JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

MINISTERE DES PECHE ET DE L'ECONOMIE MARITIME (MPEM)
INSTITUT MAURITANIEN DES RECHERCHES OCEANOGRAPHIQUES
ET DES PECHES (IMROP:EX-CNROP)

# THE STUDY FOR THE FISHERY RESOURCES MANAGEMENT PLAN IN THE ISLAMIC REPUBLIC OF MAURITANIA

## FINAL REPORT



## DECEMBER 2002

SANYO TECHNO MARINE, INC.
OVERSEAS AGRO-FISHERIES CONSULTANTS CO.,LTD.



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# PREFACE

In response to the request of the Government of Islamic Republic of Mauritania, the Government of Japan decided to conduct a development study on "The Study for the Fishery Resources Management Plan in the Islamic Republic of Mauritania" and entrusted the implementation of the study to the Japan International Cooperation Agency (JICA).

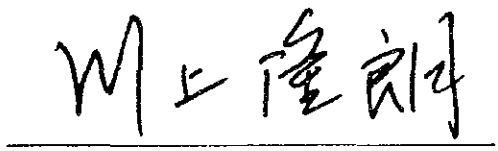
JICA sent a study team to Mauritania between February 2000 and September 2002, headed by Dr. Keisuke Okada, Sanyo Techno Marine, for the first time and by Dr. Keiichiro Mori, Sanyo Techno Marine, for the last five times.

The team held discussions with the officials of the Government of Mauritania, and conducted field surveys in the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the appropriate fisheries management and to the enhancement of friendly relations between the two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of Mauritania for their close cooperation extended to the team.

December, 2002



Takao Kawakami
President
Japan International Cooperation Agency

December, 2002

# Letter of Transmittal

Mr. Takao Kawakami
President
Japan International Cooperation Agency
Tokyo, Japan

Dear Mr. Kawakami,

We are pleased to submit you the Final Report of the Study for the Fishery Resources Management Plan in the Islamic Republic of Mauritania that was recently concluded.

Our joint venture, Sanyo Techno Marine, Inc. and Overseas Agro-Fisheries Consultants Co., Ltd. implemented the study here reported from January 2000 to December 2002, based on the agreement with your Agency. Field research was carried in accordance with the present situation of the fisheries in the Islamic Republic of Mauritania. It also followed the prior accord established between the officials of the Government of Mauritania and us after extensive discussions on the implementation of the study. An accurate evaluation of the results of this study, taking into consideration the current situation of the fishery resources and of industrial and artisanal fisheries, in a context geared toward continuous fisheries production, led to the proposal of a fishery resources management policy for Mauritania.

In addition, transfer of technology necessary for the study in the future was implemented according to the technical level of the concerned officials of the Government of Mauritania.

We would like to express our gratitude for the understanding and support of the officers of the Ministry of Foreign Affairs (including your Agency) and the Ministry of Agriculture, Forestry and Fisheries for the study. We are also grateful for the invaluable advice and immeasurable cooperation we received from the officers of your Agency and the Embassy of Japan in Senegal during our stay in the Islamic Republic of Mauritania. We also acknowledge the advice and support given by the officials of the Government of Islamic Republic of Mauritania in the course of the study.

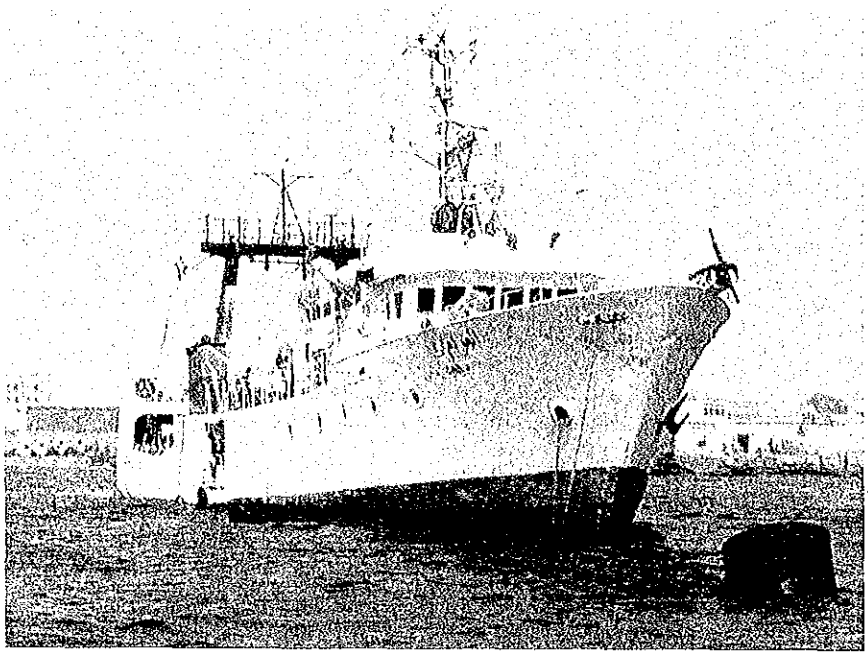
Finally, it is our earnest wish that this report be put to good use for the promotion of the fishery resources management policy of the Islamic Republic of Mauritania.

Very truly yours,

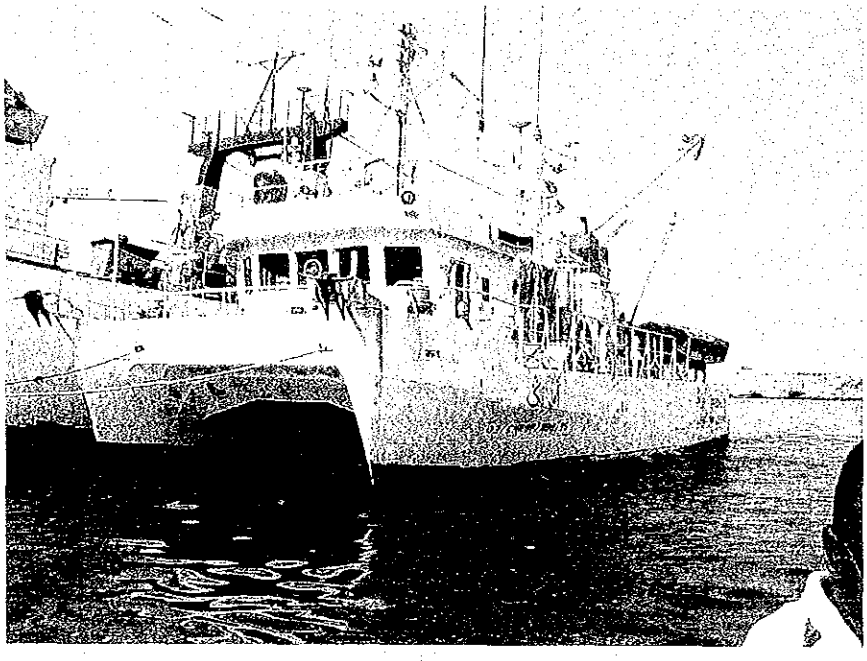
Dr. Keiichiro Mori
Sanyo Techno Marine, Inc.
Representative of the joint venture
Team Leader
The Study for the Fisheries Resources Management Plan
in the Islamic Republic of Mauritania


(NATIONAL GEOGRAPHIC ATLAS OF THE WARLD, NATIONAL GEOGRAPHIC SOCIETY, 1999)

**The Map of the Islamic Republic of Mauritania.**



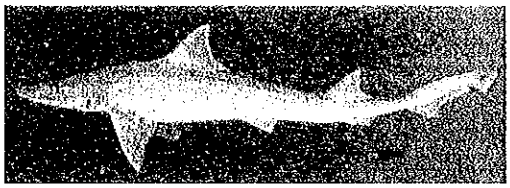
*Al-Awam*



*Amrigue*

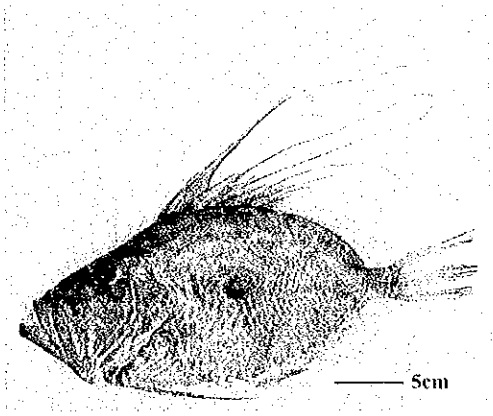
**Research Vessels Belonging to the CNROP/MPEM**

1. Fishes

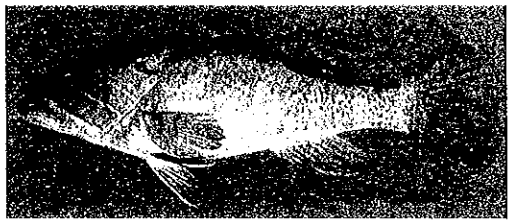


Triakidae *Mustelus mustelus*

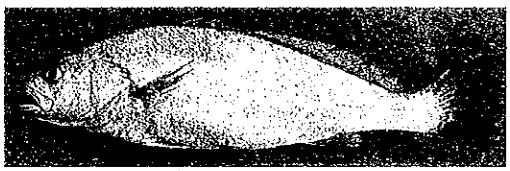
Merlucciidae *Merluccius senegalensis*



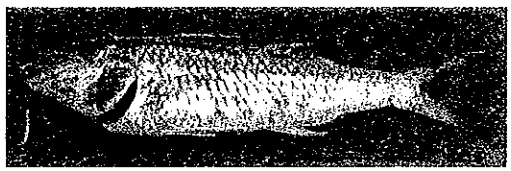

Zeidae *Zeus faber*



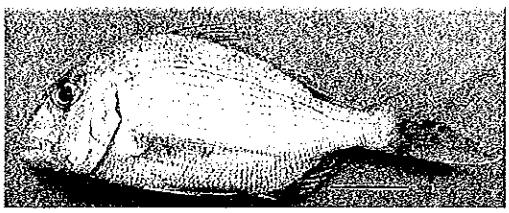
Serranidae *Epinephelus aeneus*



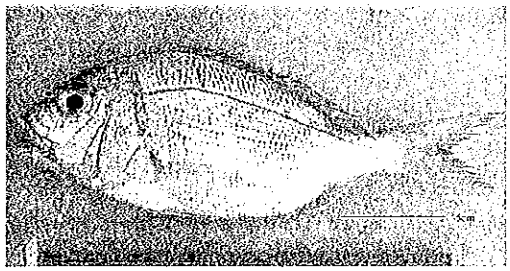
Sciaenidae *Argyrosomus regius*



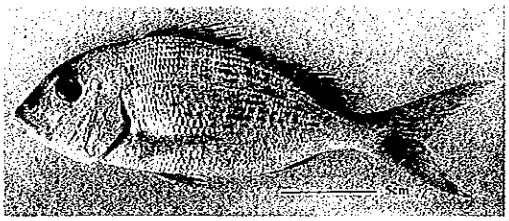
Mullidae *Pseudupeneus prayensis*



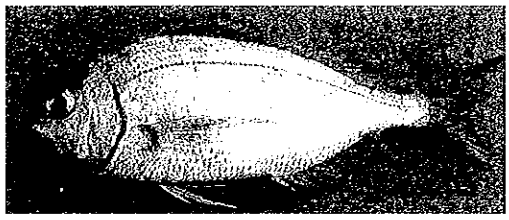
Sparidae *Pagrus caeruleostictus*



Sparidae *Dentex angolensis*

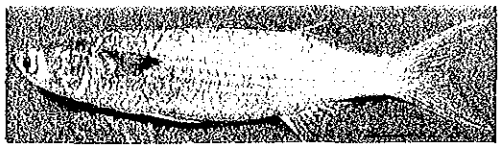


Sparidae *Dentex canariensis*

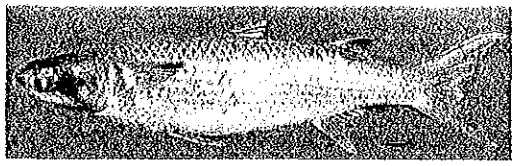


Sparidae *Pagellus bellottii bellottii*

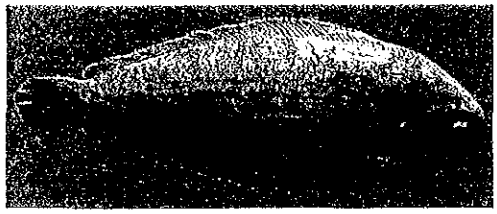
**Target species caught in resources survey by bottom trawl.**



