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INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION (of UNESCO)

SUMMARIES OF CONTRIBUTIONS PRESENTED AT THE WORKSHOP ON WEST AFRICAN FISHERIES ORGANIZED DURING THE ADVANCED COURSE ON UPWELLING SYSTEMS (ATLANTIC OCEAN EASTERN BOUNDARY)

A JOINT EFFORT FROM IOC AND THE EUROPEAN UNION MAST PROGRAMME

Las Palmas, Gran Canaria, Spain
9 - 10 August 1995

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GENERAL INTRODUCTION
by

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The great importance of the marine living resources of the East Atlantic Ocean forces us to think, in detail, on their behaviour. Two outstanding aspects need be considered : the first one relates to the environmental conditions and the second one to the spatial and temporal distribution of the fishing pressure.

The relationship between environment and resources can be obtained in first approximation by a simple comparison of the areas of high productivity (upwelling zones) with the concentration of living resources (fishing grounds). The process of high productivity in the East Atlantic is generated by three different mechanisms of the marine dynamics : The Canary Current, The Benguela Current and the particularities of the Gulf of Guinea. Each mechanism is composed of several processes that generate subsidiary productive zones.

In the North, the structure of the coast and the bottom morphology generate upwellings, and the presence of the Canary Islands Archipelago is related to productive zones. There is also a high production area as a consequence of the collision between the Canary Current and the Northern Intertropical waters. This frontal zone oscillates along the coast of Mauritania throughout the year.

In the south of Africa the situation is similar and symmetric. The Benguela Current moves parallel to the shore (SE-NW) and meets with the Southern Intertropical Waters at Cabo Frio (17°S), turning west subsequently. There are other important secondary upwellings. One is located north of Cape Town (Santa Helena Bay) and an other in the zone of Lüderitz. It is possible to detect zones of high productivity in the area of Walvis Bay. The main upwelling is manifested in the same way than that of Cape Blanc, a frontal zone that oscillates along the coast of Angola throughout the year. The movement of oscillation of the frontal zones presents the same rythm north and south of the equator.

Off Cape Palmas and Three Forcas, in the Gulf of Guinea, the current, probably assisted by the favourable winds from offshore, generates upwellings of variable intensity throughout the year. The influence of the rivers (specially rivers Niger and Congo) is also important in the dynamics of the ecosystem. The structure of the shore, with many coastal lagoons, favors the presence of many species that need the existence of waters of low salinity during their different developmental stages. On the other hand the high temperature and the environmental conditions of the Gulf of Guinea favor the concentration and reproduction of species of tropical tuna.

An other important aspect is the structure of the continental shelf, not very wide in general. However, there are zones wide enough. The first one is located off the Sahara and the second off Namibia. In the Gulf of Guinea the shelf is narrow and presents many obstacles (rocks, reefs, etc). It si important to observe the symmetry distribution that characterizes the African Coast.

In relation with the spatial distribution of the most important species, the pelagic ones also show a symmetric distribution. This is clear in clupeoids, engraulids, scombrids and carangids. It is important to point out the presence of small-sized pelagic coastal fish in the Gulf of Guinea. The demersal fish show a different pattern of distribution. The sparids are present at North and South, while the scianids are present in the Central Zone. The hake is the species of major fishing interest from those bottom species, and its distribution is also symmetric concerning the equator.

Finally, the fishing pressure in the zone influenced by the Canary Current is practiced by industrial fleets, specially by non-African Nations. This situation is also comparable with that of the Area of the Benguela Current. On the contrary, the Central Area shows a lower fishing activity, with a major development of the local artisanal fleets. The offshore fisheries on tuna fish and swordfish need a special reference.

In summary, the distribution of the fishing resources and fishing efforts are strongly conditioned by the geomorphology of the zones. The solution to these problems requires deep analysis in the global oceanography and biology. The mesoscale processes should be objectives of special attention for the correct management of fisheries.

FISHERIES RESEARCH OF THE INSTITUTO ESPAÑOL DE OCEANOGRAFIA (IEO) ON THE UPWELLING SYSTEM OF NORTH-WEST AFRICA - SARDINE RESOURCE

by

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The north-west african coast is very rich in fish due to the special oceanographical conditions ocurring in the area. For this reason, and for the proximity of Spain the Spanish Fishing fleet has traditionally been operating in Morocco, Saharan Bank, Mauritania, etc. for centuries.

The activity of this fleet has been investigated since 1974 with the initiation of the Research Program "FISH RESOURCES OF AFRICA" wich has been run by the IEO up to the present day. This Program is conducted from two labs based in Fuengirola (Malaga) and in Tenerife (Canary Islands), and the **main resources studied** are :

CENTRO OCEANOGRAFICO DE FUENGIROLA

-Crustacean (*P. longirostris, Penaeus spp.*) in Morocco, Mauritania, Senegal and Guinea Bissau
-Demersal Fish (*Merluccius spp., Sparidae...*) in Morocco, Mauritania and Senegal
-Pelagic Fish (*E. ancrasicolus*) in Morocco

CENTRO OCEANOGRAFICO DE CANARIAS

-Tuna fish (*K. pelamis, T. thynnus, T. albacares, T. alalunga, T. obesus*) in Canary Islands, West Africa and Indian Ocean
-Crustacean (*P. longirostris, Penaeus spp., Ch. maritae, A. varidens*) in Angola and *Ch. affinis* in Canary Islands
-Cephalopod (*O .vulgaris, Sepia spp., L. vulgaris*) in Saharan Bank and Guinea Conakry
-Demersal Fish (*Sparidae* and others) in Saharan Bank and Mauritania
-Pelagic Fish (*S. pilchardus*) in Morocco

The **Sardine** (*Sardina pilchardus* Walb., 1792) is a pelagic migratory species with an inshore distribution, short life-span, fast growth, main spawning seasons in winter and spring and planktonic feeding. It is distributed from the North Sea to Senegal, and in the Mediterranean, Adriatic and Aegean Seas, but its distribution along the African coast is not uniform. There are different fishing zones named :
-Zone North (33°N-36°N)
-Zone A (29°N-32°N)
-Zone B (26°N-29°N)
-Zone C (22°N-26°N)

From may to August, most of the sardines that are in the Zone B migrate northwards (Zone A), descending again to the south in October for reproduction. From June to September, the sardines in the Zone C move to the north (25°N) and come back again to the south in October-November.

The Spanish fleet has traditionally fished in Zone B, but since 1983 it has also fished in Zone C. The fleet is currently composed of 11 units of Purse-Seiners based mainly in Lanzarote (Canary Islands). The sardines are stored in bulk or in boxes, and are generally preserved deep-frozen or on ice. The destination of the catch is for fish meal as well as for canning.

Most of the catch is composed of sardines with a size higher than 19 cm. The percentage of sardines smaller than 16cm (immature) is lower than the 5%, being 0% in some years.

The last international assessment of the Stock-Central (Zones A+B) took place in 1991 using catches from 1976 to 1989. The results of the VPA indicated an increase of biomass across the period, reaching its highest value in 1986. The results of the three simulations carried out to assess the level of exploitation of the Stock showed that the values of Fishing Mortalities (F) were under the optimum, indicating a situation of moderate exploitation.

HYDRO CLIMATIC CONDITIONS AND FISHERIES IN THE MAURITANIAN EEZ

by

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The paper presents a description of hydroclimatic characteristics of the region and their effects on marine living resources in the 200 miles Exclusive Economic Zone (EEZ) of the Islamic Republic of Mauritania (RIM). The main fisheries are characterized and their main target species presented. The paper is briefly discussing the dilemma of, on the one hand the need for developing domestic fisheries and on the other hand, the likelihood of economic risks due to the unpredictability of the main target species.

The RIM is situated in the Northwest quarter of the African continent. It has a surface of 1,085,000 km² and about 2,300,000 inhabitants. The 700 km coastline along the Atlantic Ocean is the land margin for 231,000 km² of Exclusive Economic Zone (EEZ) territory. This EEZ is located in a region heavily influenced by Upwelling systems, and by four alternating hydrologic seasons (i.e., cold, warm and two transitional seasons) determined by the displacement of a frontal thermal zone, separating the Canary current and the Guinean current. The influence of these systems make this EEZ highly productive in all marine living resources.

More than 200 species have been identified in the Mauritania shelf region and around 100 species have been identified in pelagic catches (M'Bareck, in preparation). The high diversity of marine species and the existence of abundant pelagic stocks are good indicators of the richness of this ecosystem.

Since the mid 1970's, a fisheries sector has developed around the exploitation of both demersal and pelagic resources. This sector becomes one of the most important sectors of the national economy. It generates more than 50% of national export and is contributing about 20% to the government budget and about 20% to the Growth Domestic Product (GDP).

Two major fisheries, the pelagic and the cephalopod, account for 80% of the total value generated by the fisheries sector. These fisheries are multispecies fisheries. The pelagic fishery has two main target species, the african horsemackerel (*T. trecae*) and the european horsemackerel (*T. trachurus*). The moroccan sardine (*Sardina pilchardus*) has increased during the last three - four years in the catches. The cephalopod fishery has one main target species, the octopus (*Octopus vulgaris*).

Pelagic fishery offers, according to the latest stock assessments, around the million of metric tons annual Allowable Biological Catch (ABC) in the Mauritanian EEZ. This fishery averaged around 400,000 MT annual catch during the last two decades. Since 1992 the activity of Eastern European countries fleets (the only fleets fishing small pelagics in the Maritanian EEZ) has known major changes resulting in serious dysfunctioning of the fishery. In 1994, for example, Pelagic Fishery in the Mauritanian EEZ caught only 180,000 MT.

Cephalopod fishery offers between 45,000 and 50,000 MT annual ABC (for three cephalopod species). This fishery is presently fully exploited. The present catches (of these species) oscillate around 30,000 MT/year.

The pelagic species in this EEZ use the region between 10°N and 22°N for their seasonal feeding and spawning migrations (Gulland and Garcia, 1984). They can be separated into two major groups with different climatic preferences. One of the groups has a more temperate affinity and migrates south following the Canary current, and, the second one has a more tropical affinity and migrates North following the Guinean current. The first group is represented by european horsemackerel, moroccan sardine, and chub mackerel (*Scomber japonicus*), while the second group is represented by african horsemackerel *Sardinella aurita, Sardinella maderensis,* and *Decapterus rhonchus*. Both groups are abundant in the Mauritania EEZ during the transitional seasons, when the thermal gradient is greatest, and are all present in fisheries catches.

These species are generaly identified as unstable stocks and seem to be dependent of environmental conditions. They have very **extended spawning periods and ranges.** It has been observed that their spawning time and area avoids the peak intensity of the upwelling. This observation seems to **agree with the theoretical hypothesis of the "optimal environmental window"** as developed in Cury and Roy (1989). For example, Cap Blanc chub mackerel spawns in April while the european horsemackerel spawns in December - January (Overko, 1979). Both species avoid May and June, the period with maximum upwelling intensity. **The replacement phenomena** (when one species collapses or is depleted and an other species replaces it), was suggested between the moroccan sardine and the european horsemackerel, (Beleveze, 1984). Since early 1970s, a very important **increase of octopus stock and a southward extension** of its distribution are taking place in the Mauritanian EEZ. In this same region, there has, also, been noted, a new southward extension of the distribution of sardine which seems to take place **periodically**. This extension was observed at least twice during the last three decades, during the first halves of the 1970s and the 1990s.

The unpredictability of these stocks and the fear of catastrophic economic effects, that would result from their sudden depletion are important concerns to those who can invest in these fisheries.The doubt about the sustainability of the biological potential of the main target species, for example, of small pelagic species, seems to be one of the main obstacles to decisive actions toward the development of a domestic pelagic fishery. On the other hand, the big investment, presently under way, on cephalopod fishery's fleets is relying specially on octopus stock with represents more than 70% of the total catch of this fishery. How to deal with these fluctuation?, how sustainable is the octopus stock?, for how long will the sardine continue to be available in important concentrations in the Mauritanian EEZ? Those are questions that need scientific answers. In other words, it is important to be able to predict the variability of stocks in a "more or less" short time (2 - 3 years).

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INFLUENCE OF THE SENEGALESE UPWELLING ON THE BEHAVIOUR AND SPAWNING OF SOME PELAGIC FISHES

by

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The Senegales Coast, under the influence of active upwelling, presents resourceful marine depths. Several species are specifically exploited. Among these, small pelagic fishes represent 2/3 of total catch. Several studies have pointed out the influence of upwelling on this kind of resources.

This presentation deals with the influence of the Senegalese upwelling on the behaviour of fish and on the dynamics of sardinella spawning.

The continental shelf is submitted to strong trade winds which generate from December to May an intense coastal upwelling along the coast. Its intensity and its environmental instability induce primary production fluctuations and affect survival of pelagic fish species of economical importance. Their abundance is affected by the environmental instability and can be partially measured by echo-integration. Some links can be found between thermal surface events and mean biomass measurements, depending on ecological differences between north and south Senegal. In the north, the high biomass is restricted to the coldest upwelling area, and in the south to the surrounding area of the upwelling whose extension is less strictly coastal. The upwelled waters are poor in oxygen and are avoided by the fish. Primary and secondary production begin after the presence of upwelled water at the surface, thus necessarily far from the origin of the upwelling and of the turbulent area.

About the influence of upwelling on the dynamics of spawning, very few studies have explored this relation. So the aim of further research will be the verification of the hypothesis suggesting a short term determinism between the coastal upwelling fluctuation and the beginning of the spawning of sardinella caught off the Senegalese coast.

Sardinella sp. (*Sardinella aurita* and *Sardinella maderensis*) are coastal pelagic species of Western Africa, abundantly exploited from Mauritania to Senegal by artisanal and industrial fisheries with more than 300,000 tons landed per year during the last few years . These species are fast growing with high fecundity. They are subject to a high abundance fluctuation, as evidenced by fisheries data and acoustic survey results.

In relation with others species sharing approximately the same area, these species are known to present a plasticiy and an adaptabiblity to the fluctuation of physical conditions. Also, they are particularly sensitive to environmental variations.

The climatic changes observed around the world, affect this kind of fisheries, in addition to inter-annual fluctuations, mainly in terms of recruitment variability.

Descriptive studies have been conducted in Senegal from 1968 to 1976, primarily on the distribution and abundance of larvae, secondarily on the variation of gonado-somatic indexes. (North and south of Cap Vert Peninsula, Senegal).

The first study suggests that the beginning of spawning during the year is globally related to the seasonality of coastal upwelling (which takes place from November to May in Senegal) with a principal spawning period at the end of upwelling (May-June). Secondary spawning takes place during the upwelling period.

The second study suggests the existence of spawning preceeding upwelling with better contribution to the recruitment. It also shows that principal spawning is spread out during all the upwelling season, and not only at the end of it.

The knowledge of diverse spawning seasons, their variability and their contribution to the process of recruitment needs a better understanding of the high seasonal variability and inter-annual dynamics of coastal upwelling in this region.

STATUS OF THE GUINEAN FISHERY RESOURCES

by

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INTRODUCTION

The republic of Guinea has 350 km of coast line formed by many rivers which constitute a very developed mangrove.

