

In Senegal the industrial fishery effort is practically identical to that of 2003 whereas the number of trips of the Senegalese artisanal fishery purse seiners decreased.

*Recent developments*

Recent changes in the various economic zones are described below.

In Zone C, a small quantity of sardinella is mentioned as bycatch in the pelagic fishery. In 2004 the zone between Cape Boujdor and Cape Blanc was exploited by pelagic trawlers operating under the fishing agreement between Morocco and the Russian Federation signed on 15 October 2002 in Moscow and by boats chartered by Moroccan operators who had left the octopus fishery due to its over-capacity. Russian pelagic trawlers (a maximum of 12 vessels) has been operated beyond the 15 mile zone from the coast for three years and target sardine, chub mackerel, horse mackerel, sardinella, hairtails and anchovy. The 3 percent rejects are authorized. The charter boats follow the same exploitation patterns as the Russian pelagic trawlers but over a four year period beginning in 2004 with a maximum number of 20 vessels.

The decrease in sardinella catch for the Mauritanian industrial fleet continued in 2004, particularly among the EU vessels. As in 2003, this decrease could be related to the late arrival of the fish in Mauritania due to the low temperatures. Furthermore, there were changes in the number of vessels fishing and an extension of the fishing limit.

For unknown reasons the Dutch boats arrived relatively late, thereby not making the most of the June to September season when sardinella are most abundant in Mauritania. In addition the availability of sardinella to the pelagic fleets in 2004 was reduced because of the increase in the fishing limit from 15 to 20 miles during the months of September and October. During these months, sardinella are distributed very close to the coast so the increase in the limit reduced the catches in comparison to previous years.

Artisanal landings at Nouakchott increased compared to 2003. Catches went up from 22 000 tonnes in 2003 to 25 000 tonnes in 2004.

A more detailed description of the Mauritanian artisanal fishery is given in Annex III.

In Senegal, in comparison to 2003, effort remained stable in the pelagic fishery. Generally the exploitation of coastal pelagic resources in Senegal is characterized by the importance of the artisanal fishery which is mainly concentrated to the south of Dakar, particularly at Mbour and Joal. Nevertheless, a 12 percent decrease in effort in 2004 can be seen in comparison to 2003.

A census of the total number of canoes was carried out in April 2003, the results were then compared with previous years (Table 3.2.3).

**Table 3.2.3:** Results of each census carried out on the Senegalese artisanal fishery from 1993 to 2003

| **Number of canoes using different gears** | | | | | | |
|---|---|---|---|---|---|---|
| | Sept. 1993 | Oct. 1995 | Sept. 1997 | Oct. 2001 | Oct. 2002 | Apr. 2003 |
| Purse seine | 344 | 294 | 394 | 476 | 393 | 395 |
| Encircling gillnet | 72 | 89 | 184 | 101 | 67 | 137 |
| Beach seine | 91 | 95 | 177 | 85 | 85 | 85 |

The number of canoes using the purse seine appears to be more or less constant, whereas the number of those using gill nets has tended to increase. The purse seines are used to catch both sardinella species, while the encircling gill nets generally catch *S. maderensis* and *Ethmalosa fimbriata*.

A notable change in the Senegalese artisanal pelagic fishery concerns the amount of regulation of effort that the fishers impose upon themselves. This involves limiting the number of purse seiner outings in certain landing areas such as Kayar in order to avoid saturating the market. This limit can be observed in the decrease in effort compared to 2003.

Part of the Senegalese artisanal fleet operates in the southern part of Mauritania and lands its catches in Saint-Louis. In 2005, Mauritania granted 270 open licences to the artisanal fishery targeting solely pelagic species, with the exception of mullet, for a duration of six months from July to December.

The industrial fishery is still composed of four sardine boats operating around Dakar. These land just one percent of the total Senegalese catch.

In The Gambia, catches have remained practically at the same level since 2003 (around 2 000 tonnes) with a slight decrease in 2004. Total sardinella catch in The Gambia is very low in relation to the total catch of the region. This is explained by the fact that no fishery targets this species. The species is landed as a bycatch of the artisanal and industrial fisheries.

## 3.3 Abundance indices

### 3.3.1 Catch per unit of effort

For Mauritania, two CPUE series are presented. One for the EU fleet and another for the remainder 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 directed at either species individually. However, around 90 percent of the catch is made up of *S. aurita*. The calculated CPUE based on effort therefore refers mainly to *S. aurita*.
The EU fleet in Mauritania mainly targets sardinella and only catches other species when sardinella are not available in the zone. The sardinella CPUE of this fleet can therefore be considered representative of the availability of sardinella in Mauritania, in particular of *S. aurita*. Effort data for the EU fleet do not include the two Irish vessels, due to the unavailability of effort data for these. For the rest of the EU fleet, the effort has been adjusted to the engine power of the vessel, using the factors given in the 2003 report, and expressed in standard fishing days of a 10 000 HP trawler.

The EU fleet series shows a decreasing trend over the last six years. In 2004, the CPUE of the fleet fell drastically (Figure 3.3.1a). There are two reasons to suppose that the CPUE of the EU fleet does not accurately reflect the 2004 variation in abundance in the Mauritanian zone. The first reason is the reduction in effort of the EU fleet during the season when sardinella are normally more abundant in Mauritania (June–September). It turns out that the fishery in 2004 over the June–September period was irregular when compared to the previous year. The second reason is the extension of the limit for the pelagic fleet during the months of September and October from 15 to 20 miles (see Paragraph 1.5). As sardinella have a very coastal distribution during this season, the extension of the limit greatly reduced the availability of sardinella for the pelagic fleet.

The non-EU fleet (Russian Federation, Ukraine and others) targets horse mackerel and chub mackerel and only catches sardinella when the other species are scarce. The CPUE for sardinella of this fleet has fluctuated around the same low level over the last six years.

Figure 3.3.1b shows the variation in CPUE for *S. aurita* and *S. maderensis* in the Senegalese artisanal fishery. The yields are expressed in tonnes per number of trips.

The highest yields of *S. aurita* were observed between 1992–1994 and 1996–1997. 1996–1999 saw a decrease, followed by an increasing trend in 1999–2001 then a slight decrease in 2002, stabilising in 2003–2004.

Two peaks corresponding to 1996 and 1999 should be noted on the graph of the *Sardinella maderensis* CPUE. There was an increase in CPUE from 2001 to 2003 followed by a decrease in 2004.

### 3.3.2 Acoustic surveys

*R/V DR. FRIDTJOF NANSEN*

In the zone south of Cape Boujdor to Cape Blanc estimated sardinella biomass show marked fluctuations between 1995 and 2004 (Figure 3.3.2a). Peaks in 1996 and 2001 are followed by drops of 78 percent in 1997 and 53 percent in 2002. In 2003 the biomass fell slightly compared to 2002, whereas in 2004 it rose slightly.

The biomass of round sardinella is always greater than that of the flat sardinella (*S. maderensis*). During the 2003 and 2004 surveys, the round sardinella made up 81 and 67 percent respectively of the total estimated sardinella biomass.

The Norwegian research vessel covered the Mauritanian zone in June and November 2003 then again in November 2004. *S. aurita* made up 66 percent of the total biomass during the June survey, but only 19 percent during the November 2003 survey and 14 percent in the November 2004 survey.

The decreasing trend in sardinella observed up until 2001 saw an increase between 2002 and 2004. This increase in total sardinella abundance was mainly due to an increase in the flat sardinella (*S. maderensis*) abundance (Figure 3.3.2b).

In Senegal and the Gambia the fluctuations in biomass vary greatly from one year to the next (Figure 3.3.2c). The years with a large abundance are 1999, 2002 and 2004.

**The whole subregion**

The estimated biomasses for *S. aurita* and *S. maderensis* in the subregion from 1995 to 2004 show fluctuations with average values of 1.5 and 1.9 million tonnes respectively (Figure 3.3.2d) for the series of surveys carried out during November and December. The lowest biomass for *S. aurita* was registered in November/December 1998, but a peak of 2 million tonnes was observed in 1999. Subsequently *S. aurita* biomass declined gradually to 1.2 million tonnes in November/December 2003 before increasing slightly to 1.6 million tonnes in 2004. Contrary to round sardinella, flat sardinella shows a more regular pattern over the last years, with a slightly increasing trend. The variation in total estimated biomass in November/December for the two species together shows a similar trend to that of the flat sardinella over the period 1999–2004.

