Intergovernmental Oceanographic Commission

Workshop Report No. 107

IOC-ICSU-NIO-NOAA Regional Workshop for Member States of the Indian Ocean - GODAR-III (Global Oceanographic Data Archeology and Rescue Project)

Indian National Oceanographic Data Centre
National Institute of Oceanography

Dona Paula, Goa, India
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UNESCO

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1. BACKGROUND AND OBJECTIVES OF GODAR

The Global Ocean Data Archaeology and Rescue Project, now known as GODAR, was the name given by the IOC Assembly at its Seventeenth Session (Paris, France, 25 February - 11 March 1993) to a new project which has been launched in the framework of the IOC International Oceanographic Data and Information Exchange (IODE) Programme. In response to the recommendation of IOC-XVII, the Secretary IOC appointed Dr. S. Levitus, Director, WDC-A, Oceanography as the Project Leader.

The GODAR Project Proposal (Annex II) was previously given strong endorsement by the IOC Committee on IODE at its Fourteenth Session (Paris, France, 1-9 December 1992), following initial preparatory activities as a result of the Workshop held in September 1990 at the US National Oceanographic Data Center (NODC) in Washington DC. After the Workshop, data archaeology and rescue activities were begun at the 3 World Data Centers for Oceanography in Washington (USA), Obninsk (Russian Federation) and Tianjin (China), as well as at the ICES Secretariat in Copenhagen, Denmark and at the Japan Oceanographic Data Centre, Tokyo.

An international Workshop (Greenbelt, Maryland, USA, 18-21 February 1992) on Ocean Climate Data, sponsored by the IOC, CEC, ICES, WMO and ICSU noted the progress achieved in data archaeology during 1991 by a few Member States and international organizations, and recommended expanding this *ad hoc* multi-lateral effort to an international data rescue and recovery project (IOC Workshop Report N$^{o.}$ 78, 1992).

The Project, which is under operation for over 3 years, is endeavouring to augment the historical oceanographic digital data archives by seeking out and recovering manuscript and ocean data not yet included in the ocean databases accessible to the world research community. The term "data archaeology and rescue" refers to this two-part process of first identifying and locating data and then performing the steps required to merge them into a digital database.

The above project is ambitious but is essential to bridge the gap in the long time-series of ocean observations which is of the utmost importance for climate change studies. Efforts in the context of the preparation for UNCED, including assessments of the state of environment, the SWCC, the IPCC and negotiations for the FCCC have shown very clearly the need for long time-series of quality data. Governments and scientists are now recognizing the value and indispensability of historical ocean data for scientific research and to national decision-making. Vigorous ocean data archaeology efforts will help to significantly enhance the ocean data record from past decades. These efforts will rely on data exchange of the IOC's IODE and the WDC systems.

The GODAR Workshop at INODC/NIO, Dona Paula, Goa, India is the third in the series after the two held at Obninsk, Russian Federation (17-20 May 1993) and Tianjin, China (8-11 March 1994). The Workshop, sponsored by IOC, ICSU, NOAA, DOD and CSIR was held following the decision taken at the first regional Workshop in Obninsk for the development of GODAR in the Indian Ocean region and in facilitating exchange of data under the IODE umbrella. Though the Indian Ocean is still least studied, yet a large amount of data have been collected but not all documented.

The purpose of the Workshop was to unearth the data and make available to the wide international community in order to build global oceanographic databases for different fields of application, including global change and climate studies, world ocean research and global ocean monitoring, and to help in the capacity building of national, regional and global infrastructures.

The desired outcome was to assess the state of data holdings in the region, to identify common goals and problems with data preservation and to recommend implementation steps and approaches to solve these problems. The Workshop was also considered as a start for laying the groundwork for a major upgrading of the entire regional ocean data management system, a major step in the development of a region-wise ocean data system modernization programme.

The present report contains a summary of the scientific papers and national reports presented at the sessions, software demonstration at Indian NODC, as well as recommendations and conclusions formulated by the Workshop.

The opinions expressed in the Workshop Report are those of the participants and do not necessarily coincide with those of the sponsoring organizations.