The continental shelf of Guinea extends from 9°N to 10°50N with a mean width of 80 nautical miles In the north part it may reach 110 nautical milles and is the largest continental shelf on the west coast of Africa. It covers 56 000 km² with a gently and regular slope (0.06%) up to the isobath 50, then it goes up to 2% (Domain, 1989). It is a best area for the development of coastal fish communities and offers large fishing grounds for artisanal and industrial fishermen. The bottoms of the shelf are covered by a softy and/or a sandy mud below 10 m depth and by sand over 10 m. At the open sea, right to the north part of the shelf the effects of the Senegalese and Mauritanian upwelling occur in March and April during the dry season, are caused by two currents, the cold Canary current from north to south and the opposit equatorial counter current and the prevailing winds. Generally the temperature, despite to seasonal changes, is low. During the dry season the surface salinity ranges from 33 p.p.t to 35 p.p.t as well as the bottom salinity The sea surface temperature ranges from 22.50°C to 27.50°C while the bottom temperature ranges from 11°C to 27°C The rainy season takes 7 months and it is very intensive from July to September (the pluviometry at Conakry reaches 4000 mm). Coastal salinity drops to 20, 26 p.p.t. This coastal desalinisation phenomenon is very important for the biology and the spatial distribution of fish communities (Domain, 1989).

The Republic of Guinea used to be called "the south rivers country" or "west African water tower" because most of the west African rivers take their sources in Guinea and flow through west African countries to the atlantic ocean such as the Niger river, Senegal river, Mano river , and Gambia river. In the lower Guinea, five main rivers (Kogon , Tinguilinta, Fatala, Konkoure, and Melakoré) bring a lot of fresh water along the coast by many estuaries such as Rio Compony, Rio Nunez, Rio Kapatchez, etc. In addition to mangroves and rivers there are lakes and reservoirs, which also constitute a important ecosystem for the inland fisheries.

CHARACTERISTICS OF THE RESOURCES

The pelagical resources are concentrated in two zones. The first zone is the coastal zone which is enriched by spates from rivers and estuaries; there are some matures of ethmalosa (*Ethmalosa fimbriato*) and some juveniles of sardinella (*Sardinella aurita, Sardinella maderensis* and *Ilisha africana*). The second zone is located to the north-west part of the EEZ. There is a concentration of *Trachurus treacea, Decapterus rhonchus* and *D.punctatus*, some sardinella (*Sardinella aurita*, and *Sardinella maderansis*) and mackerel (*Scomber japonicus*) during January to April (Fontana 1992).

The demersal resources present a high productivity, but the biomass of fishes, crustaceans and cephalopods are charasterised by a remarkable decrease from the coast to the open sea. In terms of fish species Domain (1989) mentioned that there are three communities of demersal species on the shelf of Guinea :

-Estuarian Scieanidae community mainly represented by *Pseudotolithys typus, Pseudotolithys elongatus, Polydactylus quadrafilis* and *Pentanemus quinquarius.* These are found in abundance at 8 m depth from the coast to 12 km. These species prefer desalinised waters were they can spawn all the year.
-Coastal Scieanidae community represented by *Pseudotolithys Brachygnatus, Pseudotolithus senegalensis, Arius latiscutatus, Galeoides decadactylus* and *Drepana africana.* These species are found at 20 m depth and they are most abundant between 8 to 15 m. They are typical of hot and desalinised coastal waters. Some of them have their biological cycle in estuaries and lagoons.
-Sparidae community represented by *Sparus coeruleostictus, Pagellus bellottii, Pseudupenaeus prayensis,* and *Epinephelus aenus.* They are found from 15 to 80 m depth. The rest of the demersal resources are found from 60 to over 130 m depth and they are very important in terms of biomass.

DESCRIPTION OF THE FISHERIES

The biomass of resources obtenaind from the fish stock evaluations in the Guinan EEZ are
-demersal species 80 000 tons;
-pelagical species 100 000 tons;
-cephalopods 30 000 tons;
-crustaceans 4 000 tons.

Inland resources are estimated at 12 000 tons for all rivers, lakes and reservoirs.

All these resources are exploited by 4 types of fisheries : Traditional Artisanal fisheries, Advanced Artisanal fisheries, Industrial fisheries for marine resources and Inland fisheries and aquaculture

The Traditional Artisanal fisheries :

These fisheries have been developed recently with the support of many important projects. They involve 8000 fishermen from all over the country including foreigners from neighbouring countries who are established in Guinea for years ago. They are using 89 beaches as landing places distributed along the coast (Domain et al, 1989) and 2500 boats motorised at 50%. The types of boats used are :
-"**Kourou**": generally long and tapered at the extremities. They are operated by one or two fishermen who use lines as fishing gears.
-"**Gbankenyi**": they are found all over the landing places, and generally used for auto consumption fishery. The fishermen use handlines and drifting gillnet.
-"**Botis**": called also "bonikal boats", they are very important in terms of dimension, they use an outboard motor fixed in a behind well. They use surrounding nets as fishing gear.
-"**Yolis**": they have a cutwater at each of the extremities. Some of them are motorised and others use the sail for propulsion.

The traditional artisanal fisheries use diversified fishing gears but the commonly used are : gillnet (set gillnet, drifting gillnet, encircling gillnet and fixed gillnet); surrounding net (purse line or purse seine, without purse line or lampaara net); beach seine, boat seine or Danish seine, lift net (boat operated and shore operated), cast net, handlines, set bottom longline, pelagic drifting longline.

The landings are estimated about 50 000 tons per year of pelagic and demersal fishes.

The industrial fisheries

The industrial fishing vessels are big freezing trawlers (60-80 m, 1500-2500 HP, <1500 GRT for pelagical fishing fleet, 20-30 m, 400-600 HP, <100 GRT for shrimp trawlers and 20-60 m, 400-2500 HP, 80-500 GRT) which can make more than two months at sea and can land rarelly at Conakry. Most of them are foreigners and are based in Guinea.

The trawlers for pelagical fisheries represent a very weak part of the fleet (8 in 1993 and 3 in 1994) and they have a weak rate of activity in the Guinean EEZ.

The demersal fishery is largely dominated by "fish species trawlers" (36 and 32 vessels in 1993 and 1994) and the "cephalopod trawlers" (63 and 14 vessels in 1993 and 1994) and the shrimp trawlers (8 and 6 vessels in 1993 and 1994). Between 1993 and 1994 the global demersal fishing effort has relatively remained constant in terms of fishing days (14 000 and 11 100 fishing days in 1993 and 1994) but has greatly decreased for the number of active vessels (107 vessels in 1993 and 52 in 1994), because of the few number of cephalopod licences issued in 1994 (Table 1)

In terms of yield and production, the estimations made for 1993 and 1994 gave a global industrial production for all species together from 30 000 to 40 000 tons yearly. This production was approximately equal to the production of traditional artisanal fisheries which has been estimated around 50000 tons/year. The catches for fishes, cephalopods and shrimps for all HP classes together have yielded up to 3 tons/day, 2 tons/day and less than 1 ton/day for all vessels in 1993 and 1994. It should therefore be noticed that there is a positive relationship between the HP of vessels and their yield (table 2). Furthemore, more productive fishing vessels may have an average yield up to 10 tons/day (Lesnoff et al, 1995 in preparation).

The pelagical catches consist of mainly *Trachurus treacea Decapterus ronchus et D. punctatus* (77%), *Sardinella aurita et S. maderensis* (12%) and, *Scomber japonicus* (7%) and the declared catches by demersal fishing vessels consist of fish species which belong to the Sciaenidae communities (Longhurst, 1969). They represent more than 50% of the total catches (*Sciaenidae, Cynoglossidae,Ariidae, Ploynemidae* and *Pomadasydae)* (table 3). The cephalopods (*Sepiidae*) come below 25% of the total declared catches and constitute a very important stock for demersal fishery. Finally, the fish species from the Sparidea community (*Sparidae*) and coastal shrimp species (*Penaeidae*) represent respectively 7% and 4% of the total catches.

CONTRIBUTION TO THE ECONOMY

The fish consumption rate in Guinea is 7.2 kg/person/year. This rate is very low comparing to those from neighboring countries. Now the government is trying to increase it from 15 to 20 kg/person/year before the year 2000.

From 1987 to 1991 the contribution of the marine fisheries to the economy is 0.5% (Fontana, 1994) is as follows :

Contributions of the fishery sector (in billions of GNF).

	1987	1988	1989	1990	1991
PIB NAT.	874	1131	1439	1860	2118
PIB FISH	3	4	7	8	10
-Ind. Fish.	0	0.1	0.6	0.8	2.4
Art. Fisj.	2.9	3.6	6.5	7.8	7.8

Source : National budget Office

Contribution (in percentage) of some economic sectors

	1987	1988	1989	1990	1991
Fisheries	0.3	0.3	0.5	0.5	0.5
Agriculture	20.1	19.7	16.8	14.0	n.a
Forestry	3.2	3.5	3.0	2.7	n.a
Husbandry	4.5	3.9	3.3	2.9	n.a
Industries	23.5	20.2	22.4	22.2	n.a

Source : National budget Office

Contribution of the fishery sector to the National budget from 1990 to 1994 (in thousands of US Dollars)

years	from EEC	Licence fees	Total
1990	3500	2900	6400
1991	3500	1700	5200
1992	3500	1200	4700
1993	3800	1500	5300
1994	993	650	643

Source: National budget Office

CONCLUSION

The upwelling phenomenon occuring in the west coast of Africa has developed many resources in the Guinean EEZ especially the pelagical resources which have contributed to the development of artisanal and industrial fisheries. These fisheries have been for decades a source of wealth for the Guineans and they have a great impact on the marine resources even though these are now decreasing because of the over exploitation. The inland fisheries and aquaculture are also growing up and they are contributing to the socio-economical welfare to the populations, but they need to be well planed, organised and supported.

ANNEX.

The inland fisheries

The Republic of Guinea has many rivers, mangroves, lakes and reservoirs which constitute a very important ecosystem where the inland fisheries and aquaculture takes place and develops. The main resources of this ecosystem consist of *Tilapia spp, Clarias spp, Barbus spp, Lates spp, Chrysichthys spp, Synodontis spp,* and *Alestes spp.*

The number of fishermen is estimated about 7 000 people. There are professional fishermen called Bosos and Somonos, about 6 000 people and the others are the Malinké, The Foulany, some Malians and Senegalese who came from neighbouring countries are ocasional fishermen and they are estimated about 1 000 people (Matthes, 1991). They use the same fishing boats and gears as the artisanal fishermen but their boats are not motorised because it is difficult to get engines and fuel.

Aquaculture

Aquaculture is a new technique in Guinea even though there is an old experimental fish farm built since 1956 at Mamou. Some tilapia species imported from Côte d'Ivoire were experimented : *Oreochromis nilocticus, Heterotis niloticus* and *Tilapia nilotica.* During the last decade the Government has given support for developing aquaculture in Guinea. Right now there is a shrimp culture project financed jointly by the government of Guinea and the Banque Africaine de Developpement (BAD). Two species are experimented *Panaeus vannamei* imported from Indonesia and *Panaeus monodon* from Panama. There are also some local species in experimentation too such as *Panaeus duararum notialis, Panaeus keraturis* and *Parapenaeus atlantica*

Post Harvest Technology

In Guinea the post harvest technologies used are freezing, smoking, salting, and drying. In terms of freezing some fishing companies COGIP, SONIT, and SOGUIPECHE established in the port of Conakry have built cold storages which receive and store fish that comes from industrial fishing vessels until their distribution to the markets.

The fish landed by the artisanal vessels is fresh and some time it is iced, dryed and/or slated, but 80% of that fish is smoked (FAO, 1990). This smoking technique is mostly done by women. The smoked fish may be sent to the internal markets without losing quality.

The price of fish is not stable 750 GNF/kg for frozen fish, 900GNF/kg for smoked sardinella, and 1150GNF/kg for smoked demersal fishes (Fontana, 1994).

Export and Import

The real quantity of fish exported is not known but according to Fontana, (1994) this quantity is about 500 tons exported to European and Asian markets. The imported fish is 30 000 tons from some cargos and vessels which fished out of the guinean EEZ.

Organisation of the fishery sector

The fishery sector is under the Ministry of Fisheries and Aquaculture which is mandated for the management and development of the sector. It has:

-Three Directories (Directory of Artisanal Fisheries, Directory of Industrial Fisheries and Directory of Inland Fisheries and Aquaculture).

-A National center for marine sciences which is in charge of the fishery research. It conducts many research programs from the stock evaluations to the socio-economical aspects.
It provides annual reports regarding to the resources status which represent a scientific advice for the Ministry of fisheries for the preparation of the annual fishery plan. It also annually updates its assessments of the fishery resources, since 1987, and presents detailed information, as needed, to administrators, managers, the fishing industries, and the public.

-A National center for surveillance and enforcement which is in charge of the application of the fishery plan and enforcement and surveillance of fisheries. The access conditions to the guinean EEZ is regulated by a yearly fishing licence system given by the center.

There are other structures such as SENADEP and OPPI related to the artisanal and industrial fisheries and some public fishing companies such as SOGUIPECHE and many important projects which are involved for management exploitation and improvement of the fishery resources.

The Ministry of Fisheries and Aquaculture has two legal documents for the management and exploitation of the resources, the fishing code adopted in 1985 and the fishing plan adopted since 1993. In the process of fishery management the fishing plan includes the fishing zones for all the fisheries such as : -artisanal fisheries from 0 to 6 nautical miles;
-industrial fisheries (advanced artisanal fishery) from 6 nautical miles;
-industrial fisheries (cephalopods and crustaceans) from 12 nautical miles;
-industrial demersal fisheries over 10 nautical miles;
-industrial pelagical fisheries over 50 nautical miles.

The plan defines also the number of vessels and their caracteristics, the fishing gears and their caracteristics, the number of fishing days, the number of fishing licences, and the access conditions to the resources including the fishing licence fees.

In spite of the National Center of surveillance and enforcement, the fishing sector is facing two main problems, the absence of surveillance and enforcement and the lack of a follow-up fishery statistical system.

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Table 1.

1993

Type of fishing licence	Nbr. Ships	Fishing day	Catch (Tons)	Mean yeald (Tons/day)	Mean activity (days/year)
Pelagic	8	593	12685	21.4	74
Demersal fish	36	6088	14051	2.3	169
Demersal cephal.	64	6918	13031	1.9	108
Demersal shrimp	8	1333	1130	0.8	167
Total	**116**	**14932**	**40897**	**2.7**	**129**

1994

Type of fishing licence	Nbr. Ships	Fishing day	Catch (Tons)	Mean yeald (Tons/day)	Mean activity (days/year)
Pelagic	3	219	3368	15.4	73
Demersal fish	32	6152	19980	3.2	192
Demersal cephal.	14	3450	7024	2.0	246
Demersal shrimp	6	1317	1015	0.8	220
Total	**55**	**11138**	**31387**	**2.8**	**203**

Estimation of the fishing effort, catch, yeald and activity of the industrial fishery vessels versus fishing licence in 1993 and 1994.

Table 2.