*R/V ATLANTIDA*

In the Mauritanian EEZ, an acoustic survey was carried out by the Russian research vessel ATLANTIDA in August 2004. Round and flat sardinella were caught in trawls carried out between 20° 41’ and 16° 11’N. The round sardinella was caught at depths of 7–105m and the flat sardinella in the less deep areas of the shelf around 3–55m. The lengths of the round sardinella presented three modal lengths of 15, 23 and 33 cm. The flat sardinella was characterized by large fish measuring 21 to 31 cm with modal lengths of 24–25 and 28 cm. The estimated biomass of round sardinella was 132 423 tonnes whereas that of flat sardinella was 61 821 tonnes.

In the zone north of Cape Blanc, the round sardinella showed modal lengths of 24 and 35 cm and the flat sardinella modal lengths of 25 and 33 cm. The estimated biomass of round sardinella was 347 709 tonnes whereas that of flat sardinella was 82 043 tonnes.

*National surveys*

**Senegal**

Two surveys were carried out by R/V ITAF DEME in 2004. The first, in the cold season, took place from 23 March to 6 April, 2004 and covered the whole Senegalese continental shelf. This survey was particularly marked by the presence of sardine and the high abundance of their biomass south of Dakar along la “Petite Côte”. Of a total biomass for all pelagic species estimated at around 1 568 000 tonnes, 30 percent is made up of sardine.

The main sardinella species is the flat sardinella with a total biomass of around 383 000 tonnes, whereas the round sardinella is estimated at only 36 000 tonnes.

The second survey took place from 25 October to 3 November, 2004 alongside the Norwegian research vessel R/V DR. FRIDTJOF NANSEN. This survey was mainly characterized by the predominance of sardinella. Of a total pelagic biomass estimated at 1 078 080 tonnes, sardinella represents nearly 526 000 tonnes, or close to 48 percent of the total biomass.

The biomass of round sardinella estimated at 255 000 tonnes, saw an increase compared to that found in March (36 000 tonnes). This biomass is comparable to that of the flat sardinella at 271 000 tonnes.

The Northern Zone accounted for less than 10 percent of the total biomass, which is very low.

**Mauritania**

In Mauritania, the Mauritanian research vessel AL-AWAM carried out two surveys in 2004 (April and November) and one survey in March 2005. The biomass of round sardinella was 861 000 tonnes in April 2004, 333 000 tonnes in November 2004 and 222 000 tonnes in March 2005. In April 2004, two modal lengths of 15 and 30 cm were observed. However, the length distributions in November 2004 and March 2005 were very similar both having four modes (8, 19, 25 and 32 cm). The biomass of flat sardinella was estimated at 956 000 tonnes in April 2004, 211 000 tonnes in November 2004 and 287 000 tonnes in March 2005. A single mode of 28 cm was observed in all three surveys.

### 3.4 Sampling of commercial fisheries

Tables 3.4.1 and 3.4.2 show the sampling intensity of *Sardinella aurita* and *Sardinella maderensis* in 2004.

*Mauritania*

The number of length frequency samples of *Sardinella aurita* carried out by the EU fleet (Netherlands) was 227 on a catch of 72 000 tonnes (3.1 samples per 1 000 tonnes). This represents an increase compared to 2004, when the frequency was 2.5 samples per 1 000 tonnes.

For the non-EU fleet (Russian Federation, Ukraine and others), 20 samples of *S. aurita* were available on a catch of 42 000 tonnes (0.47 samples per 1 000 tonnes). This level of sampling is considered to be insufficient.

For the artisanal fishery 24 samples were taken on a total catch of 24 000 tonnes of *S. aurita* (1 sample per 1 000 tonnes).

For *S. maderensis*, the sampling rate was 14.8 samples per 1 000 tonnes for the EU fleet and 1.5 samples per 1 000 tonnes for the non-EU fleet.

*Senegal*

There is an imbalance in the sampling of the industrial and artisanal fleets. On a total catch of 885 tonnes of *Sardinella aurita* by the industrial fishery, 41 samples were taken (Table 3.4.1). However, in the artisanal sub-sector, only 43 samples were taken on a total catch of 111 000 tonnes (0.39 samples per 1 000 tonnes). This level of sampling is insufficient for such an important fishery.

*The Gambia*

In The Gambia, pelagic fish sampling has not yet begun.

### 3.5 Biological data

A change in the measurement system over the whole subregion was introduced in 2004. The measurements must now be carried out on total length. It appears that the transition took place without too many problems.

To compare the length distributions of *Sardinella aurita* in 2004 for the EU fleet with those of past years, the distributions of the previous years were converted to total length using the Boely *et al.* 1982 equation (*S. aurita* TL = 1.21 FL–0.857). Hence a comparison of the length frequencies of the EU fleet with those of previous years is given in Figure 3.5.1. It turns out that the fish in 2004 have a unimodal distribution with a peak of 32 cm. The decrease in length first identified in 2003 thus continued in 2004.

The results of the R/V DR. FRIDTJOF NANSEN acoustic survey in December 2004 are shown in Figure 3.5.2. The data on *S. aurita* in Mauritania from the R/V DR. FRIDTJOF NANSEN show peaks at 8, 17 and 26–29 cm lengths. These fish were smaller than those caught by the EU fleet in Mauritania over the summer, which it would appear, migrated to Morocco in December. The round sardinella sampled by the R/V DR. FRIDTJOF NANSEN in Morocco in December 2004 had approximately the same lengths as those caught by the EU fleet in Mauritania.

### 3.6 Assessment

*Method*

The logistic surplus production model, implemented on an Excel Spreadsheet, was used. This model is described in Appendix II.

*Data*

The model requires a time series of total catch data and a series of stock abundance indices.

The estimates of total catch obtained by adding the catches of the different fleets were used as the catch series.

For the abundance indices, two time series were used, the acoustic survey abundance indices from the R/V DR. FRIDTJOF NANSEN and the CPUE of the Senegalese artisanal fleet (1990–2004). The CPUE series of the artisanal fishery were chosen partly because they reflect sardinella abundance better than the industrial fishery series and partly because they are more closely related to the abundance indices of the acoustic surveys.

Considering that the R/V DR. FRIDTJOF NANSEN surveys were carried out at the end of the year, the indices obtained were judged to be representative of the following year's stock abundance.

Separate series were used for catch of *Sardinella aurita*, *Sardinella maderensis* and the two sardinella species together, that is *Sardinella* spp.

In the data series, 1999 is an exceptional year, with stock growth conditions that cannot only be explained by the dynamics of the stock. Research has shown that 1999 showed strong upwelling activity. Thus, an environmental index which takes into account the peculiarity of 1999 was incorporated into the model.

*Results*

The model was applied to *Sardinella aurita* data and to the two species together using abundance indices from the acoustic surveys and the CPUE series of the Senegalese artisanal fishery. The results of the model for *Sardinella maderensis* as well as for all the models using the Senegalese artisanal fishery CPUE were unsatisfactory. Therefore only the models that used the indices from Nansen applied to *Sardinella aurita* and *Sardinella* spp. were considered (Figures 3.6.1 and 3.6.2).

***Sardinella aurita***

For *S. aurita* the model shows a continual decline in abundance over the last few years with a slight increase in 2004. It appears that the reduction in catch in 2004 has had a positive effect with an increasing trend in biomass being estimated during the acoustic surveys.

The results of the model show that the catch is less than the natural production of the stock. The present biomass is less than that producing the maximum sustainable yield and fishing mortality is below that of sustainable fishing mortality at the present biomass level (Table 3.6.1).

***Sardinella* spp.**

When the two species are combined, the model highlights the decrease in abundance over the last few years with a slight increase in 2004 due mostly to the increase in biomass of flat sardinella (Figure 3.6.2).
The current biomass of the two species together is very close to that producing the maximum sustainable yield and fishing mortality is practically at the sustainable level.