Mugilidae *Mugil capurrii*

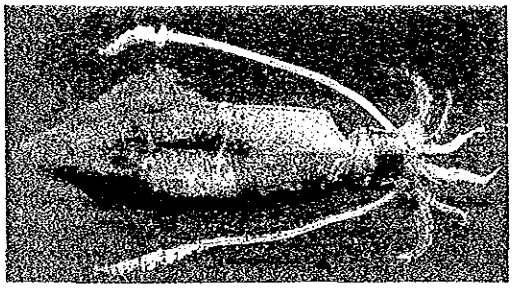


Mugilidae *Mugil cephalus*

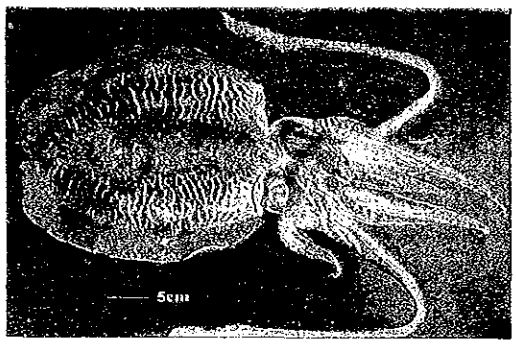


Soleidae *Solea senegalensis*

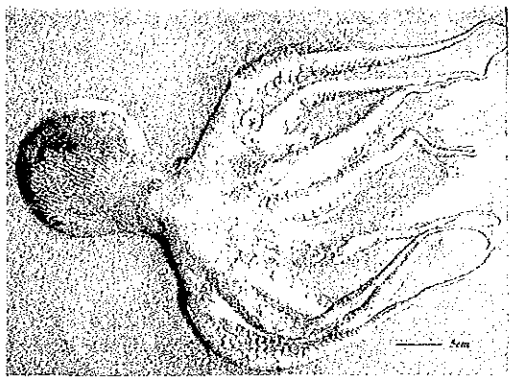
2.Cephalopods



Loliginidae *Loligo vulgaris*



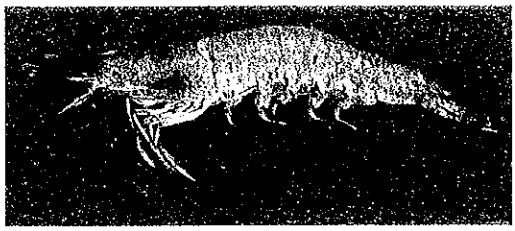

Sepiidae *Sepia officinalis*



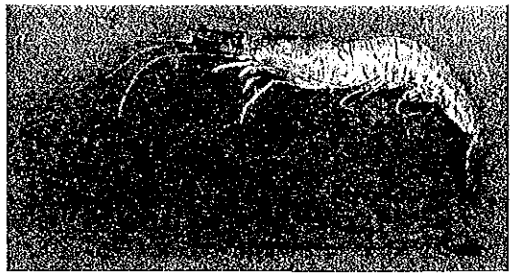
Octopodidae *Octopus vulgaris*

**Target species caught in resources survey by bottom trawl.**

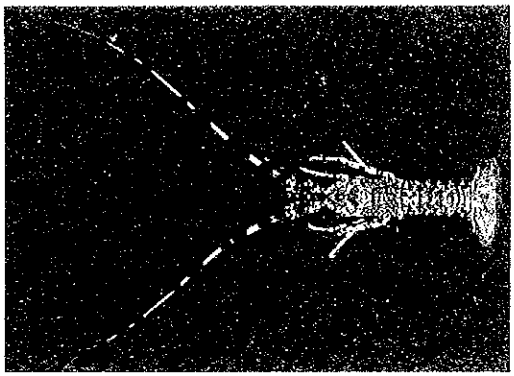
3. Crustacea



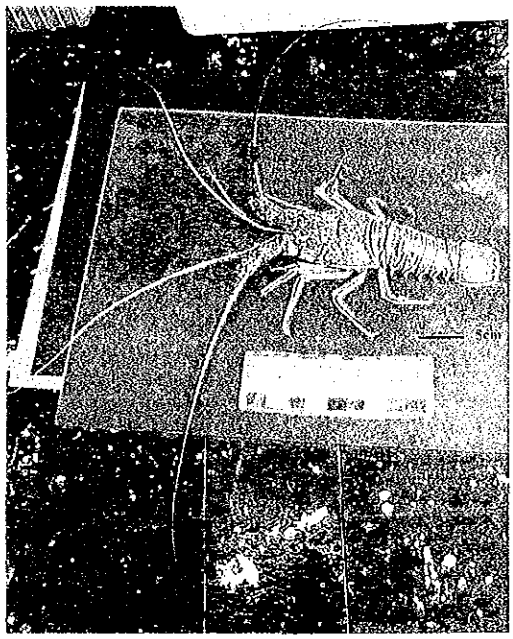
Penaeidae *Penaeus notiaris*



Penaeidae *Parapenaeus longirostris*



Palinuridae *Palinurus mauritanicus*



Palinuridae *Panulirus regius*

**Target species caught in resources survey by bottom trawl.**

## SUMMARY

## 1. INTRODUCTION

With a coastline of extending over approximately 740 km, an Exclusive Economic Zone (EEZ) of 200 nautical miles spread over 234,000 $km^2$, and a continental shelf with a surface area of 34,300 $km^2$, one cannot say the Islamic Republic of Mauritania – located in Northwest Africa – benefits from a wide fisheries production area. However, as a result of the seasonal variation of the interaction between the southward-bound, cold Canary Current and the northward-flowing, warm Guinea Current, the potential productivity of the fishing grounds is high, and the annual yield in a 15-year period (1966-2000) varied from 300 to 650 thousand tonnes, with a mean value of 520 thousand tonnes. In these fifteen years, industrial fisheries production comprised 95 - 98% of the total fisheries production, while pelagic fish species accounted for 73-89% of the industrial fisheries production. Fishery product exports correspond to a large portion of the foreign revenue of the IRM. In 1998, they amounted to 26,8 billion UM, or 34% of the total foreign revenue of the country. The pelagic species occupied about 30% of the total market value of the fishery product exports, as opposed to 61% of demersal species (including 50% of cephalopods and 11% of fishes). Therefore, fisheries in the IRM are a fundamental asset of the country's economy: and, although, the pelagic species make up for most of the catch, the demersal species – particularly cephalopods – contribute more as export values. Nevertheless, in recent years, the yield of commercially valuable demersal species has followed a downward trend. The primary cause of this is pointed out as a decline in resources level due to an increase in fishing effort.

In these circumstances, in April 1995 the Government of the Islamic Republic of Mauritania adopted a *Fisheries Sector Development Policy Letter* whose priority is the sustainable utilization of fishery resources and the implementation of a system for their management. Based on this, in order to promote fishery studies and research, the Government of the IRM reorganized and consolidated the CNROP, but this was not enough to achieve satisfactory results.

In March 1998, during a conference of donor countries organized mainly by the World Bank, the following actions were proposed for a short-term resolution to the problem of diminishing fisheries yield in the IRM: (i) conduction of resources surveys; (ii) implementation of a management system, and (iii) reinforcement of a monitoring system. The accorded agreement specified the implementation of a rational management policy of fishery resources as a condition for the alleviation of the country's debt.

In response to these proposals and agreements in the conference, in June 1998, the Government of the IRM drew up the *Strategy for the Management and Development in Sector of the Fishery and Maritime Economics* that defined the principal axes more clearly.

It was under these conditions that, in September 1998, the Government of the Islamic Republic of Mauritania requested to the Government of Japan to conduct a fishery resources survey. In response, in June 1999 the Government of Japan sent a preparatory study mission to the IRM through JICA. That mission had discussions and field visits with concerned officers of the Government of the IRM,

verified the background and contents of the request and signed an agreement on the details of the implementation of the Study.

This Study was planned and implemented as established in the S/W and M/M documents, and is outlined as follows:

1) The objectives of the Study were: to evaluate the demersal fishery resources within the 200 nautical miles of the Mauritanian EEZ, to propose a proper policy that allow for administrative planning, and to implement transfer of technology to IRM counterparts in OJT during the Study period.
2) The Study was divided in two Phases, with two surveys each in the cold season and the warm seasons respectively, i.e. a total of four surveys.
3) The Study was implemented by DEARH, CNROP and JICA in cooperation.
4) The Study comprised a Sea-borne Survey, a Laboratory Survey and a Landing Site Survey.
5) The Sea-borne Survey was conducted by the CNROP vessels *Al-Awam* and *Amrigue,* on grounds where trawl operations were feasible in the depth range of 3-600 m over the 200 nautical miles of the Mauritanian EEZ. It comprises a resources survey, a biological survey (in this Report, these two surveys refer to as a resources survey by bottom trawl) and an oceanographic observation.
6) The Laboratory Survey aimed at the age determination of the main target species.
7) The Landing Site Survey was mainly conducted in the region of NDB, NKC and Banc d'Arguin. It dealt with issues concerning the catch and the socioeconomic aspects in fishing villages.
8) Based on the second field survey, a study for the implementation of administrative guidelines was conducted.
9) The following main target species were surveyed :

Fishes

*Mustelus mustelus*
*Merluccius senegalensis*
*Zeus faber*
*Epinephelus aeneus*
*Argyrosomus regius*
*Pseudupeneus prayensis*
*Pagrus caeruleostictus*
*Dentex angolensis*
*Dentex canariensis*
*Pagellus bellottii*
*Mugil capurrii*
*Mugil cephalus*
*Liza aurata*
*Solea senegalensis*

Cephalopods

*Loligo vulgaris*
*Sepia officinalis*
*Octopus vulgaris*

Crustaceans

*Penaeus notiaris*
*Parapenaeus longirostris*
*Palinurus mauritanicus*
*Panulirus regius*
*Chaceon (Geryon) maritae*

Others

## 2. OCEANIC ENVIRONMENT AND FISHING GROUND ENVIRONMENT IN SEA-BORNE SURVEY AREA

The area for the oceanographic observation was a region under the interaction of both the Canary Current (cold) and the Guinea Current (warm). The Sea-borne Survey was carried out both in

the cold season, when the former prevailed, and in the warm season, when the latter predominated. The objective of the oceanographic observation was to examine the general oceanic environment of the survey area in both the cold and warm seasons. The results of these observations can be summarized as follows:

1) The oceanographic observation was conducted simultaneously with the resources survey by bottom trawl. The choice of parameters to be observed[1] and the deployment of observation stations and layers were previously determined jointly by JICA and CNROP.
2) Water temperature and salinity, and their resulting $\sigma$ t were analyzed with respect to their horizontal distribution at specific depths, their vertical cross-sectional distribution at specific depth zones (along the continental shelf), and their vertical distribution by area.

Water temperature at the 2 m below surface was low in the cold season and high in the warm season. In the cold season, it was high in the Northern coastal area and low in offshore area near Cape Blanc and the region from Cape Timiris to 18° N. In the warm season, it was high in the Southern area, decreasing northwards and abruptly changing from Cape Timiris to Cape Blanc. Off Cape Timiris, the tropical front in which water temperature ranged between 22°C and 24°C was clearly observed. Salinity was high in the Northern coastal area in both the cold and warm seasons. Relatively high salinity was also distributed in the Central coastal area, but in other regions salinity was level as a rule. During the Phase 2 warm season, salinity had a tongue-shaped distribution in the Southern area, at the southern coast tip, apparently due to the influence of the Senegal River waters. $\sigma$ t was high where the temperature was low and/or salinity was high.

Vertical section distribution of temperature, salinity and $\sigma$ t along the continental shelf is stratified from surface to bottom, temperature and $\sigma$ t stratification being particularly evident in the warm season.

Vertical distribution of temperature, salinity and $\sigma$ t at different coastal observation stations was, for each season and region, uniform from surface to bottom. At diverse offshore observation stations, however, contrary to an almost unchanging vertical distribution of salinity, temperature and $\sigma$ t did vary (the former decreasing and the latter increasing from surface to bottom), particularly during the warm season. Again in the warm season, the existence of a strong thermocline and pycnocline around 50 m deep was observed in all areas.