Type of fishing licence	Power class (HP)	Mean yeald (tons/day)
Pelagic	>=1500	18.7
Demersal fish	<500	0.7
	500-999	1.2
	1000-1999	2.7
	>=1500	4.5
Demersal cephal.	<500	0.5
	500-999	1.9
	1000-1999	1.9
	>=1500	4.8
Demersal shrimps	<500	0.5
	500-999	1.0
	1000-1999	1.5

Mean yeald of the industrial fisheries versus type of fishing licence and versus power class for the whole period 1993-1994

Table 3.

Species	Type of fishing licence (demersal) fish %	cephalop %	shrimp %	Total %
Scieanidae community				
Pseudotolithus brachygnathus, P.senegalensis, P.typus.	15	6	1	12
Pseudotolithus elongatus	14	1	_	10
Cynoglossus canariensis, C.monodi, C.senegalensis.	6	14	5	8
Arlus heudeloti, A.latiscutatus, A.parkill.	5	4	_	5
Galeoides decadactylus.	4	6	_	4
Pomadasys incisus, P.jubelini.	3	5	_	4
Drepane Africana, Chaetodipterus goreensis, C.lippel.	2	1	_	2
Dasyatis margarita.	3	1	_	2
others.	10	7	1	9
sub-total	62	45	7	56
Sparidae community				
Pagellus bellottii, Sparus caeruleostictus.	6	2	1	5
Pseudupeneus prayensis.	1	1	-	1
sub-total	7	3	1	6
Unclassified fish species				
sub-total	8	8	41	8
Cephalopods				
Sepiidae.	21	35	5	23
Octopodidae.	1	3	-	2
sub-total	22	38	5	25
Shrimps and crabs				
Parapenaeopsis atlantica, Penaeus notialis, P.kerathurus.	1	5	41	4
Portunus validus.	-	1	5	1
sub-total	1	6	46	5

Specific compositions of industrial fishery catches versus the licence type for the whole period 1993-1994

UPWELLING PHENOMENON IN THE REGION OF THE SIERRA LEONE EXCLUSIVE ECONOMIC ZONE AND ITS LINKS WITH THE FISHERIES

by

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INTRODUCTION

Sierra Leone is a small country on the West African coast with a coastline of about 350 km stretching from 7°N to 9°N. It covers an area of 71,740 km² and its latest population estimate is around 4 million. The shelf off the Sierra Leonean coast is about 100 km wide in the north at the border with Guinea, but narrows to only 13 km in the south, towards Liberia. Total shelf area is around 30,000 km², representing an important fishing ground along the West African coast. (J.M. VAKILY 1992).

The area under study lies between longitudes 10°14' and 13°17'W and between latitudes 6°55' and 10°00'N. The inner continental shelf which is between 22-37 km in width contains pockets of sand bars running mostly parallel to the coastline.

The outer shelf is wider, being widest in the north averaging about 167 km around the 200 m isobath contour. The shelf break occurs at depths 90-140 m. Sierra Leone shelf waters experience a well marked alternation of wet and dry seasons. The dry season lasts from December to April and the wet season from May to November with two equal periods - May to June and September to October. the monsoon period is generally from July to August.

This paper seeks to describe the general character and pattern of the upwellings in the area and their influence on the fisheries. The information used for this purpose has been obtained from various research publications and analysis of existing hydrographic data on the area. The paper gives a general overview of upwelling phenomenon in the Sierra Leone area and its possible influence on the productivity of the fisheries.

HYDROLOGICAL CHARACTERISTICS

The distribution of temperature and salinity with depth at a hydrological station within the Sierra Leone shelf waters shows, the the waters are characterised by a stable and shallow thermocline lying at mid shelf depth and determined by the 25° C isotherm and the 40 m isobath respectively. Seasonal changes of thermocline depth are due to the effects of the monsoonal wet season (May-October), high river discharges, reduced surface salinities and lowered surface solar radiation (Longhurst, 1963, 1983). The thermocline depth also depends on the thickness of the Ekman layer which has a minimum depth here of around 50 m on the average.

The structure of the shelf waters (both shallow and deep), recorded during the cruise of R/V Atlantida November 28 - December 7, shows that the shelf waters of Sierra Leone consist of several types of zones differing in oceanographic characteristics.

The inshore type occupies the zone passing along the shore and is characterised by warm diluted waters due to river drainage and heavy precipitation. Its temperature ranges from 26-29°C and the salinity is below 30.0 p.p.t. with dissolved oxygen content between 3.2 and 5.3 ml/l (Atlant Niro, 1990). Below the pycnocline (rapid density gradient area) lies the equatorial subsurface waters at depths greater than 25-40 m with temperatures between 13 and 24°C, salinity between 34.0 and 35.9 p.p.t. and the disolved oxygen content between 1.7 and 4.0 ml/l.

UPWELLING PHENOMENON IN THE SIERRA LEONE REGION

A prerequisite for upwelling is often considered to be the existence of thermally distinct two water layers. Upwelling in the shelf waters of Sierra Leone have not been studied in detail apart from generalisations deduced from circulation and wind patterns coupled with observed increased nutrient enrichment.

The mean long-term wind regime shows the prevalence of northwest winds from April to May. From May to November the winds are unstable in terms of direction and from June to October southwest monsoon winds dominate. The Harmattan associated with winds from the northeast and the predominantly nortwest wind during the months of December to February are believed to cause upwelling of deep cold high salinity water in the region.

According to Longhurst (1968), the continental shelf waters of Sierra Leone are influenced by the Cape Verde divergence to the north and the convergence at the northern margin of the Equatorial Counter Current (ECC) further south of the equator. Upwelling is characteristic of the former whilst downwelling is a feature of the latter. Khlytov (1976) has noted that in both of these areas individual water masses carried by different currents followed complicated spiral-like trajectories.

Most researchers associate the concentration of fish species to the north of the Sierra Leone shelf waters to the occurence of upwelling there. The Sierra Leone-USSR fishery surveys results also suggest a large aggregation of the sardinella species in the northern region and the northward migration of *Sardinella aurita* during the months of September and October; the northward migration of *Sardinella maderensis* with respect to the seasons showed that this species move north during the raining season. This pattern of migration has been attributed to the high nutrient supply there. It is however unclear whether the nutrient enrichment is due to upwelling or to high river discharge at that time in that region.

CONCLUSION

Upwelling phenomena have not been studied in detail in Sierra Leone. It is obvious that the general picture which has been presented requires explanation. For instance it is unclear as to whether the increase of nutrients is due to the mixing of water masses from the North and South Atlantic central waters or to the occurence of upwelling. From the above it is clear that there are gaps regarding the occurence, persistence and the likely effect on productivity of upwelling phenomena of the Sierra Leone coast.

UPWELLING OFF THE COTE D'IVOIRE-GHANA AND SARDINELLAS FISHERIES IN THE WESTERN GULF OF GUINEA

by

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INTRODUCTION

The Ivorian and Ghanaian pelagic fish stock runs from Côte d'Ivoire to Benin. This stock is exploited by artisanal and industrial fisheries. The main species fished are the round sardinella (*Sardinella aurita*), flat sardinella (*Sardinella maderensis*), *Engraulis encrasicolus* and *Scomber japonicus*. Among those four species, total landings of *Sardinella aurita* seems to be more linked to the environmental features than the others. This paper shows the evolution of the industrial fishery of *Sardinella aurita* in term of total landing during the last ten years (i.e. from 1984 to 1994)

UPWELLING OFF THE COTE D'IVOIRE AND GHANA

The Ivorian and Ghanaian upwellings are non Ekman type upwellings (Bakun, 1978) and a lot of mechanisms are supposed to influence the upwelling activity (Picaut, 1983; Colin, 1988). In the gulf of Guinea the cooling of the sea surface temperature is the main way to detect the upwelling.

Two upwellings seasons are observed off the Côte d'Ivoire and Ghana : these are the major upwelling in July-October each year and the minor upwelling of January-February and sometimes, March.

The major upwelling lasts for about three months while the minor one lasts for just about three weeks and sometimes longer. In the Ivorian-Ghanaian area, the upwelling is assumed to have started when the sea surface temperature drops to 26°C or less. The strength of the upwelling is measured in term of an upwelling index which takes into consideration the time period within which the sea surface temperature is below 26°C. Dayly sea surface temperature are measured at twelve stations on the Ivorian-Ghanaian coastline. Means values have been computed on a yearly basis. Figures B and C show sea surface temperatures recorded during upwelling time.

SARDINELLAS FIHERIES IN COTE D'IVOIRE

In the gulf of Guinea, particularly in Côte d'Ivoire, industrial fisheries for sardinellas which had begun during the mid sixties, show an irregular evolution when we consider total landing. Artisanal activity which began a few years later provides a substantial quantity of fishes, more particularly *Sardinella aurita*. With this artisanal fishery, the main problem is the difficulty to accede to the total catch : people who practice this kind of fishing are scattered on the coastline and are not, in most case, interested in research inventories.

In industrial or artisanal fisheries of sardinella, the importance of climatic variations are seen by the fishermen at the capture level. Upwelling seasons follow other upwellings seasons but they have not the same intensity and by this way, the total landing rises or decreases with a large amplitude. So the main problems of the sardinella fisheries in the gulf of Guinea, particularly in Côte d'Ivoire are their dependence to this environmental factor.

The importance of this phenomenon is in direct relation with the total catch of the industrial production (see fig. 1). A brief comment of this figure shows that a high cooling of the sea during the major upwelling (in 1985) or during the both upwelling seasons (in 1992) leads to a good production of *Sardinella aurita*. On the other hand, from 1986 to 1987, the major upwelling intensity was not good, but the high cooling ot the sea during the minor upwelling was enough to bring a good level of sardinella total landing. It was the case in 1990 which, although with a gool level of cooling during the minor upwelling, the production was bad because of the "warming up" of the sea during the previous years (1988, 1989). This relative "warming up" did not, probably, allow the necessary recruitment.

CONCLUSION

Success of Sardinellas fisheries in the gulf of Guinea, in Côte d'Ivoire as well as in Ghana, depend on a lot of factors of environment. The main factor is the coastal upwelling with its two season periods. The minor upwelling which is more intensive off the Côte d'Ivoire than off the Ghana coast could contribute to the good level of the total landing. Researches made actually on *Sardinella aurita* are to evaluate the importance of the reproductive activity of this species during the minor upwelling.

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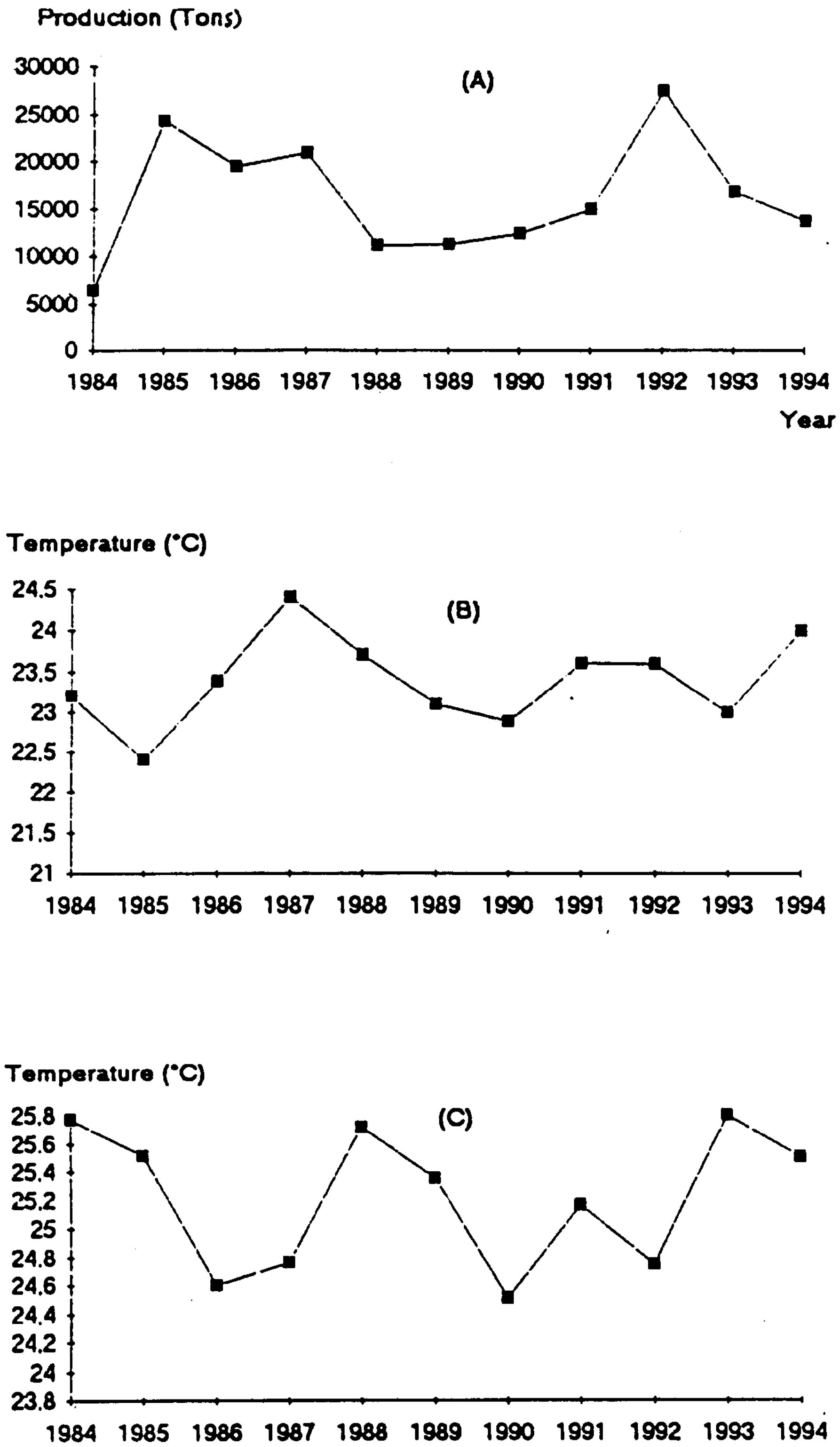

Figure 1. Total landing of *Sardinella aurita* (A) with the variation of the major upwelling (B) and the minor upwelling during the last ten years.

THE WESTERN GULF OF GUINEA COASTAL UPWELLING-PECULIARITIES,CHANGES, AND FISHERIES IMPLICATIONS : A REVIEW

by

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INTRODUCTION

The waters of the western Gulf of Guinea, (Côte d'Ivoire-Benin), form part of the Guinea Current Large Marine Ecosystem. Off Ghana and Côte d'Ivoire, two upwelling seasons, major and minor, occur annually. Small pelagic fisheries in the western Gulf of Guinea depend heavily on the coastal upwelling. Total landing has been between 200,000 and 260,000 tons annually in the last decade. *Sardinella aurita* is the most important small pelagic species. In the demersal fishery, several high-valued species are exploited amounting to 60,000-100,000 tons annually. This paper reviews the knowledge about the western Gulf of Guinea coastal upwelling and examines the observed changes in the marine environment in as much as they affect pelagic fisheries. It then sets the stage for detailed analysis of spatio-temporal changes in the demersal fishery vis-à-vis changes in the marine and climatic environment.

