

**REPORT OF THE SCIENTIFIC MEETING  
ON DYNAMICS AND USE OF SARDINELLA RESOURCES  
FROM UPWELLING OFF GHANA AND COTE D'IVOIRE  
(DUSRU, OCTOBER 1993)**

**RAPPORT DU COLLOQUE  
SUR LA DYNAMIQUE ET USAGE DES RESSOURCES EN  
SARDINELLES DE L'UPWELLING IVOIRO-GHANEEN**

**SUMMARY**

The scientific meeting on the Dynamics and Uses of Sardinella Resources from Upwelling off Ghana and Côte d'Ivoire (DUSRU) was held in Accra from 5 - 8 October, 1993. It was jointly organised by ORSTOM, the Fisheries Research and Utilization Branch (FRUB) of Ghana and Centre de Recherches Oceanologiques (CRO) of Côte d'Ivoire. Some support was provided by the Food and Agriculture Organisation (FAO), Rome and its Regional Office for Africa (RAFR), Accra. The main objective of the meeting was to bring together scientists and users of the fishery resources referred to as small pelagic, notably the sardinellas. This coastal resource is shared by Côte d'Ivoire, Ghana, and to a lesser extent, Togo and the Republic of Benin.

The apparent abundance of this resource increased rapidly between 1982 and 1985 and has remained at a very high level since. This has resulted in large increases in catches of industrial purse seiners in Côte d'Ivoire and canoes in Ghana, reaching a peak of 150,000 tonnes of the principal species Sardinella aurita and 300,000 tonnes for all species in 1992. The meeting discussed the possible reasons for this remarkable increase in landings, the present state of the small pelagic fishery resources and actions to ensure good or better utilisation of this resource in future.

The meeting was attended by 50 participants of which 35 were scientists from Ghana, Côte d'Ivoire, Benin, Senegal, USA and France. The first part of the meeting consisted of presentation of 23 papers on the oceanography of the Ivorio-Ghanaian coast, the biology and ecology of sardinellas, economics and sociology of the fisheries of small pelagic species. Two workshops, one on the dynamics and ecology of the resource and the other on the socio-economics of the fishery and marketing were organised to facilitate exchange of ideas. The conclusions are that the increase of the resource appears to be the result of

changes in the local upwelling, in particular the upwelling in the minor cold season, which has improved the reproductive conditions and growth of Sardinella aurita. The mechanisms of the upwelling remain hypothetical but certain hypotheses are very probable, in particular for the minor cold season. A multi-disciplinary programme to study the oceanography of the minor upwelling is envisaged.

With respect to socio-economics, the adaptability of the Ghanaian fishing canoes were underlined but also notable is the flexibility in the management of the Ivorian industrial vessels. The necessity to completely study the economic and financial status of the boat owners and marketing system is also evident in the light of currency adjustments in both countries. Future work on network of socio-economists is anticipated.

## **RESUME :**

*Le colloque DUSRU s'est tenu à Accra du 5 au 8 octobre 1993.*

*DUSRU était organisé conjointement par l'ORSTOM, le Fishery Research and Utilization Branch Tema (FRUB) et le Centre de Recherches Océanologiques de Côte d'Ivoire (CRO). Il a bénéficié du soutien de la FAO à Accra. Le but de ce colloque était de réunir des scientifiques intéressés et des utilisateurs de la ressource en poissons dits «petits pélagiques», notamment les Sardinelles. Cette ressource côtière est partagée entre la Côte d'Ivoire, le Ghana, et en moindre mesure le Togo et le Bénin. Or l'abondance apparente de cette ressource s'est accrue rapidement de 1982 à 1985 et depuis se maintient à un haut niveau.*

*Ceci a permis une forte augmentation des captures, semi-industrielles en Côte d'Ivoire, piroguières au Ghana, culminant en 1992 à 150 000 tonnes de l'espèce principale Sardinella aurita, et 300 000 tonnes toutes espèces confondues. Le colloque devait débattre des raisons possibles de cette augmentation remarquable mais inattendue de la ressource, de l'état actuel de celle-ci et des actions futures, pour un bon ou meilleur usage de cette ressource.*

*Le colloque a réuni une cinquantaine de participants dont 35 scientifiques du Ghana, Côte d'Ivoire, Bénin, Sénégal, USA. La première partie a consisté en présentation de 23 documents traitant de l'océanographie des côtes ivoiro-ghanéennes, de biologie et d'écologie des Sardinelles, d'économie et de sociologie des pêcheries de petits poissons pélagiques. Puis deux ateliers l'un sur la dynamique et l'écologie de la ressource, l'autre sur la socio-économie des pêcheries et des marchés ont permis les débats.*

*Les conclusions sont que l'accroissement de la ressource semble bien due à une modification locale du régime des upwellings, en particulier de l'upwelling mineur (petite saison froide) qui aurait amélioré les conditions de reproduction et de croissance des Sardinella aurita. Les mécanismes des upwellings restent hypothétiques mais certaines hypothèses sont maintenant plus probables, en particulier pour l'upwelling mineur. Un programme pluridisciplinaire d'étude océanographique de cet upwelling mineur est envisagé.*

*Au plan socio-économique, l'adaptabilité des pêches piroguières ghanéennes a été soulignée mais on note aussi une grande souplesse dans la gestion des armements semi-industriels ivoiriens. La nécessité d'études complètes des aspects économiques des armements et des systèmes de commercialisation est aussi apparue, surtout dans le contexte d'ajustements monétaires en cours dans les deux pays. Un futur travail en réseau des socio-économistes impliqués est prévu.*

## **1. OPENING OF THE MEETING**

The meeting was opened on October 5 th, 1993 by the Deputy Minister for Food and Agriculture responsible for Fisheries, Major (Rtd) E. Tetteh. The opening ceremony was chaired by Mr. M. Armah, Director of Fisheries of Ghana and was attended by many dignitaries including the FAO Deputy Regional Representative for Africa, the President of ORSTOM and the Ambassador of France in Accra.

In a welcome address, Mr. M. A. Mensah, Deputy Director of Fisheries, introduced the Sardinella Problem in the western Gulf of Guinea, especially off Ghana and Côte d'Ivoire. In another address Dr. F.X. Bard, the Director of ORSTOM in Côte d'Ivoire, stressed the need for scientific co-operation in research on the Sardinella resources in the Western Gulf of Guinea. Other addresses were delivered by Dr. M. Okai, Deputy FAO Regional Representative for Africa, Mr. M. Levallois, President of ORSTOM, and His Excellency Mr. H. E. Brochenin, the Ambassador of France in Accra. Text of the addresses are included as annex 4.

## **2. ADOPTION OF AGENDA**

The Agenda, as in annex 1, was adopted. Scientific sessions of the meeting were chaired by Dr. E. A. Kwei of Starkist International, Tema and Dr. F. X. Bard served as the general rapporteur.

## **3. PRESENTATION OF PAPERS**

In the first part of the meeting, twenty four papers, listed in Annex 2, were presented. This lasted for about a day and a half. The papers covered the oceanography of the Ivorio-Ghanaian coastal waters, the biology and ecology of Sardinella and the economics and sociology of the fisheries of small pelagic fish species in the sub-region.

## **4. WORKING GROUPS**

Two Working Groups were held on October 7 th; one was on the dynamics and ecology of the resource, including physical and biological effects of the environment, and the other was on socio-economics and management policies of such resources in Africa. The report of each Working Group is presented as follows

**REPORT OF THE WORKING GROUP ON IMPACT OF ENVIRONMENTAL  
VARIABILITY ON COASTAL MARINE PELAGIC POPULATIONS  
WITH SPECIAL REFERENCE TO THE GHANA-COTE D'IVOIRE  
SARDINELLA AURITA**

**Moderator : P Cury, Rapporteur : F. X. Bard**

The Working Group met on the 7<sup>th</sup> of October, 1993 in the main FAO Conference Hall. The agenda for deliberations was set as follows :

- A - What happened to the small pelagic resources of Ghana and Côte d'Ivoire ?
- B - What is the actual situation now ?
- C - What can be done ?

**1. The increase in the small pelagic catches** off Ghana and Côte d'Ivoire, and to lesser extent Togo and Benin (Figure 1), since the mid 1980's is particularly remarkable (Table 1 and Figures 2,3 ). The increase of the catches of Sardinella aurita is the most prominent feature, but the increase of anchovy catches is also noteworthy. On an other hand the relative stability of the catches of Sardinella maderensis is also remarkable. For other species, such as Brachydeuterus auritus, Ilisha africana and various small carangids,... the stability of the catches is general, as shown by the catches of the small ivorian purse seiners (Figure 4).

Consequently , the Working Group decided to focus on Sardinella aurita., reviewing first the physical and environmental processes that could have generated this recognised phenomenon, and then the biological consequences particularly on the life cycle and eventually the fisheries of this species.

**2. Physical and Environmental features**

The upwelling off Ghana and Cote d'Ivoire has been studied for quite a long time. Two cooling seasons, the major upwelling (July - September) and the minor upwelling (January - March) are classically described. The mechanisms causing the upwelling are not well understood. The DUSRU group reviewed the available data on each upwelling - major and minor.

**Environment, dynamics and changes.**

The Working Group's discussions on the environment focused on the identification of possible qualitative and quantitative changes that may have

occurred during the last 30 years. The data available for the analysis of the environmental changes were as follows :

- i. sea surface temperature (SST) collected at several coastal stations along the coasts of Ghana and Cote d'Ivoire.
- ii. weather observations collected by merchant ships; these facilitated the creation of time series of SST, wind speed and direction, atmospheric pressure, etc.
- iii. some limited information on vertical structure of sea water temperature : 1 station off Abidjan, Cote d'Ivoire and 4 stations on 1 transect off Tema, Ghana.
- iv. some data on plankton collected along the Tema transect.

Unfortunately there is no information on long term changes of nutrients, chlorophyll or primary production available.

Remote connections between the Pacific ocean and the Atlantic ocean (ENSO events) were cited as possible mechanisms to explain environmental changes that have occurred in the Atlantic. Strong «La Nina» conditions in the Pacific are thought to favour anomalous warm conditions in the eastern part of the Atlantic. In the Pacific, the 1983 ENSO (El Nino) was followed by a strong «La Nina» in 1984 and strong positive temperature anomalies in the Gulf of Guinea. The changes recorded along the Cote d'Ivoire and Ghana coasts may therefore be related to large scale climatic variations.

The existence of thresholds was also cited as important characteristic of the dynamics of the environment : increasing upwelling intensity during the summer upwelling does not appear to result in a similar increase in the standing stock of plankton in the coastal area.

River discharge is an important characteristic of the environment in the Gulf of Guinea. Inter-annual changes may have important consequences on the environment in some coastal regions.

The circulation over the shelf is characterised by the eastward Guinea current flow and the westward undercurrent. There is an important shear between the two opposite flows and this may have an important ecological effect. Inter-annual fluctuations in the strength of the Guinea current or of the undercurrent may also have occurred. It appears that anomalous warm situations are recorded in the Gulf of Guinea when the westward undercurrent rises to the surface.

