Intergovernmental Oceanographic Commission

Workshop Report No. 136

IOC Regional Workshop for Member States of Western Africa - GODAR-VI (Global Oceanographic Data Archeology and Rescue Project)

Accra, Ghana
22-25 April 1997

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SUMMARY REPORT

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1. OPENING CEREMONY

Mr. C.A. Biney, Ag. Director of the Water Research Institute of the Council for Scientific and Industrial Research (CSIR) who is also the Chairman of the Ghana National Committee for the IOC, introduced Dr. M.A. Odei, an eminent scientist, a pioneer in marine research in Ghana and also the Deputy Director-General of CSIR as the Chairman of the Opening Ceremony.

Dr. Odei called the Workshop to order at 9:30 on 22 April 1997 and welcomed the participants to the Sixth Regional GODAR Workshop for the countries of Western Africa, which took place at the auditorium of the Science and Technology Policy Research Institute (STEPRI) of CSIR.

He stressed increased national and international interests in the oceans as source of food, mineral resources and water. He emphasised that an increase in population increases our demands for resources. Industrial development of coastal areas and waste disposal from urban regions can dramatically change the coastal oceanic environment. The agro-chemicals which are so important for food production after being washed off to the sea alter nature's balance and bring changes in the physical, chemical and biological conditions of the oceans.

Dr. Odei then referred to the importance of the studies of the ocean processes and ocean-atmosphere interactions. He called on the participants to know more about geological and physical processes that determine the nature and character of the ocean and sea floor. To achieve this goal there is an urgency in systematic collection of vital oceanographic data, protection of collected data and managing such data in accordance with internationally agreed procedures.

In a welcome address, the Secretary-General of the Ghana National Commission for UNESCO, Mr. Kusi Achampong outlined the activities of the Commission. He identified linkages with IOC that made it relevant for the choice to host the Workshop in Ghana.

He then referred to the IOC 'Comprehensive Plan for a Major Assistance Programme to Enhance the Marine Science Capacities of Developing Countries' as the basis for the marine-related activities in Ghana. Established in November 1985, the twenty-one member Ghana National Committee for IOC provides a valuable national mechanism for the implementation of the plan and co-operation with the international community in the field of ocean science and services..

Speaking on behalf of the Executive Secretary IOC, Dr. I. Oliounine expressed thanks to the Government of Ghana and national institutions for hosting the Workshop and providing facilities. He paid special tribute to the Ministers of Education and Environment, Science and Technology, as well as to the National Commission for UNESCO and the National Commission for the IOC, for their valuable contributions to the Workshop. He cited that among the reasons for selecting Ghana as a meeting place, was the interest of the country in marine-related activities, the presence of the IODE infrastructure in the country and the strong UNESCO and IOC National Bodies. He briefly presented the objectives of the Workshop which included promotion of marine-related activities and collection and protection of data, identification of national and regional needs in ocean data management and establishment of co-operation between data managers. He wished the participants every success and a nice stay in Accra.

The GODAR Project Leader, Mr. S. Levitus, presented the history of the project development, stressed the benefits of the project implementation through the regional approach and outlined the broader objectives of the GODAR project as making oceanographic data easily accessible and available worldwide without restriction.

Mr. Levitus informed the participants of the progress achieved in the project implementation. He also presented some products developed on the basis of the data rescue operation and emphasized that the GODAR Project could not be successful without the goodwill of scientists and data managers and their readiness to co-operate. He praised the local organizers of the Workshop and noted that more data due to the project work will be available to the world in future.

The Vice-Chairman of the IOCEA Regional Committee, Mr. J. Wellens-Mensah highlighted the significance of data rescue and outlined the activities of IOCEA for the period 1995-1997. He paid special attention to the IOCEA decisions related to facilitating IODE programmes in the region including the establishment of a regional oceanographic data centre, launching of the RECOSCIX-CEA Project, assistance in organization of national data management infrastructure and the organization of training courses and workshops. These give an indication of the importance that IOCEA attaches to the management, dissemination and integration of oceanographic data.

The statement of Mr. J. Wellens-Mensah concluded with a specific recommendation with regard to soliciting funds for the establishment of data centres, for overcoming communication problems faced by people in the region, and for meeting needs in training and equipment.

A brief remark by Mr. B.C. Eghan, Chief Director of the Ministry of Environment, Science and Technology who represented the Ministry, stated Ghana's commitment and obligation to co-operate with the international community in programmes designed to protect the environment. Ghana has therefore signed a number of conventions in this direction.

To conclude the opening ceremony, the keynote address was delivered by Mr. J.S. Dalrymple-Hayfron, the Chief Director of the Ministry of Education who conveyed the assurance and best wishes of the Minister to the Workshop. The Minister tasked the Workshop to make positive efforts in identification of data holdings, formulation of recommendations for data rescue and facilitation of co-operation in data exchange between Member States of the Region. The Minister also expressed the belief that the Workshop will adopt practical approaches which would be realistic and beneficial to the region.

The Chairman declared the Sixth Regional Workshop on GODAR open. Full texts of the welcome addresses of Mr. J. Kusi-Achampong and Mr. J.S. Dalrymple-Hayfron are presented in Annex III.

2. ADMINISTRATIVE ARRANGEMENTS

The Workshop was co-Chaired by Mr. S. Levitus (USA) and Dr. L. Awosika (Nigeria). The provisional programme was adopted as circulated and it was agreed that necessary adjustments would be made if the need arose.

Mr. S. Levitus invited nomination for a Rapporteur. The expert from Senegal, Dr. A.O. Ba proposed Mr. A. Abdulai-Saiku from Ghana as the Rapporteur. This nomination was accepted by acclamation. The Co-Chairmen congratulated the elected Rapporteur and invited him to join the podium.

The Technical Secretary reviewed the arrangements for the Session, explained the format for preparation of the Workshop report and introduced the Timetable. It was agreed that though the Workshop would work in plenary, *ad hoc* working groups could be arranged if the need arose.

A Representative of the local organizing committee informed participants of the local arrangements and expressed the hope that the participants would find time in their heavy schedule to look around and enjoy the proverbial Ghanaian hospitality.

3. TALKS BY INVITED SPEAKERS (ABSTRACTS)

3.1 IODE TODAY AND AFTER THE YEAR 2000 - *I. Oliounine*

Since its establishment in 1961, the IODE Programme has matured to become one of the most respected and important IOC programmes. Today, the International Oceanographic Data and Information

Exchange System has a global coverage and comprises of more than 60 NODCs/DNAs, 11 RNODCs and 5 WDCs for Oceanography and Marine Geology and Geophysics. The objective of IODE is to create an integrated and technologically advanced data management, data and information processing and data distribution system to serve a wide range of user communities by providing products and services for science, industry and education. To achieve it, the system is based on free and open access to data. Some achievements of IODE were highlighted including the implementation of the GTSPP and GODAR projects and the development of GTSPP and World Ocean Atlas '94 CD-ROMs; support to GLOSS and GEBCO programmes by the issuance of joint CD-ROMs; publication of numerous guides and manuals to help data managers in their work; and arrangement of training courses and workshops in order to assist Member States in their capacity building.

The last decade marked a remarkable increase of interest in oceanographic data and the IODE activities. Political changes and technological achievements together give users a strong hope that their needs in data will be successfully met.

The talk showed what the IODE's role in new observing systems can be. The Speaker identified the shortcomings in the IODE system and presented ways to overcome them. At least two aspects required special attention and development. They include development of methods for integrating metadata and quality control information into databases and methods for handling huge volumes of the non-conventional data.

Future IODE system will have, as possible core elements, inputs from *in situ* data, remote sensing and models. This will include elements inter-relating the different outputs, calibration and validation procedures, integration of the data from different input sources in a common geo- and time-referenced network using GIS as a tool and development of sophisticated knowledge-based and information referral systems. The philosophy of end-to-end data management will be a foundation of the IODE system modification.

3.2 GODAR PROJECT: PAST, PRESENT AND FUTURE - *S. Levitus*

Since its inception in March 1993, the GODAR Project has resulted in the 'transfer' of approximately 1.4 million temperature profiles and 300,000 salinity profiles to the World Data Centre archive of digital data. Approximately 500 sets of the World Ocean Atlas 1994 CD-ROM series have been distributed internationally. The distribution of the next set of GODAR products is planned for the latter part of 1997. The new release will contain an additional 600,000 temperature profiles, 100,000 salinity profiles, 120,000 chlorophyll profiles and 600,000 plankton observations, as well as smaller amounts of other parameters such as nutrients.

A review of the results of the first phase of the GODAR Project is tentatively scheduled to be held in 1998, in Washington DC, through arranging a Global GODAR Conference.

3.3 RECOSCIX-WIO PROGRAMME - *E.Vanden Berghe*

The RECOSCIX-WIO is an information project working towards establishing a lasting network of marine and aquatic institutions in the Western Indian Ocean (WIO) region with the Regional Despatch Centre (RDC) in Mombasa as its central node. Through its information services to the scientific community, the project aims at promoting the scientific capabilities of this region.

The objectives of the RECOSCIX-WIO project are as follows:

- provide marine scientists of the WIO region with the necessary bibliographic and scientific literature;
- make full use of the scientific literature available in the WIO region;

- promote and facilitate communication between the WIO region and other regions;
- provide scientific information and equipment, software and training to make full use of this information.

The system is based on a network of co-operating institutions (CIs) and co-operating libraries (CLs). Furthermore, there is a pool of contacts spread throughout the world. The Regional Dispatch Centre (RDC), based at the Kenya Marine and Fisheries Institute (KMFRI) acts as the traffic controller, linking the different components of the system. The network consists of scientists from over 60 institutions, in 9 different countries. The project has gone through different stages sponsored by various organizations. During a pilot phase sponsored by UNESCO, the necessary collaborators for the network were sought and a start made with the project services described below. A first operational phase was sponsored by the Flemish Inter-University Council (VLIR), with substantial funding from IOC. The emphasis during this phase were on library services and on the creation of databases. The second operational phase is funded by VLIR and IOC. The activities of the previous phase were continued in addition to the handling of scientific data and information.

Library Services

Scientists can request the RDC for information on queries on literature databases available in the Centre (i.e., Query Handling, QH) or reprints of scientific documents (i.e., Documents Delivery, DD). The main source of information for QH is ASFA. For DD, the RDC is in contact with over 20 libraries worldwide for those documents unavailable from the RDC. Scientists are also kept informed on relevant recent publications by the circulation of pages of contents of some 10 journals to which the project subscribes.

Databases

Two databases have been developed: WIODir and WIOLib. WIODir is a directory of marine scientists and institutions in the region. An earlier version was printed in 1992 with the assistance of UNEP. WIOLib should ultimately become a collective catalogue for marine science libraries in the region. To achieve this, libraries in the region have been supported with hard and software and with training.

Since the ASFA Advisory Board Meeting in China (1994), the KMFRI has become an ASFA input centre. RECOSCIX-WIO performs the inputs on behalf of KMFRI, IOCINCWIO countries and Eritrea. There is currently no CI in Somalia.

Newsletter

The RDC, in collaboration with the Western Indian Ocean Marine Sciences Association (WIOMSA), produces a newsletter, WINDOW (Western Indian Ocean Waters), which appears 2-4 times a year. Presently, the print run is 1,500 copies and the newsletter is distributed to over 1,200 addresses in more than 50 countries around the globe.

Oceanographic Data and Information Network in Eastern Africa (ODINEA)

Through ODINEA, the countries in the region will be assisted in enhancing their strengths in managing oceanographic data. The first step in the process is to establish a number of 'Designated National Agencies' (DNAs). These should evolve into 'National Oceanographic Data Centres' (NODCs), which will become full partners in the global network of such institutions. ODINEA will assist through the provision of training and equipment. The objectives are:

- to encourage the use of standard methods for data collection and storage in the region;

- to encourage active involvement of national institutions in global oceanographic programmes;

- ensure scientists in the region have access to datasets collected in and outside the region;

- develop capacity for the preparation of data products for scientists and policy makers.

The network will be co-ordinated through the mechanisms already established through RECOSCIX-WIO and will operate within the framework of the IOC International Oceanographic Data and Information Exchange System (IODE).

CD-ROM Production

More and more information is made available through the Internet and on the World Wide Web. Unfortunately, for many scientists in this region it is impossible to access the Web. In many countries, it is technically impossible because of the bad telecommunication infrastructure, while in others it is prohibitively expensive. Once again, the scientists in the region are in danger of being left behind in terms of acquisition of information.

Within RECOSCIX-WIO, a new set of activities was undertaken, namely compilation and collation of scientific baseline information. These data will be distributed, together with the earlier data products of RECOSCIX-WIO, on a single CD-ROM. Several important organizations such as IOC, the World Data Centres for Oceanography, the ASFA Advisory Board, FAO and ICLARM, have granted permission to redistribute limited subsets of their data holdings.

At this stage of RECOSCIX-WIO development, the training component will be even more important than the support in terms of equipment. The objective of the training will not only be to educate partners on the use of new hard and software, but to bring them to a level where they can actively participate in gathering information on marine sciences. While the first issue of the CD-ROM will largely be compiled at the RDC (with support from the University of Antwerp, Belgium, and made possible by the kindness of the organizations supplying the information), the hope was expressed to see a progressively larger input from the regional partners in its future issues.

3.4 RESCUE OF HISTORICAL OCEANOGRAPHIC DATA IN WESTERN AFRICA: IMPLICATIONS FOR RESEARCH DEVELOPMENT AND MANAGEMENT OF THE MARINE ENVIRONMENT - *L.F. Awosika*

The coastal zone is the socio-economic nerve centre of the states bordering the Central Eastern Atlantic. A large percentage of the urban population of the countries live in coastal cities. Archiving and rescuing of oceanographic data in the IOCEA region has both environmental and socio-economic implications for the region.

Oceanographic research in the Central Eastern Atlantic (IOCEA) region in the past has generated moderately large volumes of data. These data mostly are not easily available to the international scientific community. Most of these historical oceanographic data were collected by foreign ships and studies, regional institutions, government agencies, United Nations agencies, private prospecting companies and individuals. Some of these historical data are still in manuscript or analogue form not available to the international oceanographic community[1]. Historical data are essential for the validation of results of on-

[1] e.g.: Fishing campaign for tuna and associated research. "***Tasmania***"(Netherlands) cruise from Liberia to Zaire 1976 during which the following data were collected: salinity, temperature, CTD, chlorophyll, etc. The R/V ***Dr. Fidtj of Nansen*** (Norway) 1981 cruise in West Africa on fisheries and hydrography within the FAO/NORAD project.

going international projects like the Global Ocean Observing System (GOOS), World Ocean Circulation Experiment (WOCE), Climate Variability and Predictability (CLIVAR) and other projects to predict seasonal to interannual or decade-to-centennial changes in the global ocean-atmosphere-land system. Such validations could enhance the effective formulation and implementation of integrated coastal and marine area management plan in the IOCEA region. Proposed strategies for archiving and rescue of data in this region should include the following stages: establishment of institutional and organizational framework; description of data holdings; data search stage; verification of data inventories with WDCs; compilation of data and planning of data digitization and evaluation; digitizing of data and production of the IOCEA region GODAR database on CD-ROM and inclusion in the world ocean database. Technical assistance in the form of training, provision of infrastructure from the developed world, United Nations and other international and private organizations could ensure the successful implementation of this project.

3.5 SCIENTIFIC RESULTS MADE POSSIBLE BY GODAR - *S. Levitus*

The result of the first phase of the IOC/GODAR Project was the addition of approximately 1.4 million temperature profiles and 300,000 salinity profiles to the World Data Centre archives of digital ocean profile database. These data, as well as all other data in the WDC system, have been made available on CD-ROM as part of the World Ocean Atlas series. This increase in the historical databases has allowed the construction of yearly maps of upper ocean temperature for the 1960-1990 period. These fields describe gyre and basin-scale variability that appear to be related to oscillations of the sea-surface pressure field including the North Atlantic Oscillation and East Atlantic Oscillation. Variability was documented at depths of 100m and 400m for the North Atlantic Ocean.

3.6 COASTAL TOPOLOGY AND THE IMPORTANCE OF OCEANOGRAPHIC DATA FOR COASTAL MANAGEMENT - *R. Folorunsho*

Problematic coastal issues like resource depletion and conflicting anthropogenic activities have raised some awareness in governments and coastal stake holders. These issues have been aggravated by high coastal population density. Coastal Topology is a means of classifying environments based on a variety of oceanographic and morphological criteria, as well as coastal issues such as flooding and erosion, pollution, mangrove decimation and other coastal problems. Successful development of a topology depends on oceanographic data, especially historical data. The relevant oceanographic data of importance in the development of coastal topology includes coastal and ocean dynamics like waves, tides, currents and meteorological data.

In most cases, large volumes of data are required for building a credible topology. Geographic information systems offer the tool for achieving this goal. The computer based software can present coastal topology in graphical and visual forms for understanding coastal issues and resources which require management. The use of coastal topology in the West and Central African region therefore could ensure the effective implementation of an integrated coastal zone management plan.

3.7 REGIONAL CO-OPERATION IN MARINE RESEARCH AND MONITORING IN WESTERN AFRICA - *I. Oliounine* and *J. Wellens-Mensah*

IOC has always acknowledged the need to use the regional approach for the implementation of its programme activities. The regional approach increases effectiveness in achieving the programme objectives because it helps to solve problems and define priorities and priority needs common to the region; it helps to pool resources and fosters co-operation among scientists at the regional level. There are 7 Regional bodies within the IOC structure. One of them is the IOC Regional Committee for the Central Eastern Atlantic (IOCEA) which was established in 1987 during its first session in Praia, Cape Verde.

Subsequent sessions were held in Lagos, Nigeria (1990); Dakar, Senegal (1993) and Las Palmas, Gran Canaria (1995). Its membership comprises of 16 Member States, namely, Benin, Cameroon, Congo, Cote d'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Mauritania, Morocco, Nigeria, Portugal, Senegal, Sierra Leone, Spain and Togo.

IOCEA promotes co-operation amongst scientists and experts in oceanography and marine sciences within the region and also encourages and co-ordinates collaboration among marine science institutions in the region.

Current activities of IOCEA are outlined in its Programme of Work for 1996-1997 drawn up at its Fourth Session in Las Palmas. The programme is presented in Annex IV to the Workshop Report.

After the Fourth Session, the following activities involving participation of scientists from IOCEA Member States have been realized:

(i) Regional Workshop on Integrated Coastal Area Management held in Conakry, Guinea from 18-22 December 1995. The output from this Workshop is a set of recommendations on a management strategy based on systematic planning of the use of coastal and marine resources and on national and regional levels of capacity building.

(ii) IOC Sub-Regional Workshop on Marine Living Resources in the Gulf of Guinea from Conakry, Guinea to Angola was held in Cotonou, Benin from 1-4 July 1996 with the participation of experts from 9 countries of Western Africa. The output from the Workshop was the development of a Sub-regional Research Project on Marine Living Resources in the Gulf of Guinea. This Workshop also considered standardization of methodologies for data collection and processing.

(iii) A marine debris pilot monitoring project for the Gulf of Guinea has taken off in collaboration with the Large Marine Ecosystems of Gulf of the Guinea Project (LME). The first set of results has been analyzed and synthesized. This was presented at the Third IOC-LME Marine Debris/Waste Management Workshop held in Abidjan, Cote d'Ivoire from 1-11 December 1996.

(iv) An international seminar on the coastal zone of West Africa was held in Accra, Ghana from 22-29 March 1996. Participation in this Seminar comprised experts from all West African countries (except Liberia), as well as experts from Europe and the USA.

(v) A project on the development of Monographs on the Topology of the Western African Coasts is in progress. Four monographs are expected to be written to cover the following themes:

(a) physical oceanography and sedimentology;
(b) marine biology and biotypes;
(c) marine geology;
(d) coastal environment.

The first volume is expected to be published in 1997. This project will be an important regional contribution to the 1998 International Year of the Ocean.

(vi) A series of national workshops on integrated coastal zone management strategy and policy being facilitated by IOC and the LME Project for the Gulf of Guinea, are planned and will be realized soon.

Realizing the similarities and commonalities of conditions and problems in both the IOCEA and IOCINCWIO Regions, IOCEA has sought to maintain close links with the IOCINCWIO Region through the participation in workshops, seminars and, possibly in the near future, in joint regional sessions. This approach has promoted collaboration between scientists in the two regions.

In spite of the many achievements mentioned above, there are still obstacles to continued regional progress. These include, among others, poor infrastructure and lack of scientific equipment, supplies and maintenance; poor communication and co-ordination between the numerous national and regional organizations supporting the marine sciences in the region; lack of co-ordinated regional training programmes; and insufficient priority given by decision makers to marine sciences and services.

3.8 INSTITUTING SCIENCE-BASED MANAGEMENT OF COASTAL AND MARINE ENVIRONMENT IN WEST AND CENTRAL AFRICA: THE GULF OF GUINEA SUB-SECTOR - *C. Ibe*

It is widely recognized that the coastal zone including the shallow ocean of West Central Africa constitutes a vast dynamic storehouse of food, energy and mineral resources that provide the potential basis for sustainable socio-economic development of the region.

However, it is known that the national management of these resources is for the most part, initiated with a lack of scientific data and information.

To overcome this problem, 5 countries of the Gulf of Guinea, namely, Benin, Cameroon, Cote d'Ivoire, Ghana, Nigeria (and Togo is to join soon) have signed on to a communal project entitled "Water Pollution Control and Biodiversity Conservation in the Gulf of Guinea Large Marine Ecosystem", launched by the Global Environment Facility (GEF) and executed by UNIDO with the technical assistance from the USA, NOAA and UNEP.

The project will provide a regional approach to address the pollution of shared water and associated degradation of critical habitats and natural resources formed therein. To this end, hierarchically arranged scientific monitoring programmes based on the large marine ecosystem concept has been designed for the acquisition of the necessary data and information for a cost effective environmental and natural resources management. As part of the scheme, national and regional databases with GIS capabilities would be put in place to provide a decision making system for ecosystem management.

It is hoped that, following a successful Gulf of Guinea phase, this science-based management plan will be extended to other countries of West and Central Africa.

3.9 HISTORICAL DATA COLLECTIONS IN THE EASTERN TROPICAL ATLANTIC AND THEIR SCIENTIFIC USE - *J-P. Rebert*

Numerous activities have been achieved during the last 50 years in the area including the Gulf of Guinea and the Central Atlantic. A review of the most important observing programmes have been provided grouped into:

(a) International programmes;
(b) Regional programmes;
(c) National activities.

For each of these programmes an assessment was made about the status and availability of the datasets.

(a) For the international programmes carried out since the 1960's, such as GATE, FOCAL/SEQUAL, TOGA and WOCE, all the datasets have been safeguarded at the

WDCs, Oceanography, included in the set of CD-ROMs of the World Ocean Atlas, or are being processed in specialized data centres which provide adequate on-line information on the status of these datasets. Examples were given on the systems used by TOGA and WOCE.

(b) The most important regional programme initially known as the 'Guinean Year' gave rise to 3 sub-programmes: the Guinean Trawling Survey (GTS), the Equalant Cruises and the Sardinella Project. While the data management for the first two programmes has been properly achieved, it is suspected that some national data of the different components of the Sardinella Project have not yet been safely archived and might be recovered from national institutions.

(c) Several national programmes undertook long-term monitoring of their shelf or coastal waters. Special attention was given to a collection of 77 time-series related to fixed coastal stations, that are safeguarded at ORSTOM (Brest), with appropriate retrieving software. However, this collection has not been updated for several years and the Speaker invited the participants to provide guidance concerning the actions to be taken.

3.10 MARINE SPECIES DATABASE FOR EASTERN AFRICA (MASDEA) - *E.Vanden Berghe*

In spite of the importance of standardized species lists for taxonomic nomenclature, no such lists presently exist for the Western Indian Ocean. In the light of recent interest in biodiversity this lack becomes even more glaring, especially as it is one of the factors to be taken into account when planning Integrated Coastal Zone Management. It was the reason for creating MASDEA, based on existing isolated databases (e.g., Veron's global list of corals which is in preparation; Shepherd's Corals of the Indian Ocean; FishBase, giving global information on fish). Another global database that was important in the preparation of MASDEA was the NODC Taxonomic Codes. While this database does not include distribution information, it was extremely useful for checking spelling and higher taxonomy.

MASDEA is a follow-up of the database that was started by Helida Oiyeke at National Museum of Kenya, Centre for Biodiversity, as a project of ROSTA/UNESCO.

MASDEA is a first, though unfinished, attempt at creating species lists. At the beginning it is intended more as a demonstration of the concepts, and a starter for correspondence and discussion, than as the reference tool it ultimately should evolve into. There is a strong hope to build links with other organizations and individuals to work together towards completion of the goal.

Structure

The dataset consists of a synonymised list, with distribution records referring to the taxon name with which the distribution information was originally published. Each distribution record (in principle, its presence in one of the countries of the region) is referenced to the literature. It is also possible to keep track of records which are known to be incorrect or doubtful. This feature, together with the way synonyms are treated, should ensure that incorrect records or records with invalid names are entered only once.

Four tables form the basis of the structure: 'Countries', 'Records', 'Literature' and 'Taxonomy'. The 'Records' table links country and taxonomy, plus gives a reference to the literature, making it possible to keep track of sources of information on the level of occurrence of a taxon in a country.