**Table 3.6.1:** Summary of the results of fitting the model using catch of sardinella and the abundance index and incorporating the environmental parameter

| **Stock/Abundance index** | **$B/B_{MSY}$** | **$F_{cur}/F_{SYCurB}$** | **$F_{cur}/F_{MSY}$** |
|---|---|---|---|
| *Sardinella aurita*/Nansen | 63% | 80% | 110% |
| *Sardinella* spp./Nansen | 94% | 91% | 96% |

*Discussion*

At the end of this assessment, it appeared, as in the previous year, that the best fit was obtained using the abundance indices of the R/V DR. FRIDTJOF NANSEN. This was predictable for the fisheries of pelagics that live in shoals, as several studies have shown that the CPUE of these fisheries tend to be less correlated to the abundance of the stocks. The positive effect obtained by integrating the environmental parameter into the model, highlights the importance of variations in the environment on the dynamic of these stocks.

The reduction in catches of sardinella in 2004 seems to have been beneficial to the stock abundance with a slight increase in biomass being observed. But due to the fluctuations in abundance of pelagic species in relation to the environment, it would be wise to avoid increasing catch until the increasing trend in abundance can be confirmed.

## 3.7 Management recommendations

The results obtained this year show that the round sardinella stock is beginning to increase, no doubt due to the reduction in catch in 2004. Although the abundance measured by the acoustic survey has increased slightly, a decrease in the CPUE of sardinella can be seen in the EU fishery in Mauritania.

Considering the incertitude surrounding this change in abundance in the short term, and as a precautionary approach, the Working Group recommends not to increase the level of sardinella catch in 2005 at the same level as 2004, 400 000 tonnes.

## 3.8 Future research

The Working Group recommends that research in the following areas should be carried out:

1. Continue the programme of otolith exchange for sardinella age reading.

2. Set up a study group between Senegal and Mauritania to carry out a deeper analysis into the demographic structures of sardinella.

3. Increase sardinella sampling intensity in the artisanal fisheries, particularly in Senegal and begin sampling in The Gambia.

# 4. HORSE MACKEREL

The two main species considered in terms of the evaluation are the Atlantic horse mackerel (*Trachurus trachurus*) and the Cunene horse mackerel (*Trachurus trecae*). For the false scad (*Caranx rhonchus*) only catch data will be presented.

## 4.1 Stock identity

Stock identity has been described during previous Working Groups, in particular (FAO, 2001 and 2002). Further studies are necessary on stock identity.

## 4.2 Fisheries

*Catch*

The annual variation in catches of the three horse mackerel species is shown in Figure 4.2.1. The catch data series are given by country and for the whole subregion in Tables 4.2.1a,b,c for 1990–2004.

The increasing trend of *Trachurus trachurus* begun in 2003, rose greatly in 2004 going from 64 057 tonnes to 169 350 tonnes, the highest catch of the 1990–2004 total catch series.

Total catch of *Trachurus trecae* practically doubled going from 102 276 tonnes in 2003 to 181 283 tonnes in 2004. Almost the whole catch of this species is taken in the Mauritanian zone.

For *Caranx rhonchus* landings increased slightly in 2004 in comparison to 2003, going from 35 459 tonnes to 43 527 tonnes

For the whole subregion a heavy increase in total catch can therefore be seen for the Atlantic horse mackerel (*Trachurus trachurus*) followed by the Cunene horse mackerel (*Trachurus trecae*) and the false scad (*Caranx rhonchus*).

*Effort*

Fishing effort of the industrial fleets is divided equally between the southern zone of Cape Blanc and the northern zone of the same cape by the Russian, Ukrainian and other fleets. It should be noted that in 2004 fishing effort of the non EU fleets (Russian Federation, Ukraine and others) increased to the south of Cape Blanc and to the north as well after a considerable decrease the two years before in the same zone.

*Recent developments*

Following the signing of a bilateral fishing agreement between Morocco and the Russian Federation on 15 October, 2002, fishing activity in Zone C north of Cape Blanc began again in 2004. This agreement authorizes Russian pelagic trawlers to exploit coastal pelagic resources (sardine, chub mackerel, horse mackerel, sardinella, hairtails and anchovy) in the area between Cape Boujdor and Cape Blanc outside the fifteen mile limit by a maximum number of 12 pelagic trawlers with a level of bycatch of 3 percent. In addition to the Russian fleet, Moroccan operators have chartered pelagic trawlers with the same conditions for exploitation as above for a duration of four years with a maximum number of 20 vessels.

In 2004, catch of Atlantic horse mackerel (*Trachurus trachurus*) was slightly greater compared to 2003 in the northern zone and in Zone A. On the other hand, catch in Zone B was slightly lower. These catches are considered to be bycatch by the trawlers and coastal purse seiners. Following the start-up of activity by the pelagic trawlers in Zone C, catches by the Russian and Ukrainian fleets reached 51 223 tonnes and 27 916 tonnes, respectively.

In Mauritania the fleets that target horse mackerel are from Cyprus, the Russian Federation, Lithuania, Belize, etc. In 2004 nominal fishing effort expressed in fishing days increased in comparison to 2003. This translated into an increase in catch, especially in *Trachurus trecae* the catches of which practically doubled in 2004 compared to 2003. In 2004 the catch of *Trachurus trachurus* increased by 53 percent going from 49 675 tonnes in 2003 to 75 979 tonnes in 2004.

It should be noted that fish meal production reached 27 391 tonnes and 31 583 tonnes in 2003 and 2004, corresponding to a gross catch of 152 293 tonnes and 175 600 tonnes, applying a conversion factor of 5.56. Despite the fact that the specific composition of the catches in the meal is not yet known, it is probable that a large proportion of the catch is made up of horse mackerel.

Catches of horse mackerel in Senegal are marginal in comparison to the level of catch in the subregion. Catches of false scad (*Caranx rhonchus*) by the artisanal fishery have risen from 3 487 tonnes in 2003 to 4 657 tonnes in 2004, whereas those of Cunene horse mackerel (*Trachurus trecae*) have witnessed a slight decline going from 3 680 tonnes in 2003 to 2 246 tonnes in 2004.

Catch of *Caranx rhonchus* and *Trachurus trecae* stabilized in 2004 at a low level of catch not exceeding 200 tonnes in The Gambia.

## 4.3 Abundance indices

### 4.3.1 Catch per unit of effort

Horse mackerel catch by the whole of the Russian, Ukrainian and other fleets does not reflect the variations in the size of the stock as nominal effort is not directed solely at horse mackerel.

Because of this, a single effort series was used for the two horse mackerel species, that of the Russian fleet in Mauritania. The CPUE index was calculated on the basis of a geometric average of daily catches during the months when the species is the most important in the catches (November–April for *Trachurus trachurus* and May–October for *Trachurus trecae*). The results are shown in Figures 4.3.1a and b.

For *Trachurus trachurus*, CPUE in 2004 shows a strong increase over that of 2003. For *Trachurus trecae*, the Russian CPUE series shows weak fluctuations from one year to the next between 1994 and 2004.

### 4.3.2 Acoustic surveys

*R/V DR. FRIDTJOF NANSEN*

The acoustic surveys of R/V DR. FRIDTJOF NANSEN in October–December 2004 provided horse mackerel abundance estimates in the subregion. The results of the survey were used to update the series that began in 1995 (See Figures 4.3.2 a, b, c, d).

Biomass estimates of the two species highlight an increase in Zone C north of Cape Blanc and a decrease in the zone to the south. The estimated biomass of *Trachurus trachurus* was higher than in 2003, especially in the zone north of Cape Blanc (Figure 4.3.2a). Conversely, the *Trachurus trecae* stock shows a slight decrease, particularly in Senegal and Mauritania.

The *Trachurus trachurus* acoustic abundance index in 2004 was the highest in the 1995–2004 series. This was due to an increase in abundance of this species in Morocco. For the first time since 1997 the abundance index of this species at a regional level is higher than that of *Trachurus trecae*.