2. OPENING AND WORKSHOP ARRANGEMENTS

The Workshop was organized by the Indian National Oceanographic Data Centre of the National Institute of Oceanography which is one of the 42 national laboratories under the Council of Scientific and Industrial Research. Dr. S. Levitus, the Project Leader of GODAR, chaired the sessions while Dr. I. Oliounine from IOC assisted him as Co-Chairman. Dr. B. Searle, Head of the Australian Oceanographic Data Centre agreed to act as Rapporteur. The Workshop Programme is attached as Annex I.

At the inaugural function, Dr. E. Desa, Director, NIO, welcomed the participants. He stated that Member States of the Indian Ocean region have collected considerable data but not properly documented. He further stressed that this Workshop will pave the way for retrieving the historical data from various sources. Dr. Desa briefed about the state-of-art of the Indian NODC and its achievements and said that INODC with its expertise and available facilities can play a significant role in the Indian Ocean Data and Information Management as part of the international programmes like IODE. He was sure that this Workshop will bring the Indian Ocean countries closer in oceanographic data exchange to benefit all. The very fact that this Workshop is being inaugurated by a scientist no less than a Secretary to the Government shows that India attaches great importance to this Workshop.

Dr. S.K. Joshi, Director-General, CSIR and Secretary to the Government of India, inaugurated the Workshop. In his inaugural address he stated that the time has come to realize the importance of data and for its free exchange in the usable form. He stressed the importance of oceanographic data in modelling studies, global climate and predicting monsoon on which depends the economy of several countries of the Indian Ocean region. Dr. Joshi divulged that NIO fulfills all the requirements to a great extent in order to serve as the Regional National Oceanographic Data Centre for the Indian Ocean region. He appreciated the involvement of scientists which will increase the co-operation between them and data managers in the rescue and archaeology of the data. He expressed confidence that the discussions in the next few days will culminate in achieving the objectives of the Workshop. He wished the Workshop a grand success.

Speaking on behalf of the Secretary IOC, Dr. I. Oliounine welcomed the participants and expressed a strong hope that the experts present at the Workshop would make an important contribution to the success of the GODAR project and of the IOC/IODE system in general. He was particularly pleased to welcome the representatives of the UNESCO Regional Offices, Mr. L. Mandalia from New Delhi and Dr. G. Kitaka from Nairobi, whose presence will help to improve further bonds of co-operation in the field of Marine Sciences between the Member States of the region and between the IOC and UNESCO Regional Offices. He expressed regret that, unfortunately, due to different reasons, not all countries invited to the Workshop were able to be represented in Goa.

Dr. Oliounine then briefly presented the main objectives of the GODAR project: digitization of data known to exist now only in manuscript and/or analog form; rescue of data that are at risk of being lost due to media decay or neglect; ensure that all the data are available for the international exchange. He informed the Workshop participants on the UN and other meetings of the last two years which were of special importance for the development of IOC and its IODE system - UNCED, UNCLOS entering into force, and the Lisbon '94 Conference. He stressed that the decision of these international fora placed a large responsibility on the governments of Member States, governmental institutions and organizations, as well as on individual scientists and data managers to ensure through IOC and its IODE an adequate follow-up in the field of marine data and information exchange and management. The regional co-operation in this field has a great potential in increasing its contribution to different components and projects of IODE and to the GODAR project, in particular.

In his final remarks, Dr. Oliounine called on the participants to take the long-term view in their discussions and to formulate recommendations which could be translated into practical benefits for all countries of the region and for all IOC Member States.

Dr. S. Levitus gave a genesis of the project on GODAR. He then also presented a set of first CD-ROMs prepared by WDC-A as a GODAR product, to Dr. E. Desa, Director, NIO, Goa. The 9 discs of the set contain global data on physical and chemical parameters for 90 years from 1900 to 1990.

Dr. R.M.S. Bhargava, Head of INODC, proposed a vote of thanks particularly to Dr. Joshi, the sponsors, the participants and his colleagues for arrangements.