\*

### ***The summer (major) upwelling***

Little attention was given to the mechanisms that cause this upwelling. Complex interactions between several processes are thought to contribute to the occurrence of the cooling observed during summer along the coasts of Côte d'Ivoire and Ghana.

### Trend in the summer upwelling

Time series of sea surface temperature (SST) were presented. Data from the COADS data file show a steady increase in SST since the 1960's. This positive trend (i.e. warming of the surface) is a feature commonly observed in almost every region of the world's oceans. It is thought to be related to the increasing CO<sub>2</sub> in the atmosphere and the greenhouse effect. This increasing trend in SST should not be interpreted as a decrease of the upwelling activity. Data from coastal stations do not exhibit a similar trend.

An increasing wind strength calculated from the observed ship data, was presented as an indication of an important change in the environment of the Côte d'Ivoire and Ghana coast during the major upwelling. Changes in the measurement procedure, however, seem to account for an important part of the observed positive trend. Consequently, a detailed time series analysis of the wind data was recommended.

The difference in SST between an offshore area (1°N-3°N and 0-6°W) and coastal areas was also proposed as a means of estimating the intensity of the summer coastal upwelling. However, it appears that this approach failed because of a possible connection between the equatorial and the coastal upwellings in the boreal summer.

The relationship between the offshore Ekman transport and SST was investigated. Instead of the negative relationship expected in the case of an Ekman-type upwelling, a positive relationship (although not statistically significant) was found. This suggests that factors other than the wind contribute to the upwelling.

### *The winter (minor) upwelling*

The mechanism of this upwelling is not well documented. A negative correlation between wind and SST is found on an inter-annual scale: higher wind gives lower SST. This is what is expected from a classical Ekman-type upwelling. In winter, inter-annual fluctuations of the depth of the 21°C isotherm appear to be correlated with the SST and wind strength: a shallow thermocline is associated with low SST and high wind. Satellite imagery appear to suggest that the intensity of the winter upwelling is maximum off the western part of Cote d'Ivoire. Interaction between the two large capes in the sub-region (Cape Three Points and Cape Palmas) and the eastward flow of the Guinea current is also thought to be a possible mechanism contributing to the coastal cooling from January through March. An intensification of the Guinea current occurs during the first quarter of the year ; this can contribute to an upward movement of the thermocline on the eastern side of the capes and to the formation of eddies. Such eddies may play an important role as a retention mechanism for larvae. (Sinclair , 1988)

Inter-annual changes occurred during the last decade. For example, there was a persistent reduction of the mean SST from January to march; this cooling is associated with an apparent increase of the along shore wind stress. The difference between the offshore SST's and coastal SST's also suggest that an intensification of the winter upwelling has occurred.

Data from the coastal stations suggest that the difference in SST between the summer and winter upwelling seasons decreased during the last decade.

## Conclusion

An intensification of the winter upwelling off the Côte d'Ivoire and Ghana coasts occurred during the last decade. A consistent pattern between the inter-annual fluctuations of several environmental parameters suggests that a slight increase of the wind intensified the winter upwelling and raised the thermocline. Unfortunately, no chemical and biological data (nutrient, primary production) are available to investigate the ecological implications of the intensification of the winter upwelling.

## 3. Biological processes

Spawning activities of S. aurita in Côte d'Ivoire were described for the years 1989 - 1991. S. aurita spawns during both the minor and major upwelling seasons. It appears that the fish is able to spawn in every favourable condition. The recent increase in intensity of minor upwelling is therefore providing a new and better opportunity for the spawning of this fish. Consequently there should be two recruitments per year; however, this fact is not fully demonstrated. If this is true then the quantity of S. aurita available to the fishery could have increased and it would thus partly provide an explanation for the increase in catches in recent years. It is possible also that the growth rate of S. aurita could have improved resulting also in an increase of the exploited biomass.

The Working Group agreed that the hypothetical effects of a change in the minor upwelling provide a consistent theory that can explain the observed changes in the S. aurita fishery. However, many points remain unclear. This hypothetical effect of the minor upwelling has been shown mainly for Côte d'Ivoire ; is it the same in Ghana where the minor upwelling seems less intense even in recent years ?

The population (or stocks) status of the allegedly two major components of the fisheries (i.e. on the eastern sides of Cape Palmas and Cape Three Points, are not clearly understood). It has been noted that genetic analysis of enzymes by electrophoresis did not show any heterogeneity between these two components of the S. aurita resource. Probably more powerful techniques need to be used in order to identify any possible differences.

The time series of eggs and larvae collected off Tema have not been fully analysed yet. That should be done.

It was also not properly explained why the biomass of S. maderensis, which is known to spawn rather continuously throughout the year, did not increase in the same manner, following the same phenomenon.

## 4. Impact on Fisheries

According to the above considerations, it seems that the high catches of S. aurita made in the late 1980's have been sustained by a remarkable increase of

the abundance of the resource. However, some points remain unclear. For example, changes in the fishing pattern have not been fully investigated. The semi-industrial fishery of Abidjan, for example, was observed to have expanded somewhat offshore its range of fishing operations; And fishing season has expanded to the major part of the year, except few months. For canoes, particularly in Ghana, the range of operations seems to have remained the same. Fishing operations, however, take place all year round, maybe as a result of fishermen's migrations along the coast.

#### **5. Actual status of the resource of S. aurita**

The 1992 catches of S. aurita were excellent, particularly in Ghana, where the total production was an all-time high. In Cote d'Ivoire, the effect of voluntary limitation of landings of Abidjan purse seiners kept the total catch to about 24 000 MT. (Table 2).

Questions arose as to whether the resource has been overexploited which could lead to a collapse as observed in 1972-1973. But fisheries data of 1993, both in Ghana and Cote d'Ivoire, show still substantial catches. The sizes of the S. aurita in both countries were comparable to those of previous years. Consequently, a collapse of the resource does not occurred as feared. *(At the time of the final edition of this report, official figures for Ghana and Côte d'Ivoire showed a very high level of catches; especially for S.aurita; see Table 1).*

#### **6. What can be done at the policy-making level of management ?**

The Working Group discussed rather extensively this matter. Conclusion was achieved under form of a specific recommendation, entitled : «Recommendation for future research to ensure better management of pelagic resource.»

Pelagic fish stocks in upwelling areas around the world are well known for their instability. The collapse of the S. aurita stock in 1972-73 was a «bad» experience in Ghanaian and Ivorian fisheries. At that time fishermen had to face difficulties and many problems that were linked to a scarce resource. From a biological point of view, the situation is different now as the biomass of S. aurita is high and the demand is also higher than before. However we have to consider the future of this resource and a possible sharp decrease (or increase) of its biomass. To manage the future of the fishery is thus a challenge for which we have no ideas now. Doing nothing appears to be a very bad strategy for managing pelagic fish resources as it always results in strong social and economic problems. In order to face drastic changes (crashes or explosions of the fish stock) and in some way to minimise risks and to take advantage of any changing situations, fisheries science must address the problem of management of the resources.

In the case of the Ivorio-Ghanaian pelagic resources we need to react promptly to adverse and new situations by developing strategies that will be adapted to

the dynamics and uses of the resources. It means that scientific research needs to integrate not only biological and ecological factors, but also economic and social factors in order to develop future strategies for the fisheries. Research on possible strategies is needed as our predictions of the fisheries are still poor. The objectives of management should be adapted to the changes. Perspectives are immense for future research on how to better exploit pelagic resources. Countries like Ghana and Côte d'Ivoire have to prepare themselves to develop scientific research on how to better manage unstable pelagic fisheries. This type of research is quite new but scientific research should anticipate and give some partial solutions to the problems of management which are to be faced.

Considering the situation of such a resource, apparently abundant but known to be unstable, the group stressed the importance of the adaptive management strategy as it is now used in some countries (South Africa, Australia). Research on such a management strategy should be initiated here and must take into account the available data gathered for the various working groups on *Sardinella*.

## **7. Recommendations for future work.**

A list of recommendations, with assignments of persons and Institutes was prepared :

### **Physical processes**

a) The possible rise in the wind intensity is not proven as this could be affected by bias, but it is still a valuable hypothesis. It is therefore necessary to check the series of wind data recorded by merchant ships (of opportunity) and from other coastal stations such as airports close to the coast. Person in charge B. Bamba.

b) Time series of upwelling indices must be checked and analysed.  
Follow-up action : CRO/CEOS, Persons in charge : B. Bamba/C. Roy

c) Data on river flow in Ghana and Côte d'Ivoire should be updated and completed to facilitate an analysis of possible relationships with the fisheries of small pelagic in 1988-1993.  
Follow-up action : ORSTOM/CRO/FRUB, Persons in charge : D. Binet/B. Bamba/D. W. Ofori-Adu

d) The long series of salinity and temperature data obtained from hydrological transects off Tema should be analysed in order to check the origin of upwelled waters and possible geostrophic currents.  
Follow-up action : CRO/FRUB, Persons in charge : Cissoko/ Ofori-Adu

e) The time series of minor upwelling indices in Ghana should be analysed and compared to those in Côte d'Ivoire.  
Follow-up action : FRUB, Person in charge : Ofori-Adu.

f) Measurements of sea level by maregraphs (or sea level recorders) is necessary. It could help to investigate the hypothesis put forward on changes in oceanic currents. It was indicated that ORSTOM oceanographers use such maregraphs in the Gulf of Guinea for other purposes. Availability of such records in the region should be checked.

Follow-up : CRO, Person in charge : S. Cissoko

g) Satellite remote sensing of coastal SST proved effective for monitoring the spatial extent of the upwelling. A continuous recording action is to be maintained.

Follow-up : FAST/ORSTOM, Persons in charge : MM. Aman Angora/F. X. Bard

### ***Biology***

a) The proposal of MM. J. Panfili and Ndah Konan for morphometric analysis of hard parts (otoliths, scales) is encouraged. A strategy of sampling juveniles of S. aurita and S. maderensis two months after each upwelling in Ghana and Côte d'Ivoire is proposed for this purpose.

Follow-up action : ORSTOM/CRO/FRUB, Persons in charge : MM. J. Panfili Ndah Konan/P Bannerman,.

b) The genetic studies currently being carried out by Mr. Chikhi is very interesting and the results should be disseminated among collaborating scientists as soon as they become available.

c) Study of possibly similar changes which may have occurred in other small pelagic fisheries of the Gulf of Guinea, particularly those which rely on two upwelling seasons (e.g. in Gabon, Congo) is desirable.

Follow-up action : CEOS, Person in charge : P. Cury

d) The possible relationships between the Ivorio-Ghanaian populations of S. aurita and the Sardinella fished off Guinea Conakry and/or Sierra Leone should be investigated. Follow-up action : ORSTOM, ICLARM

e) Improvement of fishery statistics (including length sampling of catches by canoes). Follow-up : FRUB/CRO, Persons in charge : K. Koranteng/J Konan.

### ***Future joint programmes***

The group identified two joint programmes that could be carried out only if international co-operation of scientists can be maintained and if external funding can be obtained. These are the strategy of adaptive management and an intensive study of the minor upwelling. These programmes could be major components of a second phase of the Joint Sardinella Programme, (GPS II).