PECULIARITIES OF THE UPWELLING

The coastal hydrography of the Gulf of Guinea is generally divided into four regimes :

- A short cold season in December - January (minor upwelling)
- A long warm season between February and June
- A long cold season between July and September (major upwelling)
- A short warm season in October-November

The following are some of the characteristics of the major upwelling :

a. The east-west orientation of the coast is as singular characteristic of this tropical upwelling ecosystem.
b. The eastward flow of the Guinea current and westward undercurrent make the structure of the surface and subsurface circulation similar to other upwelling areas.
c. The depth of the thermocline is shallow varying seasonally between 10 and 60 m.
d. There is large seasonal amplitude of sea sufrace temperatures (21° - 30°C).
e. The dominant wind is the southwesterly monsoon with maximum speed of about 5m/s in June - September

The upwelling has at one time or the other been attributed to one of the following :

i. Wind (i.e. Ekman-type); Verstraete (1970).
ii. Evaporation : FRU (1970); Pople and Mensah (1971).
iii. Current : Ingham (1970); Marshall and Picaut (1977).
iv. Remote forcing by equatorial upwelling originating from the western Atlantic : Moore *et al.* (1978); Servain *et al.* (1982)

Intensification of the Guinea current in January-February and the local wind are thought to be important contributing factors to the occurrence of the minor upwelling.

From a fortnightly upwelling index Iqz, calculated from Iqz = (26 - Mqz) x Nqz where Mqz is the mean of temperatures lower than 26°C within the fortnight, and Nqz is the number of days in the fortnight for which temperatures were less than 26°C, the following are noticeable :

a. strong upwelling on the western part of each country and to the immediate east of Cape Palmas and Cape Three Points
b. comparatively stronger major upwelling in Ghana than in Côte d'Ivoire
c. a relatively stong minor upwelling off Côte d'Ivoire and which gradually weakens from west to east.

RECENT OBSERVED CHANGES IN UPWELLING CONDITIONS

Analysis of offshore temperatures extracted from the COADS data set and daily SST recorded at coastal stations showed the following :

a. that the two upwellings did not follow similar evolution with time;
b. there is intensification of the minor upwelling;
c. there is a narrowing of the difference between the intensity of the two upwellings;
d. the intensification of the minor upwelling on the western side of Côte d'Ivoire is much more than anywhere else in the sub-region.

FISHERIES IMPLICATIONS

Small Pelagics (*Sardinella aurita*)

i. Since 1983 high landings of this species have been observed in both countries.
ii. There has been extension of its distribution towards western Côte d'Ivoire.
iii. Importance of *S.aurita* abundance during the minor upwelling season has increased.
iv. There has been increase in sizes of fish caught (Côte d'Ivoire : 15-18 cm in the 1960s and 1970s to 18-24 cm in the 1980s; Ghana 14-17 cm to 17-21 cm)
v. Increase in length at first maturity of the fish (Côte d'Ivoire: 15-16 to 18-19 cm; Ghana 14-17 cm) and increased spawning activity outside the major upwelling season

Demersals

The most important demersal and semi-pelagic fish species found in the Ghana-Côte d'Ivoire coastal waters are of the families *Sparidae, Haemulidae, Sciaenidae, Lutjanidae,* and *Serranidae.* From 1973, there was a proliferation of *Balistes carolinensis (=capriscus)* or triggerfish in this ecosystem; but towards the end of the 1980s the species completely disappeared from the sub-region. Occuring about the same time, and sometimes linked with the disappearance of the triggerfish, is a large increase in the biomass and catch of globefish (*Lagocephalus laevigatus*) and cuttlefish (*Sepia officinalis*).

The ecological balance of demersal and semi-pelagic fishes in the western Gulf of Guinea ecosystem appears to have been tipped. The question is how much of these changes in the demersal stock situation could be attributed to human interference as opposed to natural changes in the marine environment.

The following questions need to be answered :

1. How have demersal fishes responded to the observed environmental changes (stock size; species assemblages, etc.)?
2. Where is the triggerfish?

3. How can possible future changes in the stock situation be predicted?
4. How must the fisheries be managed to minimise the effects of environmental factors?

These are the major objectives of present research

CONCLUSION

The coastal region off Côte d'Ivoire and Ghana is unique in the Guinea Current large marine ecosystem and is different from other upwelling areas. The intensities of the two seasonal coastal upwellings that occur in this ecosystem have changed; with the minor upwelling assuming greater importance especially in the recovery and sustenance of the *Sardinella aurita* stocks.

The observed changes in the biology and dynamics of *S.aurita* have been attributed to the increasing impact of the minor upwelling on the ecosystem.

In the demersal fisheries, the extent to which the recorded changes in the marine environment have affected changes in population dynamics of *B. carolinensis, L. laevigatus, Sepia spp.,*and other demersal species remains to be assessed.

FISHERIES POTENTIAL EVALUATION AND A PROBABLE UPWELLING PHENOMENON OFF THE BENIN COAST

by

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OCEANOGRAPHIC CHARACTERISTICS OF THE BENIN COASTAL ZONE

Republic of Benin is a West Africa country lying between 6°N and 13°N. Benin has about 140 km of coastline between 1°40E to 2°45E; it opens on the Gulf of Guinea by the Gulf of Benin.

Predominant wind direction is South-West with an average speed about 4-6 m/s. South-East and South wind directions can occur in April and May. In the Benin coast, surface sea temperature varies from 25°C (July-September) to 32°C (February-March) and salinity varies from 33 to 35%° Benin coastal tides are of semi-diurnal type. Extreme tidal ranges are +1,95m and 0,25m. Generally, swells have South-West directions. Collected data these last years give the following directions: S-E to S for 12%., S to S-S-W for 36%., S-S-W to S-W for 52%. We observe in the coastal zone two types of swells : a long swell with wavelength and period reaching 220m and 12 seconds, generated by storms and a short swell which is due to local winds with about 50m wavelength.

Off the Benin coastline there are many types of currents but the most important are :

- Coastline currents with an eastern direction and a speed between 0,5 and 1,5m/s.
- Marine currents along the coast, also with an eastern direction, but off the coast they vary and can reach 0,1m/s.

From June to December, this marine current becomes very strong and periodically changes direction, so that between July and August, it gets a western direction. Tidal currents are not important in this coastal zone.

FISHERIES POTENTIAL EVALUATION OFF THE BENIN COASTS

Many fish populations evaluations surveys, pelagic and demersal, have been realized along the Benin coast. The most importants of them are :

a)Pelagic : cruises on R.V. "John Elliot Pillbury" in 1964 and on R.V. "Sera" in 1964-1965; pelagic accoustic prospecting on R.V."Fridtjof Nansen" in 1981.

b)Demersal : survey realized on "Thierry" in 1963-1964 and "Ombago" in 1963-1964 using bottom trawling. Sovietic/Beninese campaign in 1977-1978 and "Propam I" prospecting in 1983-1984.

In 1985 and 1986, in order to actualise these first results, two bottom trawling surveys "Benin 85.01" and "Benin 86.01" on the R.V. "André Nizery" on the Benin continental shelf have been carried out by ORSTOM (France) and C.B.R.S.T. (Benin). The first results of these surveys have been published and contain :

- the detail of catches and equivalent catches per hour by species.

- the length frequency distributions of the measured samples.
- the total length frequency distributions of the most important species.
- the biomass evaluations, by species.

Another survey, in progress, using bottom trawling, has been initiated and carried out by the Centre Beninois de la Recherche Scientifique et Technique (C.B.R.S.T.) with the help of the Canadian Agency for International Development (CAID).

Data used in this paper concern the industrial fisheries sector, the artisanal fisheries sector and also cruise results on R.V. "Dauphin"

The artisanal sector relies on canoes using many gears, like set nets, hand lines. Canoes are mainly dug - out and planked and fitted with out-board motors with an average horse power between 8 H.P.and 25 H.P. In the industrial sector, there are about ten companies which operate off Benin.

CATCHES

On the basis the last surveys, catches for different kinds of fish are represented on the following tables and graphics. They give the monthly landings of commercial fishes by many types of vessels for 1993 and the catch per unit effort (CPUE).

EVIDENCE FOR A PROBABLE UPWELLING PHENOMENON

In the tropical regions of the Atlantic, a stratum of warm (T>24°C) tropical surface water of usually low salinity overlies a cold water mass of south Atlantic Central water. As the warm water layer is much thinner in the eastern Atlantic (30 to 40m) than in the western Atlantic (up to 150m) the Gulf of Guinea thermocline is always close to the surface. The seasonal vertical oscillations of this thermocline result in equatorial and coastal upwellings. Recent studies indicated that this upwelling phenomenon is mainly linked to zonal winds outside the Gulf of Guinea.

According to Longhurst (1964), the water on the continental shelf off Benin, when stable, presents of five recognisable layers as follows:

-Supra thermocline water 26-29°C. -Thermocline 1 water 20-25°C	Tropical water
-Inter-thermocline water 15-19°C -Thermocline 2 water 11-14°C -Sub-thermocline water 11°C	South Atlantic Central water

The depth of thermocline 1 is between 30 and 40m
(See graphic on bottom temperature variability)

The existence of two water layers, thermally distinct is a prerequisite for upwelling. Warmer water at the surface normally constitutes the outward flow and colder subsurface water the return flow in an upwelling situation. Published data of physical characteristics, meteorology and results of pelagic prospecting and bottom trawling surveys on the Beninese continental shelf favour the probable occurrence of upwelling phenomena in Benin's inshore water, near Cotonou between July and September. A second, but small upwelling occurs in December-January.

This informations are corroborated by the periodic abundance of some pelagic fish including *Sardinella maderensis, Ethmalosa fimbriata,* and semi pelagic like *Pseudotholithus typus*.

In this period, surface water temperature falls down to 20°C off Cotonou.

CONCLUSION

Information gaps remain as to the details of the causes, persistence and effects of possible upwelling phenomena off the Beninese Coast. All the above mentionned surveys concern only potential fisheries estimations.

It would be desirable to initiate a regional multidisciplinary research project on the upwelling phenomenon in the Gulf of Guinea i.e. from Côte d'Ivoire to Cameroon.

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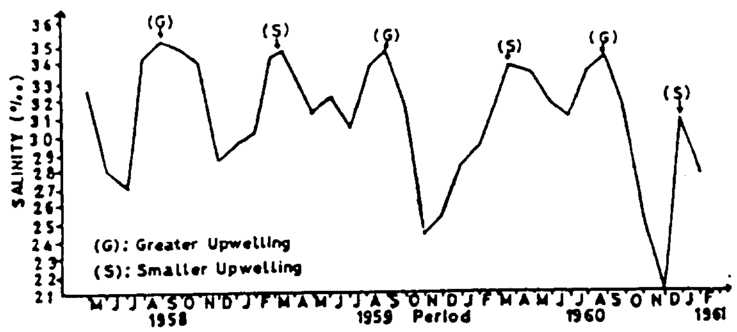
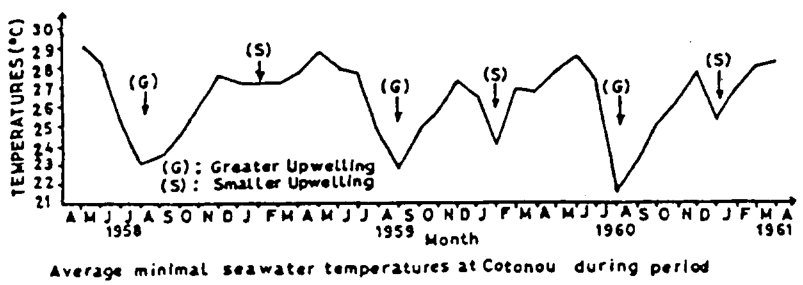
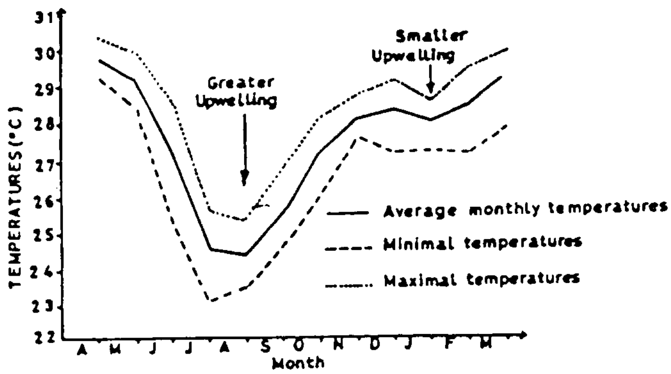


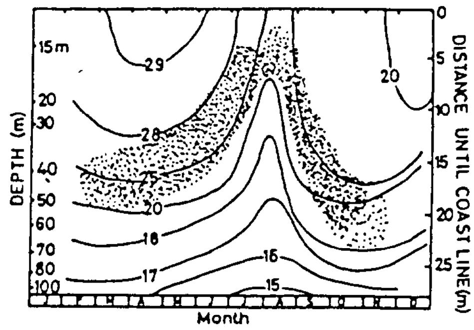
Monthly average salinities at Cotonou on a three years period (May 1958 - January 1961)



Average minimal seawater temperatures at Cotonou during period April 1958 - April 1961



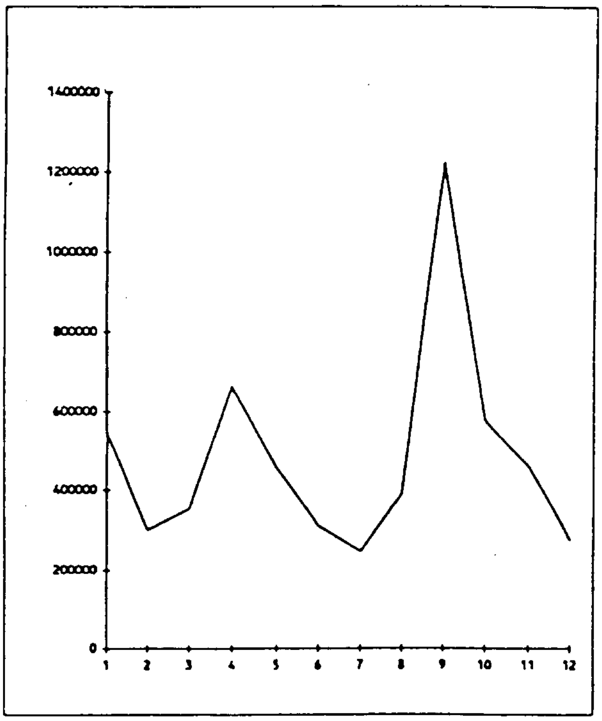
Monthly average seawater temperatures (Average Minima Maxima) at Cotonou during period April 1958-April 1961 (by Pliya 1970)



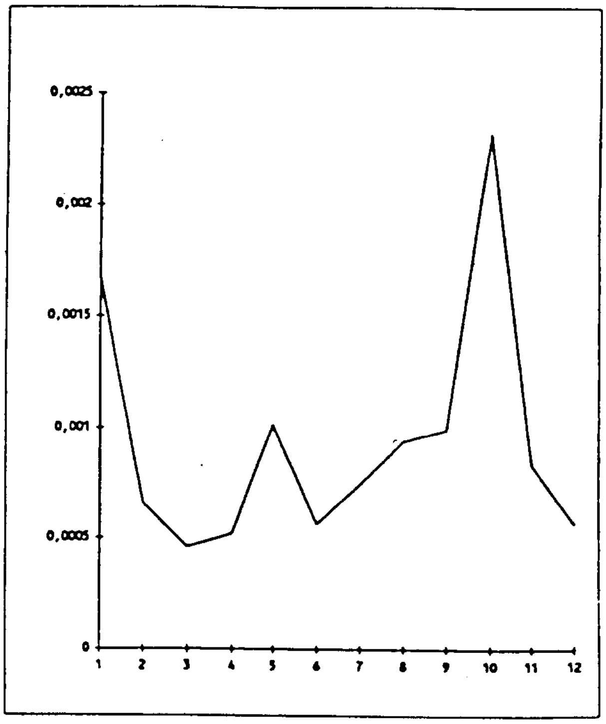
Bottom Temperature variability at Cotonou