The Workshop was attended by 33 participants which included scientists, data managers, planners and administrators from India and abroad (Annex III). In addition to the participants, there were several observers who took keen interest in the deliberations. The Workshop was a great success in all respects i.e., lectures, discussions, recommendations and local arrangements for which the local organizers were duly acknowledged.

The programme was conducted in 4 parts: (i) Scientific presentations by selected experts in their fields; (ii) The presentations of National Reports by the representatives of the countries which were the crux of the Workshop. These reports exposed the data activities in various countries; (iii) Software demonstration at INODC; and (iv) Round table discussions on planning and implementation of GODAR in the Indian Ocean region. The conclusions and recommendations follow in the latter part of the report.

The definition, type of data, etc., remain the same as given on page 3 of IOC Workshop Report, N$^{o.}$ 88, 1993.

3. SCIENTIFIC PRESENTATIONS

Regional Programmes of IOC and UNESCO: General Policy and Status of Implementation in the Indian Ocean Region

I. Oliounine, Head, Ocean Services Unit, IOC, Paris, France
and
L.A. Mandalia, UNESCO, New Delhi, India

The regional mechanism of UNESCO and IOC have been established to foster intergovernmental co-operation in different types of programme activities and, specially, in marine sciences. UNESCO and its IOC, from the start, emphasized the needs for and benefits of regional co-operation with the participation of all states, both from inside and outside of the region in question.

The decisions of UNCED, UNCLOS and the Lisbon '94 International Conference on Oceanography gave a new stimulae for widening and deepening co-operation in the regions to achieve sustainable development and to foster regional, national and multilateral economy.

IOC is operating today 4 Regional Committees *viz*. IOCINDIO, IOCINCWIO, SOC and IOCEA and 2 Regional Sub-Commissions - WESTPAC and IOCARIBE. The establishment of a Sub-Commission was only done after careful and in-depth evaluation of the interests in and developments of the marine programmes in the region. The possibility of organizing a new IOC Sub-Commission for the Indian Ocean and adjacent seas on the basis of the IOCINDIO and IOCINCWIO Regional Committees is under consideration.

Presentation was focussed on marine-related activities of UNESCO and IOC in IOCINCWIO and IOCINDIO regions. Matters of priority for these regions are very close. They include such IOC programmes as Ocean Dynamics and Climate, Ocean Science and Living Resources, Ocean Science and Non-living Resources, Pollution Research and Monitoring, preparation of Bathymetric charts and participation in data collection and management in the framework of IGOSS, GLOSS and IODE.

It was stressed that co-operation with other governmental and non-governmental organizations in the implementation of regional programmes is an important component of future success. A few examples were presented such as an IOC-SAREC Workshop on Marine Water Quality and intercalibration exercise for nutrient analysis; an IOC-UNEP Workshop on Regional Climate Impact Assessment in October 1992, in Dhaka, Bangladesh; Regional Workshop on Integrated Coastal Zone Management held in Dhaka, Bangladesh in

December 1993; an International Workshop on Integrated Coastal Zone Management held in October 1994 in Karachi, Pakistan; the RECOSCIX-WIO project in the Western Indian Ocean Region for exchange of scientific information and others.

It was further emphasized that to enhance regional capabilities in order to interpret and use the results from field experiments there is a need to train people to use both the data and interpret the results so as to provide advice on actions to decision-makers and different user groups. A few examples are: Training Programme in Coastal Marine Science "*Modelling and Monitoring of Coastal Pollution*" at New Delhi, December 1994; UNDP-UNESCO Research and Training Pilot Programme on "*Mangrove of Asia and the Pacific: Status and Management*".

At the end, the authors identified major problems which have been encountered in the process of carrying out regional activities such as: lack of communication, lack of governmental commitment or priority setting, lack of funds and lack of trained personnel and equipment.

Mechanisms have been demonstrated which could help to overcome some of the difficulties through encountered demonstration of the importance and benefits of marine research and systematic observations and an increase in governmental and public awareness of the role of the ocean for sustainable development.