3) The observed water current direction and speed (current vectors) was analyzed with respect to the horizontal distribution at specific depths and frequency distribution at three specific depths.

Such observations were done instantaneously on the spot. Taking this into consideration, and with regard of the overall picture of water currents in the survey area, the appearance of a strong current should be expected at the upper layer (4 m below surface) in the region between Cape Blanc

[1] Water temperature and salinity, water current direction and speed, pH, chlorophyll-a (pheophytin included), nutrient salts (nitrites $NO_2$-N and nitrates $NO_3$-N), and meteorological observations (weather, temperature, atmospheric pressure, wind). Wind data on land in NDB and NKC was also collected for a long period.

and Cape Timiris (inshore or offshore flow), and in the coastal area around 16-17° N (northward flow).

4) The water column in the entire survey area was divided into eight water masses according to a T-S diagram, and horizontal distributions of those water masses at four specific depths were studied.

Seven of the eight water masses identified corresponded to the seven water masses described by Dubrovnine *et al.* (1991). The remaining water mass with no direct counterpart was the high temperature, low salinity mass formed by the above-mentioned Senegal River.

5) The vertical sections of pH, chlorophyll-a and nutrient salts on the seven across-isobath transects were studied with the sections of water temperature and $\sigma$ t.

In that direction (east-west), pH in the cold season tended to be high in the offshore (west) surface layer, being more accentuated in the southern transect (16° N and 17° N); in the warm season, it was remarkably high, exceeding the cold season value and tending to reinforce the stratification. In the cold season, chlorophyll-a was abundant in the surface layer, more so in Phase 2, consolidating the stratification, markedly in the northern area (transect at 20° 30' N); in the warm season, it was abundant at the surface layer during Phase 1, but in Phase 2 it tended to have peak values distributed in the middle layer (around 10-40 m deep). Among nutrient salts, in both the cold and warm seasons nitrates ($NO_3$-N) in the offshore tended to have high values in either the middle or bottom layer.

6) Frequency by class for each meteorological parameter was established and frequency distribution of data on wind direction and speed on land was analyzed.

Prevailing wind direction (and speed) during the Sea-Borne Survey was north-northwestward or northward (speed in the 5-9 m/s class range) for the cold season and northward (in the 3-6 m/s and 7-9 m/s ranges) for the warm season.

On the other hand, prevailing winds on land during the Sea-borne Survey at NDB and NKC were analyzed from the monthly data from January 2000 to October 2001. In NDB, both in the cold and warm seasons northerly winds prevailed at a mean speed of 8 m/s. In NKC, wind frequency was lower than in NDB in both seasons, but northerly winds also prevailed, at a mean speed of 8 m/s in the cold season and 5 m/s in the warm season.

7) Based on previously published literature and data, an outline of annual changes in the oceanic environment of the survey area was summarized, and then representative features observed during the surveyed season were reviewed, taking into account surface water temperature anomalies.

Among the oceanographic observation data obtained in this survey in both cold and warm seasons, results of the analysis centered on water temperature and salinity took into consideration some oceanographic characteristics such as the seasonal dynamic or interaction of both the cold Canary Current and the warm Guinea Current, the stagnation of the water mass in the Northern coastal area including the Banc d'Arguin, the periodical dynamics of upwellings, etc.

8) The nectobenthic habitat was analyzed by using the horizontal distribution of water temperature and salinity near the bottom and T-S diagrams, and besides the relationship between the nectobenthos and the oceanic environment was considered.

The dynamics of water temperature and salinity near the bottom as analyzed by means of T-S diagrams and the relationship between the nectobenthos and the oceanic environment were taken into consideration. The dynamics of temperature and salinity near the bottom varied at the 80 m-depth boundaries. The magnitude of seasonal temperature and salinity changes varied according to depth when the bottom was shallower than 90 m; however, when it was below that, it stabilized as a rule independently from the depth. Also, north of 19° N, because of the influence exerted the year round by the Canary Current, temperature and salinity variation was relatively small in the entire survey area – except for the Northern coastal area, where water temperature and salinity was respectively higher than elsewhere.

9) The monitoring of the oceanic environment was proposed as the focus for future work concerning the elucidation of the relationship between the oceanic environment and biological phenomena.

## 3. RESOURCES SURVEY BY BOTTOM TRAWL

The main objective of this survey was the stock size estimates and gathering biological information on species important for fisheries (here called target species[2]) living within the 200 nautical miles of the Mauritanian EEZ. Also, the data obtained in the course of this survey was reflected in the recommendation of resources management plan for the sustainable utilization of those target species. The survey results can be summarized as follows:

1) The survey was jointly conducted by JICA and CNROP/MPEM aboard the CNROP vessels *Al-Awam* (301 GRT) and *Amrigue* (62 GRT), in two Phases, in 2000 (Phase 1) and 2001 (Phase

[2] These were 22 species distributed as follows: 14 fishes (smooth-hound *Mustelus mustelus*, Senegalese hake *Merluccius senegalensis*, John dory *Zeus faber*, white grouper *Epinephelus aeneus*, meagre *Argyrosomus regius*, West African goatfish *Pseudupeneus prayensis*, bluespotted seabream *Pagrus caeruleostictus*, Angola dentex *Dentex angolensis*, Canary dentex *Dentex canariensis*, red pandora *Pagellus bellottii*, narrowhead grey mullet *Mugil capurii*, flathead grey mullet *Mugil cephalus*, golden grey mullet *Liza aurata*, and Senegalese sole *Solea senegalensis*), 3 cephalopods (European squid *Loligo vulgaris*, common cuttlefish *Sepia officinalis* and common octopus *Octopus vulgaris*) and 5 crustaceans (southern pink shrimp *Penaeus notialis*, deep-water pink shrimp *Parapenaeus longirostris*, pink spiny lobster *Palinurus mauritanicus*, green spiny lobster *Panulirus regius* and West African geryon *Chaceon maritae*). Of these, two species – the golden grey mullet and the West African geryon – were not caught at all during the survey.

2), each covering both the cold season (April-May) and the warm season (September-October) in a total of four surveys. Trawl operations were performed within the possibilities on survey blocks (a 3-minute interval in both latitude and longitude) determined by the random stratified sampling method. Also, in the Phase 1 cold season, a comparative experiment of fishing efficiency between the two vessels was carried out by the parallel haul method.

2) The difference in the catch capacity between the two vessels was significant, and it was difficult to obtain the relative fishing efficiency by target species. This summary cannot describe the condition on the *Amrigue*, whose catch capacity was markedly lower than that of the *Al-Awam*.

3) The fauna and the diversity of the nectobenthos was examined focusing on fish species. Moreover, the nectobenthos caught at each trawl station was clustered by the similarity between trawl stations.

Fishes caught in the four survey were of 294 species belonging to 113 families and 25 orders (the total number of species in each season varied from 186 to 235). The total number of species of the nectobenthos (fishes, target cephalopods and crustaceans) caught in the four surveys in the Northern, Central and Southern areas was 211, 262 and 255 respectively. Of those, the number of the geographical representative species in each area (defined as the species that appeared throughout the four surveys) was 57, 72 and 65 respectively – a total of 96 species, of which 39 were common for all areas.

As for the species diversity, the diversity index *H'* for the nectobenthos in the entire survey area was, in chronological order of surveys, 2.649, 3.009, 3.211 and 3.312.

Nine groups were defined by the cluster analysis in the four surveys. Their dominant species and those main occurrence stratum were the following: (1) false scad *Caranx rhonchus*, bigeye grunt *Brachydeuteus auritus* and lesser African threadfin *Galeoides decadactylus* groups at the 3-20 m and 20-30 m strata; (2) red pandora *Pagellus bellottii* group at the 30-80 m stratum; (3) Senegal sea bream *Diplodus bellottii*, thinlip splitfin *Synagrops microlepis* groups at the 80-200 stratum; (4) Cunene horse mackerel *Trachurus trecae* group at the 30-80 and 80-200 m strata; blackbelly rosefish *Helicolenus dactylopterus* group and warm season shortnose greeneye *Chlorophthamus agassizi* at the 200-400 m stratum.

4) The distribution of the catch per unit area (CPUA in kg/km$^2$) of the nectobenthos and the CPUA by stratum were obtained. Also, the top-ranking species in terms of CPUA were also simultaneously defined.

The CPUA of the nectobenthos tended to be high in the coastal area shallower than 20 m and/or in the offshore area deeper than 200 m. The CPUA by stratum for the entire survey varied between 90 and 120,489, and the mean CPUA for the entire survey area in each season was within the

5,294-8,745 range. The mean CPUA by stratum for the entire survey area was the highest at the 3-20 m stratum in the cold season and at the 200-400 m stratum in the warm season, with an approximate value of 20,000 in each season. As for the mean CPUA by area in each season, the highest CPUA was observed in the Northern area, followed by the Central and Southern areas in decreasing order. In particular, the mean CPUA at the 3-20 m stratum in the Northern area during Phase 2 was remarkably high, in the 35,000-38,000 range.

Overall, the five top-ranking species of CPUA amounted to 13 species: Senegalese hake *Merluccius senegalensis*, deepbody boarfish *Antigonia capros*, blackbelly rosefish *Helicolenus dactylopterus* dactylopterus, offshore rockfish *Pontinus kuhlii*, thinlip splitfin *Synagrops microlepis*, bastard grunt *Pomadasys incisus*, rubberlip grunt *Plectorhinchus mediterraneus*, bluespotted seabream *Pagrus caeruleostictus*, large-eye dentex *Dentex macrophthalmus*, Senegal seabream *Diplodus bellottii*, red pandora *Pagellus bellottii*, lesser African threadfin *Galeoides decadactylus* and common octopus *Octopus vulgaris*.

5) The standing stock size of the nectobenthos was estimated by the area-swept method, and the top-ranking species in terms of estimated stock size were defined.

The stock size of the nectobenthos in the entire survey area during both the cold and warm seasons in Phase 2 was about 350,000 and 400,000 tonnes respectively. 70%, 20% and 10% of the total stock size was found in the Northern, Central and Southern areas respectively. Also, more than 60% of the total was concentrated at the 3-20 m stratum.

Fourteen species exceeded a stock size of 10,000 tonnes in any one of the four surveys. Eleven of those were exactly the same as the above-mentioned top-ranking species in terms of CPUA, excluding the lesser African threadfin and the common octopus. The other three were the smooth-hound *Mustelus mustelus*, the Benguela hake *Merluccius polli* and the largehead hairtail *Trichiurus lepturus*.

6) The CPUA distribution and the CPUA by stratum for the twenty target species was examined, and estimated according to the area-swept method.

Among the 20 target species, the distribution and stock size of those with a total stock size exceeding 1,000 tonnes in any one of the four surveys are summarized below. The ratio of the combined stock size of the twenty target species to the total stock size was about 25% for all seasons, except for the Phase 2 cold season, where it was 10%.

**Smooth-hound *Mustelus mustelus***

This species was mainly distributed in the Northern area at depths shallower than 80 m. Its total stock size in the Phase 2 cold and warm seasons was 4,902 and 22,933 tonnes respectively. Over 97% of the total stock size was concentrated in the Northern area. The ratio of the stock size at the 3-20 m stratum to the total stock size was an overwhelmingly high 98% in the cold season, against

64% in the warm season. These results suggest that large stocks of this species migrate toward the Northern area in the warm season, and that the species is unevenly distributed along the coast in the cold season, while a portion of the coastal stock moves offshore in the warm season.

**Senegalese hake *Merluccius senegalensis***

This species was widely distributed at depths deeper than 80 m. Its total stock size in the Phase 2 cold and warm seasons was 2,731 and 2,032 tonnes respectively. The Northern area accounted for 67% (cold season) and 78% (warm season) of the total stock size respectively, the Central and Southern areas following in decreasing order. 52% of the total stock size in the cold season was found at the 80-200 m stratum, but 69% of the total in the warm season was present at the 200-400 m stratum. The seasonal variation of the stock size by stratum suggests this species moves to deeper waters in the warm season.