Bottom Thermocline position

Artisanal fisheries in 1993



Monthly evolution of total catch (kg)



Monthly evolution of CPUE

Marine industrial fisheries data 1993

Month	Total Number				Total catch	CPUE		
	ships	(H.P.)	TDB	Tides (t)	(Kg)	C/(ship*t)	C/(HP*t)	C/(TDB*t)
Jan.	6	1812	426.56	63.604	44255	115.96	0.38	1.63
Feb.	5	1749	429.16	64.708	25506	78.83	0.23	0.92
March	6	1529	438	107.04	33714	52.49	0.21	0.72
April	6	1265	302	80.708	22068	45.57	0.22	0.91
May	6	1265	312	58.458	34109.5	97.25	0.46	1.87
June	6	1579	405.26	60.791	26982.5	73.98	0.28	1.10
July	4	710	129.54	52.541	23780	113.15	0.64	3.49
Aug.	6	1265	296.06	71.666	47069	109.46	0.52	2.22
Sept.	6	1565	422.86	78.041	56079	119.76	0.46	1.70
Oct.	4	1185	325.26	45.416	35989	198.11	0.67	2.44
Nov.	5	1785	419.96	95.916	89918	187.49	0.53	2.23
Dec.	6	1875	423.96	62.25	63004	168.69	0.54	2.39
Total/year	66	17584	43330.62	841.139	502474	1360.75	5.12	21.61
Mean/month	6	1465.33	360.885	70.094917	41872.83	113.396068	0.42694825	1.80058555

Industrial fisheries

Month / Species	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Galéoides décadactylus		467	3991	1497	2414	6751	1099	4350	6576	3258	9268	7250	46921
Pseudotolithys spp.		4881	8230	3417	3887	3451	2630	5298	9391	7301	23845	21225	93556
Dentex spp.	130	928		1478	1082	861	110	1272	1194	134	100	123	7412
Sphyraena spp.		190	167	142	515	705	108	131	134	27	53	138	2310
Lutjanus spp.	120	559	33	1660	232	85	300	100	2175	219		686	6169
Ilisha africana				50	150	450	975	350	300	286	1040	650	4251
Pomadasys spp.		255		457	678	715	38	306					2449
Polydactylus quadrifilis		113	52	72	73	35	10	12	93	48	76	74	658
Pagellus spp.									181	54	552	94	881
Sardinella spp.					170								170
Scomberomorus tritor		1043	65	134	406	213	140	63	25	30		2	2121

Artisanal fisheries

Month / Species	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Galéoides décadactylus	8215.19	8143.26	4614.58	2990.55	5482.27	6605.40	6431.42	952.72	1551.37	6343.92	7504.74	4610.17	63445.59
Pseudotolithys spp.	15454.60	10511.00	4045.42	6100.41	6494.45	9140.52	7952.23	1930.11	2460.52	4009.33	12073.10	3479.67	83651.36
Dentex spp.	135.74	132.09	1239.02	1075.76	2556.21	105.63	290.17	410.41	80.28	295.36	15315.80	190.77	21827.23
Sphyraena spp.	10742.60	16007.50	934.74	3508.43	4162.03	3305.05	6023.69	1635.70	722.50	644.13	5017.24	948.53	53652.14
Lutjanus spp.	1783.97	3467.33	179.51	4709.22	3324.01	5727.50	2296.09	106.75	140.49	276.51	3031.47	79.49	25122.33
Ilisha africana	5565.21	4418.36	3782.73	3519.22	3340.86	8972.69	2014.84	1017.72	1614.28	647.27	5323.56	2981.56	433398.30
Pomadasys spp.	814.42	412.78	0.00	283.44	655.44	438.01	1272.30	67.61	175.61	201.10	1605.52	710.07	6636.30
Polydactylus quadrifilis	659.29	445.80	122.59	209.44	112.36	1345.73	451.33	374.82	374.60	201.10	580.94	79.49	4957.49
Pagellus spp.	0.00	1358.04	967.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2325.55
Sardinella spp.	24044.80	2171.21	2963.14	9136.02	7000.08	3045.67	814.72	1378.31	1264.38	3917.08	14629.20	3990.18	74354.79
Scomberomorus tritor	37288.90	1959.20	1324.39	3839.73	14433.70	11558.30	7652.38	3430.35	6305.83	2947.30	4409.89	1565.87	96715.84

REFLECTIONS ON THE UPWELLING PHENOMENON IN NIGERIAN COASTAL WATERS

by

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HYDROGRAPHIC AND METEOROLOGICAL SETTINGS

The hydrography of Nigerian Coastal Waters can be best described in terms of the Gulf of Guinea (GG) L.M.E.: a prominent feature is the existense in most parts, at most times, of a stratified water column. In the eastern flank, the primary thermocline generally lies between the 30m & 100m isobaths and is approximately marked by the 18°C-24°C isotherms. It is shallower in the western flank. Depending on the season and longitude, surface temperature values range between 25°C & 13°C except when there is a breadkown of thermal stratification.

Salinity values recorded in the GG range between 27 & 34.8 p.p.t. depending on season and location. The Guinea Current (GC) dominates the regions's hydrography and for most of the time, flows in a West-East direction.

The migratory pattern and instability of the ITCZ determines the seasonality of the climatic elements. The coastal belt is under the influence of south westerlies most year round and humidity is generally high.

UPWELLING IN THE GULF OF GUINEA

Upwelling occurs along the northern boundary especially between longitudes 1°E and 7°W. The main upwelling season is the June-October period with the possibility of minor upwelling in December/January. There is however evidence, that in this region, the mechanism can not be solely explained in terms of the classical wind-driven Ekman transport (Moore et al, 1978, Servain et al, 1982). Suggested mechanisms include remote forcing and current intensification but without absolutely precluding a role for the winds.

THE NIGERIAN SITUATION

Based on comparative results of previous resource surveys in Nigerian waters and those of notable coastal upwelling zones like Mauritania, Senegal and Ghana, Nigeria is often excluded in discussions of the GG upwelling. However, there is hydrographic and biological evidence suggesting that upwelling, even if comparatively poor or transient, does occur (Berrit 1961, Longhurst 1964, Oyewo et al, 1982). Besides, certain features of Nigeria's coastal hydrography are salient to the upwelling phenomenon : periodic reversals of the GG, the origin of the Guinea undercurrent and its possible relationship with the poleward undercurrent are some of these features. The probable role of the reversal of the GC in upwelling around and west of Nigeria also needs to be investigated.

CONCLUSION

Although there is some information on upwelling in the GG, there is a need for the continued monitoring of relevant phenomena in the entire region and the individual countries which it comprises. Even in established upwelling arears in the GG, there still exists some uncertainties and the phenomenon is subject to inter-annual varialbility in time, space and intensity. The significance of the upwelling phenomenon, of the position of the front between the GC and GUC has only been recently recognized (Binet and Marchal, 1993). Therefore, continuous monitoring in the GG will not only facilitate the further elucidation of the phenomenon, it will lead to the identification of any local peculiarities, and the detection of any changes wherever and whenever they occur and lead to the generation of data which will be invaluable in the validation of models and the judicious management of biological resources in the region

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THE PRESENT STATE OF MARINE FISHERIES IN CAMEROON

by

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INTRODUCTION

Cameroon has a coastline of 360 km on the Atlantic Ocean, with a continental shelf of about 15,400 km considering the isobath 200.

The production of Cameroon Marine Fishery resources estimated in 1993 was about 72,203 tons and the distribution was as follows :

a) Demersal species: 13,718 tons, of which 6,718 tons were produced by industrial fisheries and 7,000 tons by artisanal fisheries.
b) Pelagic species: 45,000 tons (mainly *Ethmalosa fimbriata* and *Sardinella maderensis*).
c) Shrimps : 10,485 tons, of which estuarine shrimps, *Palaemon hastatus,* production was about 10,000 tons.
d) Others : 3, 000 tons.

Marine fisheries represent 60% of the national production. The fishery industry in Cameroon constitutes the most important source of animal protein in the diet of the lower income population. The annual consumption per inhabitant lies between 13.6 and 19 kg, representing approximately 42.3% of animal protein and presently 9.5% of total needs.

In 1993, Cameroon imported 30,699 tons of frozen fish, but within the same period, 10,000 to 20,000 tons of fish were exported informally towards the neighbouring countries. 850 tons of shrimps were exported officially

Catch values for 1990 could be presented as follows :

- Industrial landings : 18.8 million US dollars, of which 9.8 million US dollars came from export of shrimps.
- Artisanal landings : 180 million US dollars.
- Exports : 40 million US dollars

The number of fishermen in the marine artisanal fishery is more than 15,000. These fishermen are divided into five administrative coastal divisions: Ndian, Fako, Wouri, Sanaga Maritime and Ocean, distributed from the North to the South of the coastline. Within the Ndian and Fako Divisions, foreigners represent 90% of the total number of fishermen. This effectively creates problems in the planning and management of the Cameroon fisheries. More than 1,500 persons are employed in the industrial fisheries. Marine fisheries thus play an important role in Cameroon's economy.

In this paper, we will first of all outline the coastal ecosystems, aquatic resources and their potential; constraints and management options are discussed; present and future research programmes are mentioned .

CHARACTERISTICS OF THE COASTAL AND MARINE ECOSYSTEMS OF CAMEROON; FISHERIES POTENTIAL

Location , Climate and Oceanographic conditions.

Cameroon is located at the base of the Gulf of Guinea, in the Bight of Biafra. The coastal zone extends from the Nigerian border (4°40'N) to the Equato-Guinean border (2°20'N) (figure 1). From Campo at the southern border to river Nyong, the coastline is high and rocky, alternating with sandy beaches. From river Nyong to Tiko and Njangassa to Rio-del-Rey, the coastline is low and swampy, characterized by the presence of mangroves with alternating sandy beaches. Between Njangassa and Tiko, the coastline is covered with volcanic deposists from the active Cameroon Mountain.

The coastal hydroclimate is influenced by heavy rains which reach annual values of 12,000mm in the Debundscha area. The river network is also dense with many rivers which empty their water into to Atlantic Ocean. This creates a surface layer with salinity less than 25 ‰ and a thickness between 20 and 30 m. Water masses at the surface are constantly warm (Crosnier, 1964). The continental shelf on the northern part of the coastline has a muddy bottom which favours the movement of trawlers. The southern part has a rocky bottom, except the area located between Kribi and river Sanaga. Each one of these zones, has a different fauna species of which the distribution and ecology are given in Table 1.

The circulation of water is slow and this results in a high rate of sedimentation. The tides are of the semi-diurnal type and can reach amplitudes of 0.5 to 2.7 m height, depending on the location. Generally, tidal currents are observed. Keita et al. (1991) measured speeds varying between 0.5 and 1.4 m/s at Mabeta during the flux and 3 m/s at reflux.

Description of the fisheries and their potential.

Level of exploitation of the resources.

The characteristics of the Cameroon coastal environment from the highest to the deepest level of the coastline show that fishing zones with the estuarine shrimps (*Palaemon hastatus*), coastal pelagic fishes (*Sardinella maderensis* and *Ethmalosa fimbriata*) and demersal species (figure 1) are very common.

In these zones, fishing activities are not affected by seasonal changes, temperature variations, salinity or density of the surface water. The distribution of different species is much along the coast (figure 1). Crosnier (1964) mentioned that 74% of the resources were located between 10 and 30 m depths.

The small coastal pelagic fish migrate along the coastline depending on their feeding cycle and periodic changes in the physico-chemical characteristics of the waters. One can distinguish several stocks in the Gulf of Guinea : a Congo-Angolan coastal stock of *Sardinella maderensis*, a Gabon stock of *Etmalosa fimbriata* and *Sardinella maderensis*. Scet (1979) estimated the potential of the Cameroon pelagic stock at a minimum of 45,000 tons per year, which meant that the pelagic fisheries of this stock had attained their maximum sustainable yield (MSY), whereas the demersal stocks were overexploited. Fishery zones and exploited stocks are shown in figure2

An analysis of the by-catch percentage confirmed the risk of elimination of demersal fish stocks. Effectively, the percentage of by-catch was 31% in 1983, 36% in 1984 and reached 37.5% in 1990. If one adds the smaller fish caught and not recorded as by-catch, this percentage for the year 1990 could be as high as 63%. This further supports the hypothesis that Industrial fisheries in Cameroon reduce the potentials of the fishery resources.

Potentials and Development

Because of the dense river network, extensive coastline of 360 km, and human resources potential, the fishing sector plays a very important role in Cameroon's development. Effectively, the natural potential of fisheries development includes 15,400 km^2 of the continental shelf and 2,700 km^2 (Valet, 1987) of mangroves. The water serves as nursery zones for several fishes (Youmbi and Djama, 1991). The fauna is rich and diversified, taking account of the 40 marine fish species exploited in Cameroon.

From the human perspective, there are a good number of national experts. There are also logistic structures, comprising of Research Centres, Training Centres and Development Organisations.

CONSTRAINTS

The marine fisheries sector faces several problems among which are : over-exploitation of demersal resources (stocks), the absence of appropriate technology of fishing gears, the non-application of management decision, losses after catch, absence of defined commercialisation and distribution guidelines and the absence of collaboration mechanism between research and users.

The over-exploitation of the stocks is due to several factors :

a) The gears are not selective enough to eliminate smaller fishes that have not attained sexual maturity (Industrial fisheries).
b) Destructive fishing practices (use of explosives, toxic chemical substances mainly in the mangrove zones, rivers and creeks).
c) Effects of pollution in the marine environment.
d) Fishing within the nursery and the two mile zone.
e) Absence of an appropriate technology and fishing methods. In order to have access to other stocks which are still under-exploited, it is necessary to develop other fishing techniques.
f) Losses after catch. Fishing camps are generally located in enclaved zones. This situation causes losses after catch which are estimated between 20 and 40%.
g) Collaboration between fishery research and users. It is noteworthy that there is no efficient collaboration between fishery research and users.

LEGISLATION AND PLANNING.

From the point of view of institutional hierarchy, the fisheries sector depends on the Directorate of Fisheries (DIRPEC) of the Ministry of Livestock, Fisheries and Animal Husbandary (MINEPIA). Fisheries and Oceanographic Research is carried out by the Institute of Animal and Veterinary Research (IRZV), through her Research Centre for Fisheries and Oceanography (CRHO) in Limbe. The last two structures are dependent on the Ministry of Scientific and Technical Research (MINREST)

Law n°94/01 of 20 January 1994 defines the different types of fisheries and related activities, conditions of fishing and granting of fishing licences, conservation techniques and management of aquatic resources, types of fishing gears and sanitary control of fishery resources. This law effectively prohibits the utilization of nets whose mesh sizes do not respect the standards. However, it fails to give the dimensions of the mesh sizes to be used for each type of fishery. There is, however, hope that these short comings will be rectified in the application decree which is currently being prepared. The law also provides for the protection of common fishing zones through measures such as limiting trawlers out of the 2 nautical mile zone and controlling aquatic pollution.