Scientific Results Made Possible by the GODAR Project

S. Levitus, Director, WDC-A, Oceanography and GODAR Project Leader, Washington, DC., U.S.A.

The global ocean datasets made available due to the GODAR project will enable scientists to conduct scientific studies not previously possible. The production of seasonal oxygen distribution for the world ocean allows for the studies of the seasonal cycle of various bio-geochemical cycles. The production of yearly fields of upper ocean, thermal structure allows for more comprehensive studies of air-sea interaction. The scientific products that have been generated by the GODAR project, as described in Annex IV will improve the boundary and initial conditions used in many scientific studies.

Red Sea Pollution Transport Studies and Need for Oceanographic Data

M.O. Moammar, King Abdulaziz University, Jeddah, Saudi Arabia

The main geographical characteristics of the Red Sea are given and general hydrographic properties discussed. Main geographical features that influence strongly on the hydrographic regime of the sea include very narrow or no continental shelf, big depths up to 2920 m and the sill with 137 m depth at the southern end of the sea which prevents penetration of water from the Gulf of Aden except in the area of Strait of Bab-el-Mandab. Due to the arid climate, evaporation is very high (average annual about 200 cm/year) and greatly exceeds precipitation. The Red Sea experiences seasonally reversible monsoon winds related to large seasonal pressure changes that occur over the Asia Continent. Due to the change of wind regime, a usual 2-layer flow of the sea water caused by density difference is replaced by a 3-layer flow: sub-surface inflow, and surface and bottom outflows. The sea-level is influenced by evaporation and meteorological oceanographic conditions. It was demonstrated that about 80% of the monthly mean sea-level variance is due to seasonal changes, caused primarily by changes in atmospheric pressure.

The detailed information has been given on the pollution of the Red Sea and major sources of pollution were described. They include shipping traffic, domestic activities in the coastal area and industrial efforts. Highly industrialized towns exist in the coastal areas where marine pollution phenomena appear with greater intensity and cause biological damage - immensely phytoplankton and algal blooms are common. Other contributions arise from petrochemical industry, phosphate, manganese and bauxite loading in the Gulf of Aqaba and Quseir and oil traffic. The last is especially dangerous as oil spills and slicks decrease the rate of photosynthesis, interfere with the daily vertical migration of zooplankton, have indirect effect on the nutrition and behaviour of plankton organisms. Oil and other contaminants discharged into the sea are potential hazards to marine life.

Special concern was expressed with the activities of the Arab Petroleum Pipeline Company (SUMED) which laid a 320 km. pipeline from the unloading terminal at Ain Sukhma in the Gulf of Suez to Sidi Kerir in the Mediterranean. SUMED service enables to optimize the use of tankers up to 500,000 DWT which cannot pass the Suez Canal. Automatically the usage of this system increases the risk of accidental oil spills in the Red Sea which may be a real catastrophe to the marine environment.

Finally, the need for oceanographic data to study regional distribution and dispersion of pollutants was demonstrated and requirements for different data collection projects shown. Data on currents, tides, sea-level, circulation models, hydrographic and meteorological condition contribute strongly to the studies. It is needed that not only the data for the future studies be conserved but the data from the previous cruises in the Red Sea be systematically arranged and preserved for modelling of climate changes studies of marine environment of the Red Sea and for studies of hydro-dynamical processes and pollution control.

General Circulation of the Indian Ocean

N. Bahulayan, NIO, Goa, India

Some unique features of the surface circulation in the Tropical Indian Ocean during various seasons and the forcing functions that control its variability were presented. The Indian Ocean has the strongest seasonal forcing of all other oceans due to reversing monsoon winds, resulting in the seasonally reversing western boundary current (Somali current), Northeast/Southwest monsoon currents north of the equator and the East African Coastal Current (EACC) south of the equator. It has a semi-annual eastward surface jet with an undercurrent beneath it during the transition seasons. The Indian Ocean has also a complex thermohaline structure due to intrusions from the marginal seas such as the Red Sea and the Persian Gulf and due to flow through the Indonesian Archipelago. The circulation pattern in the non-monsoonal areas, south of 10^{o}S latitude, is more or less permanent throughout the year.