The 'Countries' table contains, besides an index field which is automatically assigned by the software, the name of the country and a short 3-letter code to be used in table headings. In principle, the countries used are the political entities. Some exceptions had to be made, to avoid losing too many biologically relevant records. First of all, Reunion is in the table as Reunion, not as 'France'. Another set

of exceptions are 'groups' of countries: 'Mascarene Islands' (Reunion, Mauritius and Rodriguez), 'East Africa' (Kenya and Tanzania), 'Eastern Africa and Madagascar' (includes also Somalia and Mozambique), and 'Red Sea'. Both Rodriguez (from Mauritius) and Aldabra (Seychelles) are listed separately, because they are relatively far from the rest of the country, and are often treated as separate entities in biogeographical texts.

The "Literature" table is kept as simple as possible: there are fields for author(s), year of publication and for a 'reference' string, which should contain title, citation, publisher, etc. Also, a field has been created for the abstract and remarks. Possible refinements would involve creating links between a 'Publication' table and an 'Author' table. It is possible that this, and other refinements, will be included in future versions.

Taxonomic information is split over two tables: the first contains species/sub-species records and the other higher taxonomy (from Family upwards). No synonymy for families has been done. Synonyms for species/sub-species are structured thus: all names are in one table; each name has a pointer to a valid name; valid names point at themselves. Each record has a pointer to a literature table, indicating where the information was obtained from. Each non-valid name has a second pointer to a reference for synonymy, space for taxonomic remarks (to do with spelling of a name, status of the taxon, etc.) and for a description of the taxon (like habitat, morphology, common name, etc.).

The table for higher taxonomy has fields for principal ranks from Kingdom down to and including Family. Because malacologists rely so heavily on superfamily, this rank was included later as an afterthought. There is a 'Notes' field, that is intended to be used for a description of the family. Higher taxonomy tends to be rather fluid, and there is no attempt to try and keep up with all name and rank changes. This table should only be seen as a convenient way to sort and filter the records in the species table.

As indicated earlier, the Records table has a pointer to literature, country and taxon. Apart from these, there are two boolean fields to qualify the distribution record: 'Valid' (Val) and 'Certain' (Cer). The certain flag is used if, for example, the author considers his identification as provisional. The valid flag is set to false if later sources indicate that this record rests on a mis-identification (about which we may be sure or not, as indicated by the 'Certain' flag).

Sources of Information

Details of the sources used in the database are documented in the database itself. However, some very important references need separate mention: FishBase (ICLARM, Philippines), NODC Taxonomic codes (Washington, DC), publications by Shepherd and Veron, Excel lists logged at CRCP for echinoderms and molluscs. The main references per taxonomic group were as follows:

- Sheppard's and Veron's publications formed the basis of the entries for the corals and were logged at the RDC. The recently available dataset for Corals of the Indian Ocean by Sheppard has not yet been included.

- Echinodermata were extracted from A.M. Clark and F.W, E. Rowe (1971) Monograph of Shallow-water Indo-West Pacific Echmoderms, published by the British Museum.

- It was not possible to discriminate between brackish-water records from marine estuaries or from Alkaline inland lakes when extracting records from FishBase. All records flagged 'True' for 'Brackish' or 'Salt' have been included in the present version. Species that are clearly not present in marine estuaries will be deleted from future versions.

– For molluscs, a list prepared by Taylor at the British Museum served as the basis, together with two older publications by Spry on the marine bivalves and gastropods of Dar-es-Salaam.

It is an intention to go back to the original literature for most of the taxonomic groups. For some, like fish, this will not be done; it seems a waste of effort to try and duplicate the excellent work that has been done by ICLARM.

There is virtue in including independent records for the same information, as it serves as a confirmation of the information. However, there is also a limit to processing power of computers and disk storage. If two records are giving the same information, preference is given either to the oldest record, or to the 'richest' record, i.e., the one that gives most supplementary information.

For the time being, all variations in spelling that are detected between different sources are written into the taxonomic remarks. In time, the remarks for variations that were mis-spellings will be deleted.

3.11 OCEANOGRAPHIC DATA COLLECTION AND INFORMATION EXCHANGE IN GHANA - *C. Biney*

The 550km coastline of Ghana is a low lying area with a narrow continental shelf extending outwards to between 25 and 35km except off Cape Coast where it reaches up to 80km.

The major primary activity of the coastal zone is fishing. Other activities of economic importance include agriculture, oil and gas exploration, salt production, recreation and tourism, as well as waste disposal.

Different kinds of oceanographic data are collected by some of the 17-member institutions of the Ghana National Commission for IOC (GNC/IOC). The most important of these is the Research and Utilization Branch of the Fisheries Department which has been collecting oceanographic data since its establishment in 1962. Available data cover temperature, current and wind characteristics, oxygen, salinity, plankton and fish production.

Steps are being taken to computerize the data, most of which are in a manuscript form. Apart from national uses, the data are made available to FAO, ICCAT, and the World Data Centre-A, Oceanography.

Other institutions also collect oceanographic data for research, regulatory and/or commercial purposes. The latter include the Ghana National Petroleum Corporation, Meteorological Services Department and Survey Department.

Due to lack of facilities for open ocean research, the activities of the other research and regulatory institutions are normally confined to the coastal zone, i.e., the immediate inshore areas and associated wetlands, lagoons and estuaries. These focus on the increasing impact of anthropogenic activities on the resources of the coastal zone.

For the future, the GNC/IOC hopes to be more involved in GODAR activities. To this end, there is a need to tackle the problems of institutional, as well as human resources development.

3.12 NODC EXPERIENCE IN OCEANOGRAPHIC DATA MANAGEMENT: A CASE STUDY - *M.L. Grundlingh*

South Africa has a coastline of about 2,700km which faces the vast expanses of the Indian, Atlantic and Southern Oceans. Data in these ocean regions have been collected or are being collected

mainly by the Sea Fisheries Research Institute (Cape Town), the University of Cape Town and the Council for Scientific and Industrial Research (Stellenbosch). A non-oceanographic organization which also collects large amounts of marine information in the form of weather reports, is the South African Weather Bureau. In terms of manpower, ships, equipment and amounts of data collected, the Sea Fisheries Research Institute is by far the largest.

The physical oceanographic data collected by South African organizations include: STD, CTD, ADCP, XBT, current meter, wave buoy and weather data. These are mostly situated on the shelf, although a fair amount is also in the deep sea.

The presentation focussed on the characteristics and history of the South Africa Data Centre for Oceanography (SADCO). After financial cut-backs in 1990 severely impacted on SADCO's ability to continue functioning as a data centre, hard decisions had to be taken about what data to retain and what to discard. By focussing efforts on the core datasets, it turned out that the essential services to the oceanographic community could be maintained and even expanded. Major alterations to operational procedures included moving the databases 1,500km, from Pretoria to Stellenbosch (near Cape Town) from a mainframe on to a small computer and establishment of another database management system.

Although the data centre is presently funded at only 20% of pre-1990 funding levels, it remains viable with storage and retrieval systems, secure backup, a regular newsletter, new products, a Homepage, brochures, on-line inventory system, on-line access countrywide and up-to-date loading of submitted data. Its success suggests a route that can be taken by small countries with limited resources, to manage their data efficiently.

4. NATIONAL REPORTS

4..1 BENIN

Abstract

The management of the coastal zone is a worldwide problem today. Some solutions have been suggested and they need to be studied in depth. GIS is a technology used today to analyze data collected by institutions and organizations. The Large Marine Ecosystems (LMEs) project has been established to co-ordinate the synthesis of data collected at national and sub-regional levels in all domains able to contribute to data analysis and data processing. Some data have been and continue to be collected at the national level.

Introduction

The Republic of Benin is located entirely in the intertropical zone between latitude $6^{o}30$-$12^{o}30$N and longitude 1^{o}-$3^{o}40$E. It covers an area of 112,622 square kilometres of which 125km lie on the coast with the northern border on the Niger River stretching for 190km, bordered on the east by Nigeria, on the west by Togo, and the north-west by Burkina Faso.

The air temperature is between 24^{o}C and 33^{o}C. There are two rainy seasons in the south and one in the north.

The main wind direction is south-west with an average speed of 4-6 m/s.

The temperature of the water surface in the coastal area changes from 25^{o}C (July -September), to 32^{o}C (February-March) with a salinity of 30 to 33 per thousand.

The population is around 4.92 M (February 1992) with 64% living in the urban areas. The population along the coast is estimated to be 54% of the total population entirely concentrated in the south (Figure 1).

General Coastal Zone Management Problems

The health of the oceans depends in part on the estuaries, coral reefs, islands and littoral management; and research must be carried out in all these areas. In Benin, ocean management calls for interaction between all the ecosystems mentioned above; the second aspect is human activity, which is the focal point of the degradation of the ocean by means of fisheries, transport by sea and tourism.

The consequences are:

- coastal degradation by erosion which removes all vegetation along the littoral and thus the ground becomes bare;
- marine pollution through oil and heavy metal discharge, mining operations, dumping of plastics. The ocean is becoming increasingly littered with persistent solids which prove a menace to marine life, and in some cases, to marine transportation.

(a) Demographic effect

- demographic growth lies at the root of several problems in the upland and coastal zone management;
- the lack of farming land brings perpetual conflict between populations;
- the lakes and the coastal zone are excessively exploited for fishing due to the ever-increasing population growth, leading to the degradation of the quality of the fish and to population conflict;
- waste dumping along the coast changes the habits of fish living both in the sea and the lakes. Consequently, the diversity of fish species is reduced;
- fishing techniques have not been modernized and the people continue to use traditional methods which greatly reduces the yield, and causes conflict between the fishermen using modern techniques and those using the traditional ones;

(b) Large Marine Ecosystem's (LMEs) goal

The Large Marine Ecosystem Project is based on the concept of marine environmental and resources management.

No policy exists for marine management, especially in regard to living resources, including fishing, forestry, etc. of the ecosystem of West Africa. The group of 6 countries including Benin, Cameroon, Cote d'Ivoire, Ghana, Nigeria and Togo need to integrate data to achieve the best management of the marine ecosystem of the Gulf of Guinea.

Each national team is composed of people and institutions which can contribute to data collection with one aim: the best coastal zone management.

Data Collection and Management in the Coastal Zone

(a) Formats and packages

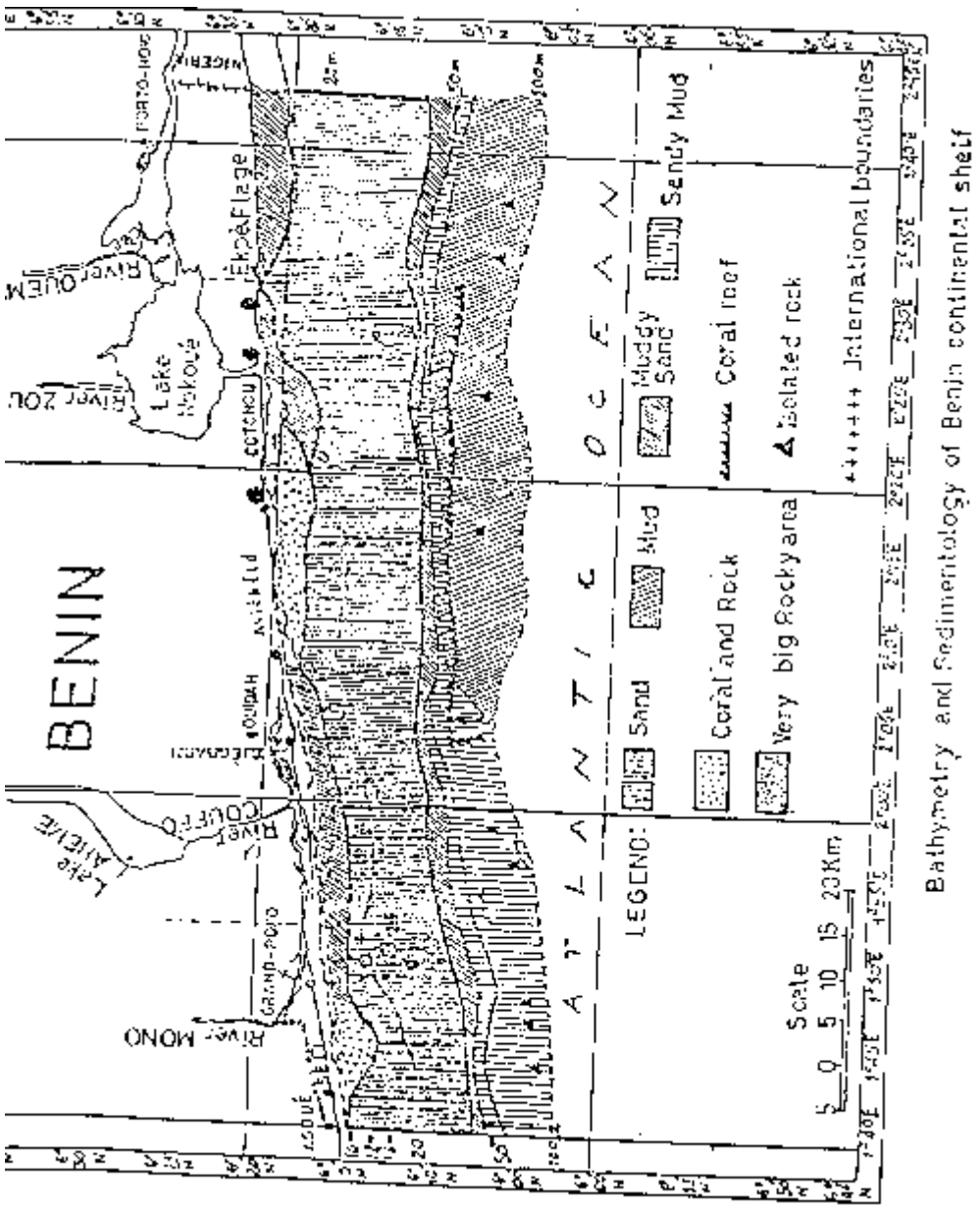

Figure 1: Bathymetry and Sedimentology of Benin Continental Shelf

- Software: ARC-INFO and ATLAS-GIS (for data digitizing);
- MS/ACCESS to integrate the tabular data. The compilation of the tabular data to the spatial data in a GIS. (Combination of features and analysis data).

(b) Type of data presentation

- Satellite images with resolution for the studies of local natural resources;
- Aerial photograph interpretation;
- Visual interpretation and automatic classification;
- Ground true/Ground data collection;
- Digitizing maps available.

(c) Examples of data

- Coastal area of Benin;
- Recent satellite image of the Benin coastal zone;
- Tabular data on fishery activity comparing sub-regional results;
- Tabular data on population, climate;
- Solid waste data from the coastal zone;
- Vegetation and soil map;
- Land use map.

(d) Problems encountered

- The difficulty of obtaining data from different institutions;
- The difficulty of using a standard format in all institutions;
- The difficulty in exchanging data.

Conclusion

Coastal zone management is a worldwide problem.

The best approach however, would be to have thorough knowledge of local problems and make efforts to solve them. This could reduce the social problems and improve productivity.

4.2 CAMEROON

Abstract

After a brief definition of the Cameroon coastal zone, this paper presents the state of oceanographic data management in Cameroon. Main institutions involved in this activity, types of data, methods of collection, treatment, storage and dissemination are given. This activity is very poorly developed in Cameroon. The paper thus gives constraints and proposals to improve data management in Cameroon and calls for support from the IOC to establish a regional oceanographic data management centre at the CRHOL to serve the Central African Region.

Introduction

The coastal zone of Cameroon stretches over 360km from the Nigerian border in the north (Akwayafe river, 4º40'N) to the Equator-Guinean border in the south (Campo river, 2º20'N) (Figure 2)[2].

[2] Here the coastal zone is defined as the region stretching 60km beyond the high tides into the continent, to the limits of the Exclusive Economic Zone (EEZ) on the seaward side.

This location places Cameroon amongst the countries in the world that need to collect oceanographic data. The main institutions involved in the domain of marine sciences include:

- The Ministry of Scientific and Technical Research (MINREST), through the Research Centre for Fisheries and Oceanography, Limbe (CRHOL) of the Institute of Animal and Veterinary Research (IRZV); the Nutrition Centre of the Institute of Medical and Medicinal Plant Research (IMPM); the National Institute for Cartography (INC); and the Institute of Geological and Mineral Research (IRGM);

- The Ministry of Livestock, Fisheries and Animal Husbandry (MINEPIA) through the Department of Fisheries;

- The Ministry of Transport (MINTRANS) through the Agency for the Safety of Air Navigation (ASECNA); the National Ports Authority of Cameroon (ONPC) and the Department of Meteorology.

Despite the numerous institutions, the collection and management of oceanographic data is very poorly developed in Cameroon. Only the CRHOL, ASECNA, ONPC, the Nutrition Centre and the Department of Meteorology collect data of this type, but the data collection activity still needs to be improved. This insufficiency is worsened by the fact that during the installation of certain measuring instruments under the programmes of the IOC, Cameroon was not taken into consideration; a case in point is the installation of tide gauges along the East Atlantic coast. The insufficiency is also due to the lack of local finances.

Types of Data and Institutions

Types of data and data management institutions are given in Table 1.

Methods of Collection, Treatment and Conservation

Table 2 summarizes methods of collection, treatment and storage of oceanographic data in Cameroon.

Constraints

The management of oceanographic data in Cameroon is faced with the following constraints:

- Lack of co-ordination between the institutions collecting data;

- Lack of a data bank; efforts made to establish a data bank have so far failed due to lack of finances.

- Inadequacy of infrastructure and facilities to guarantee storage and dissemination of data;

- Lack of equipment and poor capacity building.

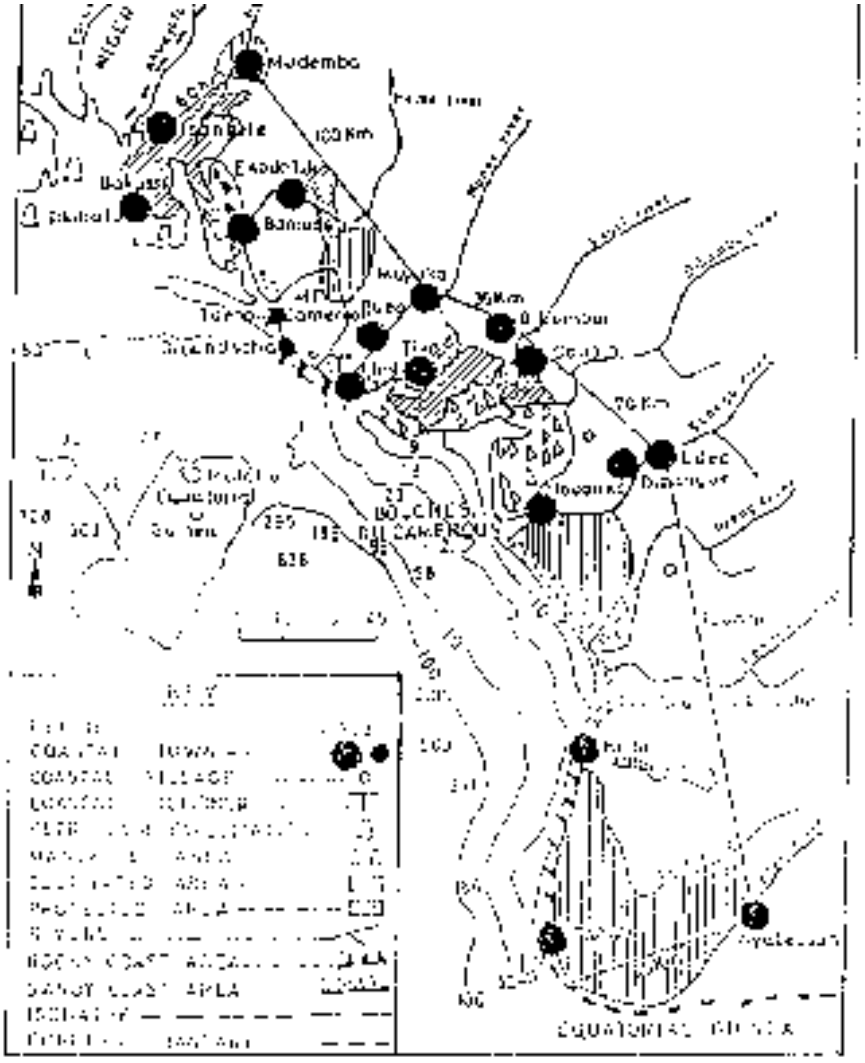

Figure 1: Definition and boundaries of the Cameroon coastal zone.

Figure 2: Definition and Boundaries of the Cameroon Coastal Zone

Proposals for Improvement and Conclusion

Proposals for improving collection, analysis and storage of oceanographic data include:

- Research and data management funding to enable regular data collection and analysis;
- Provision of data management facilities such as computers and modern libraries;
- Extension of capacity building through training to include scientists and technicians involved in data collection and storage;
- Creation of a data bank for the Cameroon Coastal Zone to hold data on all aspects of oceanography;
- Provision of communication facilities, such as access to the Internet system, e-mail, fax and telephone lines to facilitate storage, dissemination and exchange of data within and out of Cameroon.

Improvement of data management in the CRHOL is a necessity because at the moment, this is the only national oceanographic centre in the Central African region of the Gulf of Guinea. With some support from the IOC, the CRHOL could become a regional oceanographic data centre for countries of this geographical region (Cameroon, Congo, Gabon, Equatorial Guinea) where knowledge of the living marine resources and oceanography in general is very scanty, compared to that of other West African countries.

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Table 1. Types of Data and Institutions

Types of Data	Institutions
Meteorological	ASECNA ONPC Dept. of Meteorology
Physical & chemical data of sea & coastal waters	CRHOL ONPC
Marine biology & ecology	CRHOL
Pollution & environment	CRHOL Centre de Nutrition
Marine geology & sedimentology	INC IRGM
Fisheries	CRHOL Dept. of Fisheries

Table 2: Oceanographic Data Holdings, Methods of Data Analysis and Dissemination

Type of Data	Method of Data Collection	Method of Data Analysis	Method of Storage & Dissemination
1. PHYSICO-CHEMICAL			
Temperature, salinity, pH	Reversing water bottle, reversing thermometer, salinometer, pH-meter	Direct readings,	Computer diskettes Publications Annual reports Presentations at workshops, seminars, conferences
Tides	*In situ* observations & from tide gauges	Computer	
Nitrogen, Ammonia, Nitrate, Nitrite, Phosphates, Silicates	*In situ* sampling	Standard analysis, Strickland & Parsons (1972)	
Current speed, current direction	Mooring	Current meter readings	
Heavy metals (Hg, Pb, Zn, Cu, etc.)	*In situ* sampling	Atomic absorption spectrometer (AAS)	
Marine debris	*In situ* sampling	Counting & weighing	
Suspended solids (Seston)	*In situ* sampling	Membrane filtration (Banse *et. al.* 1963)	
Pesticides	*In situ* sampling	AAS	
Solid & liquid effluents	Inventory from factories	Desk top calculation	
2. BIOLOGICAL			

Chlorophyll a,b,c, Pharopigments, Organic carbon	*In situ* sampling	Membrane filtration, Spectrophotometer (Richard Thompson, 1952)	Computer diskettes Annual reports Publications Conferences, workshops, seminars
Phytoplankton biomass & systematics	Plankton net	Utermohl (1958)	
Primary production	*In situ* sampling (incubation in oxygen bottles)	oxygen method	
Zooplankton biomass & systematics	Plankton net	Microscopic observation	
3. METEOROLOGICAL			
Wind direction, wind speed	Anemometer	Direct readings, Computer analysis	Diskettes Annual reports
Rainfall	Rain gauge		
Light intensity	Light meter		
Sea state	Visual observations		
4. FISHERIES			
Stock assessment, catch effort data per species & year	Observations & measurements	Holden and Bravington (1992)	Computer diskettes Annual reports Publications Workshops, seminars Conferences
Growth parameters L k_{oo} T_o	Field & laboratory measurements	SLCA & ELEFAN measurements method Holden & Bravington (1992)	
Mortality parameters Total mortality (Z) Fishing mortality (F) Natural mortality (M)	Field measurements at landing sites	Pauly (1980)	
Exploitation rate Exploitation ratio (E) Maximum sustainable yield (MSY)			
Productivity (Mbv) M - natural mortality Bv - Biomass			

5. FISHERIES SOCIO-ECONOMY			
Types & life span of fishing gears Distribution of fishermen by nationality, sex and age limits Cost of replacement of fishing material Number of types of fishing gears Distribution of fishery products Transformation of fishery products Migrations & fishing seasons	Systematic surveys Questionnaires Interviews by simple random sampling	Computer analysis Database interrogation through the EPI-INFO computer programme	Annual reports Computer diskettes Workshops, seminars, conferences

4.3 COTE D'IVOIRE

Cote d'Ivoire has a long maritime facade of about 600km with a continental shelf covering 14,000km^2.

Several institutions, based in Cote d'Ivoire, are currently working in the oceanic zone and they manage data to various extent.

Among those institutions, based in Abidjan, one can cite the University of Abidjan-Cocody, CRO, CIAPOL, PAA and the PETROCI.