The strategy of co-operative research in GPS through various scientists from Ghana, Côte d'Ivoire and ORSTOM, proved very effective. It is recommended that this network of scientists continue to work on basic research in fisheries, alongside the two special programmes proposed above.

## **REPORT OF THE WORKING GROUP ON SOCIO-ECONOMICS**

**Moderator : A. Wayo Seini, Rapporteur: Ernest O. Tettey.**

While much of the current research efforts on small pelagic have been directed at the biological and environmental issues, socio-economic research has lagged behind. Recognising the need to address socio-economic issues confronting the artisanal operators, the working group was charged with the responsibility of identifying priority areas in which studies can be undertaken in conjunction with scientific work currently being pursued.

Priority areas identified include :

- database on socio-economic research
- impact of currency fluctuations on artisanal fish operations
- fishermen migration
- fish marketing and trade
- costs and earnings studies at the production level and
- fisheries credit

### **1. Database on Socio-economic research**

Despite the inadequacy in socio-economic research in artisanal fisheries, some work has, however, been initiated or accomplished. The initial task is to assemble socio-economic literature in the region. This would permit researchers to know what has already been done, lessons which can be drawn from past experiences and directions in which future work should take.

It has further been observed that information exchange pertaining to socio-economic issues between research institutions, universities and fisheries administrations in the region has been poor and this has slackened research work as well as development efforts.

**The working group therefore recommends that :**

- Countries in the region should be encouraged to establish data bank on socio-economic literature, initially at national level and eventually co-ordinated from a regional focal point.

- A by-annual fisheries newsletter, summarising scientific and socio-economic research in the region should be initiated and

– Exchange of information between fisheries research institutions, universities and fisheries administrations should be intensified

Follow-up action : RAFR (FAO Regional Office) / Fishery Research Institutions / Fisheries Administrations

The FAO regional office intends to establish a regional library and information system on fisheries and would incorporate a fisheries database as part of its activities. Collaboration of national research institutions correspondents in regularly feeding the database with information would be required. Participating institutions which have been currently identified together with local correspondents include ;

Nigeria : Nigerian Institute for Oceanography and Marine Research, NIOMR (Economist)

Benin : Direction des Pêches (Mme Gbaguidi Amélie)

Ghana : FRUB (A. Bortey)

Côte d'Ivoire : CRO (Konan Jacques)

Senegal : CRODT (MM. Kébé/Deme)

Country coverage will eventually be expanded to include others in the region.

## **2. Currency Fluctuations**

Impact of currency fluctuations on the economic activities of the artisanal operators is quite immense. The continuous decline in the value of the cedi or the inflationary pressures in Ghana have had serious consequences for the operators - now fewer fishermen can afford out-board motors and rate of motorization in canoes is lower now than in the 1980's.

**The working group therefore recommends that :**

– The effect of changes in the value of currency on the operations and standard of living of the artisanal operator be studied and

– Implications of the non-convertibility of the CFA (and its possible devaluation) on fish trade in the sub-region be examined.

These studies will provide the basics for an appropriate government intervention to alleviate the sufferings of the artisanal operators (such as the provision of pre-mixed fuel at special rates to Ghanaian fishermen).

Follow-up action : Universities / Research Institutions

Consequences of currency fluctuations on fish trade in Ghana and Nigeria are to be studied. Institutions identified to submit project proposals are;

– Ghana : ISSER, University of Ghana (A. W. Seini)

– Nigeria : NIOMR, (Economist) or University of Ibadan (Mabawonku)

The studies will also examine the issue of non-convertibility of the CFA on fish trade.

### **3. Fishermen Migration**

One of the major issues confronting artisanal fisheries in the region is fishermen migration. About one half of the artisanal fishermen in Côte d'Ivoire are Ghanaians and Ghanaians similarly constitute a large percentage of the fishermen population in Togo as well as Benin. Fish production, in a large measure, is influenced by the migration patterns in these countries.

It has been further observed that, the migrants are often unaware of the existing immigration requirements in their host countries and as a result they are exposed to illegal demands, making their stay very difficult.

#### **The working group recommends that :**

- Studies on fishermen behavior and migration patterns be reviewed and
- Legal and administrative aspects of migration be also examined

Follow-up action : IDAF Programme / Research Institutions

Fishermen migration issues have been one of the key activities of the IDAF Programme based in Cotonou, Benin. IDAF could take a leading role and coordinate research efforts in this area.

Recognising that migration patterns in the sub-region have their origins in Ghana and Senegal, institutions from both countries should be actively involved.

Ghana : ISSER, University of Ghana (Mrs. Bortei-Doku)

Senegal : CRODT (Diaw)

The only legal expert present at the meeting, Mr. Kouakou Koffi, was asked to develop an «Immigration Guide» in close collaboration with ECOWAS. This Guide is expected to clarify immigration requirements for each ECOWAS member country as well as administrative procedures.

### **4. Marketing and Trade**

A number of studies on fish marketing and trade have been undertaken in the region but these have often been limited to price trends, transportation and other marketing costs as well as trade formalities. Very little has been done on price analysis in relation to other commodities. Impact of frozen fish imports on local producers has also created a lot of concern and in Ghana, the Government has had to ban frozen fish imports during the main fishing season in order to protect local producers.

#### **The working group therefore recommends that :**

- Fish price analysis in relation to other commodities, income elasticity of demand, etc., be undertaken

- Studies on fish trade should be intensified, particularly the legal and administrative aspects of intra-regional trade as well as harmonisation in trade policies with proposals aimed at improving fish trade.

– Impact of frozen fish imports on artisanal fisheries should also be examined.  
Follow-up action: INFOPECHE / Research Institutions

INFOPECHE would take the leading role and co-ordinate studies on intra-regional fish trade.

ISSER (Seini) was also asked to submit proposals to undertake fish price analysis. Geographical coverage will be limited to Côte d'Ivoire and Ghana.

## **5. Costs and Earnings in Marine Fisheries**

Costs and earnings studies contribute immensely in understanding socio-economic behaviour. Effect of high costs of canoes, out-board motors, fishing nets have had serious consequences on production activities in marine fisheries but these effects need to be quantified in order to properly address these issues.

### **The working group recommends that :**

– Cost structure at the production level be identified and impact of high prices of fishing inputs - canoes, out-board motors, fishing nets, etc., should be investigated

– Migration effect on fishermen's costs and earnings be examined and

– Socio-economic issues affecting fish production e.g. children dropping out of school and going into fishing should also be examined.

Follow-up action : IDAF Programme / Research Institutions

The IDAF Programme is again active in costs and earnings studies on artisanal fish operations in the region and could co-ordinate research efforts in this regard. Active collaboration of research institutions such as, University of Ghana (ISSER), University of Cape Coast, CIRES (Côte d'Ivoire) and CRODT (Senegal) was also recommended.

RAFR (FAO Regional Office) indicated it will assist in funding some of the studies.

## **6. Fisheries Credit**

Credit features prominently in artisanal fish operations, be it production, processing or marketing. But the artisanal operators shy away from the formal channels of obtaining credit such as banks, savings and credit unions, etc. except when special grants have been placed at their disposal in these institutions. Collateral's from the artisanal operators are often not accepted by the financial institutions. Due to these difficulties, they depend on relatives and close acquaintances who charge exorbitant rates of interest, at times wiping away a huge chunk of their margins.

There is therefore the need to identify an appropriate credit system adapted to the needs of the artisanal operators. Such a system should have simplified procedures, be operated with the full involvement of the operators themselves and should have elements which will ensure high repayment rate.

**To achieve this, the working group recommends that :**

– Existing credit systems for artisanal operators be examined for countries in the sub-region, specifically, Côte d'Ivoire, Ghana, Togo and Benin. Such studies should address sources of credit, administrative procedures, conditions for repayment and default rates, among other things, and make proposals on how to implement a sustainable credit system.

Follow-up action : EEC Regional Fisheries Programme

Fisheries credit will be a major component of the second phase of the EEC Regional Fisheries Programme for West Africa which is expected to become operational by the end of the year (1993). The Programme should be contacted (by Tettey) to co-ordinate work in this area.

## **7. CONCLUSIONS AND RECOMMENDATIONS**

The conclusions of the two workshops were reviewed during a final general meeting. In an introductory remark at this session, the chairman, Dr. E Kwei, quoted an extract from the Report of the Working Group on S. aurita of Ivorio-Ghanaian coasts, held in Abidjan 28 June-3 July 1976 : «The working party agreed that the stock of S. aurita is now so low that, in the present ecological conditions it is highly improbable that the stock may recover to its previous level. In that case no meaningful technical advice can be given for the recovery of the species».

It was agreed that this summary, reflecting the state of knowledge on *Sardinella* resources in the 1970's, compared to the actual information gathered during this meeting, clearly demonstrate the difficulty of understanding the dynamics of such an unstable resource and the forecasting of any level of abundance. Clearly the ecological conditions changed in an unexpected way during the 1980's and *Sardinella* populations reacted positively to these changes. The amount of research carried out during the first phase of the Grand Programme Sardinelle (GPS I) on biological and oceanographic conditions which affect the *S. aurita* population provided some insights into these changes. The first workshop detailed these points. It was noted particularly that the effects of hydro-climatic changes in minor upwelling conditions east of Cape Palmas, and to a lesser extent east of Cape Three Points, could have been a determining factor for the change in abundance of the resources.

Possible follow up on research on physical oceanography, biology and ecology according to the workshop recommendations were discussed, and responsibilities for every action were assigned as indicated in the working group report.

A new study approach on *Sardinella*, and more generally small pelagic, in the region is in the economics and sociology of fishing and on commercial activities related to these resources. The second workshop addressed these matters and follow up of researches on economics were proposed. Responsibilities for every action were also assigned as indicated.

Two joint programmes were identified :

*a) Adaptive management*

The necessity of being prepared for a possible decline of the resource has been shown. This preparation and a strategy of appropriate reactions involve many fields, not only economic, social and political but also physical and biological appraisals.

The DUSRU group thinks that a special meeting devoted to Adaptive Management of the Ghana/Côte d'Ivoire resources is highly desirable. The meeting should include presentations of examples from other countries in the world (South Africa, Australia).

*b) Intensive study of the minor upwelling*

Strong effects of the minor upwelling on several stages of the life cycle of S. aurita has been hypothesised. All this theory could be proven only if a field research is undertaken. It should take place in western Côte d'Ivoire (off San Padre) and in western Ghana (off Takoradi).

Research should include physical, productivity and planktonic measurements in the coastal area where minor upwelling occurs from January to March. An accurate timing of the field actions will be necessary. A technical meeting should be convened in 1994 for developing the programme, identifying actions, participants, necessary logistics (including an oceanographic ship) and costs.

It was stressed that, if a joint programme is established for studying the minor upwelling in areas off western Côte d'Ivoire and western Ghana, measurements of temperature, salinity, and currents will be of paramount importance. The study of eggs and larval retention (or drift) must also be included.

The publication of the Proceedings of DUSRU was put in the care of Messrs. Bard and Koranteng who will be the Scientific Editors. This should preferably be done before the end of 1994, for making this report really useful.