*R/V ATLANTIDA*

This vessel carried out eight surveys between 1994 and 2004 in the Moroccan zone to the north and south of Cape Blanc. The data are shown in Figure 4.3.2e.

**The Atlantic horse mackerel (***Trachurus trachurus***)**
This species was recorded in catches between Cape Blanc and Cape Timiris (20°41’–18°30’N). Trawl depths are between 21 and 270 m. The estimated biomass is 312 908tonnes.

**The false scad (***Caranx rhonchus***)**
This species forms concentrations around the shelf at depths of 3–55 m between 19°41’ and the Senegalese border (16°06’N). The estimated biomass is 63 060 tonnes.

**The Cunene horse mackerel** (*Trachurus trecae***)**
This species is caught in depths of 7 to 280 m and is found between 20°45’ and 17°25’N except in the zone south of the Mauritanian EEZ. The estimated biomass is 625 336 tonnes.

***National surveys***

**Mauritania**

The R/V AL-AWAM carried out two surveys in 2004 (April and November) and one in March 2005. The Cunene horse mackerel (*Trachurus trecae*) biomasses were 226 000 tonnes, 24 000 tonnes and 248 000 tonnes respectively.

The Atlantic horse mackerel (*Trachurus trachurus*) biomasses were estimated at 5 000 tonnes in April 2004 and 114 000 tonnes in March 2005. In November 2004 this species was not encountered.

The false scad (*Caranx rhonchus*) biomasses were 410 000 tonnes in April 2004, 90 000 tonnes in November 2004 and 84 000 tonnes in March 2005.

**Senegal**

Two surveys were carried out by the R/V ITAF DEME in the Senegalese EEZ in 2004. During the first from 23 March to 6 April, 2004, horse mackerel were found along the entire coast and predominantly on the Petite Côte. Total biomass was around 264 000 tonnes. During the 25 October to 3 November, 2004 survey, horse mackerel were mainly concentrated around the Petite Côte south of Dakar with a total estimated biomass of about 186 000 tonnes.

## 4.4 Sampling of commercial fisheries

In Mauritania sampling is carried out on the Russian and EU (Dutch) fleets. In Morocco it is carried out mainly on the Russian fleet in Zone C and the Moroccan purse seiner fleet in Zone A (Tables 4.4.1, 4.4.2 and 4.4.3).

The three species were all sampled during 2004. For the Russian fleet, sampling took place all year round and was concentrated more on the two *Trachurus* species. It should be noted that *Caranx rhonchus* is only sampled onboard the European Union fleet operating in Mauritania.

As in 2003, sampling intensity is presented by quarter for the two main fleets (Russian Federation and the Netherlands). It should be noted that the highest rate of sampling is carried out by the European Union fleet at a rate of 19 samples per 1 000 tonnes sampled in 2004 for *Trachurus trachurus* and 6 samples per 1 000 tonnes for *Trachurus trecae*. For *Trachurus trachurus*, sampling by the Russian fleet operating north of Cape Blanc was carried out at a rate of 4 samples per 1 000 tonnes. The lowest sampling rate was that of all three species in the zone north of Cape Timiris. The total lack of sampling in Senegal and The Gambia is regrettable even if the catch is marginal when compared to total catch in the subregion.

As for *Caranx rhonchus*, the number of samples taken by the industrial fleet is very low, never going over 1 per 1 000 tonnes in 2004.

## 4.5 Biological data

The length distributions of *Trachurus* spp. obtained during the R/V DR. FRIDTJOF NANSEN survey of October–November are shown in Figures 4.5.1a,b. The distributions are bimodal for *Trachurus trecae* and unimodal for *Trachurus trachurus*. For *Trachurus trecae* the mode was 20 cm and for *Trachurus trachurus* the modes were 12 and 20 cm.

A quarterly age–length key for the Russian fleet catches in the Mauritanian EEZ of *Trachurus trecae* and *Trachurus trachurus* was given to the Working Group (Tables 4.5.1a, b, c, d, e, f, g, h). These keys are based on sampling data on board the Russian fleet operating in the zone.

***R/V AL-AWAM***

It should be noted that the lack of large sized individuals is probably due to the fact that the R/V AL-AWAM can not trawl at depths greater than 100 m.

*Trachurus trachurus*
In April 2004 two modal lengths were observed, 10 and 20 cm. The length distributions of November 2004 and March 2005 were similar in that they both had two modes of 12 and 22 cm.

*Trachurus trecae*
This species was not encountered in November 2004. A single mode of 18 cm was observed in April 2004, whereas a bimodal distribution was seen in March 2005 with modes at 9 and 23 cm.

*Caranx rhonchus*
In April 2004 three modes of 20, 27 and 33 cm were observed. In November 2004 there were two modes of 13 and 24 cm, whereas in March 2005 a single mode of 25 cm was observed.

***R/V ATLANTIDA***

*Trachurus trachurus*
The modal classes were 10 and 37 cm and the average weight was 284 g. In the shallower areas of the shelf the horse mackerel juveniles measuring between 9 and 12 cm were present in small quantities. The larger individuals measuring between 30 and 44 cm were caught at depths greater than 100 m. Pre-spawning and spawning individuals with gonads at the IV and VI–IV stages of sexual maturity as well as juveniles were encountered.

*Caranx rhonchus*
The length of fish varied between 11 and 45 cm, with modal classes of 26–27 cm and an average weight of 202g. Most of the individuals were at the pre-spawning or spawning stage.

*Trachurus trecae*
Individuals measuring 7 to 49 cm were caught with modal classes 26–28 cm and an average weight of 172 g. Three groups of fish were identified, differing in their length–weight and biological state. The first group were immature individuals measuring 8–15 cm, the second group measuring 19–29 cm were in a stage of maturity and spawning and the third group were individuals measuring 33–46 cm which had finished spawning.

## 4.6 Assessment

*Data quality*

In order to test the quality of the data available for the assessment, the sub-group carried out an exploratory analysis of the data, calculating the linear correlation between the estimated catches of each age-group and the corresponding number of the same year-class the following year. Age structured data for 1990 to 2004 were used. Part of this data (1990–2002) was presented in the Working Group report (FAO, 2003). The data for 2003 and 2004 was calculated on the basis of age structure of the catches from the Russian fishery raised to the total catch for these years. Catch at age data for *T. trachurus* are presented in Table 4.6.1, and catch at age data for *T. trecae* are presented in Table 4.6.2. The results obtained (Table 4.6.3, Figures 4.6.1, 4.6.2) indicate a very low correlation between the catches of the same cohort through life.

**Table 4.6.3:** Values of $R^2$ between the estimated catches of consecutive ages of the same cohorts for horse mackerels

| Species/age groups | 1–2 | 2–3 | 3–4 | 4–5 | 5–6 | 6–7 |
|---|---|---|---|---|---|---|
| *Trachurus trachurus* | 0.002 | 0.001 | 0.008 | 0.005 | 0.276 | 0.605 |
| *Trachurus trecae* | 0.021 | 0.018 | 0.007 | 0.030 | 0.009 | 0.018 |

This lack of correlation, indicating that cohorts cannot be reliably followed by the catch data, could be the consequence of several factors; incorrect ageing, changes in the exploitation pattern, inadequate sampling, specific targeting of a few length groups, or incorrect stock delimitation. Irrespective of the source of uncertainty, however, the result is that these data cannot be relied upon for an age-structured analytical assessment.

Trial runs of the age structured models confirm poor quality of the data for VPA applications. Several runs were carried out using the XSA (Darby and Flatman, 1994) and ICA (Patterson and Melvin, 1996) software.

For both species the XSA and ICA methods produced unrealistic results. Therefore, the Working Group decided not to use the age-based analytical models for the assessment of these stocks, at this stage. The logistic surplus production model, implemented on an Excel spreadsheet, was used. This model is described in Appendix II.

*Input data*

The Working Group prepared data to run the dynamic production model for both species, *Trachurus trachurus* and *Trachurus trecae*. Two runs of the model were carried out. As input data for *Trachurus trachurus* the time series of total catches for 1990–2004 estimated by the Group was used and as abundance indices the following were used:

Run 1Tt: Standardized catch per unit of effort of the Russian vessels BATA, which operated in Zone C in November–April of 1990–2004; Run 2Tt: Abundance index from R/V DR. FRIDTJOF NANSEN in November/December (1995–2004).