Only the first 3 cited above made available their data to the public because of their public-oriented research activities.

Centre de Recherche Oceanologiques (CRO)

Created in 1958 as a government service managed until November 1991 by ORSTOM, the centre was organized as a relational public institution. Its assignments are:

- To carry out the research necessary to: understand the aquatic environmental interactions enabling its environment conservation and protection; put into practice the rational exploitation and management of living or non-living aquatic resources.

The centre is in charge of:

- promoting all technology and methodology which supports national development through the aquatic resources;

- providing scientific and technical information to different professional, cultural and social groups;

- participating, for the benefit of exterior public and private partners, in research and production projects, consulting in its fields of expertise.

Like other institutes in the West African region, the CRO produces a considerable number of articles, periodicals and reports and has a very rich documentation centre.

It is divided into 4 research departments which are:

- Aquaculture Department;
- Aquatic Living Resources Department;
- Environment Department; and
- the Department of Scientific and Technical Information.

Scientific and Technical Information Department

This department is in charge of collecting scientific publications and data and ensuring for the research workers the required documentation for their studies.

It is divided into 3 services:

- the scientific publishing service which is in charge of diffusing the different periodicals of the CRO;

- the duplicating and technical drawing service which insures printing, copying and binding of all the centre's documents; and

- the documentation service which centralizes, archives, updates and ensures public access to a documentary source of approximately 2,210 books, 200 reports and theses, 800 periodicals, 2,000 microfilms, a map library and a database with about 1,363 references.

Data Collection and Management Facilities

Six stations spread along the coast allow to have data on surface temperature. A fixed coastal station in Abidjan allow to have data on:

- Temperature, salinity, currents and transparency;

- Daily meteorological data (wind, atmospheric pressure, swell field, temperature, salinity);

- Sea surface temperature at a large scale from meteosat is also available.

At the lagoon level, physico-chemistry data are available related to ph, salinity, temperature, etc.

The CRO has been chosen to pilot the regional co-operation exchange of information for the Centre-East Atlantic Ocean.

The objectives of this prospect are:

- to promote communication between scientists;
- to collect, record, broadcast results from research activities;
- to address at best, the need of data users;
- to print and dispatch the various documentary products.

The CRO is provided with various computer programmes for documentation and database management.

At the CRO, the following statistical data on living resources are available:

- On *sardinella aurita* and *sardinella maderensis*;
- on tuna fishing (*albacore*, *patudo* and *listao*);
- on a fish belonging to the two groups (*sciaenides* and *sparides*);
- on shrimp fishing (*panaeus duorarum notialis*).

In the domain of the lagoon, the problem is more complex because in many instances, researchers cannot act freely in terms of their research activities. The reason being that village communities consider the lagoon where they live as their private property including resources within. Statistical data available deals with *ethmalose*.

In aquaculture, data are relative to:

- fertility, larva death rate;
- initial and juvenile growth rate;
- conversion indices;
- responses to different feeding;
- resistance to salinity of different fish species including *sarotherodon melanotheron, chrysichthys nigrodigitatus, heterobranchus longifilis, heterobranchus bidorsalis.*
- fish feeding and fish parasitology.

Difficulties of the CRO Data Holding

Unfortunately, information is not sufficiently distributed. This is closely linked to the lack of financing for equipment and staff training in the various documentation centres of the region. In consequence, information is poorly known and under-utilized by the scientific community and the general public throughout the region.

The direct consequences of this situation are:

- Poor use and application of research results in decision making and management;
- Duplication of research efforts;
- Difficulties in satisfying the user requirements for scientific information;
- High cost for obtaining information;
- Lack of public awareness in matters concerning the marine environment.

ln order to solve these problems, it is important to establish a marine documentation and information network for coastal states of the Central Eastern Atlantic.

UNIVERSITY

The Department of Animal Biology in the Faculty of Sciences and Technics carried out several studies concerning biology and physiology of fish from sea and lagoon waters. Some of these investigations were jointly undertaken with the CRO.

The Department of Earth Sciences in the Faculty of Sciences and Technics holds data concerning:

- suspended materials (concentration, composition);
- currentometry of continental shelf water;
- bottom sediments of the continental shelf and the abyssal fans;
- bathymetry at 1/50.000 scale of the continental shelf.

CIAPOL

Its domain of intervention is the lagoon. The following data are archived at this institution:

- pH, salinity, dissolved oxygen, temperature;
- nitrates and nitrites;
- chlorophyll and several bacteria.

The station number and date when data have been collected, are included in the data archive.

RECOSCIX-CEA Project

During the Third Session of IOCEA (Dakar, Senegal, 18-22 January 1993) the Delegate of Cote d'Ivoire introduced the project proposal "Projet de creation d'un reseau documentaire pour les Sciences Aquatiques et les Peches des pays Cotiers de la Mauritanie a l'Angola".

Objectives

The main objective of RECOSCIX-CEA project is to establish a marine information exchange and dissemination network for the Eastern Atlantic region. The regional network consists of the Member States of the IOC in the Central Eastern Atlantic (IOCEA) region with established research institutes and documentation centres whose activities focus on marine sciences, systematic ocean observation and related services.

In order to reach this objective, the project has to undertake the following activities:

- better respond to the needs of users by supplying directories, bibliographies, copies of publications, abstracts, etc.;

- promote communications within and between national, regional and international scientific communities;

- produce and distribute various information products relevant to marine sciences, ocean observation, related services, training and education opportunities in the region;

- produce and distribute news on scientific and other related activities in the region.

The project has to offer to its users a well balanced set of products and services concerning science, observations, technology and management of the marine environment and related training, education and capacity building opportunities.

Expected Products and Services

Two types of services must be offered by the network:

- An information retrieval service: will provide abstracts of marine science and related publications according to detail search requests defined by the user;
-

- A document delivery service: will provide copies of documents (monographs, periodicals and reports) thanks to national, regional and international library collaboration.

The project has also to compile a series of information products related to activities carried out in the region:

- A directory of institutions and of scientists;
- A directory of libraries and documentation centres in the region;
- A catalogue of library holdings in the region; this catalogues will be a computer-based catalogue using UNESCO's micro CDS-ISIS software;
- A catalogue of scientific and technical publications, published in the region;
- A newsletter with information concerning scientific and related activities including applications and services in the region, as well as other information relevant to the region.

All services and products will be provided free of charge to RECOSCIX-CEA co-operating institutions and co-operating libraries and other institutions or individuals.

Realized Activities

The activities were divided into two phases: the preparatory phase and the operational phase.

The preparatory phase began with the establishment of the regional dispatch centre by:

- the identification of a project office;
- the identification of local staff;
- the identification of equipment.

It continued with the distribution of an IOC Circular Letter and questionnaires to identify co-operating institutions and libraries.

The results of the questionnaire survey have been completed and sent to IOC to be published.

The preparatory phase ended in April 1995.

Since that date all activities have been stopped because of the lack of finance.

4.4 GHANA

Introduction

The Republic of Ghana (Figure 3) lies along the Gulf of Guinea in West Africa. It occupies an area of 230,000 km^2 between latitudes 4º45 and 11º10'N and longitudes 1º12' and 13º15'W. To the east, west and north of Ghana lie the Republics of Togo, Cote d'Ivoire and Burkina Faso, respectively.

Administratively, Ghana is divided into the following 10 regions (capitals in parentheses): Ashanti (Kumasi), Brong Ahafo (Sunyani), Central (Cape Coast), Eastern (Koforidua), Greater Accra (Accra), Northern (Tamale), Upper East (Bolgatanga), Upper West (Wo), Volta (Ho) and Western (Sekondi/Takoradi).

The climate is governed by two tropical air masses: the hot, dry, dust-laden harmattan from the north-east across the Sahara Desert and the moist and relatively cool monsoon air from the south-east across the Atlantic Ocean. These two air masses meet along a broad front called the Inter-Tropical Convergence Zone, the oscillation of which causes seasonal changes in the weather.

As the country is situated in the belt of tropical and equatorial climates, temperatures are high, between 25ºC and 36ºC with little variation throughout the year. In most parts of the country, the hottest months are February and March. The coldest month is January, except along the coast where the lowest temperatures occur in August.

The Coastal and Marine Zone of Ghana

The 550km coastline of Ghana is generally a low lying area, not more than 200m above sea-level, with a narrow continental shelf extending outwards to between 25 and 35km except off the Cape Coast and Saltpond where it reaches up to 80km (Figure 4). The rocky and sandy shoreline is fringed by mangrove and coconut trees, interspersed by river estuaries and lagoons. The major rivers which flow into the sea here are, from the east, the Volta, Densu, Ayensu, Nakwa, Amisa, Kakum, Pra, Butre, Ankobra and Tarro. Some of these, such as the Densu, Ayensu, Nakwa and Amisa flow into the sea by way of lagoons.

About 90 lagoons occur along the coastline of Ghana. These are of two main types, the first remains closed to the sea, at least, for most of the year, examples of which are the Laiwi, Gao, Kpeshie and Fosu which are linked to temporary streams. The second type is open to the sea and associated with rivers which flow all the year round. These include the Korle, Sakumo I and Nakwa, situated at the heads of the rivers Odaw, Densu and Nakwa respectively. The Keta and Angaw lagoons, although closed to the sea are linked to the Volta river.

The coastal and marine zone of Ghana is normally defined to include the 200 nautical mile limit which was claimed in 1977. The territorial water sectors with estimated areas are given below:

Territorial waters	**Area (km2)**	**%**
Continental Shelf (down to 200m)	23,700 194,820	10.8 89.2
Total	218,520	100

(adapted from Bernacsek, 1986)

The zone is well endowed with natural resources which are exploited by different sectors of the economy. The major primary activity of the zone is fishing. Other activities of economic importance that occur in the zone are agriculture, transportation, salt production, oil and gas exploration, sand and stone winning, recreational and industrial developments. The zone is also known to be important internationally, for the provision of feeding, roosting and nesting sites for thousands of birds especially migratory species. The coastal and marine zone is also currently used for the disposal of industrial and municipal wastes, an activity which is being actively mitigated by the EPA through direct intervention and education.

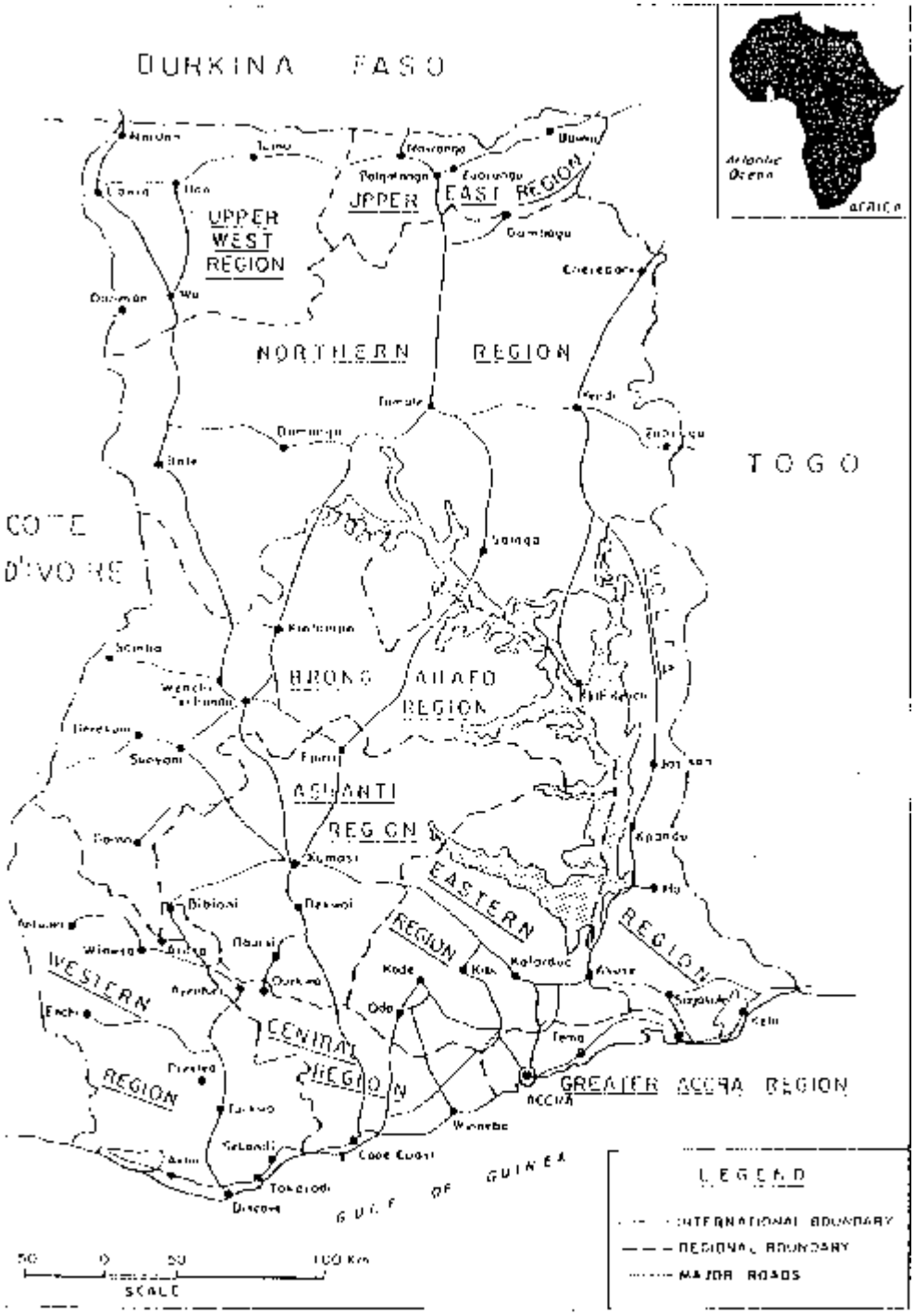

FIGURE 1. ADMINISTRATIVE REGIONS OF GHANA

Figure 3: Administrative Regions of Ghana

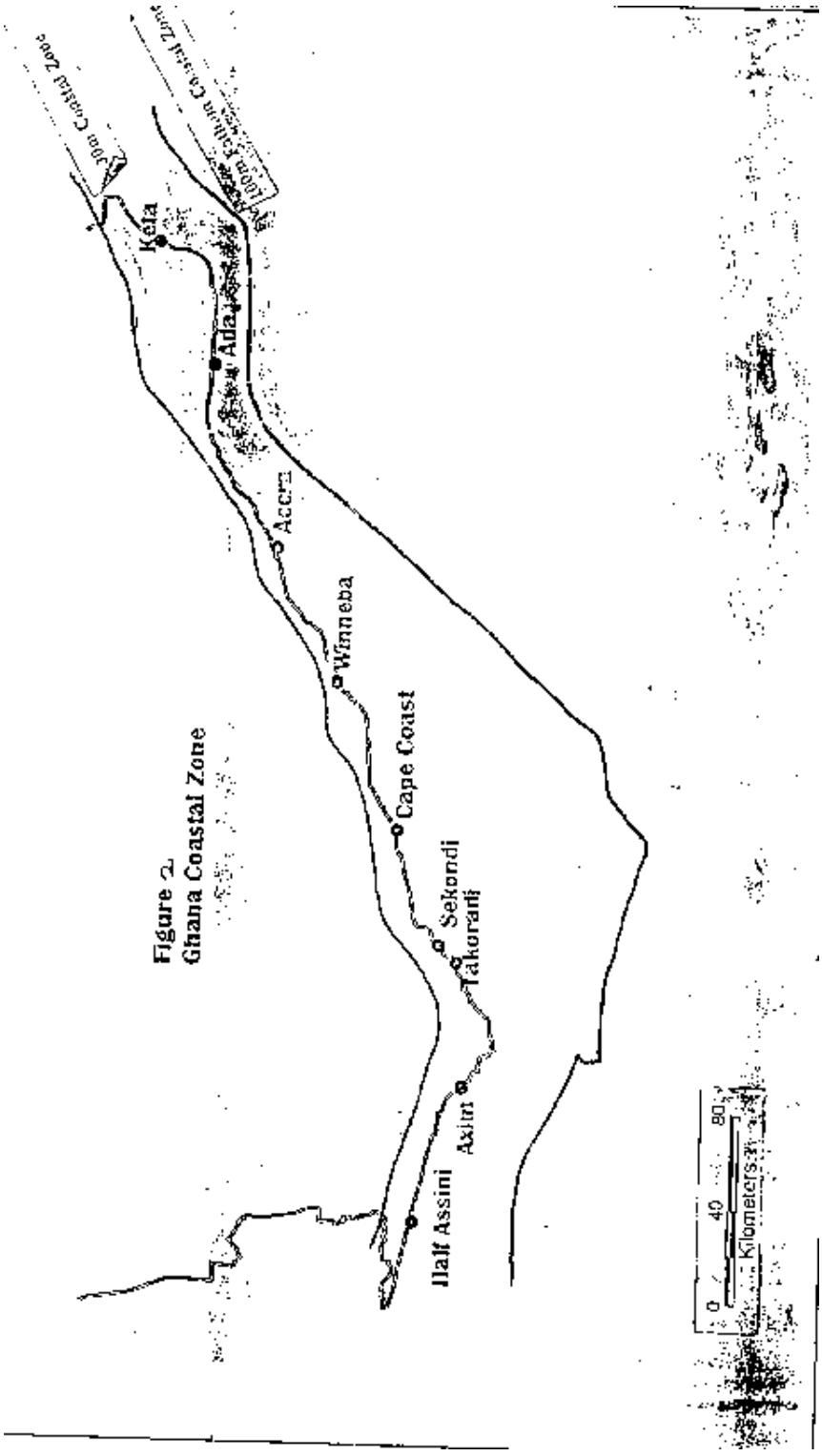

Figure 4: Ghana Coastal Zone

Ghana National Committee for the Intergovernmental Oceanographic Commission (GNC/IOC)

The GNC/IOC has a function to co-ordinate national research activities dealing with marine science. It currently has a membership of 17 institutions as follows:

1. Water Research Institute (CSIR).
2. Department of Oceanography and Fisheries, UG.
3. Department of Chemistry, UG.
4. Department of Zoology, UG.
5. Research and Utilization Branch, Fisheries Dept., MOFA.
6. Environmental Protection Agency.
7. Survey Department.
8. Geological Survey Department.
9. Architectural and Engineering Services Corp. (Hydro. Division).
10. Meteorological Services Department.
11. Ghana National Petroleum Corporation.
12. Regional Maritime Academy.
13. Ghana Shippers Council.
14. Ministry of Justice.
15. Ministry of Lands and Forestry.
16. Ministry of Foreign Affairs.
17. Ghana National Commission for UNESCO.

Different kinds of oceanographic data are collected by some of these institutions for research and/or commercial purposes. The most important of these institutions is the Research and Utilization Branch of the Fisheries Department, MOFA (Fisheries Research and Utilization Branch).

Fisheries Research and Utilization Branch (Fisheries Dept. of the Ministry of Food & Agriculture)

The Fisheries Research and Utilization Branch (FRUB) of the Fisheries Department of the Ministry of Food and Agriculture. FRUB was established in 1962 as a small Marine Fisheries Research Unit with provision for expansion, depending on the needs of the fishing industry and availability of trained Ghanaian manpower. In 1966, it became a full Fishery Research Unit under the UNDP project implemented by FAO and the Ghana Government.

The main functions of FRUB are twofold:

(a) To carry out scientific fisheries research aimed at obtaining the required information to be applied in effective management and exploitation of the marine fisheries resources.

(b) To provide the technical advice based on the scientific results to the Government of Ghana for the formulation of fisheries policies and promulgation of fisheries laws and regulations for the rational exploitation of the fisheries resources.

Apart from the Government individuals from the fishing industry obtain advice from the Branch on the sort of fishing gear they should use, the type of fishing they should venture into, the type of fish species available in the waters and whether their exploitation is economically viable. Staff from the Branch assist fishermen in physically mounting or constructing their nets.

In order to carry out the above named functions FRUB performs the following activities:

Fisheries Oceanography

The Branch carries out research on the marine environment insofar as it affects the coastal fisheries of Ghana. This involves studies on the following:

(a) Systematics of phytoplankton and primary production.

(b) Systematics of zooplankton and variability in zooplankton abundance. Systematics and variability of ichthyoplankton.

(c) Hydrography in relation to fish abundance. This includes studies on water temperature, salinity, oxygen, turbidity, currents and nutrient concentration. This information is obtained by:

(i) Collecting and studying the daily beach sea water surface temperatures and salinities at 8 selected beach sites namely Keta, Tema, Winneba, Elmina, Takoradi, Cape Three Points, Axim and Half Assini (Figure 5).

(ii) Execution of weekly oceanographic transect off Tema for collecting information on sea water temperature, turbidity, ocean currents, wind speed and direction. as well as samples for dissolved oxygen., salinity and plankton studies at 4 predetermined stations. (Figure 6).

Fisheries Biology and Statistics

This is split into the following:

(a) FISH CATCH STATISTICS: Catch and Effort data are collected from the Artisanal fleet, Semi-Industrial fleet, Industrial fleet and Tuna fleet. Fish catch records for the Artisanal fleet are collected at 54 selected landing sites along the coast. The data are collected according to the type of gear used. Data for the Semi-Industrial fleet are collected at the Tema Fishing harbour and 6 other centres. The Industrial and Tuna vessel operators supply the Branch with their catch records. These catch records are analyzed in order to obtain the fish production by the various sectors of the fishing industry.

(b) FISH STOCKS: The Branch undertakes monthly and quarterly trawling surveys at Saltpond and at 40 stations on the entire shelf area of Ghana respectively in order to achieve the following objectives:

(i) To regularly assess the potential of demersal stocks in order to forewarn any likelihood of depletion.

(ii) To study the distribution of the fish stocks in time and space.

(iii) To identify trawlable grounds. Occasionally acoustic surveys are carried out in conjunction with foreign organizations to assess the pelagic stocks.

(c) FISH BIOLOGY: The life history of some economically important pelagic, as well as demersal fishes are studied. The studies include spawning, feeding, growth and behaviour of the fishes.