## TABLE AND FIGURES

**TABLE 1**

Historical catches of the four main species of small pelagic fish, 1966-1993 for Ghana and Côte d'Ivoire.

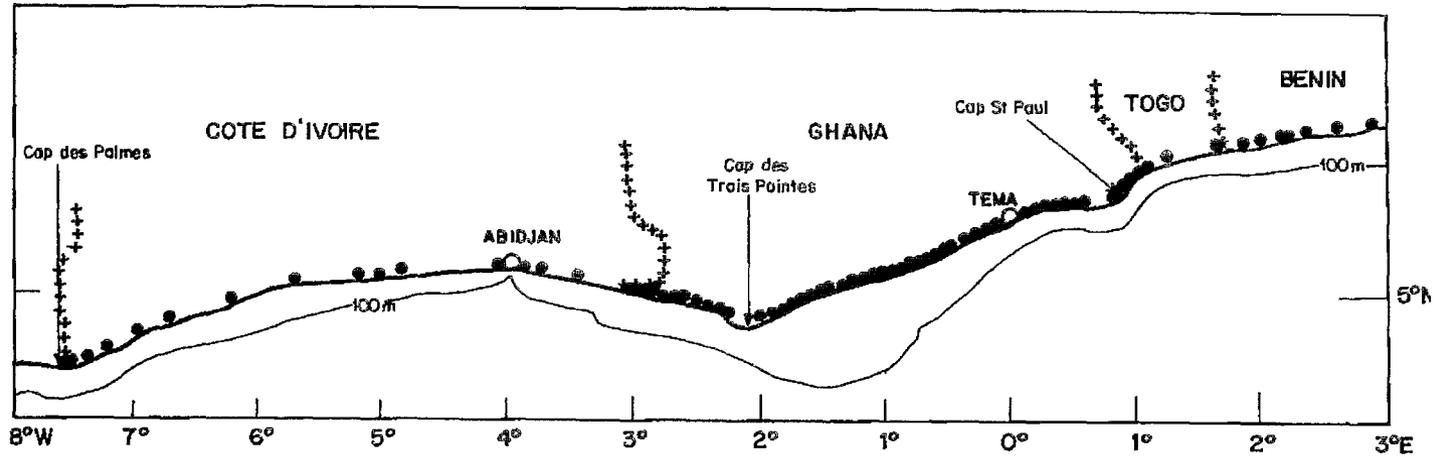
<b>CATCHES GHANA , COTE D'IVOIRE, MAIN SPECIES OF SMALL PELAGICS</b>							
YEAR	S. aurita GH	S. aurita CI	S. maderensis GH	S. maderensis CI	MACKEREL GH+CI.	ANCHOVY GH	Total
	Ghana	Côte d'Ivoire	Ghana	Côte d'Ivoire	GH+CI	Ghana	
1966	10000	5779	0	9757	341	0	25877
1966	7460	500	0	9090	380	0	17430
1967	36200	11022	0	9849	2356	0	59427
1968	4300	4443	0	12660	582	0	21985
1969	22500	7115	0	6390	1064	0	37069
1970	19500	10911	0	5991	2630	0	39032
1971	31216	4471	4627	7979	5230	0	53523
1972	87066	7560	5263	11094	8917	26780	146680
1973	8988	181	12582	5458	11181	14455	52845
1974	2032	45	18622	8029	726	33439	62893
1975	2066	9	29472	7885	910	31173	71515
1976	13803	1049	19209	10110	152	29126	73449
1977	16366	937	16732	11234	567	35939	81775
1978	46374	3629	12368	8921	553	51992	123837
1979	12844	1719	15857	15597	187	38222	84426
1980	21894	2735	11955	8878	470	41936	87868
1981	15596	10297	13304	10547	500	71088	121332
1982	21985	17407	14877	5439	393	61843	121944
1983	45324	27037	8279	17216	312	30780	128948
1984	38215	19139	11110	11172	803	57184	137623
1985	63501	42863	24060	15019	250	37082	182775
1986	50998	39436	18721	18838	20577	19185	167755
1987	48074	34278	27177	9183	457	92988	212157
1988	75924	17251	10546	8676	8514	81375	202286
1989	65228	15125	14428	9842	14942	80803	200368
1990	45563	15979	15490	16424	9646	75491	178593
1991	52712	17661	8450	9903	24323	66547	179596
1992	125815	28280	14410	4472	12209	85384	270570
1993	92700	21300	17000	6000	4000	81350	222350

**FIGURE 1**

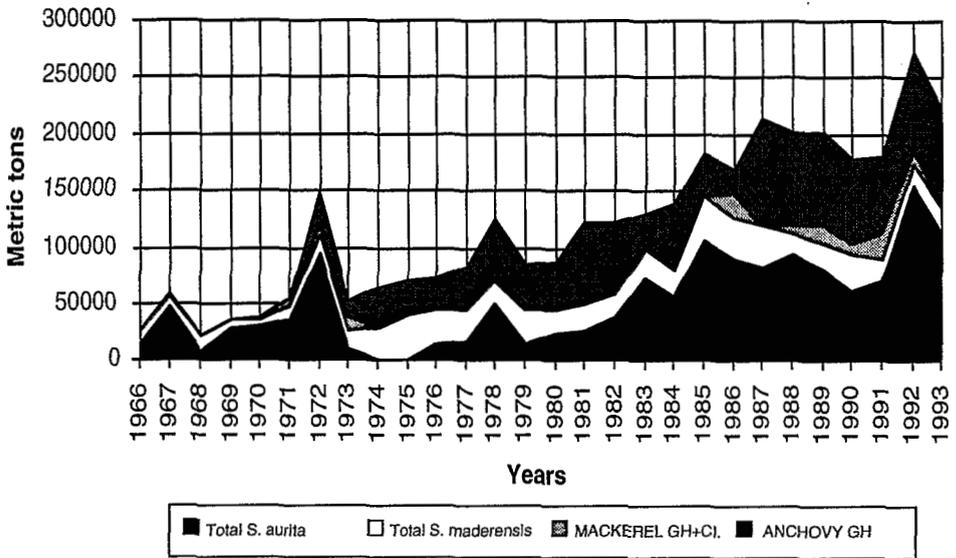
Map of the inshore area for Western Gulf of Guinea showing potential fishing area for small pelagic.

### SITUATION DES PECHERIES DE SARDINELLES

- : Point de débarquement des pêches piroguières
- : Point de débarquement des pêches industrielles



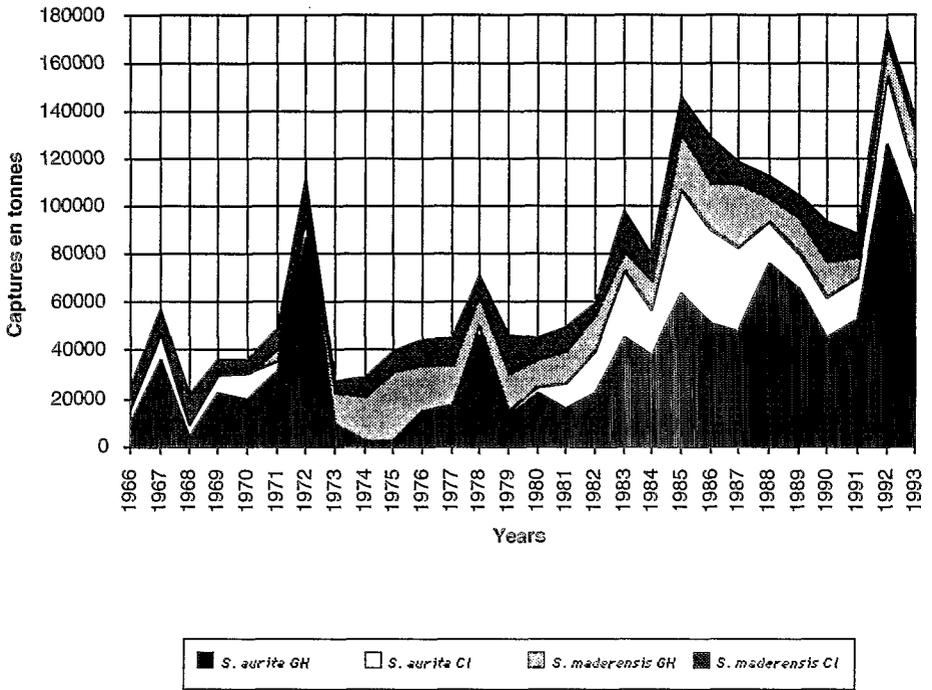
### Catches of small pelagics Ghana and Côte d'Ivoire, main species



**FIGURE 2**

Total catches (1966-1993) of the four main species of small pelagic fish, for Ghana and Côte d'Ivoire.

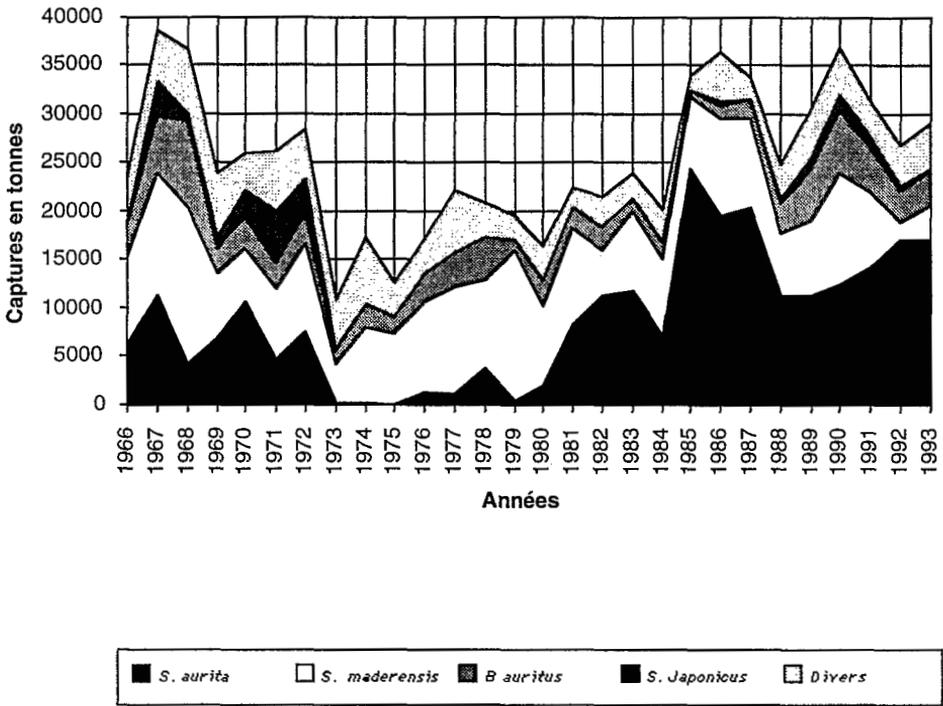
### Catches by country, *S. aurita*, *S. maderensis*



**FIGURE 3**

Catches (1966-1993) of *Sardinella* sp. for Ghana and Côte d'Ivoire. Note the parallel increase of the catches of *S. aurita* in both countries, compared to the relative stability of *S. maderensis* catches.