The assessment of the *Trachurus trecae* stock was carried out using the same model. Two runs were performed and in each run total catches for 1990–2004 estimated by the Group were used. The abundance indices were:

Run 1Tc: Standardized catch per unit of effort of the Russian vessels BATA, which operated in the Mauritania zone in May–July of 1990–2004; Run 2Tc: Abundance index from R/V DR. FRIDTJOF NANSEN in November/December (1995–2004).

An environmental effect was introduced into the model, to account for non-average growth conditions for the stock in some years of the series. The parameters of the equations (described in Appendix II) were determined during the multiple runs of the model.

*Results*

***Trachurus trachurus***

For this species an environmental level effect was introduced, to account for non-average growth conditions of the stock in some years. For run 1Tt, environment effect levels of ±0.5 and ±0.3 were adopted for 1990 and 2003 respectively. For Run 2Tt these effects were applied in 1995 and 2003 with levels of ±0.5 and ±1.0 respectively.

The two series of abundance indices probably reflect different parts of the stock, since the Russian commercial data exploit only the adult fraction of the stock. This may explain the difference in the years to which non-zero environment effect levels were attributed, between the two runs.

Diagnostics of the model tuning were presented for Run 1Tt and for Run 2Tt. For both runs the tuning was satisfactory. Pearson's correlation coefficients were 0.81 and 0.75 respectively. The model follows the main trends in the abundance indices, reacting to the variations in catches. The Working Group decided to adopt run 1Tt as the best description of the state of the stock (Figure 4.6.3a). The model results from Run 1Tt indicate that the current biomass is at the level of the biomass producing the maximum sustainable yield, on average, but the current fishing mortality exceeds the sustainable one at the current biomass levels (Table 4.6.4).

**Table 4.6.4:** Summary of the current status of the stock and the fishery for *Trachurus trachurus* using Russian standardized CPUE

| **Stock/Abundance index** | $B/B_{MSY}$ | $F_{cur}/F_{MSY}$ | $F_{cur}/F_{SYcur}$ |
|---|---|---|---|
| *Trachurus trachurus/*Russian standardized CPUE | 96% | 295% | 280% |

***Trachurus trecae***

Diagnostics of the model tuning were presented for the Russian standardized CPUE and for biomass indices estimated using the R/V DR. FRIDTJOF NANSEN. Tuning of the model was good for the run where the abundance index from R/V DR. FRIDTJOF NANSEN was used: Pearson's correlation coefficients were 0.95; and not so good when catch per unit of effort of the Russian vessels BATA was used, with a correlation coefficients of 0.39. The Working Group decided to keep the results from Run 2Tc (Figure 4.6.3 b). It should be noted that in spite of model parameters differing appreciably, the estimates of the current state of the stock derived from both model runs are similar.

The model results from Run 2Tc indicate that current biomass is below the level of biomass producing the maximum sustainable yield, on average, and that current fishing mortality is close to the level corresponding to MSY fishing mortality (Table 4.6.5).

**Table 4.6.5:** Summary of the current status of the stock and the fishery for *Trachurus trecae*

| **Stock/Abundance Index** | $B/B_{MSY}$ | $F_{cur}/F_{MSY}$ | $F_{cur}/F_{SYcur}$ |
|---|---|---|---|
| *Trachurus trecae/*NANSEN biomass indices | 68 % | 105% | 80 % |

*Discussion*

The results from the assessments indicate that the dynamic production model is a flexible and effective tool for horse mackerel stock assessment. Application of this model and interpretation of the results do not cause problems in the most cases.

This is the case with the stock assessment of *Trachurus trecae*. The results from both runs are similar, even though the length of the time series from the acoustic surveys is 30 percent shorter than the catch per unit of effort series. This is particularly important when taking into account the number of the unknown parameters in the model. The model fit indicates that current total biomass of that species is below the level corresponding to MSY, but current fishing mortality is very close to the fishing mortality corresponding to MSY.

A more complicated case is the stock of *Trachurus trachurus*. There are some differences in determination of the parameters of the model. These are probably the result of the different nature of the indices used: the catch per unit of effort refers mainly to fisheries activity, focused on specific areas and size-groups, but the abundance index takes into account the spatial distribution of the species and full age structure of the population. Detailed comparison of the two runs shows that Run 1Tt is slightly better than Run 2Tt for *Trachurus trachurus* in that the correlation coefficient is a little higher. Also, run 2Tt produces highly inconsistent results, mostly because of the last data point.

There were difficulties assessing this stock with regards to the threefold increase in total catch last year. At the same time the catch per unit of effort of the Russian fishing vessels has been approximately constant over the last years. However, indices of abundance from acoustic surveys by R/V DR. FRIDTJOF NANSEN indicate an increase in the total biomass last year compared to the period 1990–2003. It is possible that changes in the *Trachurus trachurus* distribution have made this fishery attractive to other vessels, resulting in an increase of fishing mortality in 2004. It is also possible that *Trachurus trachurus* appear in areas that are not usually covered by acoustic surveys, an abnormal occurrence brought about by environmental factors. If this is so then it is very likely that the fishery will return to the mean fishing level of the last years.

## 4.7 Management recommendations

The analysis of these stocks indicates that their biomass seems to be close to the MSY level. Based on the precautionary approach and taking into account the possible uncertainties in the estimates the Working Group recommends that catches of *Trachurus* species should not exceed the average level of the last five years .

## 4.8 Future research

In order to reduce the uncertainties associated with the assessment, the Working Group recommends:

1. Improving the sampling of the catches in all fleet segments.

2. Implementing a specific sampling programme for estimating the amount, the species composition and the length structure of the fish discarded or used for fishmeal in all fleets.

3. Investigating the approach to standardize fishing effort in the area based on the generalized linear modes and utilizing fishery statistics from different sources.

# 5. CHUB MACKEREL

## 5. 1 Stock identity

Chub mackerel distribution (*Scomber japonicus*, Houttuyn 1782) was described by previous Working Groups (FAO, 2001, 2002 et 2003).

Two chub mackerel stocks have been identified in the Northwest African region, the northern stock situated between Cape Boujdor and the north of Morocco, and the southern stock situated between Cape Boujdor and the south of Senegal. No new information was provided to the Working Group on these stock identities.

In 2001 and 2002, only the southern stock was assessed by the Working Group. Since the 2003 meeting, due to the uncertainty of identifying the two stocks and migration of chub mackerel, the Working Group decided to assess the two stocks together over the whole distribution area.

## 5.2 Fisheries

In the northern zone, between Tangiers and Cape Boujdor, chub mackerel are exploited solely by the Moroccan fleet. This fleet is composed of coastal seiners that mainly target sardine, targeting chub mackerel when these are available.

During 2004, the zone between Cape Boujdor and Cape Blanc was exploited by Moroccan coastal seiners, pelagic trawlers operating under the Morocco–Russian Federation fishing agreement and boats chartered by Moroccan operators (see Chapter 3).

Several pelagic trawlers from different countries (Russian Federation, Ukraine, European Union and others) operated in the Mauritanian zone. Chub mackerel is not the main target species for these fleets. In Senegal and The Gambia, chub mackerel is considered to be bycatch by the Senegalese artisanal fleet.

*Catch*

Annual catches of *Scomber japonicus* by country for the period 1990–2004 are given in Table 5.2.1. This table was updated with data from 2004 and corrections have been made to the catch data of the Mauritanian, Senegalese and Gambian fleets for 2003.

Catch for the northern fishery (north of Cape Boujdor) oscillated between 10 000 tonnes and 56 000 tonnes between 1990 and 2004. In 2002, landings for this fishery which were 22 700 tonnes, saw a continual increase reaching a record catch in 2004 of 56 000 tonnes. This catch was mainly obtained in Zone A with the highest catch of the series, 44 000 tonnes (Table 5.2.1).