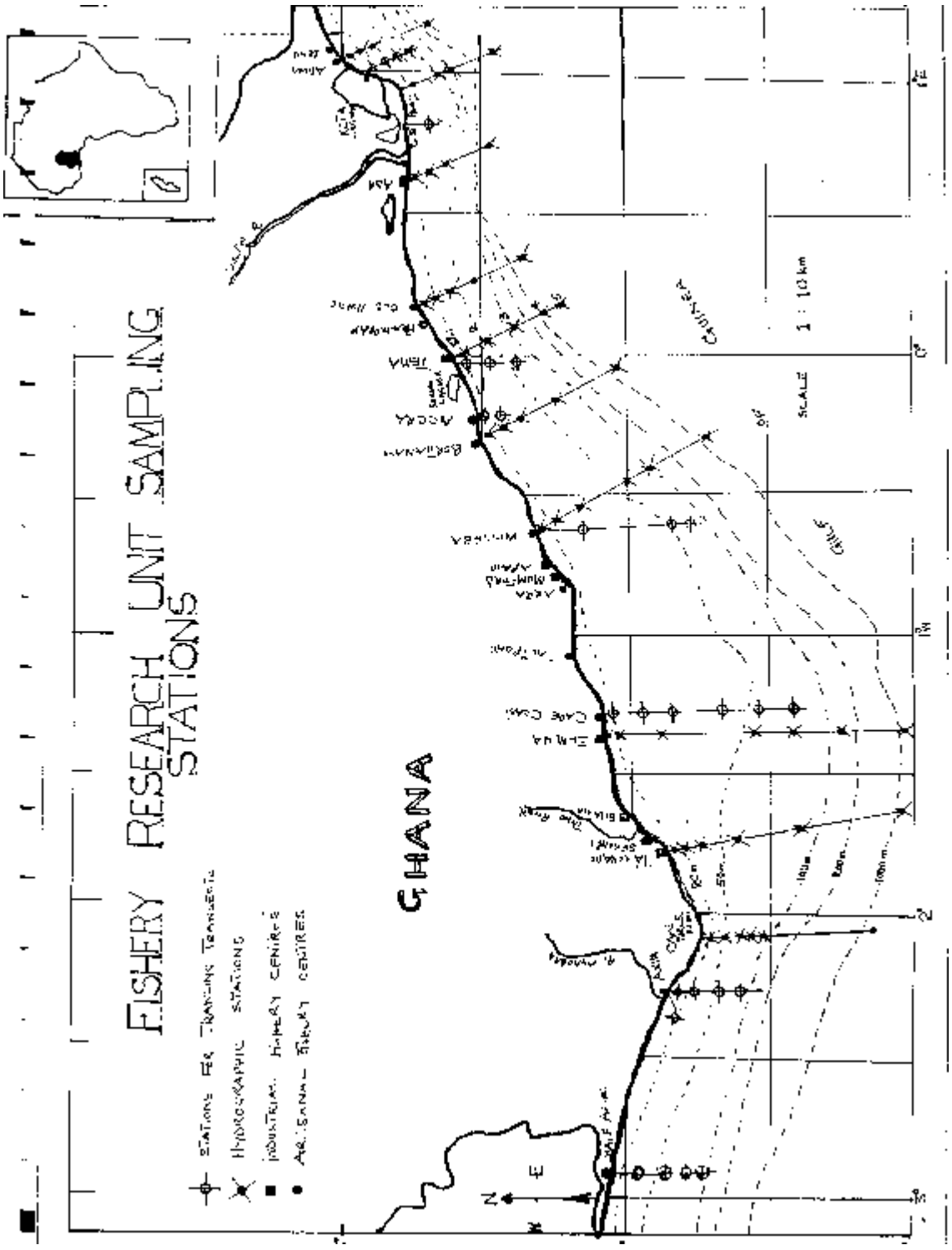

Figure 5: Fishery Research Unit Sampling Stations

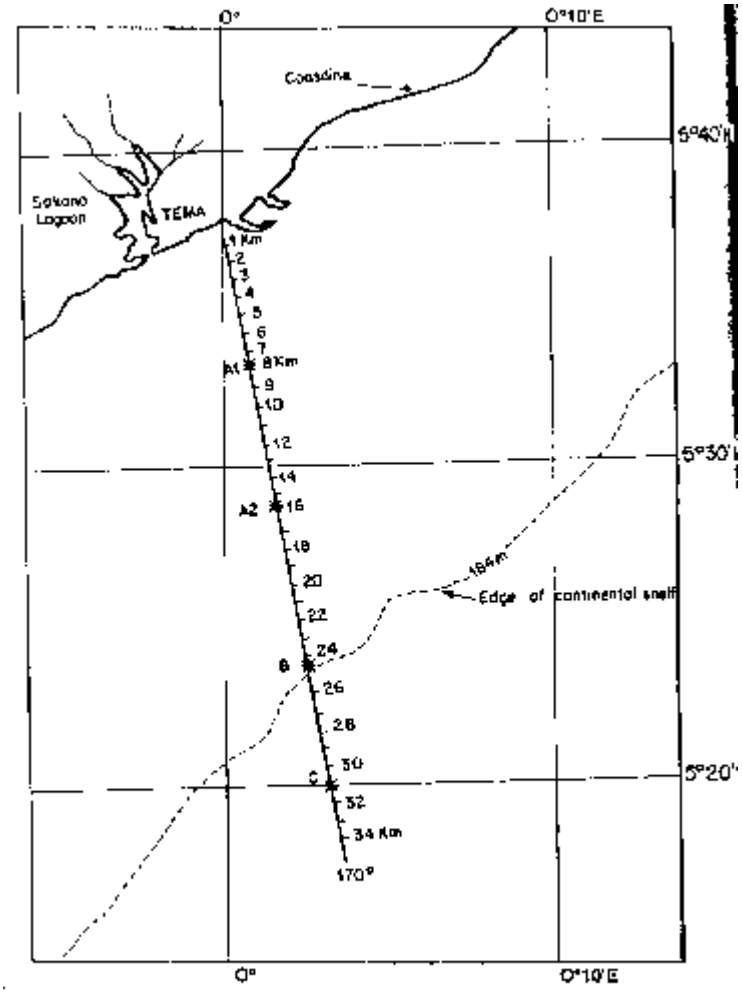

Figure 4: The coastline and continental shelf off Tema, showing the position of the transect and four stations A1, A2, B and C (Culled from Mensah, 1974)

Figure 6: The Coastline and Continental Shelf off Tema showing the Position of the Transect and Four Stations A1, A2, B and C (Culled from Mensah, 1974)

Scientific Cruises

The information needed for the discussed specialized fields of research is obtained from sea. The scientists and technical officers go to sea on board research vessels *R.V. Kakadiamaa* and *R.V. Sangonaa* to carry out the series of research activities in order to obtain the required field data. The entire continental shelf stretching from Aflao to Half Assini (550km long) and extending to sea for a distance varying from about 16km in the Volta Region to 80km in parts of the Central and Western Regions is covered.

Coastal Upwelling

From the annual temperature cycle observed, 3 main oceanographic regimes have been identified. Namely:

Two hydrographic stability or Thermocline Periods: These occur from October- December and February or March to June. These are the periods of the year when sea-surface water temperatures are high >26^{o}C and salinity is low <35.00$^{o}/_{oo}$. There is a distinct thermocline layer which lies between 40-50m depth. The water density during this period is low (22.00 and 19.00 Sigma-T), dissolved oxygen values are high (>5ml/1), nutrient values are low. This period is characterized by low biological production (plankton, fish, etc).

The Major Upwelling: This occurs between July-September or October. The duration and intensity of the major upwelling varies from year to year. During this period, sea-surface water temperatures are below 25ºC and can fall as low as 19ºC. Salinity values are high (35.5$^{o}/_{oo}$) nutrient concentrations are high, dissolved oxygen values are low (>3ml/1). Water density is high with average Sigma-T values of 26. Biological production during this period is usually very high.

The minor upwelling: This occurs annually for a short period of about 3 weeks in January or February. The intensity of the minor upwelling is lower than that of the major upwelling and the biological production is equally much lower. However, it has been observed that the duration of the minor upwelling in a particular year has some effect on the production of the small pelagics especially the Sardinella in the following year.

Many theories have been put forward to explain the mechanism that triggers the Ghanaian upwelling but none of them has been accepted by oceanographers. More work needs to be done on this.

Plankton Production

There is a clear annual cycle of phytoplankton and zooplankton production which is influenced by the coastal upwelling and the stability periods. Zooplankton volume displacement values range between 53.2ml/1000 litres during the non-upwelling period and 157.8 ml/1000 litres during the major upwelling period. The dominant species during the upwelling period are copepods which form the main diet for the Sardinella species that form the bulk of fish production during this period. Phytoplankton cell counts range between >1000 cells/litre during the non-upwelling period to <1000 x 10^{9} cells/litre during the major upwelling period. Diatoms that form the main diet for the copepods form about 80% of the composition of the phytoplankton. Primary production studies using C^{14} indicated average rates of 2,358 mgC/m^2/day for the major upwelling period and 600 mgC/m^2/ day for the non-upwelling periods.

Stock Composition

Marine fish landings have been dominated by the small pelagics accounting for about 60% of annual marine fish landing. The round sardinella is the most abundant fish species in Ghanaian waters. For about one decade (between the late 1970's and 1980's) the Trigger fish *Balistes capriscus*, a demersal fish species, was the most abundant species. Presently Burrito is considered to be the most abundant

demersal species in Ghanaian waters. The Trigger fish has almost disappeared from the Ghanaian waters. The reason for the disappearance is not quite clear. Detailed analysis of available environmental data might throw more light on the possible cause. *Lagoceghalus laevigatus* (the Globe-fish) has increased in abundance in the absence of the Trigger fish. There has also been an increase in Cephalopod population.

Fish Stocks and Production

The marine fish resources are grouped into 3 categories, namely, the small pelagics, the large pelagics and the demersal stocks.
Marine Fish Production m/tons (1990-1995)

Table 1

YEAR	LANDINGS
1990	320000
1991	290000
1992	370000
1993	320000
1994	290000
1995	273000

Source : FRUB Record

The annual marine fish production for the past few years decreased from the peak of 370,000 mt. in 1992 to 273,000 mt. in 1995,

The small pelagic are dominated by 4 species namely *sardinella aurita* (Round sardinella); *sardinella maderensis* (Flat sardinella), *Engraulis encrasicolus* (the anchovy) and *Scomber japonicus* (Club mackerel). They form about 90% of the total annual landing of the small pelagic resource. Apart from the anchovy which occurs all year round, the others mentioned are seasonal and the bulk of the annual landings is caught during the major upwelling. It is estimated through acoustic surveys that the total biomass of the small pelagic resource in Ghanaian waters ranged between 246,000 and 378,000 mt. with a maximum sustainable yield of between 98,000 and 151,000 mt. During the last 5 years the annual landings of the resource decreased from 279,000 mt. in 1992 to 156,000 mt. in 1995. It is clearly evident that the present level of exploitation of the resources is very high. There is a decreasing trend in the catch per unit effort which indicates that the stock is being depleted.

Table 2: Annual Production of Small Pelagics

YEAR	PRODUCTION (m/t)
1990	205000
1991	190000
1992	280000
1993	230000
1994	160000
1995	156000

Source: FRUB records

The large pelagic are made up of 3 tuna species that are of high commercial value. They are highly international migratory species that are caught all year round. The main species are *Thunnus alpacares* (Yellowfin); *Thunnus obsesus* (Bigeye) and *Kapsuwonus pelamys* (Skipjack). There are other tuna-like species of less economic importance such as Black skipjack and Frigate tuna.

The annual landings of the tuna resource is dominated by the skipjack which accounts for about 70% of the landed catch. The maximum potential yield of the skipjack in Ghanaian waters is estimated to be 80,000 mt. In the past 5 years the annual tuna landings increased from 30,775.6 mt in 1992 to 33,905.0 mt, in 1995. The tuna resources is currently under exploited.

Table 3: Annual Production of large pelagics (Tuna)

YEAR	**PRODUCTION (m/t)**
1990	41000
1991	38000
1992	31000
1993	37000
1994	37000
1995	34000

Source : FRUB records

The most important demersal species belong to the families *Sparidae* (Sea Breams); *Pomadasidae* (Buro); *Mullidae* (Mullets); *Scianidae* (Croakers); *Lutjanidae* (Snappers) and *Cephalopodae* (Cuttlefish). It has been estimated that the maximum potential yield of the demersal resource in Ghanaian waters is between 24,000 and 42,000 mt. In the last 6 years the annual demersal fish landing fluctuated between 41,000 mt, and 51,000 mt. The present level of exploitation exceeds the level necessary for the sustenance of the resource. It has also been observed that there is a decrease in the average lengths of most of the demersal fish species being landed. These are clear indications that the resource is being over exploited and the stock is being depleted.

Table 4: Annual Production of demersal fish species

YEAR	**PRODUCTION (m/t)**
1990	52000
1991	45000
1992	41000
1993	42000
1994	43000
1995	51000

Source: FRUB records

Species Composition

Over 200 different fish species have been identified in the Ghanaian marine coastal waters.

Economic Value

The fisheries sub-sector accounts for about 3% of Ghana's GDP and 5% of the Agriculture GDP. Fish is the most important non-traditional export in the country. A total of 9,000 mt of fish (frozen or cured) valued at US$ 11 million were exported from Ghana in 1994. The fishing industry employs about 500,000 fishermen, fish processors, traders, boat builders and maintenance personnel. Apart from export fish forms about 60% of the animal protein intake by the Ghanaian population.

Fishing Fleets

There is a well developed marine fishing industry consisting of the artisanal, semi-industrial, industrial and tuna sectors. The artisanal sector contributes about 70% of the annual fish landings. This sector uses several fishing gears which are operated from dug out canoes ranging between 5 and 18 metres in length.

The semi-industrial fleet consists of locally built wooden vessels fitted with inboard engines up to 400 HP. They operate as purse seiners during the upwelling period and as trawlers during the non-upwelling periods. The length of the vessels range between 8 to 25 metres.

The industrial fleet consists of imported distant water vessels used for trawling and shrimping. These are normally more than 35m in length and have engines of over 600 HP. The shrimpers are normally up to 30m in length with engines up to 400 HP. There are over 40 industrial vessels operating in Ghanaian waters. The Tuna fleet are bait boats using live anchovy as bait. They are more than 30m in length with engines up to 1,500 HP. About 30 tuna vessels are now in operation. Recently some tuna purse seiners have started operating from the Tema Port.

Level of Effort

The last canoe frame survey conducted in 1992 estimated the number of canoes operating in the artisanal sector to be 8,700. They operate from 300 landing sites along the entire 550 km length of the coastline. About 49% of these canoes are powered by outboard motors of up to 40 HP. The number of artisanal fishermen are estimated to be 96,400. The average number of canoes and fishermen over the last decade were 8,320 and 97,500 respectively.

There are 156 operational inshore vessels operating from 8 landing sites along the coast. The figure forms about 39% of the registered semi-industrial fleet. The remaining 61% are lying idle due to lack of funds to operate them. The sector was affected by the disappearance of the triggerfish the main resource base of the sector. The estimated number of fishermen for this sector is 6,500.

Analysis of Samples and Data

All the field samples, data and information are subjected to series of analysis in the laboratory before interpretation is done. Results are written as Technical, Information or Scientific reports. Special occasional reports are also produced for management purposes.

Data Storage and Retrieval

Until now, most of the data are stored in manuscript form which makes the process of retrieval very tedious. Steps are being taken to computerize the available data for easy retrieval. Some of the data which were stored on floppy diskettes (5.25 inches) could not be retrieved because such diskettes were found to be corrupted. Most of the data collected by foreign research vessels are also not available. Some effort is being made to retrieve the data from the Guinean Trawling Survey.

Data Dissemination

Data on annual fish production as well as oceanographic data and information are sent in accordance with Ghana's international obligations to FAO Statistical Session in Rome (annual fish production) to ICCAT (on tuna) and to the World Data Centre-A, Oceanography in Washington (sea surface temperature).

Apart from these international organizations, research reports are conveyed to the Ministry of Food and Agriculture through the Director of Fisheries. In addition, research reports are distributed to the interested public, other research institutions, international libraries and some kept in the local library.

The reports are in titles such as:

(a) Marine Fishery Research Report.
(b) Information Report.
(c) Marine Fisheries Research Technical Reports.
(d) Marine Fishery Research Special Papers.

Available Data

All data available at FRUB are summarized in Table 5.

Table 5: The Data Situation

Type of data	**Year**	**Method of Storage**
a. Sea Surface Temperature[3]	1962 to date	Processed data files & Charts
b. Wind speed & direction	1973 to date	Raw data files
c. Current speed & direction	1973 - 1974	Raw data files; Publications
d. Oxygen (dissolved)	1964 to date	Processed data files; Publications
e. Salinity	1963 to date	Processed data files; Publications
f. Zooplankton	1966 to date	Processed data files; Publications
g. Phytoplankton, chlorophyll & Primary Production	1973 to date 1973 - 1974 1973 - 1974	Processed data files; Publications
h. Trawling Surveys[4]	1980 to date	Processed data files; Publications
i. Fish species	1963 to date	Publications; Processed files; Diskettes (D-base and spreadsheets software)
j. Fish production	1972 to date	Publications; Processed files; Diskettes (D-base and spreadsheets software)
K. Turbidity	1966 to date	

[3] There are gaps in the time-series for the environmental data due to breakdown of research vessels.

[4] There have been trawling and acoustic surveys with intervals between 1963-1990.

Based on Scientific data given to the Government, Fisheries Laws and Regulations have been passed for the effective management of the fisheries resources.

A list of commercially important fish species in Ghanaian waters is made available to fishermen engaged in fishing and those aspiring to engage in fishing activities.

Prospective fishermen are guided by fish catch and effort data in deciding what fishery they can safely invest in.

Trawlable grounds have been identified for trawling vessels.

Areas suitable for shrimp fishing have been identified for shrimpers.

Data emanating from FRUB from 1963 to date are being analyzed by scientists from FRUB, ORSTOM and Warwick University to ascertain the effect of changes in marine environmental factors on the fisheries in the Gulf of Guinea.

Other Institutions

Other institutions which are involved in oceanographic data collection may be grouped into two kinds as follows:

- Commercial and Service Institutions, which include the Ghana National Petroleum Corporation, Meteorological Services Department, and Survey Department.

- Research and Regulatory Institutions, notably University Departments, Environmental Protection Agency and Water Research Institute.

Ghana National Petroleum Corporation (GNPC)

The Ghana National Petroleum Corporation collects data in the course of its petroleum exploration activities. These are:

(i) Seaborne Gravity and Magnetic data; 1967-1990;
(ii) Seismic reflection data;
(iii) Drilling data - mainly well logs, cutting samples and core samples (sidewall and conventional).

To date, a total of 53,872 km of seismic data and 8,000km of gravity and magnetic data have been collected in the four offshore basins of Accra/Keta, Saltpond, Cape Three Points and Tano. These data are stored in the form of raw field tapes, processed magnetic tapes, film and paper copies of the processed tapes.

Some of the tapes are stored locally in Ghana but the majority are stored with a professional data management company in the United Kingdom. However, there are plans to bring the data under one storage facility in Ghana. At the same time, copies of all the data on a high-density storage medium will be maintained outside Ghana for security reasons.

Companies that require the use of these data can apply through GNPC which makes copies available for a fee. Any company that enters such data has to sign a confidential agreement not to divulge any information so received to a third party without the written consent of GNPC.

A total of about 45 wells have been drilled in the offshore basins. Vital data on these wells in the form of cutting samples, fluid samples, sidewall and continental core samples have been gathered and stored locally.

In addition to these, navigation data collected in the course of seismic data acquisition are available.

Survey Department

The Survey Department has been engaged in the collection of data for tidal analysis since December 1927. On 28 November 1927, a tide gauge was sited at the Takoradi Harbour to begin the collection of tidal data in Ghana. In 1963, another gauge was sited at the Tema Harbour.

The sea-level values obtained from the tide gauge readings are referred to a base called the Chart Datum Admiralty which is 2ft below the National Level Datum in Accra. A bench mark at Takoradi Harbour Bbf GCS H4 is 8.13ft above the National Level Datum. At Tema Harbour, the bench mark PL.8/5 is 9.20ft above the National Level Datum.

Tide gauge readings are recorded automatically and registered on a chart. Apart from the continuous readings automatically recorded, there are visual readings taken by officers stationed at the tide gauge sites. These are made on the graduated scale of the tide gauge at 5-minute intervals for half-an-hour before and after a predicted high tide and a predicted low tide each day, as given by the Admiralty Tide Tables.

In addition, three extra visual readings at 5-minute intervals are taken midway between the times of the predicted high and low tides, thereby giving observations of the tide at the time when it is changing most rapidly. From these readings the sea-levels and mean sea-levels are calculated.

Monthly mean sea-level readings for each year are sent to the Permanent Services of Mean Sea Level (PSMSL) of Bidston Observatory in the United Kingdom. Other agencies and companies are supplied with such data from tide gauge readings upon request. In addition to the tidal data, bathymetric data are also collected by the Hydrographic Division of the Ghana Ports and Harbours Authority. The data are used to produce resource maps for nautical charts, oceanic or fisheries research, coastal protection, defence purposes, etc.

Meteorological Services Department

The Meteorological Services Department collects information on, among others, ambient temperature and humidity, rainfall and other weather indicators which influence ocean processes. Such data are used for weather prediction, agricultural production, aviation transport and military purposes.

Due to lack of facilities for open ocean research, the activities are normally confined to the coastal zone, i.e., the immediate inshore areas and associated wetlands, lagoons and estuaries. These focus on the increasing impact of anthropogenic activities on the resources of the coastal zone.

For example, the Environment Protection Agency's involvement in oceanographic data collection is linked to its activity objectives of:

(i) Establishing a database for industrial effluent discharge into coastal lagoons and water systems;

(ii) Making environmental information readily available to all stakeholders in order to promote environmental research and management.

Industrial discharge into drains which eventually empty into coastal lagoons with outlets into the sea are being monitored since May 1996. The aim of the monitoring programme is primarily meant to establish a basis for setting industry-specific standards for effluent discharge. However, this would certainly be relevant to efforts at minimizing adverse anthropogenic impacts on the coastal waters.

Parameters being monitored are effluent temperature, dissolved oxygen, pH, conductivity, total dissolved solids, turbidity, oil, grease, nitrate and ammonia.

The agency has compiled a bibliography of reports, dissertations and publications related to the environment. The document referred to as Ghana Historical Database on the Environment (HIDEN) published in 1996 with ODA assistance, contains information on nearly all available published works related to the environment in Ghana. It includes 230 published works, reports and dissertations on the marine ecosystem, pollution, resources and coastal zone management.

The Water Research Institute of the CSIR and University Departments such as Oceanography and Fisheries, University of Ghana and Zoology and Chemistry Departments, University of Cape Coast collect data within the coastal zone. These cover studies on pollution, hydrology, land use, biology of important fish species, disease vectors and coastal erosion.

Activities of note include the FAO/IOC/IAEA/WHO/UNEP Project on Monitoring of Pollution in the marine environment of West and Central Africa and the UNIDO Gulf of Guinea Large Marine Ecosystem Project.

Except for the recent ones, most of the data are in manuscript form. Some efforts are, however, being made to put them on diskettes.

Some Observations on Pollution and Environmental Degradation

Beach Erosion: The entire coast of Ghana is undergoing varying rates of erosion. The most seriously affected areas include the following: The Keta coast from Dzelukope to Blekuso, the Ada-Foah Beach from the Volta estuary to Otrokpe, the Labadi Beach from Osu to Kpeshie Lagoon and the Nkontompo Beach between Sekondi and New Takoradi. In all these areas, the rate of erosion exceeds 1.5m. per annum which is rather high. There may still be other areas where rates of erosion are not known because of poor accessibility.

Sand Winning: The growth in the economy in recent times has speeded up the rate of urbanisation and construction. As sandcrete and concrete are favoured building materials there has been increasing pressure on these resources. The first problem is that of destruction of beaches by direct removal causing changes to the beach profile and disturbing or destroying the fauna of the beach. The removal of sand from one beach can cause sea erosion at another locality.

Finally, where the sand is collected from sites inland, there is the danger of rain carrying the unconsolidated material away from the sites as sheet run-off which can cause increased silting up of inshore waters and lagoons.

Climatic Change: The extreme dry weather conditions of the early 1980's caused several water bodies to dry up completely, e.g., the Keta lagoon. Though the sea is not directly affected by drought, the reduction of freshwater input into the various lagoons and estuaries causes changes in recruitment of marine species which breed or use brackish water as nursery grounds.

Sea-Level Rise: Roberts (1991) makes a number of predictions for sea-level rise in Ghana. The effects of sea-level rise would include permanent flooding of low lying areas, an increase in the penetration of salt water inland, intrusion of salt water into fresh groundwater, increase in coastal erosion and a change from closed to open conditions of lagoons. The loss of coastal wetlands could also reduce

fisheries production as many of the commercial species depend on coastal wetlands for key phases of their life history.

Coastal Pollution: The coastal zone, especially Accra, Tema and Takoradi have been the major area of industrial development in Ghana. Almost 60% of all industries in the country are located in the Accra-Tema metropolis which covers less than 1% of the total area of Ghana. This trend has led to the coastal industrial centres. Along the whole coastline of Ghana, since discharges into the environment are, to a large extent, untreated and unregulated, the risk of pollution and modification of the marine environment is increasing especially in the centres of high population densities.

Urban Development: In Ghana, an urban settlement is defined as one with a population greater than 5,000. There are over 15 urban settlements along the coast of Ghana including two of the largest city complexes in the country, Accra/Tema and Sekondi/Takoradi. The critical issue is that in these urban centres, problems exist in regard to planned expansion and delivery of infrastructural and other utility services especially sanitation, drainage facilities and water supply. These problems, e.g., the extraction of coastal clay, sand and washed stones for construction and the disposal of human waste respectively, ultimately lead to environmental degradation and human health hazards. These have posed serious risks of pollution and epidemic and also reduced the tourism potential of the coastal zone.

Oil Pollution

Oil pollution along the coast of Ghana arises mainly from the transportation of petroleum hydrocarbons across the Gulf of Guinea. Petroleum hydrocarbons, when accidentally or intentionally released into sea-water, increase in viscosity as the lighter fractions dissolve into the water or evaporate into the atmosphere and finally form what is known as tarballs. Being less dense than sea-water, tarballs float on the water and are carried by wind and current action to be stranded on beaches. Compared to other forms of petroleum hydrocarbons, tarballs are relatively biologically inert but they persist for long periods and hinder the development of tourism by reducing the aesthetic quality of beaches. Also, since such lumps of tar still contain some of the carcinogenic fractions, their presence on recreational beaches may constitute a severe public hazard through skin contamination.

As part of the joint FAO/IOC/WHO/IAEA/UNEP Project on the monitoring of pollution in the marine environment of the West and Central African region (WACAF 2) surveys of stranded tar on beaches were undertaken in the Greater Accra Region. Monthly deposition rates ranged from zero to 1g/metre of beach. These values are considered as generally low compared to other areas of West Africa.

Trace Metals in Marine Organisms

Also, as part of the WACAF-2 Project, samples representing 17 families and 27 species of marine biota from the coast of Ghana were analyzed for Hg, Cd, Pb, Cu, Zn and Fe.

The levels of trace metals in all groups were below or comparable with the WHO limits for food. Cd and Mn for example were not detected in fillets. Hg concentrations ranged from <0.01 in *Mugilidae* to 0.15 ug.g-l fresh weight in *Balistidae* with an overall mean for marine biota of 0.62 + 0.032 ug.g-l. Generally, there was not much variation in Hg concentrations between the different groups. Pb concentrations were also low with mean values ranging from <0.02 ug.g-l in *Mugilidae, Cynoglossidae* and *Cichlidae* to 0.082 ug.g-l in *Penaeidae*. Just as for Pb, the lowest concentrations of Cu and Zn occurred in *Mugilidae*, and the highest in shellfish. In relation to the other elements, Fe was detected in relatively high concentrations.

While the concentrations of trace metals were of the same range as for other West and Central African countries, Hg was low compared to the Mediterranean region.