**Catches of small pelagic by Ivoirian purse seiners, 1966-1993**



**FIGURE 4**

Catches of small pelagics by Ivoirian purse seiners, 1966-1993.  
Divers includes : *I. africana* ,small carangids and various species of minor importance.

## ANNEX 1

### ASSIGNMENTS OF DUSRU AND AGENDA

#### 1. BACKGROUND TO THE FISHERY

Small pelagic fish constitute the main fishery resources of the world. They represent between a third and a half of total world fish catches, but they are characterised by great instability due partly to their sensitivity to the environment. Larger stocks of such species have experienced collapse which resulted in economic disasters for the regions concerned (e.g. the Peruvian anchoveta fishery in the 1970 s, and the Californian sardine fishery since the 1950 s). Recoveries of depleted resources or «demographic explosions» of such species (e.g. the Japanese sardine by 1985) could also occur without simple explanation.

The coastal pelagic resources of the Côte d'Ivoire-Ghana region are of special interest because the stocks involved are small, have been studied for a long time and are of great socio-economic importance for the coastal populations. A lot of scientists have been involved in biological studies, fisheries and environmental components of the coastal pelagic ecosystem of Côte d'Ivoire and Ghana since the 1960's.

Moreover a dramatic increase of the abundance of *Sardinella aurita* has been observed in the 1980 s.). This phenomenon, dubbed «the Sardinella puzzle» is being studied intensively by Ghanaian, Ivorian and French scientists, since 1988.

By mid 1990 it was decided to increase the research effort, particularly through an intensive joint program submitted as «Grand Programme Sardinelle» (GPS) to various potential donors. It was accepted by ORSTOM and submitted to the French Ministry of Co-operation for funding.

From 1991 to 1993 this France-Ghana-Côte d'Ivoire joint Sardinella research programme (GPS), has been in operation. Various results described herewith have been achieved. This led to the end of the first phase of the GPS. An intermediate meeting, dedicated to an evaluation of the results of this first phase, and to the preparation of a program for a possible second phase, was decided.

Meanwhile, Mr. Levallois, ORSTOM President, having been introduced to the GPS, during his visit to Ghana, in May 1992, suggested that the intermediate GPS meeting should be held in Accra, taking into account the potential interest for Ghanaian economic and political authorities and private users of the resource.

Therefore this DUSRU meeting is to be jointly organised by the Fisheries Department of Ghana ( Ministry of Food & Agriculture), and ORSTOM. FAO and French Embassy in Accra indicated their willingness to collaborate.

## **2 . AIMS AND OBJECTIVES OF THE MEETING**

This meeting would be an opportunity to present to the world scientific community, and also the economic and political authorities of Ghana and Côte d'Ivoire, the situation of the knowledge of this ecosystem, the resources and their utilisation by man. Different but complementary parts are evident, namely: the fishes and their biology, the fisheries and socio-economics and the environment and its variability which affects both the fishes and the fisheries.

This meeting is intended to be an occasion to open the discussion to all parties concerned and have the view of some of the well-known experts on such problems. Therefore, the meeting is aimed at presenting knowledge acquired in over 25 years of joint research on the pelagic resources of the Gulf of Guinea, especially on the *Sardinella*, and place this particular situation in the appropriate perspective in the world.

For this purpose, the meeting will be connected with the Climate and Eastern Ocean Systems (CEOS) program which is a collaborative study addressing potential effects of global versus local climate change on the populations of the highly productive ecosystems of eastern ocean upwelling regions, and on directly associated economic, cultural and ecological issues.

## **3. FORM OF THE MEETING**

This meeting will be held in English and it could be divided into two parts :

1. A papers presentation session by invited speakers which will present the general problem according to the following framework of basic questions :
  - Changes in coastal pelagic populations during the last decade, off Ghana-Côte d'Ivoire ; artefacts or real changes ?.
  - Fisheries impact and/or environmental changes ?.
  - Is Ghana-Côte d'Ivoire upwelling an exception among other upwelling ecosystems ?.
  - What can we learn from other upwelling ecosystems and their related fisheries ?.
  - What future researches are needed ?.

These items concern the questions related to the Côte d'Ivoire - Ghana region but also those involved in the CEOS program.

2. A session of workshops which would discuss particular points. Two workshops are proposed. They will be organised as a comparative approach in order to study the basic case of Ghana-Côte d'Ivoire, and compare it with other cases in the rest of the ecosystems of eastern ocean upwelling regions. The two themes will be :

- Environmental variability ; impact on coastal marine pelagic populations and resources, particularly Sardinella aurita.
- Economics and management policies of coastal pelagic fisheries in Africa and in the world.

#### 4. PRODUCTS

A book will be prepared and edited jointly by ORSTOM and FRUB. It will include invited lectures in English or French , reports of the workshops, recommendations and conclusions. Scientific Editors will be members of the steering committee.

A data base including the information retrieved, gathered and checked during the first phase of GPS will be made available to participants, on diskette.

A research program of the second phase of the Grand Programme Sardinelle (1994-1996) will be prepared by end of 1993 in order to seek for potential donors and joint political endowment of Ghana and Côte d'Ivoire governments. It will be based on the recommendations made by the participants for future research on environment, fisheries, trade, sociology and economics linked to small pelagic resources of the Ivorio-Ghanaian upwelling ecosystem.

#### 5. AGENDA

*First day : October, 5th, 1993.*

Morning : .

**Introduction of Chairman**

**Chairman's Response**

**Welcome Address : The Sardinella Problem**

Dr. Martin A. Mensah, Deputy Director of Fisheries

**The need for cooperative research on the sardinella resources in the Western Gulf of Guinea.**

Dr. F. X. Bard, ORSTOM Representative in Cote d'Ivoire

**Address by FAO Official, Dr Okai.**

**Address by M. le President of ORSTOM, Mr. Levallois**

**Address by M. l'Ambassadeur de France, M. Brochenin**

**Opening address**

The Deputy Minister for Food and Agriculture, Major (Retired) E. Tetteh

*Second Day : October 6 th, 1993.*

All the day long at FAO meeting room :

Presentation of Papers classified according to the three following categories :

- Physical processes and environmental conditions.
- Environment impact on biology, ecology and fisheries
- Socio-economics and management policies.

*Third day October, 7th, 1993.*

All the day long, Workshops in FAO building.

*Fourth Day October, 8th, 1993*

Morning at FAO meeting room: Presentation of workshop reports, conclusions and recommendations.

Afternoon : Closure :

Closing addresses by Chairman of meeting , and Director of Fisheries.

## ANNEX 2

### LIST OF SPEAKERS AND PAPERS

Angora A. Fofana S. (Université d'Abidjan, Côte d'Ivoire). Coastal Sea Surface Temperature as detected by the METEOSAT satellite and received at the University of Abidjan.

Bakun A. (FAO, Rome, Italy). Global changes and the impact on the Gulf of Guinea and other upwelling areas.

Bard F.X. (ORSTOM, Abidjan, Côte d'Ivoire). Predation by tropical tunas on *Sardinella*. Possible induced changes in tuna populations by increase of *Sardinella* abundance.

Binet D. (ORSTOM, Nantes, France). Hypothesis accounting for the variability of *Sardinella* abundance in the Northern Gulf of Guinea.

Chikhi L., Bonhomme F and Agnese J.F. (ORSTOM, Montpellier, France). The search for genetic differentiation of two sardine species (*S aurita*, *S maderensis*).

Cury P. (ORSTOM/PFEG, Monterey, USA). Comparison of the Ivoirian-Ghanaian fisheries dynamics with other upwelling ecosystems.

Durand M. H. (ORSTOM, Bondy, France). Mode de formation des prix des espèces pélagiques et enjeux d'exploitation pour les zones d'upwelling faiblement productives.

Ferraris J., Koranteng K.A. (ORSTOM, Dakar, Senegal/FRUB, Tema, Ghana). Statistical analysis of canoe fisheries data in Ghana with particular reference to *Sardinella*.

Gbaguidi A. Pêche artisanale des Sardinelles au Bénin.

Konan J. (CRO, Abidjan, Côte d'Ivoire). Ivorian canoe fishery for *Sardinella*.

Koranteng K.A. (FRUB, Tema, Ghana). The Ghanaian canoe fishery for *Sardinella*.

- Kouakou Koffi J. (Direction des Pêches, Abidjan, Côte d'Ivoire). Legal aspects in the management of the resources of small pelagic of the Ivoirio-Ghanaian ecosystem.
- Kwei E.A. , Koranteng, K.A. and Bannerman, P.O. (Tema, Ghana). Tuna Bait boat baiting time and the availability of anchovy in Ghanaian waters.
- Mensah M.A. (FRUB, Tema, Ghana). Availability of Sardinella eggs and larvae off Tema during the period 1969 - 1992.
- Mensah M.A. (FRUB, Tema, Ghana). Occurrence of zoo plankton off Tema during the period 1969 - 1992.
- N'dah K. (CRO) Age determination and the hypothesis of annual double cycle of growth in *Sardinella aurita* (Val).
- Panfili J. (ORSTOM Brest). Use of otoliths for stock discrimination and age estimation in *Sardinella* : proposal for a regional research project in Western Africa.
- Pezennec O. (ORSTOM, Abidjan, Côte d'Ivoire). Ecological importance of the Ivorian and Ghanaian minor upwelling season.
- Roy C. (ORSTOM/PFEG, Monterey, USA). Ghana-Ivorian upwelling. Dynamics and environmental changes.
- Samba A. (CRODT, Dakar, Senegal). Senegalese canoe fishery for *Sardinella*.
- Seini, A. WAYO (ISSER, University of Ghana, Legon). Economics of canoe fisheries in Ghana.
- Tetty E. (INFOPECHE, Abidjan, Côte d'Ivoire). West Africa Markets for small pelagics.
- Tetty E., Koranteng K.A. (INFOPECHE, Abidjan, Côte d'Ivoire/FRUB, Tema, Ghana). *Sardinella* market trends in the West African sub-region.

## ANNEX 3

### TEXTS OF THE INTRODUCTORY ADDRESSES

#### WELCOME ADDRESS DELIVERED BY DR A. MENSAH ON THE OCCASION OF THE OPENING OF THE SCIENTIFIC MEETING ON THE DYNAMICS AND USES OF SARDINELLA RESOURCES FROM THE UPWELLING OFF GHANA AND COTE D'IVOIRE (DUSRU)

Mr. Chairman,

Honourable Minister of Food and Agriculture

I deem it an honour to be given the opportunity to welcome our distinguished guests and invited scientists from far and near to this all-important scientific meeting on the sardinella resources off Ghana and Cote d'Ivoire. I believe that quite a good number of you who have come from outside Ghana have already been to Ghana before and most likely, several times. For this reason the proverbial Ghanaian hospitality is nothing new to most of you, distinguished guests. To the very first time visitors to this country, you will surely find the broad smiles on the faces of most Ghanaians who are all too willing to help you out of any difficulty whether in the streets, in the play houses, in the tourist places or the markets. Whenever you are convinced that there is a problem, the Ghanaian will smilingly assure you otherwise by telling you: «No problem». I am sure you will enjoy our peaceful atmosphere here, because you could go to any place any time of the day and night without fear of your lives.