In the Gulf of Guinea, taking account of the migratory nature and the geographic and biological interdependence of marine stocks, it is wished that management and development programmes on fisheries be established in the nearest future on a regional basis. The mechanisms of such an approach were the subject discussed since 1983, following an initiative of the EEC which promoted the creation of the Regional Committee of Fisheries of the Gulf of Guinea (COREP). The convention signed in June 1984 in Libreville (Gabon) and establishing the COREP is open for access to Cameroon and Angola. The convention which foresees the terms of elaboration of concerted policies also favours cooperation in connection with access to the fishing zones between member states. In fisheries research, the CRHO Limbe could play an important role in the sub-region.

Cameroon actively participates in the Fisheries Committee of the Central-East Atlantic (COPACE); it is important that pertinent planning measures recommended by the committee be effectively taken into consideration within the internal laws of Cameroon.

PRESENT AND FUTURE RESEARCH PROGRAMMES.

The existing research programmes are centred on :

- the biology and ecology of the Cameroon marine fauna and flora,
- the evaluation, identification of different types of pollutants in coastal and marine environment and their effect on the living resources exploited in Cameroon,
- the evaluation of fisheries stocks of the continental shelf,
- the conservation of fisheries products.

Marine fisheries research could be centred on :

a) Studies on biodiversity with a view to identifying the marine and coastal fisheries potential.
b) The introduction of new fishing techniques for the exploitation of the new resources.
c) Dynamics and evaluation of resources for their rational management.
d) Studies on the environment for a long-lasting development of the marine fisheries sector.
e) Evaluation and follow-up on the state of beaches, with particular attention on marine debris.

f) Introduction of improved techniques of handling, transformation, packaging and distribution of fishery products.
g) Studies on hydrodynamic parameters responsible for the dispersion of different stages of larvae of pelagic fishes and transportation of pollutants within the coastal and marine environment.
h) The evaluation and identification of toxic algae on marine fishes.
i) Monitoring and evaluation of different types of pollutants in resources.
j) Biomass studies and production mechanisms of plankton in the Cameroon coastal marine water

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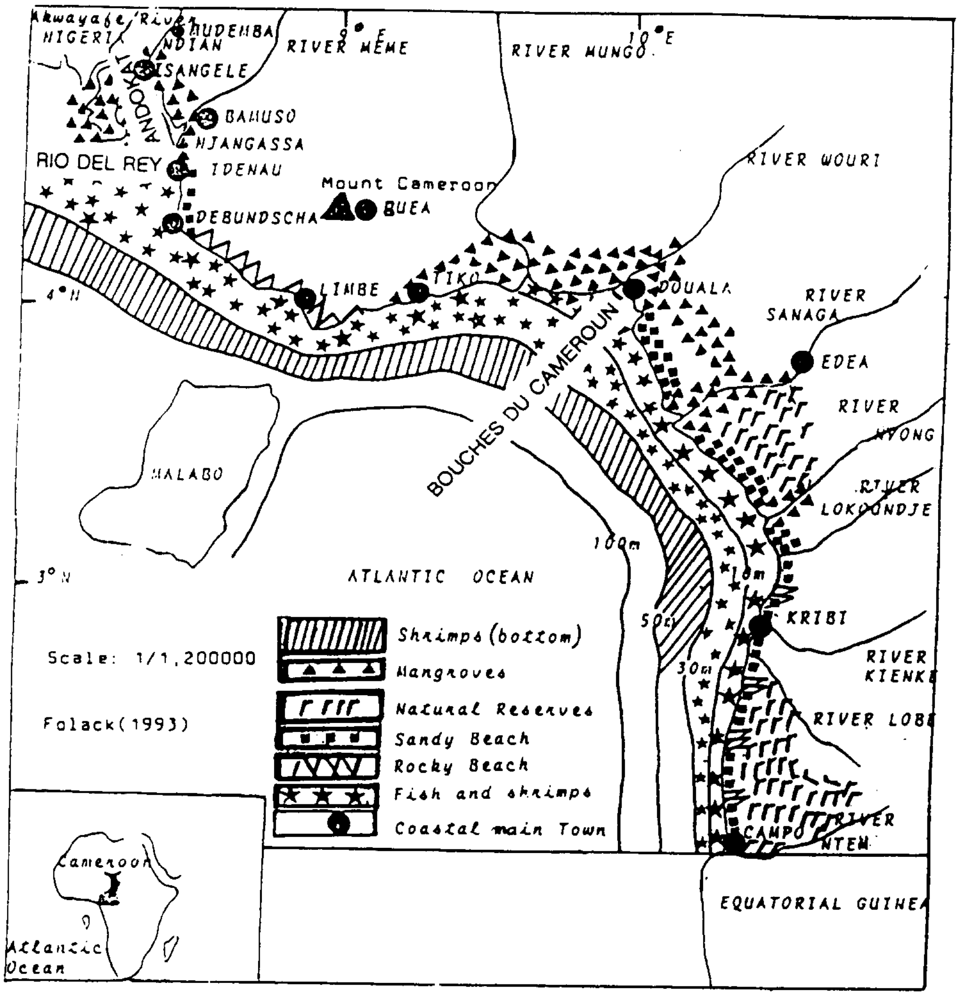

Figure 1. Characteristics of the Cameroon coastal zone

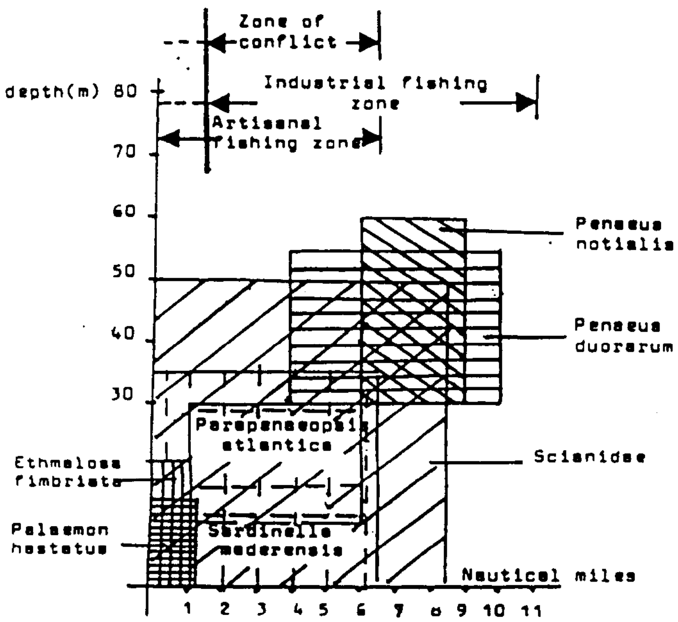

Figure 2. Fishing zones and different stocks exploited in Cameroon

Table 1:

Distribution and Ecology of principal species and main commercial categories exploited on Cameroon marine coastal water. (Folack, 1995).

Commercial categories	Scientific Name	Water characteristics	Nature of the bottom
Bar	*Pseudotolitus typus* (Bleeker, 1863) *P.Senegalensis* (Valenciennes, 1833)	Off-shore surface Water warm and little salted	
Petit Capitaine	*Galeoides decadactylus* (Block, 1795)		
Friture	*Brachydeuterus auritus* (Valenciennes, 1831) *Pteroscion peli* (Bleeker, 1863)		
Sardinelle	*Sardinella maderensis* (Lowe, 1939) *Ethmalosa fimbriata* (Bowdick, 1925)	Estuary. Water warm and salted	Light sandy-mud (6-30m)
Bossu	*Pseudotolithus elongatus* (Bodwick, 1825)		
Machoiron	*Arius spp*		
Disque	*Drepane africana* (Osorio, 1892)		
Friture	*Pentanemus quinquarius* (Linnaeus, 1758)		
Crevette	*Parapenaeopsis atlantica* (Blass, 1914) *Palaemon hastatus* (Aurivillius, 1989)		
Dorade rose	*Dentex angolensis* (Poll & Maul, 1953) *D.congolensis* (Poll, 1954)	Under thermocline Water cold and salted.	Light muddy-sand (40-108m)
Mérou	*Epinephelus aeneus* (Geoffroys St.Hilaire, 1809)		
Gros	*Lutjanus dentatus* (Dumeri, 1860) *Lutjanus goreensis* (Valenciennes, 1830)	Base of thermocline	
Sole	*Cynoglossus spp*	Thermocline zone	Light: mud and muddy-sand (15-100m)
Crevette	*Penaeus duoratum* (Burkenroad, 1939)		

THE IMPACT OF ANOMALOUS ENVIRONMENTAL CONDITIONS ON THE FISH STOCKS OF THE NORTHERN BENGUELA SYSTEM 1993 to 1995

by

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INTRODUCTION

The Benguela system is one of the four major eastern boundary upwelling regions and Namibia's coastline forms the eastern boundary of 1500 km of the northern part of this system. The upwelling process supports one of the richest fishing grounds in the world and, as with other coastal upwelling systems, the northern Benguela has relatively low species diversity. A dominant characteristic of these low-diversity/high productivity systems are their low levels of stability which are easily affected by anthropogenic and natural processes, particularly over-exploitation and anomalous environmental conditions.

For research and management purposes the Namibian marine system is divided into several biological zones in which a number of commercially important species of fish occur, for example :

Surface or epi-pelagic zone	*Pilchard Sardinops ocellatus*
Mid-water or meso-pelagic zone	*Horse mackerel Trachurus capensis*
Mear-bottom or demersal zone	*Hake Merluccius capensis*

This account describes some of the anomalous environmental conditions between 1993 and 1995 and the population dynamics of one of these species: pilchard. In particular we examine the impact of oceanographic conditions on the status of the pilchard stock during this period.

ENVIRONMENTAL CONDITIONS

The occurence of a Benguela Niño during 1994-1995 in the northern part of the system has been observed. Benguela Niños may be interpreted as an extension of the seasonal southward intrusion of warm, high salinity Angolan water, which is a normal occurrence during late summer off northern Namibia. During anomalous years the warm water penetrates further south than usual; as far as southern Namibia during a Benguela Niño in 1984 and at least to central Namibia during the 1995 event, and may persist for six months or more. The advection of warm, nutrient poor water may result in a deepening of the thermocline. Hence even under upwelling conditions, it is warm nutrient deficient water from above the thermocline which is brought to the surface and consequently the productivity of the system remains reduced.

Environmental conditions experienced off central Namibia from March 1995 indicated a Benguela Niño event. SST measurements and satellite imagery showed a strong intrusion of warm, highly saline water from Angola which reached the coast off central Namibia.

During 1993 and 1994 shipboard SST measurements in the northern Benguela were similar to the long-term mean. However, these years were characterised by other environmental anomalies in the system. Profiles of dissolved oxygen taken during 1993 showed a layer up to 100 m thick of very low oxygen water (<0.5ml/l) on the Namibian shelf. During 1994, these low oxygen conditions persisted, the tickness of the <0.5 ml/l layer reaching 300 m at times. Low bottom dissolved oxygen levels were recorded along virtually the entire coastline throughout the year. During 1994 large numbers of one of the top predators in the system, the Cape fur Seal *Arctocephalus pusillus* died from starvation. Also stocks of most of the commercially important fish species which had increased from 1990 to 1992, decreased during 1993 and 1994. This decline will be discussed below with reference to one of the small pelagic species, the pilchard.

PILCHARD STOCK DYNAMICS

During the last 18 years the pilchard stock size in the northern Benguela has been extremely low compared to the estimated virgin stock size. Historically there were two major declines in the pilchard stock, the first in the late 1960's followed by another in the early 1970's. These were precipitated by excessive fishing pressure, but changes in the environment are also likely to have played a role. The stock reached its lowest point in the early 1980's and has, until recently, failed to recover.

A significant increase in the size of the pilchard stock, compared to the 1980's, was documented between 1990 and 1992. It is believed that this increase was due almost entirely to the successful recruitment in 1990 of a cohort spawned during the summer period of 1988/89. Acoustic biomass surveys during the last three years have recorded a decline in the stock size, which is now at a comparable level to the early 1980's.

RECENT ENVIRONMENTAL IMPACTS ON THE PILCHARD STOCK

During the past 4 years there has been a gradual northwards movement of the stock. This change in distribution became particularly pronounced in 1994 and 1995 when most of the stock occurred in Angolan waters. This northward shift appears to be related to the unfavourable environmental conditions in the central Namibian region discussed above, but could also be due to localised over-fishing close to the off-loading port of Walvis Bay (in the central region).

While some recruitment occurred during 1991 and 1992, few recruits have joined the adult population since then. This recruitment failure is likely to be related to the adverse environmental conditions prevalent throughout much of the pilchard's normal range during this period, but is probably also linked to the small size of the adult sotck.

At the beginning of 1995 the pilchard stock was in a severely depleted state. During the Benguela Niño which developped in March a southwards movement of pilchard of some 2° to 4° latitude was recorded, which seemed to be consistent with the intrusion of the warm oceanic water.

The condition factor of pilchard measured throughout the area showed that the fish in the north, within the warm oceanic waters, were in a poorer condition than those south of the warm front. This suggests that the warm waters in the north caused stress to the fish; possibly by pushing them towards their physiological thermal limits or simply through lack of food resulting from the low primary productivity.

Two areas with dead and dying fish were recorded. Large numbers of dead horse mackerel *Trachurus capensis* were recorded over a long-shore distance of about 2° latitude and from the coast to the 100 m isobath. The density of dead fish increased considerably at the mouth of an ephemeral river which had recently flooded. It is suspected that the combination of warm marine water and an influx of fresh river water, with a high sediment load, may have resulted in the increased mortality in this region. The second region where large numbers of dead fish were recorded was in a northwards facing bay in southern Angola. It is possible that the pilchard in the bay had been trapped by the warm water intrusion approaching the coast from the north-west.

The impact of the warm water intrusion recorded during this time period seems to have been severe on at least some parts of the pilchard stock, affecting both movements and causing mortality to the normally resilient adult fish. In addition, this period of the year is normally the peak of spawning and so it must be assumed that any spawning activity or egg and larvae development could also have been disrupted. The implication for future cohorts may therefore be even more severe than for the current adult fish.

CONCLUSION

Namibia attained political independence in March 1990. The management and control of the marine resources by Namibians became possible at the same time and a strong policy of rebuilding the depleted resources to benefit to the people of Namibia was initiated. Despite several years of apparently rational and responsible management of Namibia's fish resources, the pilchard resource is currently in a worse state than at Independence. This applies to most of the living marine resources in Namibia. This seems to be a clear indication that the environment plays a dominant role in determining the state of the living resources in an upwelling system and that even the best management systems can thus be rendered ineffective. It is also worth noting that enhanced periods for recruitment and fish survival are likely to promote large increases in the fish populations, regardless of the management policies adopted.