4.5 NIGERIA

The Nigerian national data centre located at the Nigerian Institute for Oceanography and Marine Research (NIOMR), Lagos was established with the aim of collating and archiving oceanographic data in the Nigerian marine area. The Institute's mandate includes collection of oceanographic and fisheries data. Since the establishment of the Institute in 1975, it has been collecting biological, fisheries, physical and geological data.

The different divisions of NIOMR consisting of Marine Biology, Marine Geology/Geophysics, Physical and Chemical Oceanography undertake several capital projects which are presently generating large volumes of data. Apart from NIOMR, there are coast-based universities like the University of Lagos, which also undertake several marine projects and generate large volumes of data.

The National Oceanographic Data Centre in NIOMR is at its developmental stage with some modest oceanographic data in its database. Large volumes are still in manuscript form while some are now in electronic form forming part of new datasets of WDC-A, Oceanography.

In 1992, NOAA provided NIOMR with the acoustic tide gauge (Next Generation Water Level Measuring System) which is also equipped with ancillary sensors for wind speed and direction, air and water temperature and barometric pressure. Since June 1992, this equipment has generated large volume of data which are in the WDC-A database, as well as in the Nigerian NODC.

The Institute also operates since 1994, the NOAA SEAS programme which involves collection of sea temperature and meteorological data along the WOCE line AX 14 (Lagos-Rio) using VOS *Clipper Sao Louis* merchant ship. Since then the ship has made well over 25 round trip tracks along this route. Collected data were transmitted in near real-time to NOAA and into the WDC-A database. The Nigerian NODC has this same data in its database.

In August 1995, NIOMR and NOAA/NODC signed a memorandum of understanding on the establishment of oceanographic data exchange programme. The types of data to be exchanged are as follows: physical/chemical station data, CTD/STD (or any similar type of sensor), XBT data, MBT data, biological data and marine geological (including remotely-sensed) data. The agreement also includes the participation of both agencies in a joint co-operative project to build a comprehensive marine database for NIOMR's geographical area of interest and any other agreed-upon area.

Meanwhile, the Nigerian NODC is compiling datasets in its achieves to determine the levels and types of existing historical data. The establishment of a functional data centre in Nigeria requires the updating of existing communication systems, acquisition of equipment and manpower development. NOAA has provided training and equipment for a Geographic Information System, as well as GIS software.

START has also provided fellowship assistance to the personnel at the LOICZ CPO in Texel, Netherlands.

Large volumes of biological data are available for rescue and archiving, the Nigerian NODC is yet to include these data in its database. The NODC is willing to co-operate with regional institutions and will be prepared to make its equipment and facilities available to regional and international IODE programmes.

4.6 SENEGAL[5]

La zone maritime du Sénégal est très contrastée. En effet, aux mécanismes très complexes qui régissent l'évolution des eaux marines de cette zone s'ajoute l'importance des échanges de chaleur entre l'océan et l'atmosphère.

La persistance d'eaux anormalement froides devant le Sénégal (particulièrement de décembre à mai-juin) s'explique par d'importants mouvements verticaux qui amènent constamment des eaux froides en surface (phénomène d'upwelling). Au nord de la presqu'île du Cap Vert, cet upwelling est côtier ; au sud, il atteint son extension maximale au large (à la limite du plateau continental).

Les traits caractéristiques de la circulation des eaux sur la côte sénégalo-mauritanienne ont été établis par Berrit (1952, l962, 1978), Doniol (1956), Dorot (1972), Accoster *et. al.* (1976), Yoshida (1967), Rébert (1983), Touré (1983).

Au large du Sénégal, deux grands courants (le courant équatorial nord et le contre-courant équatorial) ont été identifiés. Le premier transporte vers l'ouest des eaux froides issues du courant des Canaries; le second transporte vers l'est les eaux chaudes et salées venant de l'Atlantique Nord.

A la côte, cette circulation zonale se transforme en circulation méridienne. Au cours de l'année, on a alternativement une période (de novembre à mai) de courants sud associés à des eaux froides et une période (de juin à août) de courants nord instables qui transportent des eaux chaudes. La dynamique de ces courants dépend de la direction de la côte, de la topographie du plateau continental et des fluctuations du régime des vents. Dans les zones très côtières, l'importance du bilan thermique et la proximité de zones à forts excédents pluviométriques peuvent induire une circulation thermo-haline assez importante.

Les Courants de Surface

La succession des deux courants (le courant équatorial nord et le contre-courant équatorial) induit une forte variabilité des courants devant les côtes du Sénégal.

Sur les bords ouest du Cap Vert, on note une divergence des courants suivie par un jet au niveau du talus continental. Ce jet, dont les vitesses peuvent aller jusqu'à 75 cm/s, se poursuit jusque vers 14ºN et sa composante dirigée vers le continent crée une convergence des eaux au niveau du talus, entraînant un resserrement des isothermes. Le jet serait du à la remontée des isobathes dans le sens nord-sud et à l'avancée de la côte vers le large au niveau du Cap Vert.

Au sud de 14ºN, l'influence du Cap Vert s'arrête et on note dans la zone des courants assez réguliers, avec des vitesses de l'ordre de 30 cm/s.

Les courants sont faibles (20 cm/s en moyenne). Ils atteignent leur maximum d'intensité au moment des vents forts.

La veine de courant maximum oscille entre les isobathes 20 et 100 m. Les traits les plus frappants de cette figure sont les deux circulations vers le nord qui entourent une zone centrale de courants sud. Sur les petits fonds, il existe un contre-courant faible dû aux caractéristiques thermo-halines de la couche de surface en zone côtière.

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[5] Resume in English is given at the end of this Chapter.

Les Courants au Nord et au Sud du Cap Vert

- au normal du Cap Vert, différentes études font apparaître la faible épaisseur du courant de surface portant vers le sud. Ce courant de surface semble correspondre à un courant de dérive pur. Au fond, on note un contre-courant caractérisé par un noyau de haute vitesse qui longe le talus continental.

- au sud du Cap Vert, ce contre courant n'apparaît pas; le courant de surface diminue de la surface jusqu'au fond. Toutefois, une faible circulation profonde vers le nord existe à l'extérieur du plateau continental. Dès que les vents soufflent assez régulièrement vers le sud avec une vitesse moyenne dépassant 5 m/s, cette faible circulation porte vers le sud sur une épaisseur dépassant 50 mètres.

La Circulation Thermo-haline

Dans les zones côtières, en plus de la circulation due au vent ou aux forces extérieures, deux processus distincts contribuent à induire des courants plus ou moins intenses dirigés vers le nord. En saison froide et particulièrement sur la Petite Côte, l'existence d'un très fort gradient thermique, dû à l'échauffement des eaux accumulées à la côte par la convergence côtière, crée un courant de pente qui s'écoulera vers le nord dans une étroite bande côtière des que les vents seront insuffisants pour maintenir l'équilibre du coin d'eau chaude. Les vitesses des courants induits par ce processus sont de l'ordre de 10 cm/s.

La circulation thermo-haline due à la présence d'eau dessalée est plus importante. Le gradient pluviométrique méridien, très élevé devant le Sénégal, crée une surélévation du niveau de la mer du nord au sud. Toutefois, le courant induit par une telle pente demeure négligeable par rapport à celui crée par la poche d'eau dessalée alimentée, sur 1a côte sud du Sénégal, par des apports fluviatiles (fleuves Saloum, Gambie, Casamance). Cette poche d'eau chaude crée une pente zonale à laquelle est associé un courant méridien dirigé vers le nord. L'intensité de ce courant est telle qu'il arrive à contrebalancer les effets du courant de dérive dû au vent tout au début de la saison d'upwelling dans la partie sud.

La Circulation Profonde

En l'absence de mesures directes sur le talus continental et au-delà, le courant en profondeur est déduit des propriétés des masses d'eaux centrales sud et nord atlantiques. Le mélange de ces masses d'eaux révèle l'existence d'une probable circulation profonde dirigée vers le nord entre la thermoc1ine et la profondeur 300 mètres d'une part, la côte et le méridien 21ºW d'autre part.

La Circulation des Eaux dans la Baie de Gorée

La baie de Gorée fait partie du complexe dit guinéen. Au nord et au sud, elle est limitée par les latitudes 14º42N et 14º20N et à l'ouest par l'isobathe 90m. Du point de vue climatique, elle est située dans la zone des alizés du nord (vents de secteur nord soufflant avec une certaine régularité et une vitesse comprise entre 3 et 6 m/s.

La circulation dans la baie est assez peu connue. Néanmoins, pendant la saison froide (de décembre à mai), Rossignol (1965), et Rébert (1978) ont mis en évidence une ramification de la circulation cyclonique du dôme de Guinée, ramification qui longe la côte vers le nord jusque dans la baie de Gorée où, par suite du changement brusque de l'orientation côtière, il s'établit un vortex cyclonique. La circulation des eaux se fait alors dans la direction du vent, c'est-à-dire vers le sud.

Pendant la saison chaude par contre, s'installe un vortex anticyclonique dû à la configuration de la côte. On note alors un courant côtier dirigé vers le nord.

Les travaux de Touré (1983) ont permis d'avoir une idée plus précise de la circulation dans la baie de Gorée. Cet auteur montre qu'en saison chaude, les courants de surface n'ont pas une direction privilégiée. C'est au niveau des 20m qu'est observée une circulation typique de la saison chaude: eaux dirigées vers le large avec des vitesses variant de 22cm/s au large à 10cm/s à la côte. A l'immersion 60m, un courant d'environ 25cm/s orienté vers le nord indique l'emplacement du sous-courant constitué par la branche nord du contre-courant équatorial.

Pendant la saison froide et à 5m de profondeur, les coupes horizontales effectuées indiquent une direction sud dans l'orientafion des courants. Les plus grandes vitesses du courant à cette profondeur sont de l'ordre de 40-50 cm/s et sont observées au large de la baie, beaucoup plus exposé à l'action des vents alizés du nord. A l'approche de la côte, ces vitesses diminuent sensiblement (5-10cm/s sur les fonds de 10m).

La caractéristique fondamentale de la circulation des eaux intermédiaires et profondes pendant la saison froide est qu'elle s'effectue, presque dans toute la baie de Gorée, vers la côte alors qu'en surface, le courant se dirige vers le large.

Résumé

La zone maritime du Sénégal est très contrastée. Aux mécanismes très complexes qui régissent l'évolution des eaux marines de cette zone s'ajoute l'importance des échanges de chaleur entre l'océan et l'atmosphère. Au large du Sénégal, deux grands courants sont identifiés. Le premier transporte vers l'ouest des eaux froides issues du courant des Canaries; le second transporte vers l'est les eaux chaudes et salées venant de l'Atlantique Nord. A la côte, on a alternativement une période de courants sud associés à des eaux froides et une période de courants nord instables qui transportent des eaux chaudes. La dynamique de ces courants dépend de la direction de la côte, de la topographie du plateau continental et des fluctuations du régime des vents.

Cette note est une compilation sommaire des études (peu nombreuses) sur la circulation des eaux marines menées au Centre de recherches océanographiques de Dakar-Thiaroye (Crodt/Isra). Elle s'est intéressée aux courants de surface mesurés des deux cotés du Cap Vert, à la circulation thermo-haline induite par l'importance du bilan thermique et la proximité de zones à forts excédents pluviométriques et à celle de la baie de Gorée qui est le siège d'importants upwellings côtiers.

Senegal is located in the intertropical zone of convergence. The Senegalese marine zone is very contrasted. Complex mechanisms and important interactions between ocean and atmosphere govern the evolution of marine waters. The persistence of anomaly cold waters (particularly from December to May/June) is the consequence of important vertical movements which bring cold waters from the bottom to the sea surface (upwelling). The driving forces of this upwelling are the north winds (Alizes). In the north of Cap Vert, this upwelling is coastal; in the south, it gets its maximal extension along the shelf.

Two great currents are identified in Senegal. The first is equatorial north current which carries to the west the cold Canarians waters; the second, the equatorial contre current, carries to the east the warm and salted waters coming from the south.

These two currents and the wind conditions are in the origin of two hydrological seasons: the seasons of cold and warm waters. The first from December to May/June is marked by a minimum temperature (about 17/18ºC) in the period of February and April. In this period, cold Canarians waters and waters from coastal upwellings are present everywhere along the shelf. The maximum of sea-surface temperature (sst) during this season is about 21/23º is observed, in May/June, when west winds start to take the place of north winds. The cold waters are progressively recovered by warm tropical waters carried by the equatorial contre current. The maximum of the sst is about 28/30ºC in August/September.

Senegalese Oceanographic Data

There are 3 types of oceanographic data:

- data from oceanographic expeditions (*Laurent Amaro, Louis Sauger*). During these expeditions sst, salinity, nutrients, currents (speed and direction), water colour were measured. The obtaining data were published after every expedition.

- data from coastal stations: From north to south, 7 coastal stations have measured sst, salinity and sometimes nutrients (Figure 7). The sst is measured every day between 7h and 8h with a classical thermometer; the samples for salinity and nutrients are analyzed in the Crodt laboratory. All the data are published in Crodt series and archived in the data bank.

- data from satellites (Meteosat and NOAA): since 1984, Crodt laboratory receives information on sea-surface temperature from European meteorological satellite (Meteosat). Every day 47 images are calibrated, combined with ships data and archived (Figure 8). Since last June, Crodt receives information on sst from an American satellite (NOAA).

All these data are utilized to explain the possible variations of hydroclimate and particularly the behaviour of the upwelling which is the principal source of enrichment of the productivity of the Senegalese waters.

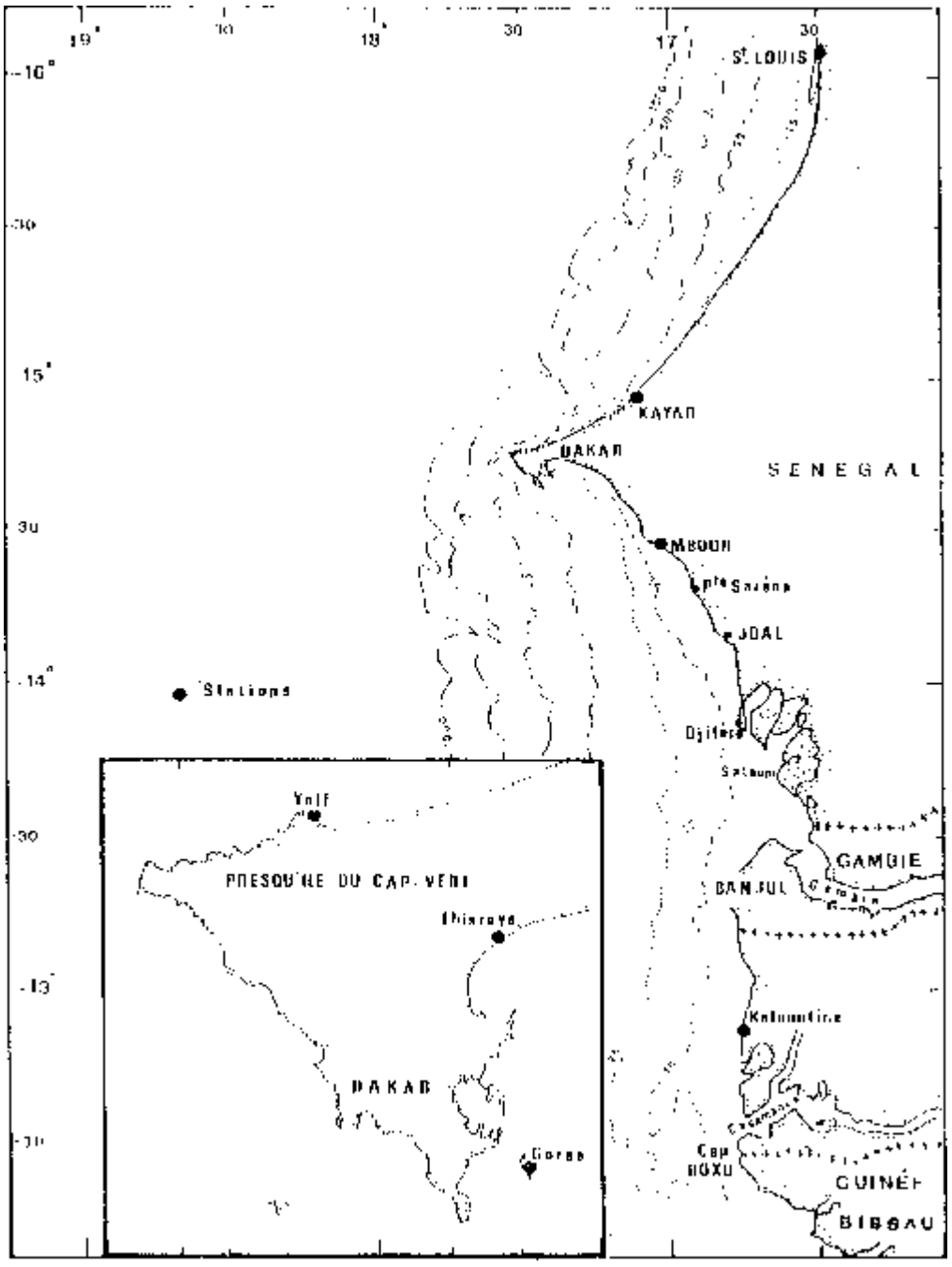

Fig. 1 - LOCALISATION DES STATIONS

Figure 7: Localisation des Stations

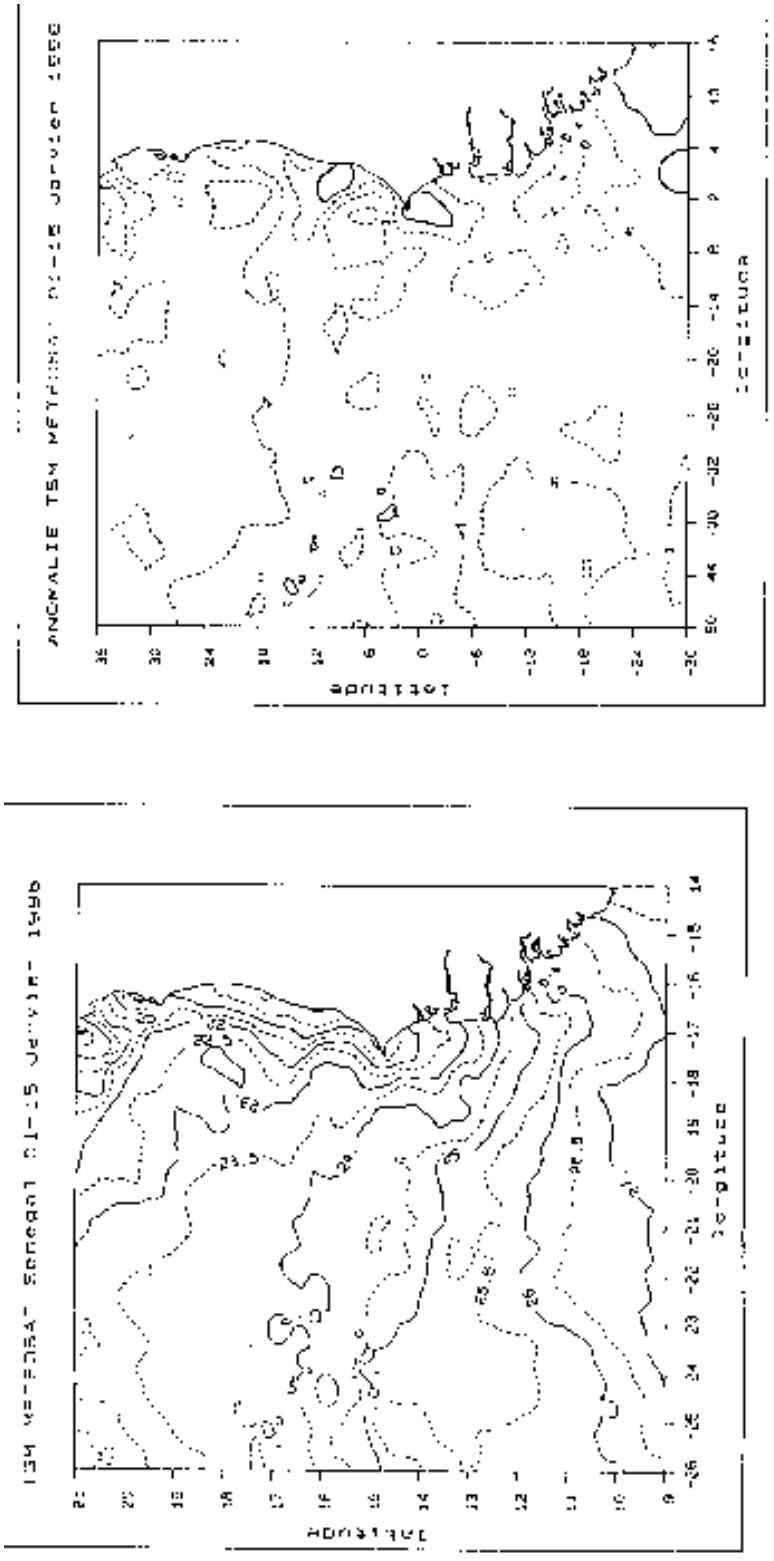

Figure 8: Data from MeteoSat

4.7 SOUTH AFRICA

Introduction

The focus of the report is on different aspects of physical oceanographic data collection and management. Nevertheless, some insight will also be provided about data management aspects of other oceanographic disciplines.

Various organizations that collect oceanographic (or related) data are provided further on in this report, with main emphasis on those that have established oceanographic data management facilities. The description of each organization is incomplete, because the focus of this presentation is not on the organizations *per se*. The section on Storage of Oceanographic Data lists the data management capabilities and data types on an organization-by-organization basis. Although there is only one official Data Centre for Oceanography in South Africa (of which more detailed information is supplied), there are other organizations that have databases which hold large amounts of data.

The data management configuration in the country is not optimal: on the one hand there is a degree of duplication, on the other there is data that has still not been submitted to a national data centre for proper storage and archiving. For that reason the section on 'Attempts to Rescue Data' reveals the status in South Africa to find and rescue old-but-valuable data.

Oceanographic Data Collecting Organizations

Sea Fisheries Research Institute

The Sea Fisheries Research Institute (SFRI), located in Cape Town (Figure 9), forms part of the State Department of Environmental Affairs and Tourism (DEAT), and is the largest multi-disciplinary oceanographic organization in South Africa (including all disciplines except geology and geophysics) with a staff of more than 700. A number of well-equipped research vessels are operated by DEAT, including the *Africana*, a fisheries-research vessel; the *S.A. Agulhas*, an Antarctic supply vessel, and *Algoa*, a coastal research vessel.

All SFRI activities are focussed towards advice on the optimal utilization of living marine resources and the conservation of marine ecosystems. The prime region of operations is the Benguela upwelling area along the west coast of South Africa, which is the main fishing grounds. All marine life is studied, including pelagic, demersal and line fish, squid, abalone, rock lobster, seaweed and mussels. Associated fields of investigation include marine mammals, seabirds, and marine pollution. The Institute is also charged with patrolling and monitoring the fishing and crayfish areas, fish catches, licensing of fishing boats, etc. The Institute represents South Africa in manifold international conventions, and personnel regularly participate in conferences and foreign research cruises. It produces the South African Journal of Marine Science, the only journal of its kind in the country. This brief description fails to cover even remotely the breadth and depth of SFRI's activities.

Within the domain of physical oceanography, two of the research vessels (*Africana* and *Algoa*) are equipped with state-of-the-art data collection systems, including Acoustic Doppler Current Profilers (ADCP) and CTDs. The Institute has the only modern CTD calibrating facility in the country. The Institute has a large number of current meters (and also designs and builds its own current meters) which are deployed off the west coast, and also collects continuously sea surface temperature data and weather data from recorders located at strategic positions along the coast. The Institute operates a small remote sensing unit, although it does not receive satellite data directly.