Mr. Chairman, distinguished guests and scientists, while warmly welcoming you into Ghana and to this scientific meeting I wish to draw your attention to the spectrum of problems posed by the marine environment, biology and fishery of the sardinellas, to the countries in the Western Gulf of Guinea, which constitute the basis of this scientific meeting.

The sardinella fishery in Ghana is as old as the marine artisanal capture fishery which has existed since time immemorial. It has proved to be the mainstay of marine fisheries in this country. Ordinarily when the Ghanaian says that there is no fish in any particular year, he/she means that the sardinella season was poor. The sardinella fishery is known to be supported by the seasonal cooling of the

coastal waters called major upwelling which takes place each year for about three months (July-September) and a relatively minor upwelling which occurs for about three or four weeks in January/February or March each year.

Two species of sardinellas occur in the Western Gulf of Guinea especially off Ghana and Cote d'Ivoire. These are Sardinella aurita or round sardinella and Sardinella maderensis or flat sardinella. The round sardinella is more abundant than the flat sardinella especially during the major upwelling. The flat sardinella is usually available after the major upwelling and in smaller quantities than the round sardinella.

Both Ghana and Cote d'Ivoire fish the sardinellas. In the early years in Ghana, sardinellas were fished by the canoe fleet only, but with the introduction of the semi-industrial fleet, the purse-seiners have also been fishing the sardinellas. The round sardinella could constitute up to about 40% of Ghana's total annual marine fish catch and practically all of this is taken during the upwelling season. The flat sardinella make up to 10% of the total annual catch but these are caught mainly outside the upwelling season. In Cote d'Ivoire, the sardinellas are fished by the artisanal and industrial fleets seasonally as in Ghana, but in lesser quantities than in Ghana.

In view of the socio-economic importance of the sardinellas to the fishermen in particular and the two countries in general, the greatest attention of scientists in both Ghana and Cote d'Ivoire has been directed to the study of these species of fish. Research into the biology and fishery of the sardinellas was the principal motive which led to the establishment of the Fishery Research Unit at Tema (now the Research & Utilization Branch of the Fisheries Department ) in 1966.

Research in this direction by both the Fishery Research Unit at Tema and the Centre de Recherches Oceanographiques in Abidjan continued for some years after which scientists thought that they had known enough about the sardinellas. This was followed, naturally, by a brief period of apparent complacency when less active research was carried out. However, some observations made about the marine environment, the biology and fishery of the sardinellas later, clearly showed that there was still a lot to be learnt. this realisation stirred up research activities again.

One of the earliest findings made about the round sardinella was that, its catch was positively related to the intensity and duration of the major upwelling. It became obvious, therefore, that research should be carried out to understand the mechanism of the upwelling and to find a means of calculating the appropriate upwelling indices (duration and intensity of the major upwelling) as a means of forecasting the strength of the upwelling and hence, of predicting the success or failure of the S. aurita fishery. Several proposals have been put forward to explain the mechanism of the coastal upwelling in the Gulf of Guinea but none is sufficiently conclusive to be accepted by all scientists.

Different upwelling indices have recently been proposed while some are still being developed but the problem of forecasting is still not close to solution. What would this seminar do about this problem ?

Another observation made which has not lent itself to an acceptable explanation is that, for the past few years, the minor upwelling which occurs for few weeks in January, February or March is assuming greater importance in the round sardinella fishery than it was previously thought. Greater spawning activities and higher catches of the sardinellas than before are being observed, especially off the western part of both Ghana and Cote d'Ivoire.

#### **BIOMASS AND FLUCTUATION IN ABUNDANCE :**

The question of greatest concern to the fisheries scientist, namely estimating how much (fish) S. aurita can be taken out of the sea without depleting the S. aurita stocks, ie. fishing at a level that will produce the maximum sustainable yield (M.S.Y.) of the S. aurita is still a puzzle. Until its decline in 1973, the size of the stock of the Ghana - Cote d'Ivoire S. aurita was estimated to be between 150,000 and 350,000 metric tons. Thus, in consonance with the old school of thought in fishery science, the potential or maximum sustainable yield was considered to be between 42,000 and 49,000 mt and so it was safe to catch about 50,000 mt of S. aurita without the fear of depleting the stock. Other two estimates put the combined biomass of both sardinellas and that of the anchovy at 40,000 and 74,000 mt respectively. Until 1972, the annual landings of S. aurita were below 40,000 mt but in 1972, Ghana alone caught over 87,000 mt. of S. aurita while Cote d'Ivoire landed 7,500 mt. This is far in excess of the estimated maximum sustainable yield, and so, as a natural consequence, the S. aurita fishery nearly collapsed. Strong indications for the recovery of the fishery were observed as from 1976 after which high fluctuations in catches have been recorded. Catches of both sardinellas since 1983 have been in excess of 49,000 mt annually and extremely high landings have been recorded since 1985, especially so in 1992 when as much as 125,814 mt and 14,410 mt of round and flat sardinellas were respectively landed. Increased catches with fluctuations are being made in Cote d'Ivoire as well.

The flat sardinella has a lower biomass in Ghanaian waters and its catches are much lower and relatively more stable than those of the round sardinella.

Mr. Chairman, distinguished guests, fellow fishery scientists and oceanographers, in the face of such high catches exceeding the estimated biomass and high fluctuations in the biomass, the S. aurita stock/stocks in the Ivoir-Ghanaian ecosystem, clearly demonstrate the inapplicability of the MSY concept to pelagic fishery resources.

#### **Recruitment :**

The problem of recruitment which is the process by which «new» fish enter the fishery, is not yet satisfactorily solved in the case of the S. aurita in the Western Gulf of Guinea. Stock-recruitment relationship in the context of the coastal upwelling has been examined by several fisheries scientists and oceanographers in the West African sub-region. However no satisfactory or conclusive results have been obtained.

Meanwhile, it is only assumed that :

a) a good upwelling enhances spawning and increases the chances of good recruitment,

b) analysis of the lengths of fish (i.e. the length of the fish from the tip of the head to the fork of the tail) indicate the age structure of the sardinella population (i.e. abundance of fish spawned in a particular year).

c) the landings of the beach seine nets are crude indications of the strength of recruitment of young fish, including the sardinellas, into the fishery.

This is so because the beach seine thrives largely on juvenile fish; a large proportion of landings of the beach seines is made up of very young fish including round and flat sardinellas. Thus, the problem of recruitment of the sardinellas into the fishery is still not understood.

### **The Migration Pattern and the Question of Stocks of the Sardinellas :**

The migration pattern of *S. aurita* had been studied in detail by several fisheries scientists in the western Gulf of Guinea and had come up with a model which was accepted. This model considers that one stock of *S. aurita* exists off Ghana - Cote d'Ivoire. A large proportion of the stock rests off Central Ghana and at the onset of the fishing season (July - September), the fish move or migrate shorewards to Cote d'Ivoire and Western Ghana. They turn eastward as they hit the coast and continue in this direction to Togo and sometimes as far as Benin. The fish that successfully make this trip, a distance of about 500 km (300 miles), return to their resting grounds about the end of the season.

Even though this model is still held valid, yet recent pieces of evidence indicate some departure from this pattern of migration. Until the last seven fishing seasons or so, the pattern of sardinella fishing conformed with the migratory pattern as explained above. The fishermen followed the fish from the west to the east along the coast. Many years ago, when out-board motors were not very popular in Ghana, the canoe fishermen virtually moved camp to follow the fish. Such migration of fishermen is very much reduced these days. Since 1987, it appears that not much of the fish continue this eastward journey past the Central Region of Ghana. Landings of *S. aurita* in the Greater - Accra and Volta Regions are becoming quite less than before; also the inshore vessels which mostly operate from Tema in the Greater-Accra Region have been recording their lowest catches. Furthermore, in recent years, the catch in Cote d'Ivoire appears more spread out on the Ivorian coast all year round. How can these observations be explained, Mr. Chairman ?

Concerning the stock, there are increasing doubts as to whether one or more separate stock of the *S. aurita* exist off Cote d'Ivoire - Ghana. What do we think about this, Fellow scientists ?

There is a second school of thought which maintains that there are two separate and independent stocks of the *S. aurita* in the Western Gulf of Guinea - one stock on the eastern side of Cape Three Points (called the Ghana stock) and

the other on the western side of the cape (the Ivorian stock). Mr. Chairman, for how long shall we continue to speculate on such important issue ? Do the fish recognise the sovereignty of our states ?

The migration pattern of the flat sardinella is less understood. It appears that the flat sardinella is a coastal and relatively sedentary species and so its seasonal migration along the coast is of a limited extent. It is obvious therefore that our knowledge of the migratory pattern of the S. aurita and the number of stocks needs to be updated.

### **Effective fishing Effort and the Problem of Modelling :**

Several gears (fishing nets) are employed in the sardinella fishery : - ali poli, watsa, beach seines, purse seine nets and sometimes trawl nets are all used. In view of the different mesh sizes and manner of operation, these gears catch different sizes of the sardinellas; they have different efficiencies and effective fishing efforts. For this reason, it has proved very difficult to obtain an effective fishing effort which could be applied in modelling. This is a challenge to us, fellow scientists.

Mr. Chairman, distinguished guests, fellow scientists, the S. aurita fishery in the Western Gulf of Guinea, is a very important and target fishery to both the artisanal and semi-industrial fleets. For this reason the unpredictable high fluctuations in abundance and catch rates for the past two decades or so affect the livelihood of the fishermen.

It is very obvious from these unpredictably high fluctuations in abundance that the fishery is not as well understood as was once thought.

The estimation of the biomass of the round sardinella has remained a difficult problem. The high catches made since 1983 cannot be reconciled with the low biomass estimated. The increasing catches especially that which was made in 1992 could also lead to a disaster just as increased catches in 1972 nearly collapsed the fishery. Furthermore, predictions about the future of such an unstable resource as the S. aurita in the western Gulf of Guinea on the basis of our present knowledge could be difficult and inaccurate.

With so much that is unknown with reasonable precision, there is the real need to raise the level of research on the sardinella resources and their environment in the Gulf of Guinea. Would it be too much to ask the coastal states in the sub-region to conduct regular acoustic surveys on the resources in order to obtain a better understanding of the state of the resources, recruitment, migrations, stocks, etc. ? The occasional surveys conducted in the sub-region by foreign vessels have just been stop-gaps.

Mr. Chairman, distinguished guests, fellow scientists, I wish to believe that while enjoying such a congenial, peaceful and hospitable environment in Ghana, you would succeed, as a result of your expected fruitful discussions within the next four days, in at least, recommending the direction of future research that would lead to the solution of such important problems as already explained, in the environment, the biology and fishery of the sardinellas.