**John dory *Zeus faber***

This species was widely distributed over the survey area, closer to the coastline in the cold season. Its distribution was centered at the 80-200 m stratum, regardless of the season. The total stock size of the species was high in the cold season, with 3,014 and 1,428 tonnes in each Phase respectively, while it was low in the warm season, with respective values of 514 and 477 tonnes: in both seasons there was a decrease in Phase 2. Half of the total stock size in the warm season was found in the Northern area, while in the cold season half of the total was in either the Central or Southern area. About 70% of the total was found at the 80-200 m stratum regardless of the season, and some 30% at the 30-80 m stratum. Its seasonal variation and geographical distribution of the stock size suggest the species migrates northward in the warm season.

**Meagre *Argyrosomus regius***

This species was distributed along the coast in depths shallower than 80 m, and was often occurred south of Cape Timiris in the warm season. The total stock size of the species in the Phase 2 cold and warm seasons was 1,264 and 442 tonnes respectively. In the cold season, 66% of the total stock size was found in the Northern area, and in the warm season 54% of the total was observed in the Central area. The ratio of the stock size at the 3-20 m stratum in the cold and warm seasons to the total was 99% and 66% respectively.

**West African goatfish *Pseudupeneus prayensis***

This species was on the whole widely distributed in waters shallower than 80 m, and concentrated south of Cape Timiris. The total stock size of the species by season (except for the Phase 1 cold season) was 3,308, 2,963 and 2,440 tonnes respectively, decreasing in survey order. Some 50 to 76% of the total was distributed in the Central area. In the Phase 2 cold season, 88% of the total was concentrated at the 3-20 m stratum, but in the warm season, 29% was at the 3-20 m stratum, 18% at the 20-30 m stratum and 53% at the 30-80 m stratum.

**Bluespotted seabream *Pagrus caeruleostictus***

This species was widely distributed at depths shallower than 80 m, being particularly concentrated at waters less than 20 m deep. The total stock size of this species in the Phase 2 cold and warm seasons was 6,381 and 43,180 tonnes respectively. In the cold season, some 50% of the total was found in the Central area; however, in the warm season, over 95% of the total was present in the Northern area. Over 95% of the total in both seasons was concentrated at the 3-20 m stratum. The concentration of the stock size in the Northern area in the warm season suggests a spawning migration from south to north along the coastline.

**Canary dentex *Dentex canariensis***

This species was widely distributed at depths shallower than 80 m. The total stock size of this species in the Phase 2 cold and warm seasons was 3,099 and 1,383 tonnes respectively. In both seasons, some 90% of the total was found in the Northern area, and over 90% of the stock size in the Northern area was concentrated at the 3-20 m stratum.

**Red pandora *Pagellus bellottii***

This species was widely distributed over the continental shelf at depths of less than 200 m, the center of distribution being present in the 20-80 m depth. The total stock size of this species in the Phase 2 cold and warm seasons was 6,826 and 16,748 tonnes respectively. In the cold season, the Northern, Central and Southern areas each occupied approximately one-third of the total stock size, and while 3-20 m and 30-80 m strata each accounted for half of the total. In the warm season, the ratio of each area was 49%, 36% and 15% from north to south, and the 30-80 stratum accounted for 85% of the total. These seasonal distribution patterns of the stock size of this species suggest a migration from south to north and from inshore to offshore.

**European squid *Loligo vulgaris***

This species was widely distributed in coastal waters shallower than 200 m, inshore in the cold season and offshore in the warm season. It tended to concentrate in the Northern coastal area from 20° N to the mouth of Lévrier Bay. Its total stock size in the Phase 2 cold and warm seasons was 1,144 and 1,671 tonnes respectively. In both seasons, some 70% of the total was found in the Northern area. In the cold season, 63% of the total was at the 3-20 m stratum; in the warm season, 86% of the total was at the 30-80 m stratum. The concentration of the squid stock in the Northern area in the cold season suggests a coastal migration for reproduction.

**Common cuttlefish *Sepia officinalis***

This species was mostly distributed in the cold season at depths shallower than 30 m, and in the warm season down to 80 m. The distribution density was denser in the warm season than in the cold season, a phenomenon accentuated in the regions north and south of NKC. Its total stock size in the Phase 2 cold and warm seasons was 1,455 and 852 tonnes respectively. The stock size of this

species tended to be biased in the Northern area and at the 3-20 m stratum. This lean in geographical and vertical distribution of the stock was remarkably in the cold season, with respective ratios of 70% and 97% of the total.

**Common octopus *Octopus vulgaris***

This species was widely distributed from north to south and from inshore to offshore regardless of the season. Areas with a significant density were off Cape Blanc in the Northern area, off south of Cape Timiris (southern portion) or off NKC in the Central area, and the region south of 17° 30' N in the Southern area. The total stock size was, in serial order of survey, 7,612, 6,274, 3,352 and 3,521 tonnes respectively. In the Phase 2, the ratio of the stock size in the Northern, Central and Southern areas to the total stock size was 18%, 48% and 34% in the cold season and 52%, 25% and 23% in the warm season respectively. In both seasons, near 90% of the total was found at the 30-80 m and the 80-200 m strata. The seasonal geographical distribution variation of the octopus stock suggests a movement between south and north.

7) Biological information such as size composition, length-weight relationship, sex ratio, maturation and feeding habits was obtained for the twenty target species. Except for length-weight relationship, such data for the eleven target species with a stock size of over 1,000 tonnes are summarized below.

**Smooth-hound *Mustelus mustelus***

The total length in this species varied between 42 and 112 cm. The mean total length by area was 62-65 cm in the cold season and 67-90 cm in the warm season. The mean total length was larger in the Southern area than in the Northern area, and in deep strata than in shallow strata. The total stock size in number comprised mainly the medium-size group (total length in the 60-80 cm range); however, the small-size group (less than 60 cm) predominated in the Northern area and the large-size group (over 80 cm) in the Southern area. In the cold season, the length and weight of females surpassed that of males, but the opposite happened in the warm season. For all seasons except for the Phase 1 cold season, the overall sex ratio (male/female) was 0.33, 0.73 and 0.98 respectively. The ratio of mature females (those with discernible fetuses) was 0% in the cold season and in the 10-56% range in the warm season. In the Phase 2 warm season, individuals in the 70-80 cm class were mostly female; however, males predominated in all other length classes. The total length at first maturity was approximately 60 cm, and the majority of females over 70 cm were mature. The smooth-hound was found to eat mainly crustaceans and also fish.

**Senegalese hake *Merluccius senegalensis***

The total length in this species in Phase 2 was in the 10-70 cm range. The mean total length by area was overall small in the Northern area and large southward in the cold season, but the opposite trend happened in the warm season. The mean total length by stratum was larger in deep strata

regardless of season. The total stock size in number comprised mainly the medium-size group (total length in the 20-40 cm range). The small-size group (less than 20 cm) was restrictively distributed at the 30-80 m stratum in the cold season and at the 80-200 m stratum in the warm season. The large-size group (over 40 cm) was distributed at the 200-400 m stratum. The mean size of females was larger than that of males. The overall sex ratio in the cold and warm seasons was 0.82 and 0.72 respectively. Females were remarkably predominant in the Central area and at the 200-400 m stratum. The female maturity ratio was 5% in the cold season and 9% in the warm season, and depended on the depth, being higher in deeper strata. The female maturity ratio showed a seasonal geographic-dependent change, being higher in the south in the cold season and in the north in the warm season. In both seasons, individuals over 58 cm were all female. The total length at first maturity was about 38 cm in the cold season and about 28 cm in the warm season. This species was found to eat crustaceans, fish and cephalopods.

**John dory *Zeus faber***

The total length in this species was in the 5-55 cm range. The mean total length was larger in the cold season than in the warm season. The mean total length by area was larger in the Central area in the cold season and in the Northern area in the warm season. The mean total length by stratum was larger at the 80-200 m stratum. The major part of the total stock size in number was made up the small-size (less than 20 cm in total length) and medium-size (20-40 cm) groups in the cold season and the small-size group in the warm season. The small individuals in the cold season were concentrated at the 30-80 m stratum; in the warm season, they also occurred in the 80-200 m stratum. The large group (over 40 cm in total length) was widely distributed in the cold season and concentrated in the Northern area in the warm season. Except for a value of 1.37, the overall sex ratio was in the 0.72-0.82 range. Geographical and vertical changes in the sex ratio did not depend on the season but varied along the survey period. The female maturity ratio was 9-14% in the cold season and 4-7% in the warm season, and depended seasonally on the geography and depth. It was higher to the south and at the 80-200 m stratum in the cold season, and to the north and at the 30-80 m stratum in the warm season. The sex ratio showed a seasonally size-dependent change. In both seasons, individuals larger than 44 cm were all female, the majority of which were mature. The total length at first maturity was found at about 22 cm. This species fed mainly on fish.

**Meagre *Argyrosomus regius***

The total length in this species was in the 9-112 cm range. In Phase 2, the mean total length by area varied seasonally and was found to be larger in the south in the cold season and in the north in the warm season. The mean total length by stratum tended to be larger in deeper strata for both seasons. The total stock size in number comprised mainly small-size group (less than 30 cm in total length). The small- and medium-size (30-60 cm) groups were distributed in each area, but the large size group (larger than 60 cm) was found only at the 3-20 m stratum in the Central and Southern areas. The mean female size was larger than that of males. The overall sex ratio was in the 0.29-0.44 range, with an

overwhelming predominance of females. No mature females were observed during the survey. The feeding habits of this species include mostly fish and crustaceans.

**West African goatfish *Pseudupeneus prayensis***

The fork length in this species was in the 6-26 cm range. The mean fork length was larger in the cold season than in the warm season. The mean fork length by area was larger in the Northern area in the cold season and in the Southern area in the warm season. The mean fork length by stratum in the Northern area was larger at deeper strata in the cold season and at shallower strata in the warm season. The total stock size in number of this species mainly consisted of the medium-size (fork length in the 15-30 cm range) group in the cold season and the medium- and small-size (fork length less than 15 cm) groups in the warm season. The mean size of males was larger in the cold season and that of females was so in the warm season. Except for a value of 1.19, the overall sex ratio was in the 0.65-0.75 range. Females were more numerous in all areas. The female maturity ratio was 3-17% in the cold season and 34-49% in the warm season; also, it was higher at shallower strata. Further, it was high in the Northern area in the cold season, and in the Central or Southern area in the warm season. The sex ratio in the Phase 2 cold season showed the size-dependent change: the larger, the higher. The fork length at first maturity was observed at about 11 cm in the warm season and 15 cm in the cold season. This species was found to eat mainly crustaceans.

**Bluespotted seabream *Pagrus caeruleostictus***

The fork length in this species was in the 4-51 cm range. The mean fork length was longer in the cold season than in the warm season. The mean fork lengths by area was large in the Northern and Southern areas. The mean fork length by stratum was, with some exceptions, larger at deeper strata. The total stock size in number of this species was mainly made up the medium-size group (fork length in the 20-40 cm range) regardless of season. The small-size group (less than 20 cm in fork length) was concentrated at the 3-20 m stratum in the Central area; the medium group widely distributed at strata shallower than 80 m. The large group (over 40 cm in fork length) was concentrated in the Central and Southern areas in the cold season. The mean size of males was, with one exception, larger than that of females. The overall sex ratio was in the 0.52-0.81 range, with a predominance of females regardless of season. The female maturity ratio was 4-11% in the cold season and 33-49% in the warm season; also, it tended to be higher at the 3-20 m or 20-30 m stratum. The female maturity ratio by area in Phase 2 was higher in the Southern area, decreasing northward. The sex ratio by size was found not to depend on length class, and females predominated in practically all length classes. The fork length at first maturity was about 24 cm in the cold season and 19 cm in the warm season. This species was found to feed mainly on crustaceans and mollusks.

**Canary dentex *Dentex canariensis***

The fork length in this species was in the 7-35 cm range. The mean fork length was larger in the cold season than in the warm season. However, the mean fork length in the Northern and Central areas in Phase 2 was larger in the warm season. The mean fork length by stratum was large at deep

strata. The total stock size in number of this species, except in the Phase 1 cold season, comprised mainly the small-size group (less than 20 cm in fork length). In the Phase 1 cold season, the medium-side group (fork length in the 20-30 cm range) predominated in the total stock size in number. The young fish less than 10 cm occurred in the warm season. The small- and medium-size groups were distributed in waters shallower than 80 m. The young fish was concentrated at the 30-80 m stratum in the Northern area and at the 3-20 m stratum in the Central area. The large group (fork length over 30 cm) was scantily distributed. The mean size of males was larger than that of females in the cold season, but that of females was slightly larger than that of males in the warm season. The overall sex ratio was in the 0.27-0.38 range, with a predominance of females regardless of season. The female maturity ratio was 14-29% in the cold season and 1-8% in the warm season. The sex ratio by length class was found not to depend on size, and females predominated in practically all length classes. The fork length at first maturity female was about 21 cm in the cold season and 25 cm in the warm season. This species was found to feed mainly on fish and crustaceans.