HATCHDATE DISTRIBUTIONS OF PELAGIC FISH SPECIES AND THEIR RELATIONSHIP TO THE ENVIRONMENT OFF SOUTH AFRICA SOME PRELIMINARY RESULTS OF A BENGUELA ECOLOGY PROGRAMME STUDY.

by

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The Benguela Ecosystem is one of the four most important upwelling areas, consisting of the shelf-sea environment of the south and west-coasts of southern Africa. The prevailing southerly winds produce the upwelling of cool nutrient-rich water which supports high levels of biological production. This production supports commercially important populations of anchovy *Engraulis capensis*, sardine *Sardinops sagax* and chokka squid *Loligo vulgaris reynaudii*. In the southern parts of the system young anchovy and sardine are transported by currents from the spawning grounds on the poorly productive Agulhas Bank in the south to the west coast where there is abundant planktonic food for growth. On their southward journey back to the spawning grounds, the fish become available to the purse-seine fleet. The Agulhas Bank is also the spawning ground for the chokka squid.

The Benguela Ecology Programme (BEP) is an interdisciplinary, multi-institutional marine ecological research programme which coordinates and facilitates research into selected living resources of the Benguela ecosystem and their environment, with particular emphasis on the southern areas. The BEP has now almost completed it's third five-year phase and deals with aspects of short and long-term variability and how these affect the key pelagic species, as well as squid. As a result of their compact life-style these species are highly vunerable to environmental change, and consequently show large interannual changes in population numbers.

The Sardine and Anchovy Recruitment Programme (SARP), a joint effort by the Sea Fisheries Research Institute (SFRI) and one of the projects within the BEP, *Factors Affecting the Distribution and Variabilbity of Anchovy and Sardine*, is an attempt to study within season-variability in the spawning of adult fish on the western Agulhas Bank and consequent recruitment of juveniles to the fishery. The attempt should provide some sort of predictive tool for the management of the two species. Simulation studies have shown that the average annual anchovy yield can be increased by 16% with just a small change in the ability to predict above median recruitment from median or below.

In conjunction with the hatchdate distributions of the recruits, several factors which are believed to have some role in regulating recruitment are monitored on a monthly basis throughout the spawning season of the two species. These include environmental factors (wind stress, and it's related SST and current profiles) and biological factors (chlorophyll measurements, zooplankton biomass and production, distribution of the fish and their predators and reproductive condition).

Sampling for the construction of hatchdate distributions is conducted on the annual hydroacoustic recruitment surveys conducted by the SFRI in May/June every year. The otoliths are removed from subsamples of fish and then daily age is determined by using image analysis techniques. Some of the data from the spawning season of 1992/1993 have been analysed.

250 anchovy and 115 sardine otoliths were successfully prepared and analysed for the construction of hatchdate distributions and growth curves. For anchovy the Gompertz growth curve provided the best fit and mean anchovy growth rate was 0.39mm.day . The hatchdate distribution indicates recruitment was unusually late, 67% occurring in late December and early January. For sardine the Gompertz growth equation again provided the best fit with a mean growth rate of 0.6mm.day . The hatchdate distribution suggests that spawning occurs throughout the year, with 3 or more peaks. The largest of these peaks occurs in January with 58%. The growth rates for both species were amongst the highest recorded for the two species, and indicate that conditions for growth were good throughout the year, but survival was poor in the earlier part of the season. However, anchovy survival after the midyear survey was poor, and subsequent spawning biomass was low. The reason for this is not clear.

The hatchdate distributions for both species show significant pulsing, pulses occurring approximately four weeks apart. Although the evidence for a lunar influence on spawning is weak, the two species may spawn out of phase with each other, anchovy coinciding with new moon, and sardine with full moon. There is also slight evidence for Cury and Roy's optimal environmental window, with higher recruitment coinciding with periods of moderate southerly winds.

Any one of several factors may have resulted in the late onset of recruitment for both species. In the early part of the season, winds were more variable, with a relatively low proportion of southerlies. This may have resulted in the reduced advection of spawning products onto the west coast. In addition, the passage of a warm Agulhas ring as indicated by the close proximity to the shore of the 16° isotherm (3.3km) may have advected spawning products offshore, preventing their return. Later in the season, southerly winds were more persistent, as indicated by the lower number of calm periods, and this is important for the strength of the frontal jet current, which transports spawning products into the more favourable food environment north of Cape Columbine.

The construction of hatchdate distributions also enables one to examine migration patterns in fish. Eggs and larvae are transported around the coast from Agulhas Bank by the jet. At 6 to 8cm the fish then migrate inshore at approximately four months of age. The fish then return south with the aid of the southward-flowing inshore return current when they retun to the Agulhas Bank to spawn in their first year. The total migration lasts approximately nine months. The second southern leg lasts longer than the first leg, and this suggests that fish do not retun immediately to the Agulhas Bank, but prefer to remain on the west, building up their energy reserves for spawning.

This work is still in the preliminary stages, and there are several other aspects that still need to be covered, for example :

i) how the amplitude and span of a peak in the hatchdate distribution is affected by the time at which a particular variable is at optimal level
ii) migration in sardine
iii) differences between inter- and intra-shoal variability in daily growth rates, and how these relate to the environment
iv) comparing early growth rates of juvenile fish caught during the season with the growth rates of fish caught in May. This is to examine how initial growth rate of young fish affect ultimate survival (May's variation on Hjort's "critical period concept")

Other than data generated by SARP, satellite imagery will provide an important tool for the study.

PRELIMINARY FOODWEB OF THE NORTHERN BENGUELA ECOSYSTEM

by

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Dynamical systems, such as the northern Benguela, will be better understood if the complex array of intractions from primary production to top consumers are assessed in terms of energy production and transfer between the various biotic components. This approach has successfully been applied in systems such as the Peruvian and southern Benguela upwelling regions, in the highly productive Chesapeake Bay, the Baltic Sea, North Sea, and various other smaller embayments, estuaries and lakes. The objective of this presentation is to provide a preliminary descriptive model of the pelagic section of the northern Benguela ecosystem given as a flow diagram that includes the biomasses and flows. The information used to provide this model were mostly obtained from the literature.

For this study the Northern Benguela ecosystem is defined as the area between 15°S and 29°S, stretching from the coast to the 500m depth contour. It covers an area of 179 000 km² and supports a substancial and diverse fishery comprising of pelagic planktivorous fish species, their mesopelagic and demersal predators as well as various other species.

The flow diagram of the Northern Benguela ecosystem includes phytoplankton as the main producer. The pelagic food web includes zooplankton, anchovy, pilchard, horse mackerel, lanternfish and gobies, whereas the demersal predators include chub mackerel, kingklip and hake. Other species of importance are the rock lobster, squid, snoek, deep sea red crabs, dolphins, birds and seals. For this presentation emphasis is put on the grazing chain, where phytoplankton is the only primary producer, zooplankton the primary consumer and pelagic fish secondary consumers.

The Benguela is generally a diatom-dominated system with microflagellates contributing a major fraction of phytoplankton carbon in the northern Benguela. Phytoplankton biomass in the Northern Benguela amounts to about 2.5 million tons C, with the overall annual carbon production being 77 million tons. Under natural conditions, healthy phytoplankton cells exude photosynthetically fixed dissolved organic carbon (PDOC) which becomes available to bacteria and the microbial loop. Losses of between 3 and 50% have been reported, but usually a value of 25% is used. Phytoplankton is also consumed by zooplankton, 15% of phytoplankton production being consumed by mesozooplankton, and 3% by macrozooplankton, while pelagic fish such as anchovy, pilchard and gobies also consume phytoplankton, although in very small amounts. The remaining 56% of phytoplankton production is assumed to be broken down into POC.

The bulk (90%-98%) of the zooplankton of the Northern Benguela, in terms of numbers and biomass, include some 20-30 species of copepods, chaetognaths and euphausiids, with copepods (40%) and euphausiids (29%) contributing almost 70% and chaetognaths contributing 7.8% of the zooplankton biomass. More than 50% of the zooplankton biomass correspond to macrozooplankton - or zooplankton larger than 2000 µm. The mesozooplankton consist of two groups, those in the size range 500-1000 µm and those in the size range 1000-2000 µm. Any zooplankton smaller than 500 µm is referred to as microzooplankton.

Microzooplankton is actually part of the microbial loop, and not well studied in the Northern Benguela, thus no biomass or any other energetic values are available at present. Under most circumstances there is little direct transfer of carbon to metazoa via active microbial food webs, but the microbial food web is an active component of pelagic food webs in the marine environment. Ciliates and other microplankters feed on algae, flagellates, bacteria, DOM and POM and are exploited by the mesozooplankton which are both filter feeders, like the calanoid copepods and rotifers, or raptorial feeders like the cyclopoid copepods.

Mesozooplanktons consist mainly of copepods and juvenile euphausiids and is considered to be primarily herbivorous. The standing stock of mesozooplankton in the Northern Benguela is approximately $1.0gC.m^{-2}$. Half of the carbon consumed by mesozooplankton comes from phytoplankton, with the remaining 50% being derived from microzooplankton (from the microbial loop). Approximately one third of the mesozooplankton carbon consumed annually is accounted for by epi- and mesopelagic and demersal fish. The combined predation by macrozooplankton and jellyfish in the Northern Benguela account for about 66% of the total consumption of mesozooplankton.

Macrozooplankton include the euphausiids, chaetognaths and hyperiid amphipods, and is typically omnivorous. The standing stock of macrozooplankton in the Northern Benguela is $0.6gC.m^{-2}$. Approximately 60% of the total carbon ingested by macrozooplankton is in the form of phytoplankton with the remaining 40% consisting of mesozooplankton. As macrozooplankton are constantly present in large quantities within the Benguela ecosystem they form a large part of the food of zooplanktivorous fish. Macrozooplankton are consumed by pelagic fish (51%), squid (4.8%), hake (12.5%) and various other predators.

Anchovy has a biomass of $0.1\ gC.m^{-2}$ and 15% of anchovy consumption is derived from phytoplankton, 5% from microzooplankton, 40% from mesozooplankton and 40% from macroplankton. Anchovy has a natural mortality of 73% and the annual catch of anchovy in 1994 was 21% of the total anchovy production. The remaining 5% of anchowy production is probably exported from the system. Of the 73% natural mortality of anchovy in the Northen Benguela 82% was consumed by predatory fish such as hake, snoek and chub mackerel, 12% by marine mammals,mainly the Cape fur seal, and 6% by sea birds.

Pilchard has a biomass of $0.2gC.m^{-2}$ and their consumption include 32% phytoplankton, 12% microzooplankton, 28% mesozooplankton and 28% macrozooplankton, while they are eaten by snoek, chub mackerel, hake and other demersal fish, sea birds and mammals. Pilchard has a natural mortality of 50% and the catch for pilchard during 1994 was 57% of the total production. Thus the total mortality is more than the total production of this species, which will decrease the biomass of this stock.

The diet of adult, juvenile and larval gobies (biomass = $0.5gC.m^{-2}$) consists predominantly of the large, chain forming diatoms, while euphausiids and copepods are the dominant zooplankton groups consumed by gobies. So 90% of the diet of gobies in the Northern Benguela is derived from phytoplankton and 10% from macrozooplankton. Pelagic gobies are a major food item for many species off Namibia, including cape horse mackerel, cape hakes, kingklip and some other predatory fish, coastal breeding seabirds, and the cape fur seal.

The diet of lanternfish (biomass = $0.6gC.m^{-2}$) caught by purse-seine off the Western Cape during the 1970s consisted entirely of zooplankton, copepods contributing 62%, amphipods 27%, and euphausiids 12%. Thus lanternfish only feed on meso- and macrozooplankton, in the ratio 40:60. Total annual mortality rates are estimated at 0.24, most of which eminates from natural mortality. Off Namibia lenternfish provide a major forage resource for many predators, being regularly reported in feeding studies of horse mackerel, hakes, kingklip and other predatory fish.

The main food items of near-bottom horse mackerel (biomass 1.1 $gC.m^{-2}$) were euphausiids and shrimps, while those for mid-water horse mackerel were chiefly euphausiids with up to 33% consisting of lanternfish. Although euphausiids are the main food source for horse mackerel, copepods contribute 74% by mass of the food of small horse mackerel. Thus, 83% of the horse mackerel diet consists of mesozooplankton, while macrozooplankton only make up 16% of the diet and the remaining 1% is derived from lanternfish. The catch of horse mackerel in the Northern Benguela for 1994 was 18% of the total production of this population and the natural mortality of Cape horse mackerel, off Namibia, ranging between 0.27 and 0.52, with 40% being thought as appropriate.

Thus pelagic fish in general feed on phytoplankton, micro-, meso- and macrozooplankton, while they are predated on by demersal fish, snoek, seabirds and mammals. If we put all these compartments together the pelagic flow diagram emerge. Other components of importance in this system include predators such as the jellyfish, squid, predatory fish, that include demersal fish, mammals such as dolphins and seals, and sea birds. The total flow diagram of this ecosystem will only emerge once all these other components has been looked at, and when the total flow diagram is compiled it will be subjected to network Analysis in order to compare this system to other systems, such as the Southern Benguela.

THE ROLE OF TRANSPORT OF ANCHOVY BY ADVECTIVE PROCESSES OFF SOUTH AFRICA : A MODELLING STUDY

by

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WHAT ARE CLUPEOIDS?

Clupeoids are small, schooling fish, inhabiting the upper layers of the ocean (epipelagic) and feeding mainly on plankton in upwelling regions. Clupeoids belong to the order Clupeiformes, which is comprised of two groups : clupeids (sardines, herring, round herring and sardinella) and engraulids (anchovy species).

HOW DO ENVIRONMENTAL FACTORS AFFECT CLUPEOIDS?

Populations of clupeoids are sensitive to environmental variability and are subject to large natural fluctuations in stock size (Shackleton 1987, Lluch-Belda et al. 1989, Lluch-Belda et al. 1992). Factors thought responsible for most of the natural variability in fish stocks include temperature, turbulence, transport, food, predation and population density (Parrish et al. 1983).

Altered conditions arising from global environmental change may influence survival of the early life stages of anchovy, and hence the quantity of anchovy available to the fishery off South Africa (Shannon et al. 1988, Siegfried et al. 1990). There is much debate regarding the consequences of global climate change, but it has been predicted that major and sudden changes in marine populations will result as the climate changes (Bakun 1994).

SETTING THE SOUTH AFRICAN SCENE

Anchovy are currently the mainstay of the pelagic fishing industry. Fig.1 and Fig.2 show the physical oceanography off South Africa, the life history and migration of Cape anchovy

THE MODEL

A model was developed to simulate spawning of anchovy eggs and the subsequent transport of reproductive products six months after spawning (age at which they become susceptible to the fishery). Young of the year retained near coastal regions were assumed to contribute to year-class strength, whereas batches of eggs and larvae transported to areas far offshore that are unfavourable for survival were considered to have been lost from the system.

1) A 1/4 by 1/4 degree rectangular grid stretching from 29°S to 36°45'S, and 15°E to 28°E was used
2) The model uses two data sets :
   a) ACOUSTIC DOPPLER CURRENT PROFILE (ADCP) data, averaged from 30m and 50m depths ie. above the thermocline, where these pelagic fish are found.
   b) ACOUSTICALLY-MEASURED SPAWNER BIOMASS DATA.
3) Transient features such as eddies and filaments, as well as smaller scale diffusion, are simulated by adding random components to the ADCP vectors.