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## WELCOME ADDRESS DELIVERED BY DR F.X. BARD, REPRESENTATIVE OF ORSTOM IN COTE D'IVOIRE

Excellency, the Minister of Food And Agriculture,  
Monsieur le President de L'ORSTOM,  
Monsieur l'Ambassadeur de France  
FAO, Deputy Representative for Africa  
Director of Fisheries,  
Mister Chairman,  
Ladies, Gentlemen

It is a great honour for me to introduce our co-operative program of scientific research which yielded this meeting. However, I beg your pardon for my ugly english, and I hope that the story of our efforts deserves your attention and is anyway understandable for this most distinguished assembly.

Small pelagic fish constitute the main fishery resources of the world. They represent between a third and a half of total world fish catches, which presently is around 50 millions tons. These small pelagics (that could be more exactly named small neritic fish) are used either for human consumption, generally at affordable price, or for fishmeal, being vital for any production requesting cheap animal proteins. Consequently the importance of small pelagic/neritic fisheries for the whole world economics is considerably high.

However, the small pelagic fish resource are characterised by huge instability, probably due to their sensitivity to the environmental conditions. Larger resources of such species have experienced huge dramatic variations, either collapses which caused economic disasters for the regions concerned or strong and fast recoveries. The most famous example is certainly the story of the Peruvian anchoveta fishery, whose landings soared up to near 10 millions tons by the sixties, collapsed to nearly nil in the 1970 s, and presently are climbing again to several (six) millions tons per year. Another example is the Japanese sardine which became suddenly very abundant by 1985, landings reaching 4 millions tons per year. But fishery collapsed again in 1992.

The coastal pelagic resources of the Côte d'Ivoire-Ghana region are of special interest because the stocks involved are small, have been studied for a long time and are of great socio-economic importance for the coastal populations. A lot of scientists have been involved in biological studies, fisheries and environmental components of the coastal pelagic ecosystem of Côte d'Ivoire and Ghana since the 1960's. One of the prominent result of these studies is a synthesis in the format of a blue book, achieved jointly by FRU, ORSTOM and CRO in 1976. A particular conclusion at this time, was that the Sardinella aurita (round sardinella)

resource had a production potential of no more than 100 000 tons/year. This maximum potential having been reached in 1972, was followed by a strong depleted phase. This low level of the *Sardinella aurita* resource convinced the involved scientist that Ghana and Côte d'Ivoire were sharing a common resource, that dwindled for several years.

Nevertheless a dramatic increase of the apparent abundance of *Sardinella aurita* has been observed in the eighties. This phenomenon, dubbed «the *Sardinella* puzzle» has been studied intensively by Ghanaian, Ivorian and French scientists, since December 1987. At this time, a meeting convened in CRO Abidjan discovered, with some delay, the importance of this phenomenon

The huge level of the 1985-1987 catches of *Sardinella aurita* caused some surprise, and trying to understand what happened, this assembly of scientists was close to announcing for predicting the very near collapse of the stock. It would in away have been «crying wolf», and fortunately we refrained this natural tendency of scientists.

Instead, we developed a strong co-operation between FRU, CRO with support of ORSTOM scientists working in Côte d'Ivoire. This co-operation led to annual meetings either in Abidjan, or in Tema, devoted to the scientific description of the level of the Ivorian-Ghanaian small pelagic/neritic resource, particularly the *Sardinella aurita*. It was indeed an improvement on past time where common meeting were held on a much less frequent rythm.

As the increase in the apparent level of abundance of the resource stayed at a high level, by July 1990 by the involved scientists decided to increase the research effort, particularly through an intensive joint program called the «Grand Programme Sardinelle» (GPS). Possible actions were listed and the GPS was submitted to various potential donators.

It was accepted by ORSTOM and I submitted it for funding to the French Ministry of Co-operation. Thanks to the good willingness of Madame Thérèse Pujolle, Director of Scientific Research in this Ministry, we were granted of a rather substantial funding which allowed us to develop some specific actions of research. However it is worky of nate that FRUB, CRO and ORSTOM on their own supported this joint program, and the results achieved are certainly the product of all dedicated scientists working in these governmental agencies.

This France-Ghana-Côte d'Ivoire joint sardinella research program has been in operation from 1991 to 1993. One of the characteristics of this task is the fact that we worked as a network of scientists, as it was impossible to stay jointly in a particular research institute. Scientists as far as from USA, Senegal, France, worked with us, and they are indeed present in this room. We wish to thank them. But it is pretty obvious that the the scientists in Tema and Abidjan did their best, and we can stand proudly at their side.

Various important results have been achieved under such an organisation. This led to the end of the first phase of the GPS. An intermediate meeting, dedicated to an evaluation of the results of this first phase, and to the preparation of a program for a possible second phase, was decided. Therefore, this meeting has several purposes.

First understanding what happened exactly in this story of increased of *Sardinella* abundance.

Second explaining to the various people in involved fishery business what is the exact situation of the resource plentiful but still an unstable resource

Third discussing jointly the best possibilities of «good use» of the resource

Fourth trying to build a new research program, that could be called GPS II, and which should address the particular topics as :

- What kind of new research do we need in economics ?. What could be done for a better use for Ghana and Cote d'Ivoire of these small fish : Laissez faire or organisation of the market, or processing (Fishmeal, or ??)

- How can we improve our fishery statistics and biostatistics ?. There is basically two type of fisheries, industrial which is easy to control (from statistical standpoint) and small scale canoe fisheries, which is much more difficult to appraise. Up to now we have been able to check that there is no major statistical bias in our systems of collection of statistical data. But it would be important to unify the statistical system in the two countries, and also in Togo and Benin, which could be an answer to the rather migratory trend of the fishermen.

- Do we need a precruitment index ?. For long living species of fish it is useful to build a statistical system providing a reliable index of recruitment. As an example for a fish such as cod off Canada it proved to be of vital interest for management of the resource. But for our short living species ( 3 years) maybe it is of no use for the fisheries community. On the other hand we could face the possibility of using new approach called «risk management» trying to take in account the fact that this resource is unstable. Just recently, the ICES held a meeting on «Management objectives and fishery management target : Risk analysis in the provision of scientific advice». This is exactly what can be considered for an «adaptive management » of our common resource.

Consequently, this meeting Dynamics and Uses of *Sardinella* Resources from Upwelling off Ghana and Côte d'Ivoire (DUSRU) is jointly organised by ORSTOM, the Fisheries Department of Ghana (Ministry of Agriculture), Centre de Recherche Oceanologiques de Côte d'Ivoire for all those reasons and questions. I wish everybody a fruitful meeting.

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**OPENING ADDRESS BY M. M. LEVALLOIS,  
PRESIDENT OF ORSTOM.**

Mr Chairman,  
Honourable acting Minister,  
Mr. Delegate of the FAO,  
Monsieur l'Ambassadeur,  
Distinguished guests and invited scientists,  
Ladies and gentlemen,

It gives me great pleasure to be present at the opening of this sardinella meeting in Accra. This first meeting organised by Ghanaian, Ivorian and French scientists is a significant step for science and for development. It will be a benchmark for north-south, and south-south scientific co-operation. To begin with, I would like to give you some facts about ORSTOM :

ORSTOM is a French scientific institute devoted to basic scientific research for development in tropical areas. It is placed under the joint control of the Ministry of Research and the Ministry of International Co-operation. For the past 50 years, it has carried out studies on various inter-tropical milieus.

To its partners in the South and the operators of development, it provides findings which concern four major issues :

- environment and major ecosystems : ocean, water and earth ;
- agriculture in fragile tropical environments ;
- evolving human beings and societies.

In addition, it offers its diagnoses and expert knowledge to French, foreign and international public and private organisations.

ORSTOM has to work with partners of the Southern countries through co-operation. Research is carried out jointly with scientific institutions in the South, as a result of scientific and technical choices defined in co-operation with French and foreign partners.

ORSTOM helps to strengthen the scientific capacities of nations in the South, through training and specific scientific supports.

The Institute employs 25 hundred agents :

- 600 are working on a long-term basis in Africa, Latin American, the Caribbean, Asia and the Pacific.

- 400 of them are posted in national, regional or international research institutions of the South.

500 are intermediate technical staff from Southern countries.  
about 100 are foreign researchers working directly in ORSTOM  
research programs, under 2 or 3 years contracts.

When I first came to your beautiful country and your nice capital last year, I was very surprised by the relevance and by the interest of the sardinella research program, ORSTOM FRUB were carrying out through close co-operation across the border with the Ivory Coast.

This led me to suggest that a scientific meeting on this program could be organised to communicate the results of a scientific activity which was launched in 1990 and which has been in relation with a scientific activity on-going for more than thirty years.

I am very thankful to the Fisheries Department, the Ghana Ministry of Agriculture, to the French Embassy, to FAO for having expressed an interest in this proposal and for having given their support for this meeting. I would like to tell them that scientific knowledge is one of the foundations of the development process and that no country can develop itself without science and scientists.

From this point of view, this program must be highlighted. The pelagic resources from the Ivory Coast to Benin are of great socio-economic importance for the local populations and science must determine whether it can help fishermen to work more efficiently. But are Sardinella a permanent or an occasional resource ?

Answering these two main questions raises a lot of other questions. What exactly do we know about sardinella fishing ? How important is this resource ? Where does it come from ? How long do they stay off your coasts ? How should fisheries be managed to make the most of them without depleting them ?

The answer to these questions requires the collection of a lot of physical, biological and economical data and a long process leading to a better understanding of the fish life in order to improve the way of fishing. And it's worthwhile to note that these problems are closely linked to more global issues concerning the pattern of winds and sea currents. Some scientists are dreaming of a special Ghanaian model rooted in an international scientific program called «Climate and Eastern Ocean System». You know that applied or finalised science is never far from strategic or basic research.

I would like to congratulate those scientists who have worked steadily, collecting data and trying to make them reliable and understandable and who have presented their results to non-scientist fishermen and policy-makers. I am sure that this meeting will foster better understanding and co-operation between these people who are not used to working together.

Finally, I would like to emphasise a particular aspect of this meeting. It's the fruit of an outstanding co-operation between an Ivorian institute, the CRO in Abidjan, the FRUB here in Ghana and a French institute, ORSTOM. The sardinella program and this meeting have been funded by the French ministry for Co-operation. You know that the French government has pledged to maintain

co-operation for and with Africa. This program and this meeting prove that science is useful for development, that science is not a northern monopoly, that good and useful science can be carried out in Africa, with African scientists. It's part of the mandate of ORSTOM and I hope that we will go further with you, in other scientific areas.

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**OPENING ADDRESS DELIVERED BY THE HONOURABLE DEPUTY  
MINISTER FOR FOOD AND AGRICULTURE IN CHARGE OF FISHERIES,  
MAJOR (RETIRED) E. TETTEH AT THE OPENING CEREMONY OF THE  
SCIENTIFIC MEETING ON THE DYNAMICS AND USES OF SARDINELLA  
RESOURCES FROM UPWELLING OFF GHANA AND COTE D'IVOIRE  
(DUSRU),**

Mr. Chairman,  
Honourable Minister for Environment  
Your Excellencies,  
The French Ambassador to Ghana,  
The Assistant Director-General and Resident Representative of FAO for Africa,  
The Resident Representative of the UNDP,  
The Président of ORSTOM, Mr. Levallois  
Directors of the Ministry of Food and Agriculture,  
Distinguished guests and invited scientists  
Ladies and Gentlemen

It is my greatest pleasure to be with you today on this very important occasion of the opening ceremony of the scientific meeting on the dynamics and uses of Sardinella resources from upwelling off Ghana and Côte d'Ivoire.