**Red pandora *Pagellus bellottii***

The fork length in this species was in the 4-30 cm range. The mean fork length in the Northern area was larger in the warm season and that in the Central area in the cold season. The mean fork length by stratum was larger at deep strata, with some exceptions. The total stock size in number of this species comprised mainly the small-size group (less than 10 cm in fork length) in the cold season and the small- and medium-size (fork length in the 10-20 cm range) groups in the warm season. The small- and medium-size groups were widely distributed over the entire area, being numerous at the 30-80 m stratum. The large group (fork length over 20 cm) was also distributed all over, but in few numbers. The mean size of males was larger than that of females. The overall sex ratio was in the 0.92-1.43 range, with a predominance of males except for a single instance. The female maturity ratio was 7-11% in the cold season and 11-31% in the warm season. The female maturity ratio by area was high in the Central area in the cold season (15-17%) and in the Northern area in the warm season (14-53%). The size-dependent change of the sex ratio was more conspicuous in the Phase 2 warm season. The sex ratio increased progressively between 8 and 25 cm classes with a rise in male ratio, but above the 25 cm that ratio decreased. This change in the sex ratio suggests sex reversal. The fork length at first maturity was about 19 cm in the cold season and 11 cm in the warm season. This species was found to feed mainly on polychaetes, crustaceans and fish.

**European squid *Loligo vulgaris***

The mantle length in this species was in the 3-54 cm range. The mean mantle length by area in Phase 1 was larger in the Central area in the cold season and in the Northern area in the warm season. In Phase 2, the mean mantle length was larger in the Southern area regardless of season, decreasing northward. In Phase 2 cold season, the mean mantle length by stratum was particularly large at the 3-20 m stratum. The total stock size in number of this species consisted of mainly the small-size group (less than 10 cm in mantle length), followed by the medium-size group (mantle length in the 10-20 cm range); the large group (over 20 cm) was rare. The small- and medium-size groups were distributed

over the entire area, being numerous in the Northern area. The large group was also found all over, concentrated at the 3-20 m stratum. The mean size of males was fairly larger than that of females. The overall sex ratio was 1.03-1.07 in Phase 1 and 1.57-1.78 in Phase 2. The sex ratio by stratum seemed to indicate a predominance of males as depth increased. The female maturity ratio, in serial order of survey, as follows: 7%, 10%, 45% and 3%. The geographical or vertical difference in the female maturity ratio was remarkable, especially at the 3-20 m stratum in the Northern area and in the Southern area in the Phase 2 cold season, being of about 90-100%. The concentration of those mature females in the coastal area strongly suggests a spawning migration toward inshore. The size-dependent change of the sex ratio was perceived, but its pattern was contradictory. The mantle length at first maturity was about 14 cm in the cold season and 12 cm in the warm season. This species was found to feed mainly on fish.

**Common cuttlefish *Sepia officinalis***

The mantle length in this species was in the 3-35 cm range. The mean mantle length by area was larger in the Central and Southern areas in the cold season and in the Northern area in the warm season. The mean mantle length by stratum was at shallower strata in the cold season and at deeper strata in the warm season. The total stock size in number of this species comprised mainly the medium- (mantle length between 10 and 20 cm) and large-size (mantle length over 20 cm) groups in the cold season, and the medium-size group in the warm season. The small size group (mantle length less than 10 cm) occurred in the warm season, and was distributed over the entire area, being numerous in the Central and Southern areas. The medium-size group was also distributed all over, concentrating in the Central area. The large group again had a wide distribution, but concentrated at the 3-20 m stratum. The mean size of males and females was larger in the cold season than in the warm season. Except in the Phase 1 warm season, the mean mantle length of males was larger than that of females. The overall sex ratio was, in serial order of survey, 1.00, 0.72, 1.16 and 1.39. The depth dependent change in the sex ratio was not observed. In the Phase 1 warm season and in the Phase 2 cold season, the sex ratio by area was high in the Northern area, decreasing southward. The female maturity ratio was 67% in the cold season (Phase 1 yielded too few specimens for inclusion in the calculations) and less than 10% in the warm season. The ratio of post-spawning females was 33% at the 30-80 m stratum in the Northern area in the Phase 1 warm season. In the Phase 2 cold season, at the 3-20 m stratum in the Northern, Central and South areas, the post-spawning ratio was 100%, 6% and 25% respectively. The size-dependent change in the sex ratio was unclear. The mantle length at first maturity was about 14 cm in both seasons for males and about 11 cm in the cold season and 15 cm in the warm season for females. The cuttlefish diet consisted of fish species, crustaceans and mollusks.

**Common octopus *Octopus vulgaris***

The mantle length in this species was in the 3-25 cm range. The mean mantle length by area was larger in the Southern area, the tendency (with one exception) being a decrease northward. The total stock size in number of the octopus comprised mainly the small- (mantle length less than 10 cm)

and medium-size (mantle length in the 10-20 cm range) groups regardless of season. The large group (mantle length over 20 cm) was uncommon, but was distributed over the entire study area. The small-size group was widely distributed over the entire area, being numerous in the Central area. The medium-size group was also distributed all over, but the center of its occurrence was not defined. The mean weight of males was larger than that of females, and while the mean mantle length of males was about the same as that of females in Phase 1, in Phase 2 it was clearly larger. The overall sex ratio was in the 0.84-0.94 range, and there was an overall equilibrium between males and females. This tendency was also observed in the sex ratio by area and by stratum. The female maturity ratio was 4-11% in the cold season and 30-32% in the warm season. Despite the low ratio, females in post-spawning or nursing stage were verified. The geographical variation in the female maturity ratio was observed: it was high up to the third survey in the Southern area, but in the fourth survey it was so in the Northern area. The female maturity ratio did not show the depth- and size-dependent changes. The mantle length at first maturity was about 6 cm for males and 8 cm for females in the cold season, and about 7 cm for males and 6 cm for females in the warm season. Octopuses fed on other mollusks, crustaceans and fish.

## 4. MESH SELECTIVITY STUDY FOR TARGET SPECIES

Mesh selectivity experiments by the covernet method were conducted in order to examine the effectiveness of the mesh-size regulations on trawl nets adopted by the IRM, particularly the 70 mm regulation size for bottom trawling.

Results are summarized below.

1) Mesh selectivity experiments for the target species were conducted utilizing the three sizes of cod-end (45 mm, 70 mm and 100 mm in the nominal mesh-size), to which a covernet of 20 mm in the nominal mesh-size was attached.
2) Selectivity parameters were obtained for more than one size of the three kinds of cod-end with respect to nine[3] of the target species. As for the common octopus *Octopus vulgaris*, the mesh selectivity estimate for the 70mm cod-end was tried by the scientists of IMROP.
3) The effectiveness of the mesh-size regulations adopted by the IRM was tested on the basis of $L_{50}$ and biological minimum size (length at first maturity) for those nine species.

The aim of mesh-size regulation is to allow the escapement of juveniles of species targeted by fisheries and prevents a growth overfishing. It was established that an effective mesh restriction should adopt a minimum mesh size considering a $L_{50}$ larger or equal to the length at first maturity.

The effectiveness of a minimum mesh size of 70 mm for bottom trawling was tested on the eight species, except for the deep-water pink shrimp *Parapenaeus longirostris*, for which no data could be obtained with a 70 mm cod-end (mean of the actual measured inner diameter: 62-64 mm). Of those eight species, the West African goatfish *Pseudupeneus prayensis* and the red pandora *Pagellus*

[3] *Merluccius senegalensis, Trachurus trecae, Argyrosomus regius, Pseudupeneus prayensis, Pagrus caeruleostictus, Dentex canariensis, Pagellus bellottii, Loligo vulgaris, Parapenaeus longirostris.*

*bellottii* had an $L_{50}$ larger than the length at first maturity, but the remaining six species had an $L_{50}$ smaller than the length at first maturity. It was concluded that the 70 mm minimum mesh regulation was effective for the West African goatfish and the red pandora, but not for the other species.

The effectiveness of a minimum mesh size of 50 mm for shrimp trawling was tested on the deep-water pink shrimp *Parapenaeus longirostris*. For this species, the $L_{50}$ for a 45 mm cod-end (mean of the actual measured inner diameter: 39-40mm) was 3 cm larger than the length at first maturity. Since the regulatory 50 mm mesh is wider than the 45 mm net used in this experiment, it is believed that it is highly efficient for this species. However, fishes captured as a bycatch by this bottom trawl shrimp net can be subjected to more growth overfishing than that of 70 mm mash size.

4) For six species[4] with the results for more than two kinds of cod-end, the relationship between mesh-size and $L_{50}$ was preliminarily determined. From those preliminary results, some reference values for effective minimum mesh size could be established for each species, as follows: 67 mm for the Senegalese hake *Merluccius senegalensis*; 104 mm for the Cunene horse mackerel *Trachurus trecae*; 42 mm for the West African goatfish *Pseudupeneus prayensis*; 92 mm for the bluespotted seabream *Pagrus caeruleostictus*; 48 mm for the red pandora *Pagellus bellottii*; 107 mm for the European squid *Loligo vulgaris*.

## 5. DIAGNOSIS OF THE CURRENT STATUS OF DEMERSAL SPECIES RESOURCES

In order to diagnose the current status of demersal species resources, it is necessary to clarify the fisheries production aimed at demersal species resources and understand the actual situation of those resources. For this, (i) the ONS fisheries statistics; (ii) the results of this resources survey conducted in cooperation (*cold and warm season surveys*); and (iii) the results of the surveys conducted by the CNROP in the transitional period between seasons (*transitional period surveys*) were utilized. A summary of the analyses and studies is presented below.

1) **Fluctuation of fisheries production by artisanal and industrial fisheries**

In the fifteen-year period between 1986 and 2000, the total fisheries production in each year fluctuated from a minimum of 306,334 tonnes in 1994 to a maximum of 644,942 tonnes in 1998. The total production decreased from 1986 to 1994, but went up from 1995 to 1998, only to decline again after 1999.

The ratio of the artisanal fisheries production (in the 10,427 tonnes in 1990 - 22,236 tonnes in 1996 range) to the total fisheries production varied from 2% to 5%, and the corresponding ratio of the industrial fisheries production fluctuated between 95% and 98%.

From 1986 to 2000, the annual fisheries production of both iced storage and freezer trawlers (in the 20,471 tonnes in 1999 - 69,703 tonnes in 1987 range) accounted for about 3% to 14% of the entire industrial fisheries production, and this ratio dwindled in a six-year period. Also, the production of both trawlers declined yearly from the 60,000 - 70,000 tonnes level in

[4] *Merluccius senegalensis, Trachurus trecae, Pseudupeneus prayensis, Pagrus caeruleostictus, Pagellus bellottii, Loligo vulgaris.*

1986 - 1987 to the 20,000 tonnes level in 2000.

2) **Fisheries production by species**

Out of the 24 fish groups classified in the IRM fishery statistic, the 9 fish groups[5] seemed to include the 22 target species in this study. The fluctuation of annual production of those 9 groups in the six - year period between 1995 and 2000 is summarized as follows.

The annual production of *poulpe* was in the 10,000 - 20,000 tonnes range, that of *merlus* around 10,000 tonnes, those of *dorades roses*, *calamars*, *seiches*, *langostinos* and *gamba* were in the 1,000-5,000 tonnes range, that of *geryon* was below 500 tonnes and that of *langoustes* was under 100 tonnes. In recent years, the annual production of *merlus*, *seiches*, *poulpe*, *gamba* and *geryon* tended to increase, but that of other groups did to decrease or remain.

3) **Current status of demersal species resources from a fisheries standpoint**

The current status of demersal species resources was studied from the standpoint of both artisanal and industrial fisheries in the 1986-2000 period, by calculating CPUE (catch per unit effort) from data on production and number of licensed boats or vessels by each kind of fisheries.