The catches in Zone C (between Cape Boujdor and Cape Blanc), exploited under fishing agreements with the Russian Federation and by chartered vessels, saw a progressive increase between 1993–1998, reaching a maximum of around 150 000 tonnes in 1998. Since then there has been a steady decrease in catch due to the end of the above-mentioned agreements and the subsequent departure of the Russian vessels in 1999 the Ukrainian and other vessels operating under charter in 2001.

During 2004 the fishery in this zone started once again following new fishing agreements with a catch of 66 000 tonnes, mostly from Russian, Ukrainian and other vessels as compared to 45 percent of the total catch being caught by the Moroccan fleet in the northern zone of Cape Boujdor.

The total catch of chub mackerel south of Cape Blanc shows an increasing trend between 1990–1996, the year in which the catch reached a level of around 100 000 tonnes. From 1996 to 1999 the catch steadily declined, recovering again between 1999 and 2003 to reach the highest recorded catch in the region in 2003 in Mauritania with over 70 percent of the total catch.

In 2004 chub mackerel catch between Cape Blanc and Cape Timiris fell below those of the whole zone to the north of Cape Blanc and were estimated at around 96 000 tonnes (Table 5.2.1 and Figure 5.2.1).

For Senegal and The Gambia the species is not targeted and only constitutes bycatch.

Total catch of chub mackerel over the whole subregion has been increasing since 1991, reaching a maximum of over 200 000 tonnes in 1997. After this year the catches fluctuate around an average value of 176 000 tonnes. Since 2002, a continual increase can be seen, reaching a record catch of over 224 000 tonnes in 2004 (Figure 5.2.1).

*Effort*

Effort for the northern fishery (north of Cape Boujdor), carried out by Moroccan purse seiners, has fluctuated over the years, with a slight increasing trend. The effort levels over the last three years from 2002 to 2004 have been around the 50 000 trips, the highest values of the series (Table 5.2.2 and Figure 5.2.2a).

For Zone C (north of Cape Blanc) fishing effort fluctuates around an average value of 3 700 days at sea by Russian and other vessels for those years where there were charter and fishing agreements.

For the industrial fleet in Mauritania, fishing effort expressed in days at sea, reached a maximum in 1996, around 10 000 days at sea. There was a slight decrease in 1997, followed by a steady increase to 2004 where the series reached a maximum of around 13 000 days at sea (Table 5.2.2 and Figure 5.2.2b).

*Recent developments*

Chub mackerel catches north of Cape Blanc increased markedly in 2004. This increase is due partly to the renewal of the fishing activity in Zone C under the charter and fishing agreements between Morocco and the Russian Federation, partly to the Moroccan purse seiners based in Dakhla that operate in the zone and partly to a record catch of 56 000 tonnes by the Moroccan purse seiners that exclusively exploit the zone north of Cape Boujdor. The 66 000 tonnes catch of Zone C (north of Cape Blanc) was mainly landed by the Russian fleet operating in this zone under charter or under the Morocco–Russian Federation fishing agreement. In 2004 effort in the time series was the highest in the zone south of Cape Blanc.

This increase in effort is due to the increase in fleets which traditionally target chub mackerel in Mauritania, in particular the Russian Federation, Cyprus and the Ukraine. The highest chub mackerel catches are recorded during the warm season and coincide with the highest catches of sardinella and horse mackerel.

## 5.3 Abundance indices

### 5.3.1 Catch per unit of effort

The CPUE are calculated using the method described in the 2004 Working Group report (FAO, 2004). In 2004 an increase in CPUE in tonnes/day RTMS can be seen compared to those of 2002 and 2003 (Table 5.3.1 and Figure 5.3.1). The increase in 2003 could be interpreted as a consequence of the reduction in fishing effort after the departure of some of the pelagic trawlers from Mauritanian waters. Nevertheless, in spite of the considerable increase in effort in 2004, the CPUE also showed an increase.

### 5.3.2 Acoustic surveys

*R/V DR. FRIDTJOF NANSEN*

Since 1999 the biomass of this species has been estimated during a series of acoustic surveys carried out by the R/V DR. FRIDTJOF NANSEN. Chub mackerel biomass between Cape Blanc and Cape Cantin in the years 2001 and 2002 was estimated at around 300 000 tonnes during the autumn surveys (Figure 5.3.2). The main concentrations were recorded between Cape Boujdor and Cape Barbas. In 2003 two surveys were carried out by the R/V DR. FRIDTJOF NANSEN in the zone between Cape Cantin in the north and Cape Blanc. The first survey took place in May–June and estimated the chub mackerel biomass at around 374 000 tonnes, whereas the second survey in November–December estimated the biomass at around 547 000 tonnes. In 2004 only one acoustic survey was carried out in the autumn, estimating the biomass at 503 000 tonnes.

*National surveys*

The Mauritanian research vessel R/V AL-AWAM carried out three acoustic surveys in April and November 2004 and March 2005. However chub mackerel was only found during the April 2004 survey. Its biomass was estimated at 190 000 tonnes, composed of individuals of a length between 20 and 39 cm.

*R/V ATLANTIDA and R/V ATLANTNIRO*

Between 1994 and 2000 chub mackerel biomass in Moroccan waters and the north of Mauritania was estimated at between 100 000 and 900 000 tonnes (FAO, 2003) during the acoustic surveys of the ATLANTNIRO Institute.

One acoustic survey was carried out in June–August 2005 by the R/V ATLANTIDA in the 16°N–28°N zone, during which dense concentrations were found all along the continental shelf north of 20N. Chub mackerel biomass in the whole zone was estimated at 705 000 tonnes.

The recruitment survey organized by the R/V ATLANTNIRO in the autumn of 2003 showed that the highest concentration of chub mackerel juveniles was found between Cape Juby and Cape Barbas, the same zone as in May 1999.

A second recruitment survey was carried out between December 2004 and January 2005 by the R/V ATLANTIDA which detected heavy concentrations of juveniles in the same zones, as mentioned above. The abundance indices of the 0 and 1+ age classes were similar to those of 2003.

## 5.4 Sampling of commercial fisheries

Length sampling intensity of chub mackerel off Northwest Africa over the course of the year 2004 in the Northwest zone of Africa is given in Table 5.4.1.

For the northern fishery (Zone A+B) which is exploited by Moroccan coastal seiners, a total of 122 samples of chub mackerel containing 4 971 individuals were taken in 2003 at the rate of 40 individuals per sample. In 2004, 130 samples were taken at a rate of 50 individuals per sample for a total number of individuals of 6 319.

In 2004, for the southern fishery (north of Cape Blanc), 284 samples comprising 75 416 individuals were taken by the Russian fleet, an average of 265 individuals per sample. Age reading was carried out on 1 722 individuals.

For the Mauritanian fishery, length sampling was carried out on board Russian and European Union (The Netherlands) pelagic trawlers by scientific observers. The number of samples taken in 2004 was in the order of 287, comprising more than 65 000 individuals, the majority therefore were sampled by the Russians (172 samples). Sampling intensity was thus at the same level as in 2003 for the European fleet whereas it was significantly lower for the Russian fleet.

## 5.5 Biological data

Length frequency distributions for the northern and southern chub mackerel stocks were analysed for the period 1992–2004. The length distributions obtained in 2004 were compared to those of 2003 (Figure 5.5.1a,b,c,d).

Landings of the Moroccan purse seiners for the northern fishery (Zone A+B) in 2003 showed a clear mode in the juveniles (12 cm) and two modes in the adults which were less pronounced (21 cm and 28 cm). In 2004 only one mode was observed (20 cm) whilst the two modes in the adults had disappeared. The mode in 2004 would seem to be due to the juvenile mode in 2003.

For the southern fishery, the length distribution shows two modes (28 cm and 33 cm) in 2003. The same modes are observed in 2004.

Figures 5.5.2a,b show the length frequency distribution of chub mackerel taken during the R/V DR. FRIDTJOF NANSEN acoustic surveys in November 2003 and December 2004. Only data for the zone north of Cape Blanc are available.

In November–December 2003, two modes were observed at 17 cm and 27 cm. However, in November–December 2004 only one mode of 18 cm was identified. The same situation was seen in the commercial catches.