4) A spawning distribution is chosen from one of the seven historical distributions.
5) Each batch is tracked on an hourly timescale. Numbers are reduced hourly by stage dependent mortality rates for 180 days or until one of the boundaries has been crossed.
6) Anchovy surviving to 180 days are summed as recruits and those crossing a loss boundary are summed as advective losses.

MODEL APPLICATIONS

The model was applied in two ways :

Spawner distribution influence spatial distribution of recruits

The model shows that the spatial distribution of spawning anchovy influences the spatial distribution of recruits (six-month old anchovy susceptible to the fishery as well as the number and location of advective losses across offshore boundaries). However, **predator-prey distributions** and **abundances** need to be considered relative to spawning position. In particular, the implications of cannibalism of eggs by spawning adults (Valdes-Szeinfeld and Cochrane 1992) should vary with spawning distribution and abundance.

In addition, since observed distributions of recruits do not differ as much from year to year (Hampton 1992), factors other than advective processes must be influencing young-of-the-year anchovy distributions (e.g. active swimming).

Altered advection effects on year class strength
(n° of young surviving to six months)

Altered Westward advection only : Model year-class strength increased under an intermediate level of reduced westward advection, but decreased when westward advection was enhanced or futher reduced. This may be viewed in terms of Cury and Roy's (1989) "Optimal environmental window" hypothesis, where an intermediate level of reduced westward advection is favourable for anchovy survival off South Africa. However, enhanced westward advection served to move anchovy eggs and larvae into the region of the jet current, thereby enhancing the proportion of recruitment off the west coast between 29°S and Cape Columbine.

Altered Westward and Northward advection : Reduced westward and northward advection led to a mean year-class strength more than double that of the base and enhanced advection scenarios and facilitated accumulation of young of the year in all strata in the model. Advective losses were restricted south and west of Cape Columbine. Enhanced westward and northward advection moved model anchovy westwards. Although transport into more productive waters of the west coast was enhanced, the likelihood of advection into unproductive offshore waters was also greater in this region, thereby preventing good recruitment under this scenario. Since advection is generally westwards and northwards, and because it was further enhanced, batches in offshore regions were lost to advection before reaching far up the west coast.

CONCLUSIONS

This modelling study of the southern Benguela system showed that the passive transport of anchovy by currents from spawning grounds to nursery areas is a fairly robust process, sensitive only to extreme change. Advection may be influenced by environmental change, through altered turbulence levels and/or current vectors, both of which have implications for anchovy transport off South Africa.

In these ways, altered advection may impact on the fishing industry. In addition to the direct effects of climate change through altered advection is the influence of a changing climate on the spatial distribution of spawners and hence availability of anchovy to the fishery. These should be viewed together when attempting to assess possible impacts of climate change an anchovy variability. How survival of young will be affected by factors other than advection should also be considered. These were not addressed by this particular study

This work is discussed in :

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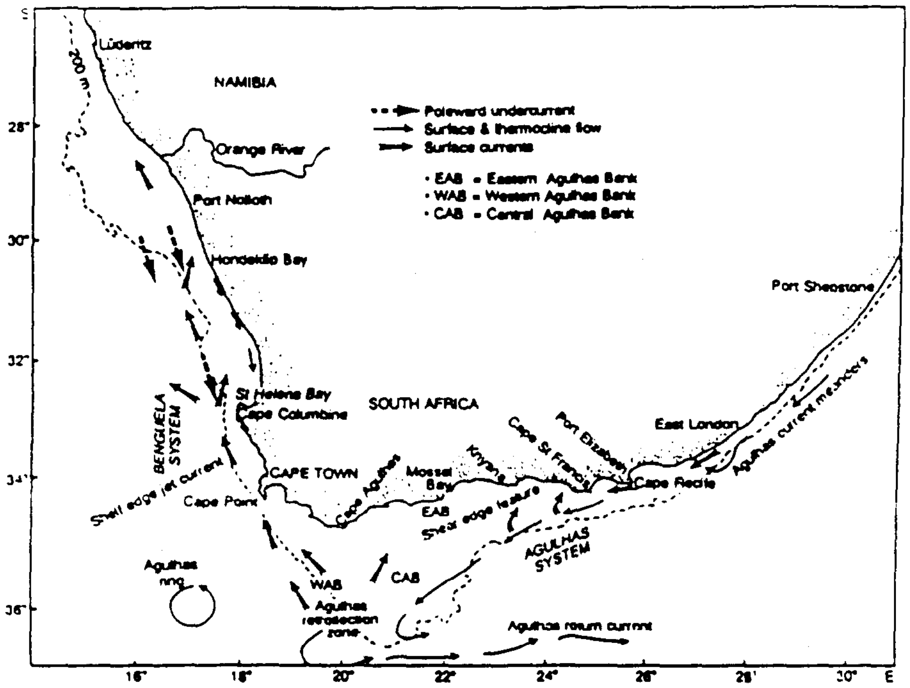

Figure 1.1. Schematic representation of the main oceanographic features off South Africa (adapted from Shannon 1989 and Shannon and Nelson in Press)

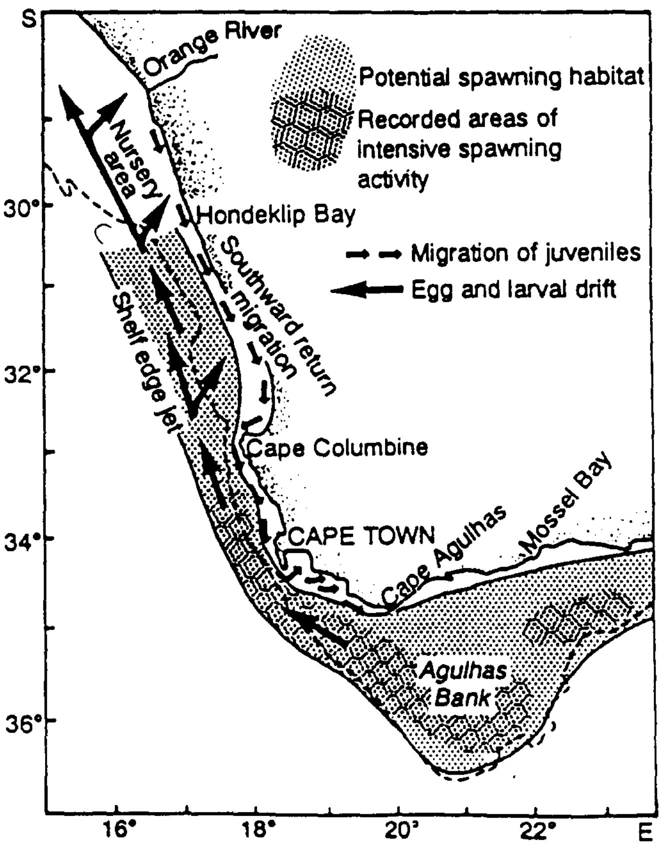

Figure 1.2. Map showing the migration of anchovy from spawning grounds to the nursery areas and back (adapted from Armstrong and Thomas 1989)

Abstracts of other contributions to the workshop

- Upwelling and hydrology processes on the continental shelf of Guinea, CAMARA Seny, CERESCOR BP 1615 Conakry Guinea

  Brief review of the activity of CERESCOR (Scientific Research Centre of Conakry Rogbane) in agreement with the more detailed contribution of S.T. Diallo, C.N.S.H.B. Guinea.(pp10-16)

- Coastal sea surface temperature study using METEOSAT IRT data, FOFANA, S., AMAN, A., KEITA, M. Dept. Physics Faculty of Sciences and Technics, Univ. Abidjan 22 PO. Box 582 Abidjan 22, Côte d'Ivoire

  IRT data received from METEOSAT during the year 1993 have been used to study the upwelling which takes place twice a year along the coast of Côte d'Ivoire and Ghana. This study shows that the use of METEOSAT data is appropriate to detect the Sea Surface Temperature (SST).
  During the year 1993, the minor upwelling has been observed two times (in January and in March during the dry season). In the two cases, it lasts for less than a week, however, the relative cooling is detected by the METEOSAT. Each time the upwelling took place, we noticed that the sky was clear. It seems therefore important for future investigations to evaluate the impact of climate on upwellings and vice-versa.
  The Major upwelling began approximatively in July and lasted 2 months. The decrease of the coastal sea surface temperature stretches out near Cape Palmas as far as the Ghana coastline.
  These preliminary results of our study confirm the importance of using satellite information in SST analyses. Spatial analyses of pelagic ressources and fisheries using METEOSAT data may provide additional perspective for understanding the origin of upwelling and for improved fishing in the study area. The multitemporal study of the SST along the coastline of Côte d'Ivoire and Ghana associated with climatic conditions evaluations must contribute to understand the mechanism of the phenomenon.

- Sea level variations along the coastal areas in Nigeria, Dr. P.C. NWILO, Dept. Surveying, Univ. of Lagos, Akoka-Lagos Nigeria

  Nineteen years of observed tidal data from Bonny supplemented with data from Forcados and Lagos have been used to study sea level variations along the Nigerian coast. All the informations were subjected to quality controls. The data from Bonny and Lagos were of good quality although the Lagos ones had several gaps. The data from Forcados covered the 19 years time span but were not good enough for some aspects of research as it seemed that all the data were not from the same location.
  From the computation and analysis of results, it was concluded that the sea level was rising at a rate of 1.0mm per annum compared to the global average of 1-2mm (Nwilo et al., 1995 & 1995). The contribution due to subsidence which is known to be taking place at the Nigerian Coast has not been determined because the tide gauge benchmark has not been connected to a stable control point and monitored regularly. Maximum surges of the order of 0.7m and seasonal variations in sea level were observed. A graph of monthly mean sea level against time showed that there were two peaks and two lows every year. The peaks occurred generally around February/March and September/October and the lows were noticed around the months of June and December. There was a maximum amplitude of about 18cm at the Bonny port, Nigeria. Similar variations were observed at the Takoradi port in Ghana and Abidjan port in Côte d'Ivoire (Nwilo, 1995). The low sea levels observed along the Nigerian coast and other West African Coasts regions up to Abidjan

around June and December seem to indicate the effect of upwelling along these coasts which has to be confirmed through further reserach.
Frequency distribution of sea levels along the Nigerian coast showed two bumps which correspond with mean low neap tide and mean high neap tide. The bumps were quite pronouced at Bonny in the east and absent at Lagos in the west. This characteristic is known to be common with areas with semi diurnal tides. When the tides along the coast were predicted without the M_2 constituent, the ranges are reduced and a frequency curve distribution of the tidal data no longer showed the two bumps. No other constituent showed this form of characteristic. This confirmed that the M_2constituent is the most dominant tidal constituent along the coast. It is also observed that the tidal ranges decreased from 4.00m in Calabar close to the Nigerian border with the Republic of Cameroon (in the east) to 1.5m at Lagos close the Nigerian western border.
Continuous data collection , further researches and regional cooperations on the issue of sea level variations and subsidence are seen as important in understanding the Nigerian Coastal dynamics.

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- The dynamics of northern Benguala upwelling system as revealed by remote sensing and its relationship to patterns of clupeoid production. A proposal. J. COLE, Ecosys. Anal. Management group, Univ. Warwick, Coventry CV4 7AL U.K.

This project aims to investigate the upwelling dynamics of the northern Benguela primarily using weekly composite images of sea surface temperature (SST) for the period 1981-1991, and to relate observed trends to patterns in the reproductive ecology of pilchard and anchovy. As such it will be a first step toward higher resolution studies of the relationship between environmental dynamics and pelagic fisheries in the region. The ultimate goal being the analysis of SST images as a basis for making recruitment predictions which are sufficiently robust for inclusion in pelagic fisheries management models.
SST images have a number of advantages over data collected from more traditional methods such as surveys. They provide synoptic coverage of large areas of ocean and the time intervals between successive images are relatively short. Their high spatio-temporal resolution consequently allows for indices of SST and upwelling activity to be constructed across a wide range of space and time scales. Futhermore SST, as an indice, has the advantage of being an integrated function of upwelling and processes which cause stratification of the water column; namely warming of the surface layers by insolation, and advection of warmer masses of water from the edges of the system. As such SST reflects the balance between the differing hydrographic processes considered important in influencing the reproductive success of clupeoid populations in these areas. The main disadvantages of SST images are related to cloud cover and to SST values which are not representative of the surface layer due to differential warming of the surface skin of the ocean during calm conditions.
This research will be seperated into two main stages. In the first stage the hydrographic dynamics of the system will be investigated. Standardized principal compoments analysis will be performed on the time series of SST images in an attempt to identify underlying trends and periodicities in the system's dynamics. In addition various indices considered to be related to upwelling activity, such as SST itself, will be extracted from the time series of images. The principal components

analysis and the extraction of indices will be performed specifically for those areas which are known to be important for the reproduction and development of pilchard and anchovy.
The second stage will involve relating observed environmental trends to the reproductive ecology of the two species for particular years. Specific theories will be tested as regards the timing and location of spawning, the timing and distribution of the main larvae concentrations, the birthdates of recruiting year classes, and recruitment success. Particular emphasis will be laid on investigating environmental variability and the phasing of upwelling vs calm conditions as regards spawning, abundance of larvae, and birthdates of recruiting cohorts.
Given the widely postulated importance of upwelling activity and variability on clupeoid recruitment success, and the ability of SST images to provide high resolution representations of upwelling activity, it is believed that the analysis of time-series of SST images in conjunction with fisheries data could prove to be valuable in gaining a better understanding of the local processes involved in determing recruitment success.

- The governance of Mauritanian fish resources J. MAUS, Ecosys. Anal. Management group, Univ. Warwick, Coventry CVA 7AL U.K.

Lack of understanding of the ecosystem (and its dynamics) is often not the main reason for the failure of sustainable resource management. "Effective" communication and interaction between researchers and managers, and between government and society are essential prerequisites for the success of resource management. In other words, a management system should "fit" both the resource it is managing, and the society in which it is placed. This basic concept is the starting point for this research. Despite of its importance, it has so far received little attention in fisheries management issues.
The theoretical framework is provided by the governance theories as developed by Kooiman (1993). It describes the interaction between society and government and the effectiveness of management systems in reaching their goals. Societal diversity, complexity and dynamics are central issues in this. The application to fisheries management issues has recently started through a research programme between the University of Warwick and the Erasmus University of Rotterdam (UoW, 1994)
Mauritania has a relative young fisheries sector and a productive, but highly dynamic and uncertain resource. The approach in Mauritania is to study :

1. The socio-political governance of the resource : analysing the role of governing institution (public and private) and societal groups in the management of the resources, especially their mutual interactions. This is mainly done through the study of data flows on fisheries in Mauritania. It enables to study the role of institutions and other actors in management, and it allows an analysis of the quality and quantity of fisheries data.
2. The ecological basis for the fishery policy, i.e; the relationship between what is known about the ecosystem and its dynamics and how this is reflected by the policies put in place. Besides fieldwork and literature review, satellite imagery in combination with fisheries data will be used as a tool to characterize ecosystem dynamics.

Fully this study will contributes to the further development of an effective, sustainable resource management system and a profitable fisheries sector in the country.

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