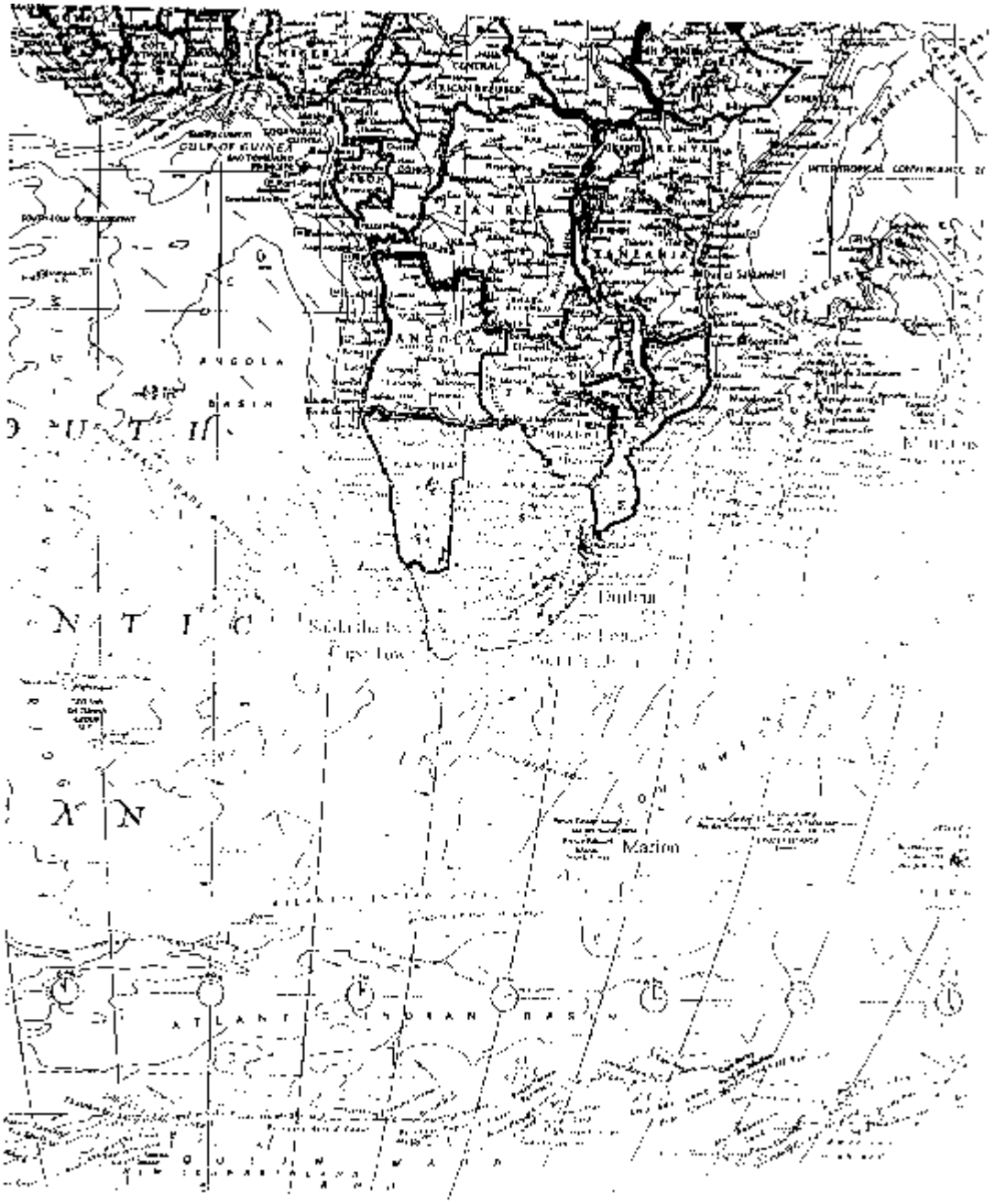

Fig. 1. Map of the southern African region indicating the areas and localities mentioned in the text

Figure 9: Map of the Southern African Region Indicating the Areas and Locations Mentioned in the Text

CSIR

The parastatal CSIR (Council for Scientific and Industrial Research), with its main campus in Pretoria, is the largest research institute of its kind on the African continent (3,000 people), and its goals are to undertake broadly-based market driven research and development in support of clients in the private and public sectors.

Only a small part of the CSIR deals with the coastal and marine environment, namely a section located in Stellenbosch, near Cape Town, and another in Durban, along the east coast (Figure 9). These two multi-disciplinary groups comprise about 70 and 15 people, respectively.

Up to 1989, the CSIR collected large amounts of shelf and deep-sea CTD and XBT data from its 350-ton research vessel *Meiring Naude*, as well as from Antarctic supply vessels. The main area-of-operations included the southwest Indian Ocean as far east as Mauritius, Mozambique Channel, Agulhas Bank, and the Southern Ocean sector south of Africa.

Today, the target area is mostly the coasts of South Africa and Namibia, although contract investigations are also undertaken in Mozambique, Mauritius, Seychelles, Angola, Israel, and South America. Since selling its research vessel about 7 years ago, the CSIR presently owns only small motor boats, and works mostly within the shelf region. Larger vessels are hired when required.

The deep-sea work was scaled down almost completely since 1990. The present activities of these two groups include mostly applied research including harbour engineering design and support, coastal engineering, marine water quality, coastal development and environmental management, bathymetric surveys, coastal dynamics, etc. CSIR also operates a number of large model basins and wave flumes. The marine equipment includes current meters, weather buoys, survey equipment, and profilers. A network of wave buoys around the South African coast is maintained.

Although not specifically involved with marine research, a Division of the CSIR in Pretoria provides important technical support by receiving, processing and archiving high quality satellite imagery, of particular relevance to oceanographic investigations, for all regions around southern Africa (from Angola to Mozambique). The data includes the following satellites: NOAA, Meteosat, SPOT, LANDSAT, ERSI and 2.

IMT

The Institute for Maritime Technology (IMT) conducts mainly applied research and development in support of operations of the South African Navy, and is located in Simonstown on the Cape Peninsula. The Institute has excellent in-house facilities for underwater testing and calibration of equipment, and a few small motor launches for close inshore hydrographic surveys. Within the physical oceanographic domain IMT collects data using current meters and CTD profilers.

University of Cape Town, Department of Oceanography

Marine science activities at the University of Cape Town are conducted largely within the Department of Oceanography and the Marine Biology Institute, although various other, smaller departments and groups are involved with marine research. The Centre for Marine Studies, which has about 110 members, integrates all marine-related departments (even Marine Law), to undertake marine investigations on a contractual basis.

Research within the Department of Oceanography falls into 3 areas, namely the South African oceanic environment, ocean-atmosphere interactions, and the South African coastal environment. Within these broad subjects, there is an Ocean Climatology research group which focuses on ocean processes and air-sea interaction south of the continent. The Benguela Physical Processes group investigates the

waters on the continental shelf of the greater Benguela region, and closely collaborates with the Sea Fisheries Research Institute. The Marine Weather Systems and Rainfall Variability group assesses the relation between changes in the large-scale ocean environment and patterns of southern African rainfall. The Sea-Level research group studies sea-level as an indicator of the ocean climate and the impacts of sea-level rise.

Members of the department regularly participate in oceanographic cruises of the Sea Fisheries Research Institute, cruises of the Antarctic supply vessel S.A. *Agulhas* between Cape Town and Gough, Marion and the South African Antarctic base, SANAE, and cruises of foreign vessels visiting the region.

Other

University of Port Elizabeth (UPE)

The University of Port Elizabeth is located along the southeast coast of South Africa (Figure 9). Activities in the field of marine science are conducted within the Institute for Coastal Research, which includes aspects of coastal geology, dunes, estuaries, coastal dynamics, regional fisheries, marine zoology and coastal botany.

Geographically, the work is mostly confined to the area surrounding Port Elizabeth and Algoa Bay (the Bay where Port Elizabeth is situated). The physical oceanographic data are collected with the help of current meters, current and CTD profilers and other continuously recording sensors.

University of Natal

The Oceanographic Research Institute (ORI) of the University of Natal in Durban conducts research of coral, fish and other biota off the east coast of South Africa. Some of the collected fish are used in the oceanarium.

South African Weather Bureau

The South African Weather Bureau (SAWB) is responsible for countrywide weather predictions, as well as maritime weather predictions, and continuously collects a large amount of terrestrial and marine meteorological data. The coastal data consists of hourly readings of wind speed, air temperature, water temperature, humidity, etc. The SAWB also collects daily sea surface temperature, from all around the South African coast.

Of great importance to maritime operations there are weather observations made by ships of opportunity, or voluntary observing ships (commonly referred to as VOS). These observations (including wave height, direction and period, air temperature, wind speed and direction, cloud height, humidity, etc.) are transmitted to the SAWB where they are used in the regular land and marine weather forecasts.

Portnet

Portnet is a large parastatal organization in charge of all ports in South Africa. To operate ports safely, and to collect information for future design of breakwaters, other structural developments, Portnet funds the continuous collection of wave, sediment, and weather data at or inside 6 major ports in South Africa (Richards Bay, Durban, East London, Port Elizabeth, Cape Town, Saldanha Bay).

SOEKOR

SOEKOR, the Southern Oil Exploration Corporation, has collected marine information on the Agulhas Bank (south of Cape Agulhas) between 1977 and the late 1980's. This information consisted of

current meter, wave and automatic weather station data on or in the close proximity to oil-drilling activities. No data of that nature is being collected any more.

Mossgas

Mossgas is an operator of an oil production platform on the Agulhas Bank, and continuous wave and weather information is collected from the oil platform.

ESKOM

ESKOM, the Electricity Supply Commission is collecting extensive, continuous environmental measurements in the vicinity of the Koeberg nuclear power station north of Cape Town, especially of wind (using sonic detection and ranging) and water temperature.

Other

Other organizations have, at various times, collected site-specific wave and other marine data around the South African coast. These would include consulting, mining and exploration companies, municipalities and government bodies.

Storage of (Physical) Oceanographic Data

SFRI Data Storage

As indicated in the section on SFRI, it is the largest marine data-collecting organization in South Africa. In support of the data-collecting effort, SFRI has an extensive data storage facility.

There are separate databases for the demersal, linefish and pelagic fish data. They contain information on species, mass, length, sex, stomach content, etc.

The physical data (STD, CTD and XBT data) are stored in a database that also contains observations of turbidity and fluorescence. This database allows multiple simultaneous users, but since the storage of data is only in support of the activities of SFRI itself, on-line access exists only within the organization. The database contains about 390 cruises, with about 90 stations per cruise (i.e., about 35,000 stations). Observations at each station has been made at about 8 depth levels.

The products provided by the database include depth profiles, vertical and horizontal sections, correlations and regressions.

The ADCP and current meter data are all computerized, but are kept in an off-line mode. The ADCP software allow averaging between cruises and over a given period (e.g., seasonal) (Figure 10 provides an example of an ADCP product). There is also a database for wind data from lighthouses and automatic weather stations. Sea temperatures are also recorded at 13 positions along the coast.

All SFRI databases are operated only to store SFRI data and to supply services to SFRI personnel. Data is made available to outsiders on an *ad hoc* basis, except the sensitive information on fisheries, fish catches, etc.

SADCO

Because SADCO is the only "national" data centre in the country, the description of the data centre is done in slightly greater detail.

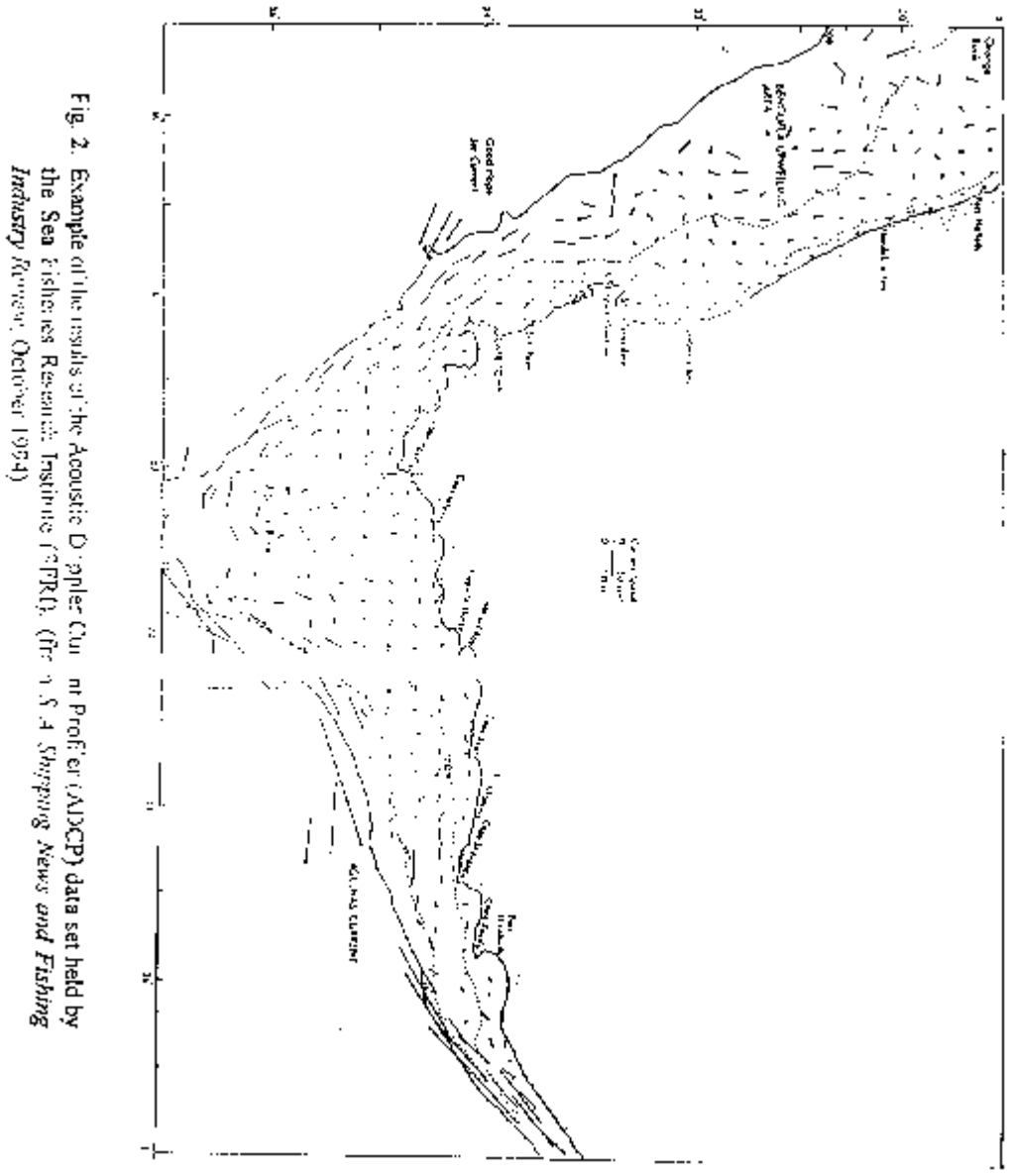

Fig. 2. Example of the results of the Acoustic Doppler Current Profiler (ADCP) data set held by the Sea Fisheries Research Institute (SFRI). (From *S.A. Shipping News and Fishing Industry Review*, October 1994)

Figure 10: **Example of the Results of the Acoustic Doppler Current Profiler (ADCP) Dataset held by the Sea Fisheries Research Institute (SFRI). (From *S.A. Shipping News and Fishing Industry Review*, October 1994)**

SADCO's Steering Committee decided in 1996 that SADCO's geographical limit should be extended to 10ºN (present limit is the equator). The reason for this is that South African organizations see a need to have access to data in this area. In addition, it is recognized that SADCO's experience can be of benefit to countries further north and this will necessitate an extension in coverage. Although such an "inter-African" service will not be fully possible within SADCO's present financial resources, it was considered that some pro-active move was nevertheless called for.

The South African National Oceanographic Data Centre (SANODC) was created at the University of Cape Town (UCT) in the late 1960's to act as national data centre for all UCT oceanographic data but also for all oceanographic data in South Africa. The data centre was not computerized, and the holdings comprised data books, cruise reports, rolls of raw data records, etc. In retrospect, the data centre also became the repository of all unwanted material. For various reasons, the data centre ceased to function within a few years.

The second version of the Data Centre (the South African Data Centre for Oceanography, SADCO) was created in 1977 at the CSIR in Stellenbosch. It was computerized and was initially located within a self-constructed Data Base Management System (DBMS) on a HP mini computer. With the rapid growth in the amount of data, the data was transferred to the CSIR mainframe in Pretoria, and onto a Natural/Adabas DBMS. The types of data included hydrographic (station) data, surface weather reports from voluntary observing ships, ornithological observations, pollution data, reports and manuals, and satellite imagery (tapes, images) from the NIMBUS VI mission. In 1989, the CSIR gave notice that the data centre would be terminated in its configuration as an omni-disciplinary, free service provider.

In its reborn configuration, SADCO was restarted in 1990 on a financial and manpower scale of only about 15% of its previous size. It is housed on the campus of the CSIR in Stellenbosch. The reduction in financial support necessitated a significant rationalization of the data holding. The NIMBUS data, available elsewhere on other media and to a higher level of processing, was discarded. The database was ported from the costly mainframe in Pretoria to a local PC of sufficient capacity. This greatly facilitated all software maintenance and development. In spite of these changes, the essential core of the data centre was maintained and the services could be continued uninterrupted. Direct access through network, as well as by dial-in modem was established. An on-line inventory of the hydrographic data was created.

The target area of the data centre is indicated in Figure 11, and stretches from the equator southwards, and from 30ºW to 70ºE. It is planned to extend the target area northwards to 10ºN.

The types of data contained in the data centre are:

- Hydrographic (ship) observations (STD, CTD, XBT, BT) with temperature, salinity, nutrients, sound velocity, etc. These have been and are obtained from South African researchers, as well as from the World Data Centres, the British, German and French Oceanographic Data Centres, or directly from researchers at oceanographic research institutes of other countries. SADCO has about 50,000 stations (all combined) from about 2,500 cruises, dating back to 1910 (including the earliest South African data). It is estimated that SADCO has more than 90% of all hydrographic stations (but not necessarily 90% of all data) collected in its target area. However, some uncertainty exists about the amount of data from SFRI still unprocessed and not submitted to SADCO.

- Sea Surface observations (about 3 million in total), containing data on sea and swell, sea and air temperature, wind, clouds, etc.. This data are provided by the South African Weather Bureau on a monthly basis, and ftp'ed from Pretoria to Stellenbosch. The data extends from 1851 to February 1997. An example of the data coverage is given Figure 12.

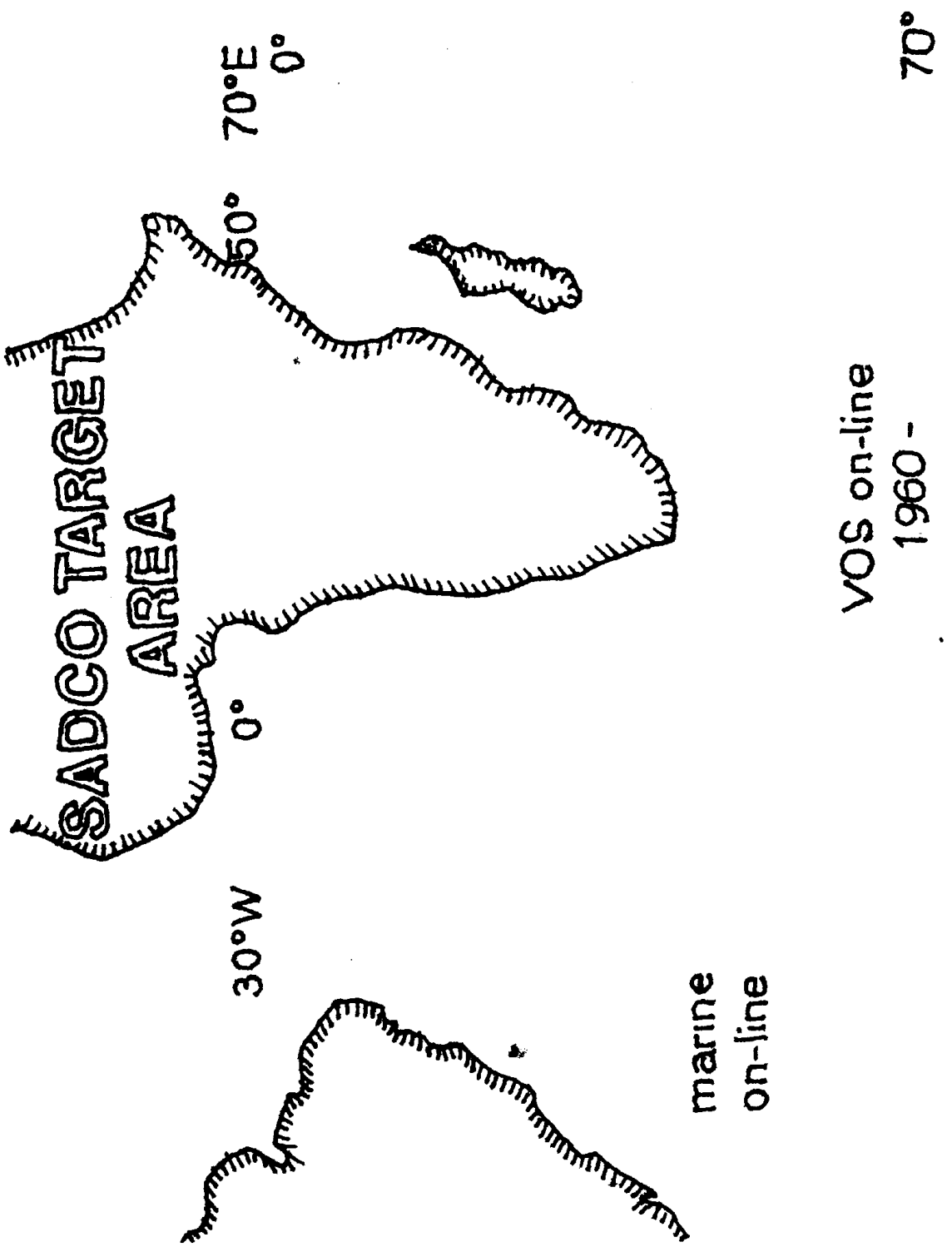

Figure 11: **Target Area of SADCO. VOS data since 1960 is kept on-line for the smaller area (0-70°S, 0-50°E), while all Marine Hydrographic Data is kept on-line for the larger areas**

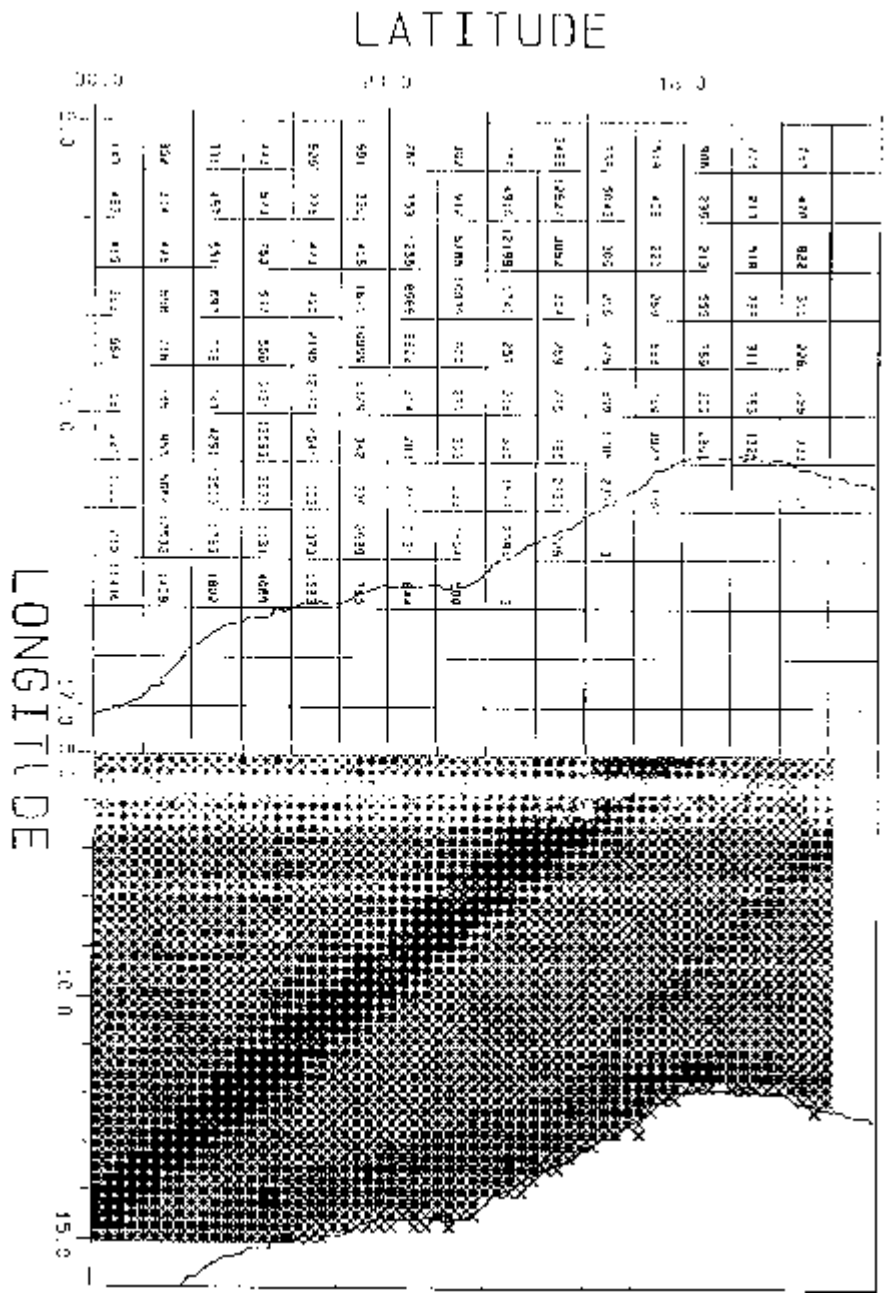

Fig. 4 Example of the data coverage of VOS sea surface temperatures in the area off Namibia between 1965 and 1978. Left: Numbers of observations per 1°x1° block. Right: Symbolic representation of the same data, indicating the large coverage in the shipping lanes.

Figure 12: **Example of the data coverage of VOS sea-surface temperatures in the area off Namibia between 1965 and 1978. Left: Numbers of observations per 1^{o} block. Right: Symbolic representation of the same data, indicating the large coverage in the shipping lines**

- Pollution data (heavy metals, etc.) at selected sites around South Africa. These observations have been collected mainly by the branch of the CSIR in Durban.