## 5.6 Assessment

*Data quality*

In order to test the quality of the available data, the Working Group carried out an exploratory analysis of the data by calculating the linear correlation between the estimated catches of each age class and the corresponding number of the same age class of the following year. The results obtained (Table 5.6.1) show the correlation to be acceptable between the catches of the same cohort, particularly between groups 1–2, 4–5 and 5–6.

**Table 5.6.1**: Values of the linear correlation coefficient between estimated catch of consecutive ages of the same chub mackerel cohort

| Age groups | 1–2 | 2–3 | 3–4 | 4–5 | 5–6 |
|---|---|---|---|---|---|
| Correlation coefficient | 0.71 | 0.34 | 0.28 | 0.66 | 0.71 |

An improvement in the correlations can be seen in comparison to those obtained at the 2003 meeting. Consequently the Working Group decided to use both the dynamic production model (BioDyn) and the analytical model "Extended Survivors Analysis" (XSA software, Darby and Flatman, 1994), for the stock assessment, based on the age structures of the catch.

*Dynamic production model*

The Schaefer logistic production model was used. This model is described in Annex II.

*Input data*

For catch data the Working Group used an updated time series of total landings in the subregion from 1992–2004.

The abundance index used was the series of standardized commercial CPUE in tonnes/RTMS day (FAO, 2001). Commercial CPUE series had to be used, despite the known limitations of this approach for pelagic fish stocks, as the series of abundance indices from the R/V DR. FRIDTJOF NANSEN acoustic surveys only began in 1999 and was therefore judged to be too short for use in the model.

*Results*

The fit of the model to the data was considered reasonable (Figure 5.6.1). The model reproduces the main trends of the abundance indices, although the time series of the abundance indices does not show many fluctuations, which reduces its reliability.

The results of the model indicate that the actual biomass (B) is above the level of that producing the maximum sustainable yield ($B_{MSY}$) and that current fishing mortality (Fcur) is also above that necessary to maintain the current level of stock biomass (B) (Table 5.6.2).

**Table 5.6.2:** Summary of the current state of the stock and fishery of chub mackerel *Scomber japonicus.* Between brackets, the variations, coefficient of the estimate as obtained by bootstrap (1 000 replications)

| Stock/Abundance index | $B/B_{MSY}$ | $F_{cur}/FSY_{cur}$ | $F_{cur}/F_{MSY}$ |
|---|---|---|---|
| *Scomber japonicus*/Russian standardized CPUE | 174 % (6%) | 170 % (9%) | 44% (61%) |

The adult part of the stock is fully exploited. The reliability of these results is subject to uncertainties concerning the abundance index used for the fit and the changes in fishing pattern. For this reason the results should be treated with caution.

*Analytical model (XSA)*

The XSA (Shepherd, 1999) allows estimates to be obtained of abundance by number of individuals and of fishing mortality by age class in the stock. As input data it uses the catch by age class matrix by number of individuals of the period under consideration, and estimates of natural mortality for each of the age classes. The algorithm employed in the calibration carried out by the XSA is based on the relationship between abundance of the population and CPUE.

*Input data*

To assess the chub mackerel stock, the following hypotheses were assumed:

i) The catchability of age classes less than three years old depends on the abundance.

ii) The estimates of survivors have been «shrunk» to the average population for ages of three years and under.

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

The catch by age class matrix for the period 1992–2004 used in the model was obtained using annual catches of chub mackerel of all the fleets fishing in the region during said period and by applying the Russian fleet age–length keys (Table 5.5.1) from Zone C. The Russian age–length keys from Zone C were applied to the whole stock due to the lack of age–length keys for the northern zone. Individuals of an age greater than or equal to 6 have been included in the 6+ age class.

The average weights by age class and by year in both the catches and the population are given in Tables 5.6.4 and 5.6.5 respectively. The proportion of mature individuals (maturity ogive) is shown in Table 5.6.6. The annual natural mortality used in the model has a constant value of 0.5 $year^{-1}$ for all years and all age classes in the series.

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

*Results*

The results of the model show some slight residuals with no particular trend. The values of the internal and external standard deviations do not differ significantly. Observation of the regression slopes, the standard deviations and the correlation coefficients ($R^2$) of the adjusted age classes indicates that the model is relatively consistent.

*Discussion*

The lack of contrast between the catch and abundance indices time series renders the results from the BioDyn model unreliable. Reliability is also affected by using commercial targeted CPUE data as the indicator of abundance as fisheries targeting pelagic fish often do not reflect the abundance of the stocks. Consequently great care must be taken when interpreting the results. The results of the model suggest that the stock is fully exploited.

Catch-at-age estimates used in the XSA model are still not sufficiently reliable, which makes the results of the analytical model unsatisfactory. They should therefore be considered to be indicative and care should be taken when interpreting the results.

The variation in biomass of the reproductive stock when compared to the biomass estimates obtained during the acoustic surveys of R/V DR. FRIDTJOF NANSEN and the ATLANTNIRO vessels suggest that stock biomass has increased.

Diagnostics on the state of the stock obtained from the two assessment models are comparable and suggest that the stock is not overexploited. Nevertheless, this conclusion should be treated with caution due to the uncertainties over the reliability of the data used in the assessments and the unpredictability of the stocks due to their sensitivity to environmental change.

## 5.7 Management recommendations

Based on the results obtained during the assessment and taking into account the reliability of the data, the Working Group recommends, as a precautionary approach, that the levels of catch do not exceed those of 2004 (220 000 tonnes).

## 5.8 Future research

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

2. Continue biological studies on growth and reproduction to determine the biological cycle of chub mackerel and the transfer of know-how at a regional level.

3. Encourage the collection and reading of otoliths so as to determine age–length keys for each fishing zone.

# 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. This species can also be found in the Baltic, the North Sea and the English Channel. It is also distributed in the Mediterranean Basin including the Black Sea and the Sea of Azov. The species is divided into several local races with limited migration (Fage, 1920).

A pelagic species often found in large shoals, *Engraulis encrasicolus* lives in estuaries and less deep waters, and sometimes up to 400m.

## 6.2 Fisheries

In the subregion the anchovy is mostly fished in Mauritania and Morocco. It is not targeted, but 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 1990–2004. For the last five years the landings of anchovy have varied between 126 000 tonnes in 2000 and 170 000 tonnes in 2004 with an average of 150 000 tonnes.

In 2004 anchovy landings (*Engraulis encrasicolus*) were 7 068 tonnes. This represents 8 percent of landings of all pelagic species in Morocco. Between 2003 and 2004 anchovy landings fell by 50 percent, that is from 17 000 tonnes to 7 068 tonnes (Figure 6.2.1).

In Mauritania data are available from 1991 to 2004. They show strong fluctuations from year to year (Figure 6.2.1). Catches are good in 1992 (17 358 tonnes) but decline steadily until 1995 (986 tonnes). From 1997 they climb steadily going from 34 511 tonnes to 162 854 tonnes in 2004.

*Effort*

No effort data are available for any country fishing this species.

## 6.3 Abundance indices

### 6.3.1 Catch per unit of effort

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

### 6.3.2 Acoustic surveys

*R/V DR. FRIDTJOF NANSEN*

The estimated biomass of *Engraulis encrasicolus* in the subregion from 2000 to 2004 shows fluctuations from one year to the next. A marked drop can be seen between 2000 and 2001 going from 237 000 to 23 000 tonnes (Figure 6.3.1).

*R/V ATLANTNIRO*

The anchovy biomass series is available for the period 1995–2004. During the survey carried out in August 2004, anchovy were detected between 20° 45 and 18° 31. Anchovy biomass was estimated at 38 294 tonnes. The average weight of the individuals was 11 g and their length varied between 8.5 and 14.5 cm with modal classes of 9.5 and 13 cm. Most of the individuals were mature or in spawning.

*National surveys*

**Mauritania**

The Mauritanian research vessel, R/V AL AWAM, carried out two surveys during 2004 (April and November) and another in March 2005. The results of each survey were used to calculate the fish biomasses in the whole EEZ. The anchovy biomasses were 328 000 tonnes in the April survey, falling to 32 000 tonnes in the November survey and to 8 000 tonnes in March 2005.