During the winter season, the surface currents vary relatively little in the course of the year in the southern part of the tropical Indian Ocean. Circulation in this region is dominated by a basin-wide gyre defined by the South Equatorial Current (SEC) to the south, the South Equatorial Counter Current (ECC) to the north and the EACC to the west. As further extensions of the SEC, there are two southward flowing boundary currents, namely the Mozambique Current (MZC) and the Coastal Current to the East of Madagascar (EMC). In the northern Indian Ocean and equatorial zone, monsoonal current regime undergoes drastic changes. In association with the northeast monsoon winds of boreal winter, there is a westward directed current to the south of India which is called the North Equatorial Current which represents the northern boundary of the counter clockwise rotating northern gyre. This gyre is bound on the south by ECC and on the west by the southward flowing Somali Current (SC) and the EACC. The axis of this gyre is located approximately on the equator. In the Bay of Bengal, an anticyclonic gyre fills the entire basin between 10^{o}N and 20^{o}S latitude. During the spring season, the most dramatic circulation feature is the appearance of an equatorial jet on the equator. The appearance of the equatorial jet (EJ) on the equator can be interpreted as the northward movement of the southern gyre observed in boreal winter. The northern gyre observed in winter disappears in April with the weakening and disappearance of north easterly winds in the northern Indian Ocean. The equatorial jet develops during spring in response to strong westerly winds that sweep along the equatorial belt. During the southwest monsoon season (summer) the South Equatorial Current, the Somali Current and the Monsoon Current form a very strong wind-driven gyre in the equatorial Indian Ocean. The associated current speeds are stronger than those found during the NE monsoon period. Two distinct anticyclonic gyres have been found along the East African coast during the summer monsoon. The northern gyre, centered at about 8^{o}N has been historically called the great whirl. The position of the northern boundary of the southern gyre varies from south of equator to about 5^{o}N. This gyre may coalesce with the great whirl during the latest stages of the summer monsoon. During the post-monsoon season, the equatorial jet appears and a clockwise gyre is formed with SEC on the south, SC on the west and EJ on the north. There are no changes in the circulation pattern in the south tropical Indian Ocean. The EACC still flows north-eastward along the East African Coast.

The presentation also dealt with the 3-D circulation in the Arabian Sea and Western Equatorial Indian Ocean which was studied with one 18-level semi-diagnostic model. The model was driven with Hellerman's wind data

and the temperature and salinity data compiled by Levitus. The model was able to simulate the surface and subsurface circulation in the model area reasonably well. One conclusion from the model study is that temperature and salinity data for the Indian Ocean area should be compiled seasonally, taking into consideration the meteorological conditions. Seasonal classification for both the monsoon winds and oceanographic variables should be the same as the former control the surface and subsurface circulation in the Tropical Indian Ocean.

Status of the IODE/GODAR Project

S. Levitus, Director WDC-A, Oceanography, GODAR Project Leader, U.S.A.

GODAR regional meetings have now been held in Obninsk, Russian Federation (eastern and northern Europe), Tianjin, China (WESTPAC) and Goa, India (Indian Ocean). As a result of the GODAR project more than 1.2 million temperature profiles and 300,000 salinity profiles are now available to the international scientific community which were previously not accessible in digital form. As part of its commitment to the GODAR Project, WDC-A, Oceanography agreed to process all GODAR data as well as all US NODC and WDC-A data and distribute these data internationally on CD-ROMs. This commitment has been met. As described in Annex IV, a set of 9 CD-ROMs is being distributed as of 6 December 1994. The first CD-ROM set was presented by the GODAR Project Leader to the Director of the National Institute of Oceanography of India. Continued success in locating and digitizing historical data means that an update of these first GODAR products will be implemented in 1-2 years.