Funding

SADCO is funded by a number of marine-related organizations in southern Africa, who form a consortium that decides on the policy of the data centre, the scope of its services, priorities in terms of development activities, etc. These organizations represent virtually all the marine research conducted in South Africa.

SADCO operates on a very tight balance between data loading, data scouting, servicing requests, developing new products. Significant developments in any sector will not be possible.

Access

Direct, on-line access (through modem or Internet) is available to all the funders of the data centre (Figure 13). In that way, data can be extracted and products (graphs, tables) generated.

Inside the target area of the data centre, all hydrographic data is kept on-line. For the VOS data only a smaller area is on-line, and only after 1960. The rest is kept in an archive that is loaded when required.

Upon request of a data donor confidential data may be placed under strict security control, with access only possible to approved organizations through a system of passwords.

Very little outside use is made of the database in an on-line mode. In most cases, an off-line (fax, phone, e-mail) submission of requests for data seems to be preferred. The reason for this is probably because the response is quicker and, mainly, because they get the service free-of-charge.

Services and Products

The services provided by the data centre are:

- Archiving of marine data from South African organizations, with complete back-up facilities, flagging of confidential data, on-line access.

- Responding to off-line requests from users for data from SADCO's own databases. If data resides elsewhere, SADCO will scout for and request such data.

- Providing output in the form of standard products (graphs, tables). Examples are: averages (annual/seasonal/monthly): Figure 14; roses and tables; cruise tracks (Figure 15); and vertical profiles (Figure 16).

- Searching literature for data reports.

- Communicating with users through a quarterly newsletter, brochures and visits.

SADCO has up to now been able to handle whatever data has been forwarded for loading. This data has been forthcoming mainly from SFRI, and has been pre-formatted (thereby minimizing the effort required for loading). The following table (Table 1) shows the amount loaded, and the amount originating from South African organizations.

Table 1

Year	Total Number of Stations Loaded	Number of Stations from South Africa
1994	184	184
1995	2326	183
1996	2290	2070

Attempts to "rescue" Data

From the information on the Storage of Oceanographic Data it is obvious that while the major data-collection is done by the Sea Fisheries Research Institute (SFRI), by the marine component of the CSIR (Stellenbosch), by the SAWB and, to a lesser extent, the University of Cape Town, the storage is confined to the SFRI, CSIR and SADCO. Of these, only SADCO handles inputs and outputs on a multi-user basis.

The manager of SADCO has been identified as the official contact person for international issues involving data communication and exchange. In addition, information on foreign research cruises that collect data in South Africa's waters is passed to SADCO by the Department of Foreign Affairs, and SADCO is charged with following up eventual transfer of the data collected by these research vessels to SADCO.

CSIR

Databases operated by the CSIR include:

- a wave database (wave heights, periods, directions, spectra) from a number of wave buoys that operate continuously around the South African coast. The data is downloaded automatically through modem connections 24 hours per day, quality controlled and stored. The data extends from 1975 onwards, and comprise some 120 buoy-years of data. The original data collection was funded by mainly Portnet and SOEKOR.

- a current meter database, with data collected by the CSIR between 1975 and 1997 around the South African and Namibian coast. There are about 250 deployments. This dataset also includes the data collected by SOEKOR.

- a weather database of automatic weather stations in the coastal region. There are about 1,500 deployments (SOEKOR data is included).

Because the most of the datasets belong to the clients that have funded the collection of data, access is strictly controlled. Therefore, the databases are accessible through network connections from the users within the Stellenbosch campus only, and only to approved users.

The CSIR has invested a large amount of money and effort to identify its old-but-valuable data. Through this concerted effort, virtually all data has been located, reformatted, checked and loaded onto databases. All CTD and STD profiles, pollution data have been transferred to SADCO, while all current meter data, wave buoy measurements, and weather station data has been placed on CSIR databases. It is foreseen that the last data still outstanding will be recovered during 1997.

A backlog of pollution data, emanating from the CSIR's Durban branch, is being transferred to SADCO, and the process will be completed during 1997.

South African Weather Bureau (SAWB)

Because of the large amount of data used by the SAWB it has probably the largest data storage facility in the country. The database contains data from weather observers, automatic weather stations, data from the GTS, VOS, satellites, etc.

All VOS data within SADCO's target area is routinely extracted from the database on a monthly basis and downloaded to SADCO's database in Stellenbosch.

SFRI

Most SFRI physical data (CTD, ADCP, etc.) is computerized, but because of the large amount of data collected, and manpower shortages in the data processing and checking section, there is a considerable "backlog" in the finalization of data.

Some older cruises have not been processed at all. Over the past year, about 20 cruises of this unprocessed set have been salvaged (and all of them executed off the coast of Namibia between 1975 and 1988). It is estimated that a major effort will be required to alleviate or fully eliminate this backlog, not only because of limited manpower but also because older data often requires specific expertise which also disappears with time.

During 1997, probably by July 1997. It is still uncertain how the hydrographic data coverage will similarly be extended.

UCT

XBT data collected on 20 cruises (about 100 stations per cruise) by the CSIR between the African continent and Antarctica was transferred to UCT for analysis and processing, and this data is presently being digitized and loaded into SADCO at SADCO's expense.

Only a few cruises remain at UCT that have not yet been forwarded to SADCO for loading.

Other

Most of the other oceanographic organizations listed in Table 2 have their own data storage facilities, but their databases are orders of magnitude smaller than the main South African databases kept by SFRI, SADCO, SAWB and the CSIR. In most cases, the backup of, access to and overall management of the data is handled on an *ad hoc* basis.

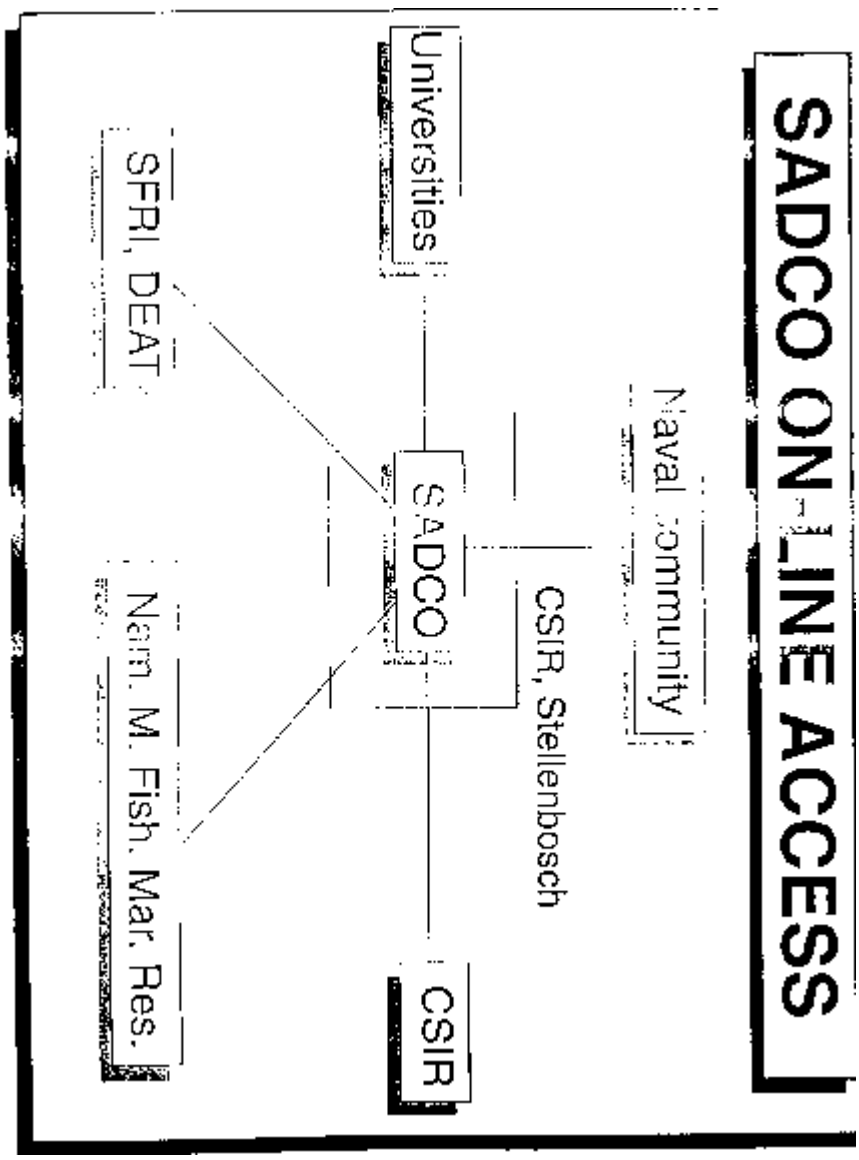

Fig. 5. Diagram illustrating the on-line access to SADCO. The access to Namibia is not

Figure 13: Diagram illustrating the on-line access to SADCO. The access to Namibia is not yet operational

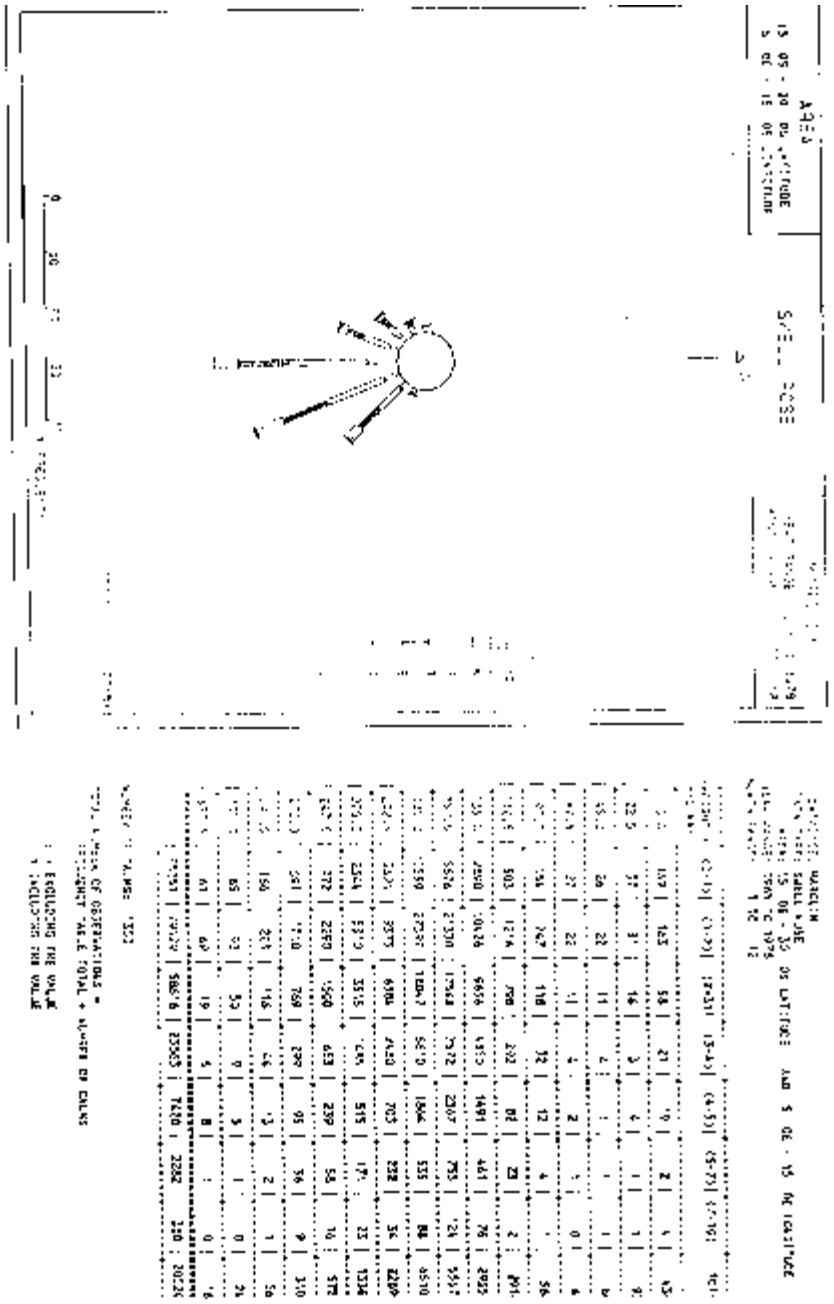

Figure 14: Example of annual swell rose for the area and period portrayed in Figure 12

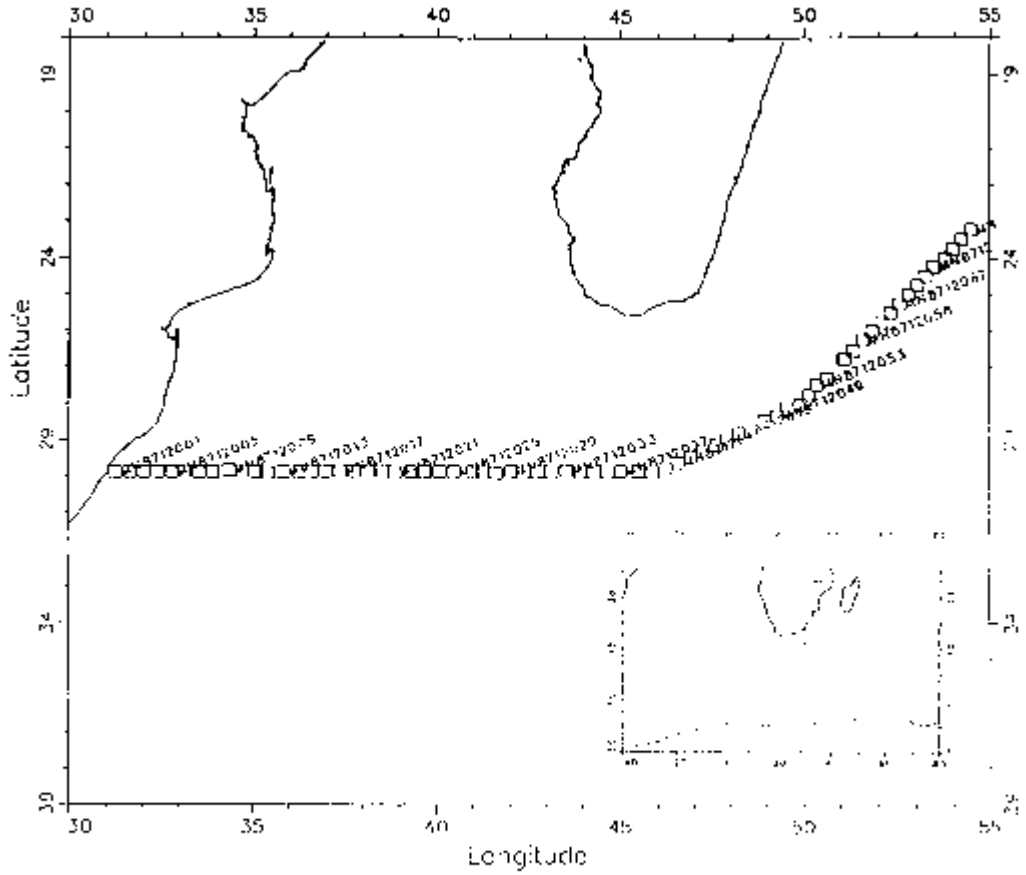

Fig. 8. Example of station plot of a CTD cruise of the RV *Meiring Naude* between Durban and Mauritius in 1987.

Figure 15: Example of station plot of a CTD cruise of the *R.V. Meiring Naude* between Durban and Mauritius in 1987

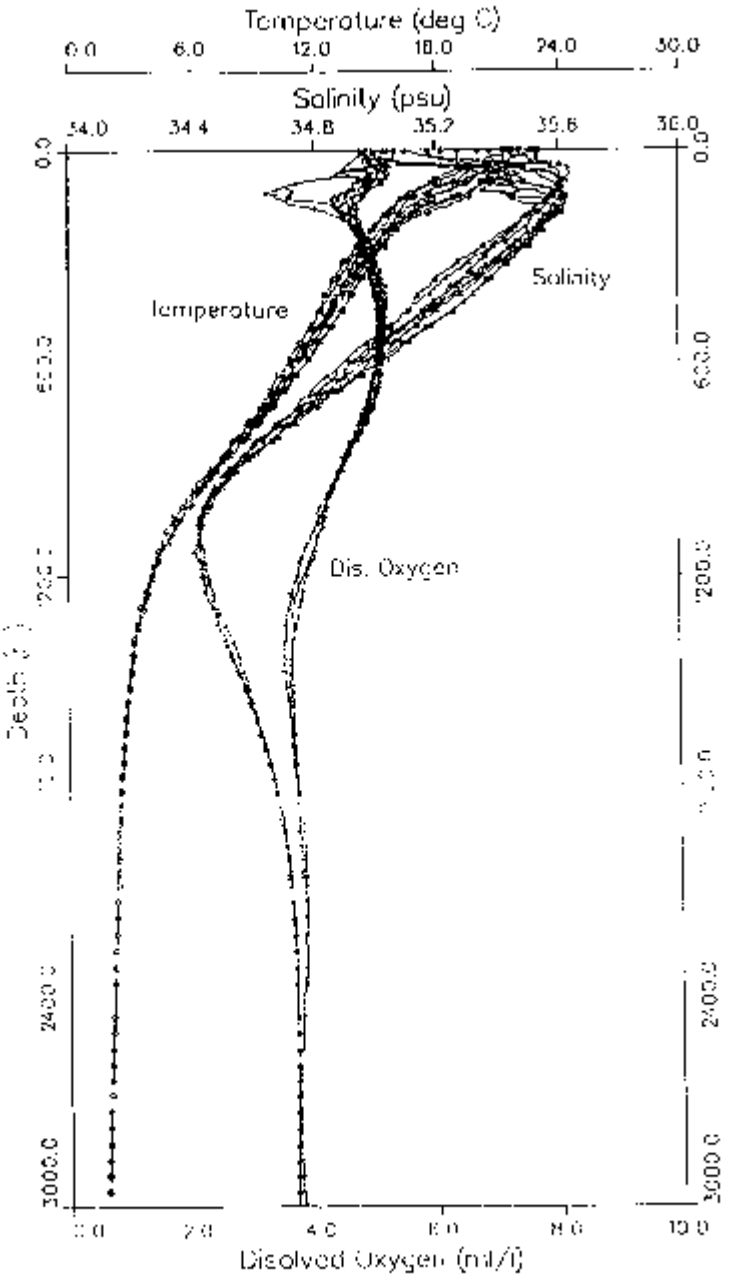

Fig. 9. Example of vertical profiles of temperature, salinity and dissolved oxygen, from the cruise in Fig. 8.

Figure 16: Example of vertical profiles of temperature, salinity and dissolved oxygen from the cruise in Figure 8

Table 2: Summary of Organizations and Marine Data Repository

Organization	Oceanographic Data |Types	Submitted to SADCO
SFRI	biological, hydrographic current meter, ADCP, weather	extracted hydrographic data
CSIR	current meter, weather, waves	all hydrographic data
IMT	current meter, hydrographic	all hydrographic data
UCT	hydrographic, XBT	all hydrographic data
ORI	biological	
SAWB	weather	all VOS data
Portnet	wave data (all kept by CSIR)	
SOEKOR	waves, current, weather (all kept by CSIR)	
Mossgas	weather, waves (all kept by CSIR)	
ESKOM	weather	

CTD data is processed only at "standard" depths, which means that large amounts of information are not recovered.

It is estimated that there are 96 cruises of the *Africana*, and 33 of the *Algoa*, of which almost none have been processed to the full resolution. Although this problem has been identified and is a source of great concern, existing funds/manpower will not allow any improvement in the foreseeable future. Main archives according to data types are presented in Table 3.

Table 3. Main Archives According to Data Type

Data Type	Location	Amount
Hydrographic	SADCO	50,000 stations*
	SFRI	30,000 stations*
Fisheries & plankton	SFRI	?
Current meters	SFRI (west coast)	500 deployments (est)
	CSIR (east & south coast)	250 deployments
Wave buoys	CSIR	120 buoy years
ADCP (ship-borne)	SFRI	100 cruises
Marine weather (VOS)	SADCO	3 million observations
Automatic weather stations	SFRI	?
	CSIR	1500 deployments
Continuous surf temperature	SFRI	13 stations, since 1991/93
Pollution data	SFRI	?
	SADCO	All East coast data

* There is an overlap of the contents of these storages.

VOS data obtained from the S.A. Weather Bureau has also been pre-formatted, so that loading is not delayed.

4.8 TOGO

The Centre de Gestion Integree du Littoral et de l'Environnement (CGILE) of University of Benin - Lome was created in the continuation of the Coastal Erosion Project which was closed in 1992.

Because of the importance of environment in the development of action plans, a group of scientists was created with the capital objective to study the complexity of the relationship between all factors in coastal area - land and sea.

The immediate objective was to collect and analyze physical, biological and socio-economical data.

It was noted that some data exist but they are in different places and in different formats and access to the data is often a big problem. The conclusion was that there is a need for co-operation between different national institutions in the field of data collection, analysis and archiving.

List of Institutions

Below is a list of institutions which may have marine data and data from the coastal zone.

- University of Benin
  Faculty of Sciences, Department of Zoology, Biology, Botanic;
  Faculty of letters and human sciences, Department of Sociology, Geography;
- Meteorological department;
- Port Authority;
- Phosphates office;
- Industries office;
- Department of fisheries;
- SHOM (Brest, France);
- Archives d'Outre Mer (Aix-en-Provence);
- ORSTOM;
- Other centres of documentation.

Types of Available Data

- Marine resources (living and non-living);
- Pollution;
- Coastal environment: morphodynamic, sedimentology, physical and chemical, mangroves;
- People and habitat: activities, demography, collectivities.

Examples of Periods of Collection and Places of Storage of Data

- Port authority - tidal data until July 1996, with many gaps. The data are in the form of paper reports.
- University of Benin: many data on living resources such as zoology and botanic.

- Department of Fisheries: many data on fisheries in lagoon and sea collected in co-operation with ORSTOM. But the data are not well organized.

- CGILE, data concerning coastal erosion, bathymetry, sedimentology, currents, climates (wind) are available.

CGILE: Objective 2000

The priority is to organize the rescue and storage of all marine data by the year 2000. Actually, there is only one computer which is being used for all activities of the Centre. There are no funds to assist national institutions in data collection. Efforts are being made to finish the land cover map of the littoral zone. However, there is a need for support of organizations, such as IOC, to complete this map that will be necessary for the development.

There is a strong need for assistance to monitor physical parameters, in hardware and software and in funds: from 1997 to 2000, US$20,000 for support of the local activities plan; in 1997, US$8,000; in 1998, US$6,000; in 1999, US$6,000.

There is a need for training of staff who will be able to take the responsibility for data collection, monitoring and processing, e.g., 3 months training in SHOM - Brest, France.

5. CONCLUSIONS AND RECOMMENDATIONS

The participants concluded that the Workshop was implemented in the right direction and in the most opportune time. It brought together scientists and data managers in diverse fields that relate to the ocean to encourage them to collect, preserve, process and share information and data on the ocean. The Workshop became a useful contribution to the programme of activities formulated at IOCEA-V, the Regional Seas efforts in the West and Central African Region and those of the UNIDO-UNDP/GEF Large Marine Ecosystem (LME). **The Workshop provided** a trigger mechanism for further exploration of available data holdings and formulated recommendations on how to make them widely available.

The Workshop noted that within the resources available, local IOCEA activities in the region are progressing steadily. There are, however, two main constraints which require immediate attention: lack of resources and poor communication arrangements. **The Workshop recognized** that the implementation of the IOCEA-V decisions relevant to IODE and Resolution IODE-XV.5 can be successful only if Member States within and outside the region, international, governmental and non-governmental organizations pool resources together in an attempt to help Western Africa in establishing an oceanographic data management infrastructure. To overcome the problem of communication within the region **it was recommended** that assistance should be provided to the countries to acquire electronic mail facilities. **The Workshop suggested** requesting for assistance from the UNESCO ROSTA office in Dakar, UNITAR and ORSTOM in this regard.

The Workshop noted the information provided by the Project Co-ordinator of the UNIDO-UNDP/GEF LME Gulf of Guinea Project on the completion of a review of available data within the Gulf of Guinea countries and on the plans to publish a final version by the end of the project. **The Workshop noted** that the UNIDO-UNDP/GEF LME has developed country profiles under the Gulf of Guinea Project that include descriptions of national oceanographic data collection and management facilities. **The Workshop participants expressed a strong desire** to receive copies of the review after the publication **and recommended** that the IODE Regional Co-ordinator take data contained in the review into account when developing the oceanographic data inventory.

The Workshop recommended that the IODE Regional Co-ordinator and the GODAR Project Leader discuss and agree on the most effective ways of co-operation with the UNIDO-UNDP/GEF LME

Gulf of Guinea Project. **The Workshop agreed** that the implementation of the project could be carried along the following lines: data search stage at local, national and international levels; verification of identified data holdings with WDC's for Oceanography in order to identify missing parts; development of a comprehensive inventory of available data holdings; incorporation of the inventory into the Global MEDI Catalogue and making it widely available with the assistance of IOC.