### 6.4 Sampling of commercial fisheries

Length frequency data for Morocco and Mauritania are available for 1990–2004.

### 6.5 Biological data

Length frequencies also exist for the whole series of the R/V DR. FRIDTJOF NANSEN surveys.

For Morocco only length frequencies for the year 2004 are available.

Length frequencies are available from the last three R/V AL AWAM acoustic surveys. The range of lengths of individuals varies from 6 to 15 cm in total length.

### 6.6 Assessment

Assessment of this species could not be carried out due to lack of effort data.

### 6.7 Management recommendations

As a precautionary approach the Working Group recommends not increasing catch above the average levels of the last three years (160 000 tonnes).

### 6.8 Future research

1. Begin studying stock identification in the subregion.

2. Look for effort data in the historical time series for stock assessment.

3. Collection of biological data on the species should be done systematically to allow for better stock analysis.

4. Provide the next Working Group with quarterly length frequency data from the whole historical time series.

5. Make anchovy biomass estimates during the acoustic surveys (F. Nansen and nationals).

## 7. BONGA

### 7.1 Stock identity

*Ethmalosa fimbriata*, West African Shad (commonly known as Bonga) is one of the four shad species (Clupeidae, sub-family Alosinae) found in Africa (Whitehead, 1985). Twaite shad (*Alosa fallax)* and allis shad (*A. alosa)* occurred in North Africa where they were in their southernmost limit. They have now disappeared from Morocco and other countries due to habitat degradation and overfishing (Baglinière and Elie, 2000). Kelee shad (*Hilsa kelee)* and Bonga are West African shads.

Bonga is a tropical species, distributed between 24$^{o}$ N (Lozano-Rey, 1950) and 12$^{o}$ S (Poll, 1953) latitude. Bonga is a species of marine origin but has a strong affinity for estuaries, deltas and lagoons (Charles-Dominique and Albaret, 2003). According to Charles-Dominique and Albaret (2003), the distribution appears to be fragmented, with juveniles, sub-adults and mature adults having different habitat preferences. The older group has a preference for the marine environment, and the intermediate one is more adapted to estuaries, with a large plasticity with respect to reproduction.

The main concentrations of *E. fimbriata* are found in Senegal, The Gambia, Guinea, Sierra Leone, Nigeria and Cameroon. They also occur in Mauritania. As they are found everywhere near shores, the likelihood of interchanges between concentration areas are most probable. Difference between different populations have been sought, but not found, by several authors (genetic comparison, Gourene *et al.* 1993; biological comparison, Scheffers and Conand 1976), although Fréon (1979) found significant morphometric differences between the Mauritanian and Senegambian populations. Yet, these morphometric differences in clupeids may depend more on environmental conditions than genetic differences in populations (Charles-Dominique and Albaret, 2003).

## 7.2 Fisheries

Bonga has been exploited for a long time in the subregion and exploitation has been especially intense in The Gambia and Senegal. As a coastal and estuarine species, Bonga is mainly exploited by artisanal fisheries.

*Catch*

Catches by country are presented in Table 7.2.1 for *Ethmalosa fimbriata*. Total catches for The Gambia, Senegal and Mauritania are graphically presented in Figure 7.2.1. For The Gambia and Senegal there have been inter-annual fluctuations in total landings of *E. fimbriata* since 1990 with an overall gradual increasing trend. For Mauritania, data were only for the last five years.

*Effort*

Effort data for Senegal are presented in Table 3.2.2 as the number of trips. It should be noted that the effort presented here is total artisanal effort (trips) targeting small pelagic fish in Senegal. There is a specific gear that target this species in Senegal (surround gillnet 80 mm mesh size) but number of trips with this gear was not available to the Working Group. For The Gambia and Mauritania there were no effort data available.

*Recent developments*

In The Gambia, *E. fimbriata* is only targeted by the artisanal fisheries. Total landings of Bonga in 2004 were significantly lower than in 2003 (Table 7.2.1). The apparent overall trend on landings of Bonga in The Gambia shows a gradual increase (Figure 7.2.1), though with annual fluctuations since 1990. Of the total landings of *E. fimbriata* in the region, 46 percent was landed in The Gambia.

Bonga, (*E. fimbriata),* is only targeted by the artisanal fisheries in Senegal. There was a significant increase in the total landings of Bonga in Senegal in 2004 compared to 2003 (Table 7.2.1). The total landings series showed fluctuations since 1990. From Figure 7.2.1 it can be seen that the trend in the overall landings is a gradual upward one. Of the total landings of *E. fimbriata* in the region, 49 percent is landed in Senegal.

In Mauritania *E. fimbriata* is only targeted by the artisanal fisheries. Total landings in Mauritania for 2004 were about 80 percent lower than in 2003 (Table 7.2.1). Catch data for Bonga landings in Mauritania were available for the period 2000 to 2004. A trend was difficult to ascertain as only a few data points were available (Figure 7.2.1). The total landings of *E. fimbriata* in the region constitute about 5 percent of the total subregional landings.

## 7.3 Abundance indices

### 7.3.1 Catch per unit of effort

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

### 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. 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

There was no length frequency data available to the Working Group for *E. fimbriata.*

## 7.6 Assessment

Given the lack of data from the subregion, assessment of this species was not done.

## 7.7 Management recommendations

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

## 7.8 Future research

1. CPUE for Senegal should be made available to the Working Group.

2. It is necessary for Mauritania and the Gambia to collect effort data for *E. fimbriata*.

3. 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.

4. Bonga should be defined as a target species for acoustic surveys.

## 8. GENERAL CONCLUSIONS

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

| Stock | Assessment | Management recommendations |
|---|---|---|
| Sardine/Zone A+B | Stock is fully exploited. | Do not increase catches above average level of last 5 years (600 000 tonnes) |
| Sardine/Zone C | Stock not fully exploited. | The total catch level may be temporarily increased but should be adjusted to natural changes in the stock |
| Sardinella/ whole subregion | Stock of *S. aurita* fully exploited; no reliable results for *S. maderensis*. | Do not increase catches of sardinella above the current level of 400 000 tonnes (2004). |
| Horse mackerel/ whole subregion | Stocks of *Trachurus trecae* fully exploited, *T. trachurus* probably fully exploited; no results for *Caranx rhonchus*. | Do not increase catches above average level of last 5 years (80 000 tonnes for *T. trachurus* and 170 000 tonnes for *T. trecae*) |
| Mackerel/ whole subregion | Stock is fully exploited. | Do not increase catches above 2004 level (220 000 tonnes) |
| Bonga *Ethmalosa fimbriata* | NA, but catch rates indicate stable stock levels. | As a precautionary measure, catch level should not exceed the average over the five last years (42 000 tonnes) |
| Anchovy | NA, but acoustic estimates highly variable. | As a precautionary measure, catch level should not exceed the average over the three last years (160 000 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 for 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). 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, except for the chub mackerel where a VPA based model was used in addition to the dynamic production model. 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 has given advice on fish stock management in terms of catch levels. It may be difficult to manage catch levels if a system of fleet or vessel quotas is not in place. However, should this be the case, catch levels can also be managed by accordingly adjusting effort.

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 artisanal catches in Senegal and Mauritania.

## 9. FUTURE RESEARCH

The Working Group recommended that the following research areas be pursued in 2005/2006:

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 Banjul, The Gambia, 25 April–4 May 2006.

2. Acoustic surveys and related activities such as coordination between countries and inter-calibration, should be continued to maintain and improve the time series; when possible, acoustic abundance estimates should be split by zones and age groups.

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. Continue to develop and improve the assessment methods integrating environmental factors. 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. 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. Refine reference points for management. A study group has been established and will work by correspondence to prepare a working paper for the next meeting.

7. Improve sampling by increasing the numbers of individuals in each sample covering all size ranges. All fleet segments should be covered. Special attention must be given to artisanal fisheries in Senegal and Mauritania.

8. Continue work on age reading of sardine and sardinella. Request ATLANTNIRO to host two scientists from the region for biological studies on horse mackerel and chub mackerel, especially age reading.