Indian Participation in International Programmes

B.N. Krishnamurthy, DOD, New Delhi, India

The paper describes the marine programmes that are being implemented and new initiatives taken by the Department of Ocean Development, Government of India, since its inception in 1981. The major ones being: (a) Sea-bed mining of polymetallic nodules in Indian Ocean; (b) Antarctic research; (c) Agenda 21. Chapter 7 of the Rio Conference; and (d) The South-Asian Regional Seas Programme. Activities and accomplishments of these programmes were explained. Apart from the above, the Department of Ocean Development is implementing national programmes having relevance to the following IOC programmes: (a) GOOS; (b) GLOSS; (c) JGOFS; and (d) IODE. All these programmes generate a large amount of data which needs to be properly archived and disseminated to bonafide users. For this purpose, a programme called National Ocean Information System (NOIS) has been started. Thirteen Marine Data Centres (MDC) have been identified in different institutes for specialized parameters. The collection and formatting of data is underway. All these MDCs have been interconnected through Micro-Earth Stations and the user may approach any of them. The data cleared for international exchange can be obtained through NODC.

The following are the on-going programmes of DOD:

(i) Antarctica;
(ii) Sea-Bed Mining;
(iii) Marine Satellite Information Service;
(iv) Marine Pollution;
(v) Marine Instruments;
(vi) Sea-level Studies;
(vii) IGBP-JGOFS;
(viii) National Ocean Information System;
(ix) Drugs from the Sea;
(x) Wave Energy;
(xi) Ships Management;
(xii) National Institute of Ocean Technology;
(xiii) Manpower Development.

The new initiatives of DOD are:

(i) Acquisition and management of coastal research vessels;
(ii) Launching of an ocean satellite;
(iii) National Data Buoy Programme;
(iv) Acquisition of an Ice-Breaker cum Oceanographic Research Vessel.

GIS Project for the Area from the Red Sea to Mozambique

H. Ong'anda, KMFRI, Mombasa, Kenya

Geographical Information System also known as GIS is a computer assisted system for the acquisition, storage, analysis and display of geographic data.

GIS is characterized by spatial and attribute database describing the earth features. Maps can be displayed on the screen or made into negatives for printing maps. Map information is normally converted from paper maps to digital form by digitizer tablets and scanners. A geographic analysis system helps in analyzing the data based on their location. Some software systems include the ability to analyze remotely-sensed images (such as LANDSAT or SPOT satellite imagery) and provide specialized statistical analysis.

Map data representation in GIS is fundamentally in two distinct formats, the vector and raster systems. In a vector system, all the attribute data is stored with a traditional database management system software. A vector map of coastal near-shore waters can be tied to an attribute database of information containing coastal bathymetry. With the raster systems, the graphic representation of features and the attributes they possess are merged into unified data files.

The geographic database is organized in a fashion similar to a collection of maps. Whereas the raster system divides data into map layer containing all data for a single system (layers), vector systems have geographic definitions of a set of features and their associated attribute tables (coverages). All the information in the GIS is geo-referenced (e.g., latitude/longitude, etc.).

Analysis in GIS involve the use of analytical tools which apply a set of analytical operations. As a result, query operations are possible, e.g., "*show me which mangrove forests are larger than one hectare*". In simple terms, normal algebraic linear relationships can be used to obtain a secondary dataset hence the term "*derivative mapping*". Other operations involve determination of distances from specified locations.

Coastal and marine resource managers and researchers may benefit from this information system in their management and analysis of coastal data. Vegetation maps can be derived from satellite photographs and the extent of vegetation types determined. Other features can be mapped in a similar manner. Such maps not only provide information on the current status of a system, but also form a historical perspective if accumulated over time. Combined with other mapping features and the relational databases that such systems incorporate, the technology of GIS proves rather interesting in ecology work. Initiatives have been taken to use the GIS tool. The IOCWINCIO-III meeting recognized the need to access and use ocean data, some of which come from large-scale experiments like TOGA and WOCE. Following this, a proposal has been designed to implement a data and information network (ODINEA) in the western Indian Ocean region. This project will, among other things, assist countries of the region in preparing maps of habitats and resource use. The resulting database will be implemented in a geo-information system (GIS).