CPUE of artisanal fisheries (tonnes/number of licensed boats) decreased from a 30.2 tonnes/boat in 1986 to 11.0 tonnes/boat in 2000, which represents a decline of 36% from the 1986 standard.

CPUE of domestic industrial fisheries' iced storage and freezer trawlers considered to catch and utilize demersal species decreased from a 495.2 tonnes/vessel in 1986 to 219.4 tonnes/vessel in 2000, a decline of 56% from the 1986 value. CPUE has diminished considerably in both artisanal and industrial fisheries, and the current status of resources cannot be said to be satisfactory.

4) **Estimated catchable stock size**

The catchable stock size was estimated with correspondence between the results of the *cold and warm season surveys* and the 70 mm minimum mesh-size regulation.

Focused on the results obtained in 2001, some particular features in the catchable stock size of both "target species" and "other species" were shown below:

- The total catchable stock size in 2000 was 72,180 tonnes in the cold season (coastal area excluded) and 120,689 tonnes in the warm season. In 2001, those values were 282,621 tonnes and 264,983 tonnes respectively. In 2001, the costal area, continental shelf and continental slope accounted for 85%, 10% and 5% of the total catchable stock size in the cold season respectively and 61%, 24% and 15% of that in the warm season respectively. Thus the ratio of catchable stock size in the coastal area was higher. In the same way, the total catchable stock size of target species was mostly distributed in the coastal area in both the cold and warm seasons, at a respective ratio of 60% and 56%.
- Considering target species, in 2001 the catchable stock size by species in the costal area

[5] *merlus* (hakes), *dorades roses* (sea breams), *calamars* (squids), *seiches* (cuttlefish), *poulpe* (*Octopus vulgaris*), *langoustes* (*Panulirus regius*), *langostinos* (prawns), *gamba* (*Parapenaeus longirostris*) and *geryon* (*Chaceon maritae*)

in both seasons was particularly large for the bluespotted seabream *Pagrus caeruleostictus*, followed by the smooth-hound *Mustelus mustelus* and the Canary dentex *Dentex canariensis*. In the continental shelf, the catchable stock size by species in both seasons was very large for the red pandora *Pagellus bellottii*, followed by the smooth-hound *Mustelus mustelus*, the Senegalese hake *Merluccius senegalensis* and the John dory *Zeus faber*. In the continental slope, the catchable stock size by species was quite high for the Benguela hake *Merluccius polli*. The ratio of the catchable stock size of the target species to the total catchable stock size in the cold and warm seasons was 13% and 28% respectively.

- The catchable stock size of the common octopus *Octopus vulgaris* was 2,760 tonnes in the cold season and 2,447 tonnes in the warm season.

**5) Resource standards of demersal species in short-term**

The importance of conducting surveys not only in the cold and warm seasons, but also in the transitional periods between seasons, for a correct understanding of the actual status of demersal species resources, has already been pointed out. The CNROP conducted three *transitional period surveys* by the *Al-Awam*, using a trawl net with a 45 mm mesh-size cod-end. For a total of seven surveys consisting of 4 *cold and warm season surveys* and 3 *transitional period surveys*, the stock size by area and by stratum (20 - 30 m, 30 - 80 m and 80 - 200 m strata) was estimated and then a 95% confidence interval and coefficient of variation were calculated for the estimated total stock size.

The total stock size in each survey was in the 70,000 - 90,000 tonnes range except for about 40,000 tonnes in the cold season of 2001. The coefficient of variation for each total stock size in the seven surveys was present between 6% and 17%, indicating these estimates of good accuracy.

The ratio of the stock size of the target species to the total stock size was in the 31 - 45% range in the *cold and warm season surveys*, and in the 25 - 42% range in the *transitional period surveys*. Moreover, there was a decline in that ratio over the years.

**6) Utilization of target species resources from standpoint of size composition**

The utilization of demersal species was studied by making a comparison between size compositions of the 12 target species[6] obtained from both the Sea-borne Survey (including the *cold and warm season surveys* and the *transitional period surveys*) and the Landing Site Survey.

The size composition of the 12 target species from the Landing Site Survey existed in larger classes than that from the Sea-borne Survey. And the mean size of those 12 species from the Landing Site Survey was larger than that from the Sea-bone Survey except a few cases. Most of the juveniles of the 10 target species with the exception of the flathead mullet *Mugil cephalus* and the meagre *Argyrosomus regius* were not landed.

**7) Evaluation of the status of demersal species resources**

In 2001, the catchable stock size for artisanal fisheries (it was restricted at the 3-20 m stratum excepting the Banc d'Arguin) was 239,885 tonnes in the cold season and 161,097 tonnes in the warm season, with a mean value of 200,491 tonnes. The catchable stock size for industrial fisheries (it was

[6] *Mustelus mustelus, Epinephelus aeneus, Argyrosomus regius, Pseudupeneus prayensis, Pagrus caeruleostictus, Dentex canariensis, Pagellus bellottii, Mugil cephalus, Solea senegalensis, Loligo vulgaris, Sepia officinalis* and *Octopus vulgaris*.

restricted at the 20-400 m strata) in the cold and warm seasons was 72,180 tonnes and 92,606 tonnes (the mean of 82,393 tonnes) in 2000, and 42,737 tonnes and 103,886 tonnes (the mean of 73,312 tonnes) in 2001 respectively.

Artisanal fisheries production in 2000 was 19,456 tonnes, but its details are not known. Official artisanal fisheries production statistics for 2001 have not yet been published. Industrial fisheries production was established as the production of the iced storage and freezer trawlers targeting demersal species. In 2000, both types of vessels produced 21,943 tonnes. Fishery statistics for 2001 have not yet been published. By hypothesizing production in 2001 would be of the same level as that in 2000, it should be around 21,000 tonnes.

Under the current status and scale of fisheries, fishing rate for industrial fisheries targeting demersal species was calculated from the mean production and from the mean catchable stock size in 2000 and 2001. Fishing rate was about 27% in 2000 and some 29% in 2001.

The estimated fishing rate was calculated by hypothesizing a 1.0 fishing efficiency of the trawl gear in estimating the catchable stock size, so the true value is thought to be lower than the calculated one.

**8) Problems with status evaluation**

Separate catch statistics by species and by fishery category are essential for the evaluation of the status of the utilization of demersal resources, but there are problems regarding their quality, accuracy and limits of application. On the contrary, for the coefficient of variation as an indicator of accuracy in estimating stock size, the mean coefficient of variation for the total stock size of six species except the smooth-hound *Mustelus mustelus* and the bluespotted seabream *Pagrus caeruleostictus* among the eight selected species[7] in relation to the five species with the highest stock was 25%. This should indicate the estimates are quite accurate.

In 2001, the mean catchable stock size at 3 - 20m stratum, targeted by artisanal fisheries, was 200,491 tonnes, about three times the amount present in the offshore area. Production of artisanal fisheries in 2001 could be tentatively estimated as about the same 20,000 tonnes of 2000, and the fishing rate of demersal species resources by artisanal fisheries was about 10% and stayed at a low level. The potential stock size in the coastal area should be efficiently explored, and it is essential to plan the promotion of artisanal fisheries and the creation of employment.

## 6. UNUTILIZED AND UNEXPLOITED FISHERY RESOURCES AND DEVELOPMENT POSSIBILITIES

The results of the resources survey made possible to assess the stocks of demersal species including target species. For the effective utilization of fishery resources, the identification and development possibilities of unutilized and unexploited resources were examined, with the following results:

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[7] *Mustelus mustelus, Merluccius senegalensis, Pagrus caeruleostictus, Dentex canariensis, Pagellus bellottii, Pseudupeneus prayensis, Loligo vulgaris* and *Octopus vulgaris.*

1) Two conditions were examined to define unutilized resources, and seven species[8] established as such.
2) The utilization of those seven unutilized species was proposed.
3) Two conditions were examined to define unexploited resources, but in fact, within the survey area, no unexploited resources as such were found at present.
   Nevertheless, there are species like the large-eye dentex *Dentex macrophthalmus* which, although being harvested, is not fully utilized, and possibly other such demersal fishes.
4) Regardless of the utilized or unutilized resources, the necessary undertaking for the more efficient utilization of resources was summarized.

## 7. AGE DETERMINATION OF MAIN SPCIES OF FISHES AND CEPHOLOPODS

In IRM, there is a need to develop and establish methods for age determination that are indispensable for the evaluation and management of fishery resources. The objectives of this survey were, with respect to key demersal fishes and cephalopods: (a) to develop techniques for age determination; (b) to clarify their age and growth; and (c) to carry out technology transfer to the Maurinanian counterpart personal through on-the-job training. The target species were: bluespotted seabream *Pagrus caeruleostictus*, Senegalese hake *Merluccius senegalensis*, Senegalese sole *Solea senegalensis*, smooth-hound *Mustelus mustelus*, common octopus *Octopus vulgaris*, European squid *Loligo vulgaris*, common cuttlefish *Sepia officinalis* and broadtail shortfin squid *Illex coindetii*.

**1) Age determination techniques**

The development of age determination techniques using age characters (otoliths, vertebrae, beak, statoliths) was successfully attained in all target species.

For *Pagrus caeruleostictus*, the otoliths were embedded in acrylic resin and sliced into thin sections (0.4-0.7mm) with a linear precision saw. The clear opaque bands were measured as a age rink. The specimens of 287 otoliths were observed.

For *Meluccius senegalensis*, the otoliths were polished with whetstone or embedded in acrylic resin and sliced into 0.4-0.5mm thick sections with a linear precision saw. The translucent and opaque bands appeared alternately. The translucent bands were clear. The specimens of 98 otoliths were observed.

For *Mustelus mustelus*, the centra were embedded in acrylic resin and sliced into 0.2-0.3mm thick sections with a linear precision saw. The staining method was examined for the clarity of the rings. The translucent and opaque bands appeared alternately. The opaque bands were clear. The speciments of 70 centra were observed.

For *Octopus vulgaris*, the beaks were embedded in acrylic resin and sliced carefully into centro-sagittal section (0.5-0.6mm) with a linear precision saw. These sections were polished with

[8] Striped panray *Zanobatus schoenleinii*, undulate ray *Raja undulata*, shortnose greeneye *Chlorophthalmus agassizi*, black slimehead *Hoplosthethus cadenati*, thinlip splitfin *Synagrops microlepis*, boe drum *Pteroscion peli*, prickly puffer *Ephippion guttifer*.

waterproof sandpaper and etched with ethlenediaminetetra acetate (EDTA), and then were observed with a binocular microscope under fiber scope reflected light. Rings in the upper and lower beaks were observed along the internal rostal axis. The specimens of 35 beaks were observed. The ring observation using statoliths couldn't lead to a good result.

For *Loligo vulgaris*, the statoliths were embedded in acrylic resin and polished with waterproof sandpaper. Rings were clear from the focus to the termination of the rostrum. The specimens of 36 statoliths were observed.

**2) Age and growth**

For the age and growth of target species, the age-length relationship for *Pagrus caeruleostictus, Octopus vulgaris, Loligo vulgaris* was examined respectively. However, in the case of *Merlussius senegalensis* and *Mustelus mustelus,* this examination was not possible because of lack of samples during the transitional seasons.

For *Pagrus caeruleostictus,* the marginal increment ratio (MIR) of the otolith suggested that rings are formed once a year from September to November. The ring formation season coincided with warm season, when the female maturity ratio is high. The age-length relationship was expressed as a quadratic equation. And the age-length key was made.

For *Octopus vulgaris*, the number of rings of beaks was 45-199, the respective extremes being the upper beak of two females: 77mm and 200mm in dorsal mantle length (DML) respectively. Based on the past feeding experiment and others, assuming that those rings are indeed daily rings, the maximum age is 6 months. This life span is shorter than one (9 months) for the species in Western Sahara (Raya and Hernandez-Gonzalez, 1998). The number of rings – DML relationship was expressed as a quadratic equation.

For *Loligo vulgaris*, the number of rings was 100-275, the respective extrems being the statoliths for a unknown-sex individuals of 110mm DML and a male of 365mm DML respectively. There is evidence that growth rings are deposited daily. Assuming that rings are indeed deposited daily for this species in IRM, the maximum age is 9 months. This life span is shorter than one (about 1 year) for the species in West Sahara (Raya *et al.*, 1999). The number of rings – DML relationship was expressed as a quadratic equation.