Based on the inventories of data holdings when they are developed, **the Workshop recommended** that WDC-A, Oceanography, be invited to help Member States in creation of a CD-ROM of oceanographic data for the region. This project will include compilation, digitization, evaluation of data and a training component with the involvement of national experts at all stages of implementation.

The Workshop appreciated the readiness of the UNIDO-UNDP/GEF LME Project to support financially the efforts of Member States of the Project directed to the identification and description of national and international oceanographic data holdings related to Western African waters.

The Workshop strongly supported the decisions of the IOC Regional Committee for IOCEA relevant to the ocean data collection and management and **urged** Member States and IOC to continue to extend assistance to Western Africa in establishing RECOSCIX-CEA and not to spare any effort for meeting the communication needs.

The Workshop recommended that all necessary actions should be taken for completion and publication of CEADIR and its inclusion in the GLODIR on-line system. A Regional Centre, when in full operation, will be responsible for keeping regular updates of the directory. Meanwhile, **the Workshop recommended** that the IODE Regional Co-ordinator should help the IOC Secretariat in implementing this important task.

The Workshop requested governments to give high priority to ocean data management issues including data search and rescue operations and development of creditable databases.

The Workshop noted that there are large volumes of oceanographic data in the domain of private industries and **recommended** that authoritative national institutions take necessary action in pursuing these industries to release data to the public domain. In future, when permission is given by a government to companies to carry out activities in EEZ areas, it would be most desirable to include in the agreement a provision for making environmental data collected from, e.g., the oil platforms or other industrial installations, available to a responsible national data management facility.

The Workshop noted that large volumes of data are available at the NODC of France (SISMER, Brest) and at various French institutions, in particular, ORSTOM, collected in coastal waters and open sea along Western Africa. The data at the French NODC are managed in the NODC's database on a cruise basis and are likely to be available, through WDC-A, for international data exchange. **The Workshop further noted** that ORSTOM maintains a specific database in Brest of the time-series of nearshore data collected in West Africa within the framework of national monitoring programmes; this database has not been updated since the mid 1980's.

The Workshop recommended that the GODAR Project Leader and the Director of the French NODC verify the availability of such data in the international domain. **The Workshop further recommended** that the IOCEA Officers, the Chairman and Vice-Chairman jointly with the IODE Regional Co-ordinator and with the IOC support, take necessary measures for transferring the database to the region. **The Workshop invited** UNIDO-UNDP/GEF LME to co-operate with IOC and French NODC in updating and making the database available to the Member States of Western Africa.

The Workshop recommended that the IODE Regional Co-ordinator and the GODAR Project Leader working in concert with the IODE Chairman should contact the NODCs of the IOC Member States which have conducted research in the Eastern Atlantic and coastal waters of Western Africa, e.g.,

USA, Russia, Germany, Norway, etc., and invite them to co-operate in the development of an oceanographic databank for Western Africa. A databank when developed, should be available on CD-ROM and widely distributed. UNIDO, IOC and Member States were invited to co-operate in this effort. **The Workshop recommended** that the IOC Regional Committee for IOCEA should discuss the location of the Centre which will take future responsibility for updating the databank.

The Workshop noted with interest the experience gained by Senegal in the usage of satellite data for analysis of sea-surface temperature fields. **The Workshop appreciated** the readiness of Senegal to provide NOAA satellite images for the years 1984-1997 to all Western African countries on request and acknowledged the open distribution policy of NOAA.

The Workshop acknowledged the recommendation made by IOCEA regarding the establishment of RNODC for Western Africa based at the NODC in Conakry, Guinea. It noted that to make the RNODC effective there is a need to have a strong national data management infrastructure in the countries of the region in order to have stable data flow and wide data exchange. **The Workshop also recalled** that the existing IODE procedures for selection and accreditation of RNODCs require submission of the Letter of Intent to the IODE Committee Chairman with the description of existing facilities. This information will form the basis for the decision on the creation of RNODC, its location and terms of reference.

The Workshop noted the efforts of UNIDO-UNDP/GEF LME in establishing a data centre for the Gulf of Guinea Project and **recommended** that a comparison should be made between the terms of reference of this centre and an RNODC for Western Africa planned to be established in accordance with the IOCEA recommendations. This is necessary to avoid duplication of efforts and make the activities of the centres complementary.

The Workshop invited UNIDO and IOC to co-operate in establishing national oceanographic data and information management infrastructure which will create the necessary environment for establishing an effective Regional Oceanographic Data Centre.

The Workshop requested the LME of the Gulf of Guinea Project to continue supporting RECOSCIX-CEA to become fully operational and **urged** RECOSCIX-WIO to share experiences with Western Africa in the development of the dispatch centre and assist with training.

The Workshop noted that the success of RNODC and NODC activities will to a large degree, depend on the individuals who will head the centres and **recommended** that dedicated people, preferably, oceanographers should be picked to run the centres.

The Workshop appreciated the efforts of NOAA and WDC-A, Oceanography, particularly, in creating the World Ocean Atlas '94 CD-ROM series and **acknowledged** with thanks the readiness of the GODAR Project Leader to distribute CD-ROMs to each member country participating in GODAR-VI. Those Member States which do not have IODE centres or IODE national co-ordinators should identify addresses to which CD-ROMs will be dispatched and inform the Project Leader accordingly.

The Workshop fully supported the view of the IODE committee and the decision of the Workshop on Ocean Climate Data, held in Washington in 1992, regarding the need to include funding of data collection and management process in the total budget of any oceanographic cruise or research project. This will help to simplify the procedure of availability of data to national data centres and will help to recover part of the expenditures required for data management.

The Workshop noted an urgent need in providing training to experts from the region in oceanographic data and information management including the use of the IODE tools and procedures, e.g., OceanPC. UNIDO and IOC were invited to consider the implementation of a joint training course on search, retrieval, processing and development of historical databases.

The Workshop felt a need for a co-ordinated regional training programme which could knit together the needs and resources available in the region. There should be an established fundamental continuum between training, equipment and research. The IOCEA Committee jointly with IODE were invited to assist in implementing the training programme development.

The Workshop noted with interest positive political changes in the southern part of Western Africa, **invited** South Africa to co-operate closely with developing countries of the region in data collection and management, and **appreciated** plans of South Africa to make data from its area of interest freely available to all the countries.

Though interest in oceanographic data collection and management has considerably increased in Western Africa over the last few years, there is still a big gap in the IODE network in the region. To date only four countries of the region have established NODCs and DNAs (Ghana, Guinea, Morocco, Nigeria). As a matter of priority, **the Workshop recommended** that governments nominate IODE National Co-ordinators who will play the role of focal points on IODE related issues. The IOC Executive Secretary as well as Member States should be informed of the names of experts recommended to these important positions.

ANNEX I

PROGRAMME OF WORKSHOP

Tuesday, 22 April - Day 1

08:30-09:30 Registration
09:30-11:00 Official Opening

10:00-12:30 Lecture 1
Subject: IODE Today & after the Year 2000
Speaker: I. Oliounine, Deputy Executive Secretary IOC, France

Lecture 2
Subject: GODAR Project - Past, Present & Future
Speaker: S. Levitus, Director, WDC-A Oceanography, GODAR Project Leader, USA

12:30-14:00 Lunch

14:00-17:30 Lecture 3
Subject: RECOSCIX-WIO Programme
Speaker: E.V. Berghe, Marine & Fisheries Research Institute, Kenya

Lecture 4
Subject: Rescue of Historical Oceanographic Data in Western Africa:
Implications for Research Development & Management of the Marine Environment
Speaker: L. Awosika, Institute for Oceanography & Marine Research, Nigeria

Lecture 5
Subject: Scientific Results made possible by GODAR
Speaker: S. Levitus, Director, WDC-A Oceanography, GODAR Project Leader, USA

Round Table Discussions

Wednesday, 23 April - Day 2

09:00-12:30 Lecture 6
Subject: Coastal Topology & the Importance of Oceanographic Data for Coastal Management
Speaker: R. Folorunsho, CPO/LOICZ, Netherlands

Lecture 7
Subject: Regional Co-operation in Marine Research & Monitoring in Western Africa
Speakers: I. Oliounine, Deputy Executive Secretary IOC, France
J. Wellens-Mensah, Vice-Chairman of IOCEA, Ghana

Coffee Break

Lecture 8
Subject: Instituting Science-Based Management of Coastal & Marine Environment in West & Central Africa: The Gulf of Guinea Subsector
Speaker: C. Ibe, Co-ordinator, UNIDO GEF Regional Co-ordination Centre, Cote d'Ivoire

12:30-14:00 Lunch

14:00-17:30 Lecture 9
Subject: Data Collection in the Eastern Tropical Atlantic & its Scientific Use
Speaker: J-P. Rebert, Past Director, GOOS Support Office, ORSTOM, France

Coffee Break

National Report of Senegal
National Reports of Cote d'Ivoire (2)

Round Table Discussions

Thursday, 24 April - Day 3

09:00-12:30 Lecture 10
Subject: "MASDEA" - Marine Species Database for Eastern Africa
Speaker: E.V. Berghe, Marine & Fisheries Research Institute, Kenya

Lecture 11
Subject: Oceanographic Data Collection & Information Exchange in Ghana
Speaker: C. Biney, Chairman, GNC/IOC, Director, Water Research Institute, Ghana

Coffee Break

National Report of Benin
National Report of Cameroon
National Report of Guinea
National Report of Togo

Round Table Discussions

12:30-14:00 Lunch

14:00-17:30 Lecture 12
Subject: NODC Experience in Oceanographic Data Management - A Case Study
Speaker: M.L. Grundlingh, Manager of NODC of South Africa, South Africa

National Report of Nigeria
National Report of South Africa
National Report of Ghana

Round Table Discussions
Coffee Break
Social Event

Friday, 25 April - Day 4

11:00-12:30 Round Table Discussions: Composition of the Summary Report, Recommendations & Conclusions
12:30-14:00 Lunch

14:00-16:00 Adoption of the Summary Report of the Workshop & Recommendations
16:00-16:30 Closure

ANNEX II

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KEY SPEAKERS

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ANNEX III

OPENING SPEECHES

A

WELCOME ADDRESS BY MR. J. KUSI-ACHAMPONG SECRETARY-GENERAL, GHANA NATIONAL COMMISSION FOR UNESCO

Mr. Chairman,
Representatives of Hon. Minister of Education and the Hon. Minister of Environment, Science and Technology,
The Deputy Executive Director of IOC,
The GODAR Project Leader,
The UNIDO Co-ordinator,
Members of the Diplomatic Corps,
Distinguished Participants and invited guests,
Colleagues,

I deem it a great honour to warmly welcome you on behalf of the Ghana National Commission for UNESCO and its specialized and National Committees, particularly that of the Intergovernmental Oceanographic Commission, to the opening ceremony of this Regional Workshop on Global Oceanographic Data Archaeology and Rescue Project.

Mr. Chairman, to date, 5 similar Regional Workshops have been held since 1993, in Russia (Eastern and Central Europe), China (Western part of the Indian Ocean), India (Indian Ocean) Malta (Mediterranean) and Colombia (for the South and Central American Countries).

Hence, this is the sixth of the Regional Workshops which is now being held in Africa. We are therefore, particularly happy to welcome experts assembled here with the aim of sharing experiences to identify oceanographic data holdings in the Western Africa.

Mr. Chairman, the IOC was created in 1960 as an unique organization whose activities are fully committed to ocean research and monitoring. As a follow-up to the world-wide acceptance of the provision of the UN Convention of the Law of the Sea (UNCLOS), the Intergovernmental Oceanographic Commission is operating now as a UNESCO body with wide functional autonomy. The IOC drew up a "Comprehensive Plan for a Major Assistance Programme to Enhance the Marine Science Capabilities of Developing Countries".

Mr. Chairman, a necessary pre-requisite for benefiting from, and participating in this programme is the formation, in a Member State, of a National Co-ordinating body on Oceanographic Research. Consequently, a 16-member Ghana National Committee for the Intergovernmental Oceanographic Commission was formed in November 1985. Currently, the IOC Ghana National Committee has a membership of 21, drawn from the scientific, civil and public service organizations and the universities.

The invitation extended to Ghana to host this important Workshop was therefore based on the existence of an active National Committee for the Intergovernmental Oceanographic Commission.

Mr. Chairman, Ghana is a peaceful country and is known for its hospitality. Accra, the capital is a place of many colours. It is, therefore, our hope, that in spite of the demanding schedule of this Workshop, participants will have some time to look around and enjoy the proverbial Ghanaian hospitality.

B

OPENING ADDRESS BY MR J.S. DALRYMPLE-HAYFRON CHIEF DIRECTOR, ON BEHALF OF THE HON. MINISTER FOR EDUCATION

Mr. Chairman,
Honourable Members of Parliament,
Distinguished participants and invited guests,
Ladies and Gentlemen,

It is a privilege for me to be here this morning and to be part of the opening of the Sixth Regional Workshop on Global Oceanographic Data Archeology and Rescue Project (GODAR) being organized for West African Countries.

I am informed that the objectives of the GODAR Project include the facilitation of the creation of global oceanographic databases for use of the international research community for the study of the role of the world ocean in the earth's climate system. The main emphasis of the project is on the digitisation of data now known to exist only in manuscript and or in analog form, ensuring that all data are available to everyone on various media including CD-ROMs.

I am further informed that since physical, chemical and biological oceanographic data, as well as surface marine meteorological observations are the specific types of data of the greatest concern to climate research activities, to ocean resources exploitation and to coastal zone management, this Workshop will specifically focus on:

- identification of datasets available in different countries and data holders, which are at risk of being lost because of media degradation, possible environmental damage or catastrophes, such as fire;

- formulation of recommendations aimed to assist Member States in rescuing data and identification of mechanisms to make it effective;

- facilitation of co-operation between Member States of Western Africa in oceanographic data collection and management, through adopting the IOC/IODE principles and procedures for national, regional and international benefits and improvements of national infrastructure available for these purposes.

Mr. Chairman, these objectives are directly in line with Ghana's national objectives on oceanographic research and development activities.

Having recognized the increasing importance of the oceans to mankind and the need for society to use the ocean's resources rationally, Ghana, has over the years, actively supported and participated in international and regional activities, concerning development and conservation of marine resources including the formulation of the UN Convention on the Law of the Sea (UNCLOS). This law which entered into force in November 1994, defined the New Ocean Regime and endorsed the Exclusive Economic Zone (EEZ) concept. It has also made available the instrument for sustainable use and development of ocean resources. Further to this, some of the recent activities that Ghana has participated include:

- The FAO-IOC-WHO-IAEA-UNEP project on Monitoring of Pollution in the Marine Environment of West and Central Africa, which began in 1984, with the objectives of assessing the state of the marine environment and developing legislation against pollution;

- The 1985 Montreal Guidelines for the Protection of the Marine Environment from Land-based Sources of pollution;

- The 1995 Washington Global Programme of Action which aims at preventing the degradation of the marine environment, by facilitating the realization of the duty of States to preserve and protect the marine environment;

- Global Environment Factor's (GEF) Large Marine Ecosystem Project in the Gulf of Guinea, which seeks to develop an effective regional approach to prevent pollution of the Gulf of Guinea while conserving its biodiversity.

From the foregoing, I wish to congratulate the Ghana National Committee for the Intergovernmental Oceanographic Commission (GNC/GNC/IOC) for accepting the invitation to host this Workshop. The shift of emphasis from the open ocean to the coastal zone, with respect to conservation and use of marine resource has necessitated a strong emphasis on regional and sub-regional co-operation, as is depicted by this Workshop.

At this stage, Mr. Chairman let me point out that the need to improve socio-economic conditions in developing countries, such as ours requires that science and technology activities become more responsive to national and regional needs. It is my hope therefore, that this Workshop will adopt a practical approach, which will serve the needs of the sub-region through the implementation of its recommendations.

Mr. Chairman, distinguished guests, ladies and gentlemen, it is now my greatest pleasure to declare the Sixth Regional Workshop on Global Oceanographic Data Archeology and Rescue Project open.

I wish you all the best in your deliberations. Thank you.

IOC Workshop Report No. 136
Annex IV

ANNEX IV

RECOMMENDATIONS OF IOCEA-IV

Annex to recommendation IOCEA-IV.1
PROGRAMME OF WORK 1996-1997

ACTIVITY (VENUE & DATES)	ESTIMATED COST & PRIORITY	IMPLEMENTING INSTITUTION/COUNTRY-PARTICIPANTS
1. Oceans & Climate		
Workshop on Oceans & Climate in Eastern Atlantic (Freetown, Sierra Leone, Dec. '96)	High	IOC; Host country - All Member States
2. Living Resources		
Workshop on development of cephalopods regional fisheries project & on fish stock assessment methodologies (Portugal, '96 or '97)	US$15,000 High priority	IOC; Host country - Recommended Groups of Experts
Workshop on environmental & alieutic resources in estuaries & lagoons (Portugal or Guinea, '96 or '97)	US$20,000 Medium/High priority	IOC; Host country - All interested Member States
Sub-regional Workshop on living resources from Guinea to Angola (Benin, '96)	US$15,000 High priority	IOC - Member States belonging to the sub-region
3. Non-Living Resources		
Monograph on topology of Western African coasts ('97)	US$10,000? High priority	IOC - All Member States
Second IOCEA cruise in Gulf of Guinea ('96 or '97) (preceded by co-ordination meeting for Second IOCEA cruise in Gulf of Guinea to be held in '96)	US$40,000 High priority	IOC- Participating Member States (co-ordination meeting) IOC - University of Venice, Italy, Nigeria, Cite d'Ivoire
Collection of information on river inputs & sediment fluxes	No cost High priority	All Member States (IOC to ensure co-ordination)
4. Marine Pollution		
Establishment of network of baseline stations (from design to concrete establishment) ('96-'97)	US$ ...? High priority	IOC; GEF (?) - All Member States

Co-ordination with LME activities in region ('96 & '97)	No cost (?) High priority	IOC; UNIDO; National efforts
5. Ocean Mapping		
IBCEA: continuation of regional projects according to editorial board plan (covering '96-'97)	---	Spain, Portugal, France (IOC to ensure co-ordination)
IBCEA Editorial Board meeting (Portugal, '96)	US$15,000	IOC; Portugal - participating Member States
6. Communications		
Establishment of e-mail network in region	Very high priority	Donors; IOC - All Member States
7. Ocean Observations (support to establishment of regional GOOS)		
Establishment of tide gauges ('96 & '97)	High priority	IOC; recipient countries
Maintenance of tide gauges ('96-'97)	High priority	IOC; national efforts - concerned Member States
Regional training course on use & collection of sea-level data ('96-'97)	US$10,000 Medium priority	IOC; donors - all Member States
Preparation of regional inventories of on-gong ocean observations (including coastal ones) (to be started in '96)	High priority	National efforts; RECOSCIX-CEA
8. IODE		
Establishment of regional data centre in Conakry, Guinea ('96)	--- High priority	IOC to provide assistance - all Member States
Assistance to establishment of national data centres	US$...? High priority	IOC; donors, national efforts
Preparation of inventories of courses, training centres, existing institutions & equipment ('96-'97)	High priority	RECOSCIX-CEA
Training Workshop on archiving & transfer of oceanographic data & information ('97 ?)	Medium/High priority (?)	IOC; RECOSCIX-CEA
9. UNCED		
Implementation of Agenda 21, Chapter 17 ('96-'97)	High priority	IOC; UN agencies, NGOs; Member States
Creation of awareness of governments, policy & decision makers & stake holders ('96 & '97)	High priority	Member States; IOC scientists
10. Capacity Building		

Assistance in establishment of degree course in oceanography at University of Lagos, Nigeria (‘96 & ‘97)	High priority	IOC; national effort
Second IOCEA cruise in Gulf of Guinea (‘96 or ‘97) (see above)		
Training components of activity groups 3), 7), & 8)		
Communication to organizations, intersessional meeting of officers (‘96-’97)	High priority	IOC Secretariat; IOCEA officers
Organization of IOCEA-V (‘97 & ‘98)	High priority	IOC Secretariat; IOCEA Officers; Host country - All Member States

ANNEX V

LIST OF ACRONYMS

ADCP	Acoustic Doppler Current Profiler
ASECNA	Agency for the Safety of Air Navigation
ASFA	Aquatic Sciences & Fisheries Abstracts
CD-ROM	Compact Disk - Read Only Memos
CDS	Computerised Documentation System
CEA DIR	Central Eastern Atlantic Directory of Marine Scientists
CI	Co-operative Institution
CL	Co-operative Libraries
CLIVAR	Climate Variability & Predictability
CSIR	Council for Scientific & Industrial Research
CTD	Conductivity, Temperature, Depth
CURAT	Centre Universitaire de Recherche et d'Application en Teledetection
DBMS	Data Base Management System
DD	Document Delivery
DNA	Designated National Agency
ESKOM	Electricity Supply Commission
EEZ	Exclusive Economic Zone
FAO	Food & Agriculture Organization of the United Nations
FRUB	Fisheries Research & Utilization Branch
GATE	GARP Atlantic Tropical Experiment
GARP	Global Atmosphere Research Programme
GCOS	Global Climate Observing System
GDP	Gross Domestic Product
GEBCO	General Bathymetric Chart of the Oceans (IOC-IHO)
GEF	Global Environment Facility
GIS	Geographic Information System
GLOSS	Global Sea Level Observing System
GNC	Ghana National Commission
GODAR	Global Oceanographic Data Archaeology & Rescue Project
GOOS	Global Ocean Observing System
GTS	Guinean Trawling Survey
GTSPP	Global Temperature-Salinity Profile Programme

HIDEN	Historical Database on the Environment
IAEA	International Atomic Energy Agency
IBCEA	International Bathymetric Chart of the Central & Eastern Atlantic
ICCAT	International Commission on the Conservation of Atlantic Tunas
ICLARM	International Centre for Living Aquatic Resources Management
IMT	Institute of Marine Technology
IOC	Intergovernmental Oceanographic Commission
IOCEA	IOC Regional Committee for the Central Eastern Atlantic
IOCINCWIO	IOC Regional Committee for the Co-operative Investigations in the North & Central West Indian Ocean
IOCINDIO	IOC Regional Committee of the Co-operative Investigation in the Central Indian Ocean
IODE	International Oceanographic Data & Information Exchange System (IOC)
KMFRI	Kenya Marine & Fisheries Research Institute
LME	Large Marine Ecosystem Project
LOICZ	Land-Ocean Interaction in the Coastal Zone (Netherlands)
MASDEA	Marine Species Database for Eastern Africa
MBT	Mechanical Bathy Thermograph
MEDI	Marine Environmental Data Information Referral System
MINEPIA	Ministry of Livestock, Fisheries & Animal Husbandry
MINREST	Ministry of Scientific & Technical Research
MINTRANS	Ministry of Transport
MOMR	Ministry of Marine Research
MSY	Maximum Sustainable Yield
NGO	Non-Governmental Organization
NIOMR	Nigerian Institute for Oceanography & Marine Research
NOAA	National Oceanic & Atmospheric Administration (USA)
NODC	National Oceanographic Data Centre (IODE)
NORAD	Norwegian Agency for International Development
OCEANPC	Ocean Personal Computer Project
ODINEA	Ocean Data & Information Network for Eastern Africa
ORI	Oceanographic Research Institute
ORSTOM	Institut Francais de Recherche Scientifique pour le Developpement en Cooperation
PC	Personal Computer
PMB	Post mail Box
QH	Query Handling

RECOSCIX-CEA	Regional Co-operation in Scientific Information Exchange in the Central Eastern Atlantic Region
RECOSCIX-WIO	Regional Co-operation in Scientific Information Exchange in the Western Indian Ocean
RDC	Regional Dispatch Centre
RNODC	Responsible National Oceanographic Data Centre (IODE)
ROSTA/UNESCO	Regional Office for Science & Technology in Africa of UNESCO
SADCO	South African Data Centre for Oceanography
SANODC	South African National Oceanographic Data Centre
SAWB	South African Weather Bureau
SFRI	Sea Fisheries Research Institute
SHOM	Service Hydrographique et Oceanographique de la Marine (France)
SISMER	Systemes d'Information Scientifiques pour la Mer (France)
SOEKA	Southern Oil Exploration Corporation
STD	Salinity, Temperature, Depth
STEPRI	Science & Technology Policy Research Institute
TOGA	Tropical Oceans & Global Atmosphere
UCT	University of Cape Town
UNCED	United Nations Conference on Environment & Development
UNCLOS	United Nations Convention on the Law of the Sea
UNDP	United Nations Development Programme
UNEP	United Nations Environmental Programme
UNESCO	United Nations Educational, Scientific & Cultural Organization
UNIDO	United Nations Industrial Development Organization
UNITAR	United Nations Institute for Training & Research
UPE	University of Port Elizabeth
VLIR	Flemish Inter-University Council (Belgium)
VOS	Voluntary Observing Ships
WACAF	Project on Monitoring of Pollution in the Marine Environment of the West & Central African Region
WDC	World Data Centre (ICSU)
WIODIR	Western Indian Ocean Directory of Marine Scientists
WIOLIB	Western Indian Ocean Libraries of Marine Science
WIOMSA	Western Indian Ocean Marine Sciences Association
WINDOW	Western Indian Ocean Waters
WOCE	World Ocean Circulation Experiment (WCRP)
XBT	Expendable Bathy Thermograph Instrument

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