Mr. Chairman, as many of us gathered here are aware, Ghana is a very important marine fishing country along the Eastern Central Atlantic. Most Ghanaians depend on fish for their animal protein requirements. Recent estimates show that fish constitutes up to 60% of the animal protein intake of Ghanaians. Due to the high annual fish catch (yearly average of about **315,000 metric tons** for the past five years). fish imports are relatively small (up to **34,000 mt** per year). Thus the local catch of fish constitutes a very important import substitution.

Furthermore, among a fairly large number of non-traditional exports, fish alone accounts for about 52% of their foreign exchange earnings. I am pleased to mention that the tunas play a significant role in this regard.

Mr. Chairman, of the four principal fleets of the marine capture fisheries, namely, artisanal, semi-industrial, industrial and tuna fleets, the artisanal fishery is the highest contributor to the fish requirements of the Ghanaian population ;

it produces 70% - 80% of the total annual catch. Results of canoe frame survey conducted along the entire marine coast in 1992 have shown that there are over 8,600 canoes. They are operated by about 95,000 fishermen with as many as 1.5 million dependants (wives and children) - this number excludes traders in fish and fishery products and processors of the canoe catch. Considering that there are about 350 semi-industrial vessels, 24 industrial vessels, 12 shrimpers and 29 tuna vessels operating in Ghana and other fisheries installations such as cold stores, repair workshops and boatyards, the size of the population that depends directly and indirectly on the marine fishing industry is estimated at about 3.5 million. The marine fishery is a very important segment of the national economy.

Mr. Chairman, of the four fleets mentioned, the main exploiters of the sardinellas are the canoe and the semi-industrial fleets. The sardinellas they produce each year form up to 40% of the total marine fish catch. When one considers that there are not less than twenty (20) commercial marine fish species in our waters, then the importance of the sardinellas to the nutritional requirements of the Ghanaian population becomes crystal clear. Consequently, the significance of this scientific meeting consisting of world renowned marine fishery scientists becomes very obvious.

Mr. Chairman, being aware of the significance of these marine fisheries resources to the national economy the Government of Ghana is committed to the rational management of this natural heritage which belongs to the past generation, the present generation and generations yet unborn. It is in the light of this commitment that Government does not only support management but also has provided the legal and institutional frame-work within which responsible fishing is expected to be ensured.

Government is conscious of the fact that many of our commercial fish species are heavily fished, especially the demersal or bottom-living species whose stock levels are precariously low. Also except the tunas almost all other pelagic or surface living species are fully exploited. Consequently, in fulfilment of her objective to conserve and manage the fisheries resources, Government, in 1990, banned further expansion in the trawl fleet size including shrimpers. The following year, Government promulgated the Fisheries Law 1991, PNDC Law 256, which is designed to control and manage the fisheries.

One important provision in the Fisheries Law is the establishment of a Monitoring, Control, Surveillance and Enforcement Unit within the Ministry of Food and Agriculture. This Unit, as the name implies, is charged with the responsibility of enforcing the provisions in the fisheries Law, through monitoring fishing operations, their control and surveillance and meting out the appropriate punitive measures. In addition, in furtherance of the Constitution of the Fourth Republic of Ghana, Parliament has passed a bill setting up the Fisheries Commission which has blended executive and advisory functions for the efficient management of the fisheries resources of Ghana.

fisheries spread through or straddle across Côte d'Ivoire, Togo and Benin. Thus the need for the countries in the West African sub-region in general, and those in the Western Gulf of Guinea in particular, to co-operate in marine fisheries research is of paramount importance.

Mr. Chairman, it is in the light of this that Government supports the objectives of the Ministerial Conference on Fisheries Co-operation between the African States on the Atlantic Coast. For the same reason, my Government notes with satisfaction the healthy co-operation in fisheries research between Ghanaian and Ivorian scientists over nearly three decades now.

Mr. Chairman, it is my expectation that this healthy co-operation shall continue and that with further co-operation directly from ORSTOM, a lot more could be achieved in solving some of the Sardinella problems mentioned in the welcome address.

At this point, Mr. Chairman, I wish, on behalf of Government to acknowledge the exemplary co-operation ORSTOM has been offering to the Research Unit of the Fisheries Department formerly through Centre de Recherche Oceanographiques (CRO) in Abidjan and now directly through its Office in Abidjan. Government has noted with appreciation, donations of equipment and office facilities to the Research Unit and ORSTOM funding of travel expenses of most participants to this seminar including other conference costs.

I am also pleased to acknowledge the very useful assistance being given by FAO. FAO has been associated with fisheries research and development in Ghana since 1962. Government appreciates the various forms of assistance it has given and still continues to give. I am pleased to learn that FAO sponsored a number of participants to this seminar and that the scientific sessions of this seminar will be held at the FAO Conference room. Government appreciates all these.

Mr. Chairman, ladies and gentlemen, at this juncture I am pleased to declare the Scientific Meeting on the Dynamics and Uses of Sardinella Resources from Upwelling off Ghana and Côte d'Ivoire duly opened.

I wish you fruitful deliberations.

## ANNEX 4

### LIST OF PARTICIPANTS

SURNAME	OTHER NAMES	FUNCTION	INSTITUTION
ABORDO	J.A.	Senior Tech. Officer	FRUB, P.O. Box B-62 Tema Ghana
ADDO	A.A.	Assist. Director	Fisheries Dept P.O. Box 309 Takoradi Ghana
AGBESI	Eric	Assist. Fisheries Officer	FRUB, P.O. Box B-62 Tema Ghana
AMAN	Angora	Maître Assistant	Faculté Sciences & Techniques - Université 22 B.P. 582 ABIDJAN Côte d'Ivoire
AMON KOTHIAS	Jean-Baptiste	Directeur C.R.O.	B.P. V 18 ABIDJAN Côte d'Ivoire
ANANG	Emelia Roseline	AG. Deputy Director	FRUB, P.O. Box B-62 Tema Ghana
ARMAH	A.K.	Senior Lecturer	Dept. Oceano. & Fisheries Univ. of Ghana P.O. Box 99, Legon Ghana
ASAMOAH	Ambroise	Research Officer	Inst. of Aquatic biology P.O. Box 38 Achimota Accra

<b>SURNAME</b>	<b>OTHER NAMES</b>	<b>FUNCTION</b>	<b>INSTITUTION</b>
ATTIPOE	F.Y.K.	Research Officer	Inst. of Aquatic Biology P.O. Box 38 Achimota Accra
AWITY	L.K.A.	Regional Fisheries Officier	Fisheries Dept P.O. Box 634, Cape Coast Ghana
BADDOO	Abdiel	Principal Technical Officier	FRUB, P.O. Box B-62 Tema Ghana
BAKUN	Andrew	Senior Fisheries Resources Officer	F.A.O. Via delle Terme di Caracalla, 00100 Rome Italy
BANNERMAN	Paul	Assist. Fisheries Officer	FRUB, P.O. Box B-62 Tema Ghana
BARD	François-Xavier	Senior Fisheries Biologist	ORSTOM, B.P. 917 ABIDJAN Côte d'Ivoire
BINET	Denis	Senior Fisheries Biologist	Antenne ORSTOM, IFREMER, B.P. 1049 F44037 Nantes Cédex France
CHIKHI	Lounes	Doctorate Student	Lab. Génome & Populations, U.M. II Unité CNRS 1493 Place Eugène Bataillon 34095 Montpellier Cédex France
CURY	Philippe	Research Scientist	ORSTOM, Dépt T.O.A. 213 rue La Fayette 75480 PARIS Cédex 10 France
DIABATE	Idrissa	Audiovisuel	08 B.P. V 40 ABIDJAN 08, Côte d'Ivoire
DOYI	Ben. A.	Principal Technical Officer	FRUB, P.O. Box B-62 Tema Ghana
DURAND	Jean-Louis	Member Scientific Committee	IFREMER, B.P. 1049 44 037 Nantes Cedex France
DURAND	Marie-Hélène	Economiste	ORSTOM, 70-72 route d'Aulnay 93143 Bondy Cédex France

<b>SURNAME</b>	<b>OTHER NAMES</b>	<b>FUNCTION</b>	<b>INSTITUTION</b>
FERRARIS	Jocelyne	Biostatistician	ORSTOM - CRODT B.P. 2241 DAKAR Sénégal
GBAGUIDI	Amélie	Chargée de statistiques	Service des Pêches B.P. 383 Cotonou Bénin
JACQUES	Guy	President of Scientific Committee 3	CNRS, Observatoire Océanologique 66650 Banyuls/Mer France
KONAN	Jacques	Biologiste des Pêches	C.R.O. B.P. V 18 Abidjan, Côte d'Ivoire
KORANTENG	K.A.	Senior Research Officer	FRUB, P.O. Box B-62 Tema Ghana
KOUAKOU	Koffi	Juriste	Direction des Pêches ABIDJAN Côte d'Ivoire
KWEI	Eric	General Manager	Starkist Int. S.A. P.O. Box 40 Tema Ghana
MENSAH	M.A.	Deputy Director of Fisheries	FRUB, P.O. Box B-62 Tema Ghana
N'DAH	Konan	Biologist	C.R.O. B.P. V 18 ABIDJAN Côte d'Ivoire
NSIAH	S.B.	Assist. Director	Fisheries Dept. P.O. 160 Tema Ghana
OFORI-ADU	Daniel	Assist. Chief Technical Officer	FRUB, P.O. Box B-62 Tema Ghana
OSSINGA	Etienne	Regional Fisheries Officer	RAFR/FAO, P.O. Box 1628 Accra
PANFILI	Jacques	Biologist	ORSTOM, LASAA B.P. 70 29280 Plouzané France
PEZENNEC	Olivier	Biologist	ORSTOM B.P. 1984 Conakry Guinée
ROY	Claude	Océanographe physicien	ORSTOM/PFEG, P.O. Box 831 Monterey, Ca. 93942 U.S.A.

<b>SURNAME</b>	<b>OTHER NAMES</b>	<b>FUNCTION</b>	<b>INSTITUTION</b>
SAMBA	Alassane	Fishery Biologist	CRODT, B.P. 2241 Dakar Senégál
SEINI	Wayo	Research Fellow	ISSER, University of Ghana P.O. Box 74 Legon
TETTEY	Ernest	Expert en Commerce	INFOPECHE B.P. 1747 ABIDJAN Côte d'Ivoire
VANDERPUYE	C.J.	Professor-Fishery Biology	Dept. of Oceano & Fisheries Univ. of Ghana, Box 99, Legon
WEST	Wariboko Q-B	Senior Regional Fisheries Officer	RAFR/FAO, P.O. Box 1628 Accra
YAQUB	Hawa Bint	Assist. Fisheries Officer	FRUB, P.O. Box B-62 Tema Ghana