**3) Technology transfer**

For the transfer of age determination technology, considering the great need for the CNROP to reinforce its research capacity, the survey team put a great deal of effort by jointly conducting experiments, analyzing data and preparing reports. As a result of a technical transfer from the Japanese side to the Mauritanian side at both theoretical and practical levels, the know-how of age determination was acquired by the latter. One of the results is a manual for age determination (Wague & Watanuki, 2001). With this publication and all the project reports, the CNROP took an important step for the evaluation of fishery resources.

**4) Recommendations**

To sustain and upgrade research in the CNROP, the following recommendations are set forth:

(a) This joint survey makes a beginning for the age study in the CNROP's future. However, except for the case of the bluespotted seabream *Pagrus caeruleostictus*, of which monthly

samples could be obtained, many questions remain unsolved on the age of target species. Exactly how old are the small and large individuals? In other words, are rings indeed formed once a year (or once a day in cephalopods)? Such questions could not be correctly answered. The CNROP should continuously conduct age determination with a size differential, by collecting a larger sample by month and by season.

(b) It is strongly recommended for researchers and technicians to write scientific papers for publication in the CNROP periodicals (*Bulletin Scientifique*, *Documents Techniques*) and/or in international journals. Papers and reports would facilitate information exchange between the CNROP and fisheries research institutes abroad countries where fisheries investigation is expanding. Much research information and aid could be obtained, and the level of research at the CNROP would also increase.

(c) Fishery resources are subject to changes, and resources assessment demands continuous implementation. As the sole fisheries research institute in the country, the CNROP must positively engage in fisheries investigation that involves age determination. Determining target species and collecting samples would not only allow for age and growth studies, but also for investigating distribution, migration, maturation, spawning, feeding habits, early life history and much other research. A multilateral approach for the realization of survey and research of target species would be indispensable for the assessment and management of resources.

# 8. LANDING SITE SURVEY

## 8.1. SOCIOECONOMIC ASPECTS

### 1) Introduction

This chapter reports the results of surveys of the socioeconomic part of the Project "Study for the Fishery Resources Management Plan in the Islamic Republic of Mauritania". The following surveys were carried out in this part :

- *Description of the marketing and distribution system and the export industry, and its role in financing the primary production subsector.*
- *Analysis of the labour structure and the importance of employment generated by the fisheries sector.*
- *Review of the management measures hitherto applied, and their advantages and shortcomings from a socio-political perspective.*

In addition to these main surveys, a number of other related subjects were also included in the work, i.e., the need to establish *a socioeconomic database, the participatory approach, and the analysis of some profit and loss accounts of a number of fishing methods employed by artisanal fisheries*. This chapter presents also a brief description of the general structure of the fisheries sector in Mauritania and its socioeconomic importance.

These surveys were carried out in close collaboration with the consultant's counterpart, Mr. Thiam Ismaila, head of the Laboratory of Socioeconomic Analysis (LASE) of CNROP, and with other

colleagues during four missions to Mauritania. The collection of data and information was made by interviews and discussions with source people, by semistructued interviews with various actors in the sector, by observation on the land and by questionnaire surveys.

**2) Results**

The objective of the survey on *the marketing and distribution system* was to test the hypothesis that a strong dependence of the primary production sector-especially the artisanal fishermen-on the export companies have developed, who in their turn depend on international fish traders. Results seem to confirm this vertical integration and concentration in the system.

Exports of fishery products represent on important part of the budgetary revenues and foreign currency earning of Mauritania. It is also important to point out again that the fish production of Mauritania is entirely export oriented. The local market outlets are limited and only supplied with low value or damaged products that cannot be sold in the more lucrative export market.

The value of fishery product exports in 2000 reached 35,442 million UMs. In this year, 26,500 tonnes of cephalopods and 15,500 tonnes of demersal fishes (in product weight) were exported. Hence, octopus still remains by far the main fishery product. The principal export markets are Japan and EU countries. There are currently 43 licensed export companies with processing plants for sales to the EU and Asia in operation; 27 in NDB and 16 in NKC. In most cases, these exporters had only a limited number of customers overseas.

With regard to the systems for procuring fish, there are two kinds of companies: those that are ship or boat owners and also equip their own industrial fishery vessels, and those that work mainly with the artisanal fishermen. Companies basing their activities on production from artisanal fisheries try to limit the commercial freedom by the fishermen. At all levels of the distribution chain, there are contractual arrangements of various kinds, specially conceived to ensure exclusive access to fishery products. This is done through the prefinancing of fishery activities and by the creating a situation of dependency that the fishermen to remain loyal to a particular company. It seems that today there are but very few fishermen who are not in this kind of financial situation with their contractors. The local prices formation process is not transparent but depends on the relationships between fishermen and buyers. As the fishermen are often in a situation of dependency on these creditors, their negotiation power is considerably weakened.

In conclusion, the sector is for the most part guided by export companies and their foreign clients. Most of the means of production, both industrial and artisanal, are directly or indirectly financed by export companies, which are often associated with foreign partners.

The objective of the survey on *the employment* was to gain a better knowledge of the jobs generated by the fisheries sector and the socio-demographic characters of employees. Counting the indirect jobs, the fisheries sector employs some 30,000 persons, about half of who have land-based jobs. As estimating the dependency ratio at 1.8, it can be conclude that over 80,000 people depend directly or indirectly on the fisheries sector for their subsistence. 9% of interviewees were women: they work mainly with fish processing or at the bottom end of the fish marketing system, as well as in indirect jobs in restaurants or as bissap peddlers.

Except for the work of Wolof fishing communities in the south and the Imraguens, the marine

fisheries are a very recent activity in Mauritania. Foreigners play an important role in the fishing activity itself, that is in primary production. This importance is both quantitative and qualitative, i.e., with regard to the number of foreign fishermen and in terms of competence and skills in fishing techniques. *18% of fishermen/captains interviewed in NDB are foreigners.*

The mobility of the actors in the sector appears high, both within and between professions and sectors and with regard to location. A large portion of the interviewees had worked in other professions before starting in the fisheries business. This is in particular true for fish wholesalers but applies also to other operators especially in the two large towns. With regard to the geographical mobility, only 9% of the interviewees declared NDB as their place of birth.

The main characteristics of *the fishery policy objectives* have remained basically the same from $1970_S$ to date, i.e., the protection of resources, the optimization of revenues generated by the sector and the creation of employment opportunities. As was noted above, the very ambitious and also somewhat contradictory. Thus, it would appear important to better define the priorities.

The technical management measures currently being applied include: zoning to separate the industrial and artisanal fisheries, a minimum-size mesh for bottom trawling, a minimum -size requirement for octopus (500g) and other important demersal species, the "biological closure"- octopus fishing being prohibited during two months every year (September and October). However, due to the mobility of landings and the many different landing sites for the artisanal fishery, it has proven difficult to enforce the technical measures. With regard to the management measures currently in place for limiting access to resources, it can be noted that they have not led to any significant decrease in fishing effort. It should also be noted that there is no output control in the form of, for example, catch quotas. This probably reflects the current situation: it would be very difficult to apply such a measure given needs for monitoring, control and surveillance it would require. Moreover, the fishery statistics deficiencies and the lack of reliable data on many aspects concerning the status of resources would make it very difficult to establish practical and realistic quota levels.

The problem for the lack of data is also remarkable in the socioeconomic part. The LASE of CNROP supplies this kind of information to others and also needs it for its own socioeconomic research. However, the collection and compilation of these important data have not received due attention or priority to data and the work is currently done *ad hoc*. Therefore, it is suggested that *a structured system for the collection and organization of socioeconomic data* be created in the CNROP. In addition to the data collection itself, a computerized database should be established and procedures for the documentation and publication of information should be contemplated.

The Code of Conduct for Responsible Fisheries (FAO, 1999a) brings up "management in partnership" and clarifies the necessity of sharing management-related responsibilities between authorities/public institutions and private interested parties. For a management plan to be effective and respected, it must be accepted by the different parties involved and their interests must be adequately reflected to make them feel responsible. This process should preferably begin already at the level of preparatory surveys and research for management plan and researchers, especially in the field of socioeconomics, should utilize participatory approaches.

For the costs and earnings analyses in artisanal fisheries, five main types of the demersal

fishing were chosen for which exploratory profit and loss accounts were drawn up. These analyses show, for example, an octopus-fishing canoe must catch between 3,800 and 5,600 kg annually to earn a profit. By multiplying these estimates with the number of active canoes fishing octopus –530 units- one arrives at a total production of 2,000 to 3,000 tonnes of cephalopods by artisanal fisheries per year. According to the similar calculations for the other fishing methods covered by the survey, it appears that the minimum annual production of demersal species by artisanal fisheries has to been between 12,000 and 17,000 tonnes per year if the subsector is to be profitable overall.

**3) Conclusions and recommendations**

Based on the surveys carried out in the socioeconomic part, the general conclusions and recommendations for the formulation of a demersal resources management plan can be summarized as follows:

- Through the marketing system, the fisheries sector are driven by the large export companies and their clients abroad. Any management measure should consider this fact in order to be effective.
- Certain management measures are still difficult to implement effectively in the context of the Mauritanian fisheries sector. The measures most likely to be effective should include limitations of fishing effort –by regulating the number of vessels and licenses –and a total closures of fisheries (during periods of several months).
- The possibility to manage the development of the sector by means of encouragement measures, economic incentives and taxation deserves to be further studied, and the measures already in place should be reexamined.
- The management in partnership should be encouraged by introducing transparent procedures and by making fishermen aware of their responsibilities.
- It must be recognized that the renewal of the fisheries agreement with the EU in September 2001 significantly limits the options for the development and management of resources and fisheries.
- All proposals for management measures should be supported by specific studies on probable socioeconomic effects, and appropriate accompanying measures should be foreseen in order to mitigate possible negative effects.

Besides, there are also other conclusions and ideas resulting from the socioeconomic studies and even if these may only be indirectly related to the technical aspects of the management plan, they are important in the broader context of the development of the fisheries sector , e.g.:

- The objectives assigned to the fisheries sector are very ambitious and, particularly in the short run. It is therefore important to be sensible and realistic in the definition of priorities by evaluating middle-and-long term options for the development of the sector.
- The jobs generated by the sector are important and about half of them are in land based activities, particularly in downstream activities. It seems wise to give priority to the creation of land based jobs, by increasing the volume of landed products and their level of valorization.
- There is the lack of data on artisanal fisheries. Without solid knowledge regarding the

performance and the impact of this subsector, it will be difficult to evaluate its social and economic potential, and therefore this shortcoming should be remedied urgently.

- To better evaluate the options related to selected objectives and priorities, it would be essential to conduct analyses with regard to the economic and social contributions made by different subsectors. It would appear important that such economic and social consequences be precisely and continuously evaluated, so that the decision-makers can base their strategic decisions on scientific, genuine and objective information.
- The capacity of the fisheries administration and research in the field of fisheries socioeconomics is far from sufficient. Given the importance of economic and social analyses for resources and fisheries management, a reinforcement of this capacity and the related competences is indispensable together with strengthened cooperation between the CNROP and the MPEM. This report gives some recommendations for actions and activities that could be integrated into the work plan of the LASE of CNROP.

## 8.II. CURRENT STATUS OF THE ARTISANAL FISHERY

In order to achieve a rational management of fishery resources, besides having an accurate understanding of the standing stock in the region, it is necessary to estimate what portion of the resources are being utilized, and to what extent they are so. However, in the IRM, as for the information for this estimation, the available information on the artisanal fisheries, especially the catch and size by species, is shortage with comparing the industrial fisheries. Here, consistently with the Landing Site Survey, interviews were conducted in fishing villages and camps scattered along the Mauritanian coast on landed species and quantity, and measurement of body length in target species was carried out. The results of this survey are summarized as follows:

1) The total landed quantity of artisanal fisheries in 2001 was estimated in some 14,000 tonnes.
2) The main landing species were mullets, drums, sea breams, groupers, rays, sharks, squids, octopuses, lobsters, etc.
3) The main fishing methods utilized were octopus pots, lines, specific nets, cages, etc. The operation of those methods largely depends on seasonal migrations of target species.
4) Fishing boats were all motorized, except for the sailboats that operate in the PNBA, where power boats are banned.
5) As for the fishing activity, it was common to have a boat with 3-4 fishermen on the average exploring fishing grounds at depths shallower than 25 m.
6) In the artisanal fishery communities, except for NKC and NDB, the basic fisheries production infrastructure (ice, fresh water, fuel supply, storage, wharf, port, etc) and the social infrastructure (transportation, electricity, communications, etc.) were yet to be consolidated.
7) The sale price of fishery products by artisanal fishermen is decided by wholesalers (purchasing traders) in most cases.
8) Body length measurements were taken from 14 landed target species (10 fishes, 3 cephalopods and 1 crustacean). The frequency of individuals by body length class was analyzed and the data

summarized as size composition graphs.

## 9. RECOMMENDATIONS FOR RESOURCES MANAGEMENT

Based on the results of the present study, this chapter considers and discusses measures of the management of demersal fishery resources that facilitate sustainable development of fisheries, to be implemented from now on.

***1) Diagnosis of the status of demersal species resources***

In this study, a four-stage resources surveys with bottom trawl were conducted in the cold and warm seasons, and at its outcome the stock size of the demersal species was estimated. The CNROP conducted three resources surveys on its own in the transitional periods in 2000 and 2001. Since the cold and warm seasons surveys and those transitional period surveys by CNROP were methodologically compatible, it was possible to utilize the results of all seven surveys. Those stock size values were accurately estimated judging from low C.V. (coefficient of variation). Analyzing the chronological fluctuation of the estimated stock size by area, decline in the estimated value for the common octopus was observed in many areas. If this decrease is indeed an accurate reflection of the resources, then the species is in a critical situation.

The fishing rate, being regarded as the ratio of the utilized portion out of the catchable stock size, was tentatively calculated. In the years 2000 and 2001, the fishing rate of industrial fisheries was at least 27% and 29% respectively. Although some questions remained on the accuracy of catch estimates, it was concluded that, on the whole, the exploitation of demersal fishery resources by industrial fisheries has advanced to a considerably high degree. The fishing rate of artisanal fisheries over the demersal species stock was estimated to be less than 10%, a very low value.

Catch per industrial fisheries vessel (iced storage and freezer trawlers) targeting demersal species and that per artisanal fisheries boat were calculated as indicators of the CPUE (Catch per Unit Effort). Those CPUE data from 1986 to 2000 indicated a general decrease.

The CPUE of artisanal fisheries as a whole follows a long-term tendency toward decline. In particular, artisanal fisheries aim at demersal species in the vicinity of large cities, behind the big markets, concentrating their small fishing boats fleet in nearby waters. And it is recognized that those stocks are also being excessively exploited. On the other hand, the fishing rate was low, which suggests that potential stock size in the coastal area is abundant overall, and that there is still some room left for exploitation, except for the vicinities of large cities.

According to the CNROP 4th Working Group, the octopus stock size not yet affected by fisheries pressure was estimated at 570,000 tonnes (confidence limits 500,000 - 800,000 tonnes), and the estimated stock size for 1998 was 90,000 tonnes. Even considering some eventual estimate errors, there are indications that the octopus stock suffered a sharp decline as it used to be quite abundant.

When the above results are added up, it appears that the stocks of cephalopods (particularly the common octopus) and demersal fish species are decreasing side by side and simultaneously.

In particular, the decline of octopus stocks was so drastic one could infer a strong possibility of some degree of overfishing.

**2) Goals and principles of resources management**

In order to establish the guidelines for resources management, the immediate goals and principles are specified below.

- When planning the management of resources at sea, it is believed to be appropriate to give top priority to the recovery of the octopus stocks of very important target species and its stock in a critical situation.
- Urgent countermeasures are thought to be necessary to prevent the depletion of octopus stocks, to assure a minimum level of resources to avoid the collapse of stocks as the first-aid prescription.
- As for the efficient utilization of a specific sea area, one should take biological characteristics into consideration for a full and practical use of the productivity.
- When regulations on catch or fishing effort are advocated, from the standpoint of the strength of the influence exerted upon the resources, the reduction of catch and fishing effort by trawlers becomes an important objective.

**3) Resources management through the regulation of catch amount and its feasibility in the IRM**

In order to regulate the amount of catch directly, suitable mathematical models are necessary to calculate exact amount of suitable catch by species. Although calculations are possible, the process requires so many hypotheses. Acquired estimates cannot be accurate enough to the degree of becoming the basis of resources management at the present stage. Due to the current lack of accurate information on the amount of catch of each species, as well as of quick reporting, it is not suitable to introduce a management measure of this kind. Instead of methods that directly regulate catch size, it was concluded that methods for controlling fishing effort are more realistic, in case the direction is correct.

**4) Socio-economic considerations related to resources management methods**

The object of fishery management measures of the IRM was threefold: protection of resources, optimization of revenues generated by the fisheries sector and creation of employment opportunities. Those goals had mutually contradictory aspects, so the need for clearly ranking them in order of priority was pointed out. And it is necessary that the partnership management whose responsibility be shared among the authorities, official agencies and related private parties must be established.

**5) Proposals for resources management**

A proper choice of measures for resources management should include as many management measures previously adopted by the IRM as possible. Today, standing on the fact that the decline of resources is already clear, catch should be substantially decreased, and for an efficient management to take place, the resources management measures currently in force should be redressed into a direction that strengthen the weak spots, indicating the aspects to be improved.

- **Reduction of fishing effort in bottom trawl fisheries**

The large catch size of trawl nets that are non-selective gear and the continuous overfishing by

it over many years are the main cause for decline of octopus and other demersal resources. In this Study, the excessive fishing effort of bottom trawl fisheries was suggested to be the most serious problem now affecting Mauritanian fisheries. Starting with the octopus, the first measure to curtail the decline of demersal resources is to reduce the catch by trawlers.

Thus, it is necessary to reduce fishing effort of bottom trawlers. It has been previously stated by the CNROP Fourth Working Group that the fishing effort for octopus should be reduced by 25%. Since those results have been widely discussed in the country, it should be the time to put them into practice. As a method of curtailing fishing effort of trawlers, a decrease in the number of licensed vessels, or of foreign vessels entering the area, or else the establishment of a closed fishing season, could be suggested.

- **Biological closure: extension of the period and/or an additional closure**

This policy is a highly feasible, superior regulatory measure. There is little need for patrolling the fishing grounds, and the control is relatively fair. The current two-month period (September - October) for the biological closure has been useful for the adjustment of distribution of product and price of the common octopus. But it has not in fact led to any substantial decrease in catch, because fishers utilize this period for a furlough, vessel repair, etc. in the year-round operational cycle. An efficient decrease in the catch of demersal species, with a focus on the common octopus, is expected here. At the same time, it is necessary to devise methods to extend and reorganize this closure period, with the objective of actively protecting the octopus in the most vulnerable period in its life cycle, particularly when it shifts toward a benthic life. The recruitment of the cold season cohort of the common octopus happens in November-December, when small-size individuals are heavily harvested. On the other hand, the recruitment of the warm season cohort takes place in May-June. The period of November-December and/or May-June could be added to the current closure period. This procedure could be suitably tried at first for three consecutive years, with a continuous monitoring of the status of octopus stocks in this period and subsequent revision of its direction.

- **Regulation of minimum catchable size**

*The current minimum catchable size regulations for the common octopus and some other* species are rational, and this should be retained.

- **Regulation of trawl net mesh-size**

In this Study, mesh-size of 50% retentions of the length at first maturity of six target species was preliminarily determined. Results indicated that the mesh-size should be larger than the current regulation, if the protection of the resources of these species is a priority.

- **Regulation and efficient utilization of specific area**

  - **Northern Region (north of 19°21'N) - Subregions 1 and 2**

    The ratio of the estimated stock size of demersal species of this Region to that of the entire area is high. It is highly probable that this Region is an important source of supply of a given demersal species for the entire area. Particularly, the importance of the PNBA area as a natural *reproduction site is well known. The current restrictions should be retained.*

- **Northern Region -Subregions 5 and 6 and regions within 3–20 miles from the coastline**

  The stock size of the common octopus has evidently suffered a sharp decline. To prevent the depletion of octopus resources, it is desirable that fishing operations targeting the common octopus and the use of gears that catch it as by-catch be regulated for necessary period in the waters down to 200 m where the species is mainly distributed.

- **Southern Region (south of 19°21'N) – Subregion 2 within 6 miles from the coastline**

  Trawl operations are prohibited in this Subregion. To protect the resources of demersal fishes, common octopus and green spiny lobster *Panulirus regius*, trawls in this Subregion should continue to be banned.

- **Southern Region - Subregions within 6, 12, 15, 20 and 30 miles from the coastline**

  Octopus stocks did not change with the season but declined over time. Presently, trawl operations are prohibited within 6 miles from the coast line (the limit for shrimp trawls is 3 miles), and expanding the prohibition offshore is believed to be an overall effective way to protect not only the octopus but all demersal resources.

- **Development of artisanal fisheries in the Southern Region south of NKC**

  In the past, the catch efforts of artisanal fisheries in the IRM have been excessively concentrated in the Northern Region. But given the opportunity, it is to be desired that some of them could be dispersed in the Southern Region south of NKC. The stock size in the Southern area cannot be said to be large. However, most of the high-ranking species are commercially valuable, and the possibilities of their exploitation should be high, particularly at the 3 - 30 m stratum that accounts for 56% of the stock size in this area. From the standpoint of the characteristics of these resources, this region is suited for coastal artisanal fisheries, and further development should be encouraged.

- **Development of industrial fisheries on the continental slope**

  Today, of demersal resources found on the continental slope, the hakes *Merluccius* spp. are specifically caught by licensed EU vessels, and its exploitation is presumed to be well developed. However, if the EU countries withdraw from this fishery, the species should be a new target for Mauritanian-registered fishing vessels. Species with possibilities of exploitation include: blackbelly rosefish *Helicolenus dactylopterus*, Senegalese hake *Merluccius senegalensis* (identity uncertain, may include *S. polli* as well) and shortnose greeneye *Chlorophthalmus agassizi* and deep-water pink shrimp *Parapenaeus longirostris*.

- **Consolidation of the system for the resources management**

For the smooth operation of resources management as a system, a co-ordination of three elements is necessary: (i) monitoring, (ii) control, and (iii) surveillance. Of those three items, some technical considerations on monitoring were proposed:

- **Periodic resources surveys by research vessels**

  When there are no fishery statistics of species level, surveys by research vessels are of great importance. Routine sea-going surveys should be conducted, and their results should be officially made public. Technical questions related to the surveys, such as problems of the fishing gear (beam trawl) on the *Amrigue*, sampling limitations of the trawl gear on the

*Al-Awam*, selection of survey period and of survey area (necessity of a wider area) for the resources survey, were discussed.

- **Establishment of data on age, body length and body weight**

  It was proposed that the periodic surveys currently being conducted by the CNROP at landing sites should add body length measurement in its menu.

- **Consolidation of catch statistics**

  A reconstruction of the data gathering system was proposed, with information on catch and fishing effort both by species and by type of fishery on monthly basis. It is indispensable information such as catch by EU fishing vessels, which are estimated to be large, must be accurately recorded and made public. The gathering of information by observers is considered vital hereafter.

- **Construction of a fisheries information system**

  In the IRM, it is urgent to be able to promptly grasp accurate catch and landing information on inshore and offshore fishing. For this, a computer network linking the main landing sites with the CNROP and the MPEM should be constructed, a system of data gathering and analysis that could process the necessary information in real time.

- **Socio-economic research and monitoring**

  The necessity of continuation of the socio-economic studies on the marketing system, employment and labor structure, review of management measures, monitoring of indicators and a socio-economic database, participatory approaches, and costs and earnings analysis was proposed.

**6) Promotion of artisanal fisheries**

- For the proper development of artisanal fisheries in the IRM, "the Law of the Promotion of Coastal Fisheries" of Japan was introduced in some detail in order to elucidate necessary measures to be taken by the local government and bodies involved.
- The present survey revealed vertical integrations in the fisheries sector of the IRM. Many of artisanal fishers are economically dependent on foreign capitals through local wholesalers. The presence of fishermen's cooperative unions is considered to facilitate the proper development of artisanal fisheries. Relevant function of the union was introduced.