The "*East African Coastal and Marine Environment and Resource Database and Atlas*" is a project funded by the Regional Seas Programme of the United Nations Environmental Programme (UNEP), with the support of the leading institutions in the region and the Belgian Government. This project is designed to enhance the East Africa Action Plan (EAF/5), the sustainable development and management of the marine environment. The plan was adopted by all 9 countries of the region, namely Comoros Islands, France (Reunion Island), Kenya, Madagascar, Mauritius, Mozambique, Seychelles, Somalia and the United Republic of Tanzania, and the

European Community. Phase-I of the project is taking place and covers Kenya for the period of June 1993 to December 1994.

The main task of this project is to collate existing information on natural resources and to summarize this information in country-map sheets. National coastal and marine resources maps will be printed at the 1:250,000 scale or at the 1:50,000 scale for islands and sites of paramount interest. Information relevant to the country-maps will be stored in a GIS database, allowing regular updating and handling of queries from regional and national organizations and institutes. At a later stage, the individual country-map sheets will be bundled in the Regional Resources Atlas for Eastern Africa.

A Brief History of the BIOMASS Programme and BIOMASS Data Centre and Some Lessons Learned from Running the BIOMASS Data Centre

M.R. Thorley, Antarctic Environmental Data Centre, United Kingdom

This report presents a brief history of the BIOMASS programme and of the BIOMASS Data Centre, then looks at the valuable lessons about data management learned from the running of the BIOMASS Data Centre. This report is based on information first published in Thorley and Trathan (1994), which should be consulted for further details.

A Brief History of the BIOMASS Programme

The principle objective of BIOMASS (Biological Investigations of Marine Antarctic Systems and Stocks) was to gain a deeper understanding of the structure and dynamic functioning of the Antarctic marine ecosystem as a basis for the future management of potential living resources.

BIOMASS had two major field campaigns, the first and second International BIOMASS Experiments (FIBEX and SIBEX). The aim of FIBEX was to try to determine how much krill is in the Antarctic. It was composed of 16 research cruises carried out between November 1980 and April 1981 and produced a synoptic picture of the distribution of krill over a large area of the southern ocean. The primary objective of SIBEX was to improve the understanding of the dynamics of the krill-dominated part of the Antarctic marine ecosystem.

SIBEX involved two field seasons, SIBEX-1 (8 cruises, October 1983 to April 1984) and SIBEX-2 (10 cruises, November 1984 to April 1985). SIBEX surveys produced a temporal sequence of observations focussed mainly on the Bransfield Strait and Prydz Bay regions.

A Brief History of the BIOMASS Data Centre

The requirement for a data centre was identified as part of the initial planning for the BIOMASS Programme. The role of the data centre was to include the creation of an inventory of BIOMASS datasets, provision of support for data interpretation workshops and to receive and store BIOMASS data. Initially, data management facilities were provided by the universities of Hamburg and later, Frankfurt. It was not until 1985 that the BIOMASS Data Centre was finally established at the British Antarctic Survey (BAS) in Cambridge, UK.

Between 1981 and 1991, 10 data validation and analysis workshops were held and they looked at the majority of the data within the BIOMASS dataset. Data validation was an important process and involved the scientists who had collected the data working together to review and analyze their individual collections in the context of the whole dataset. In 1990, the BIOMASS database and data holdings of the BIOMASS Data Centre were reviewed. This revealed a number of problems with the structure of the database and the amount of documentation available. As a consequence, a programme of re-organization and rationalization of the BIOMASS database and dataset documentation was carried out.

Some Lessons Learned from Running the BIOMASS Data Centre

Valuable lessons have been learned from the management of the BIOMASS Data Centre which should be taken into consideration by similar programmes in future. Some of these are reviewed.

There was a poor integration of the management of the BIOMASS data with the scientific objectives of the programme. The work of the data centre was too reactive, with the majority of the resources going on loading data and preparing for data analysis workshops, with little time for long-term data management.

The BIOMASS dataset was held in 3 non-proprietary database systems before the Oracle RDBMS was used. Each time the data were migrated between systems, some data were lost or corrupted.

Considerable effort was expanded in designing a comprehensive set of data transfer formats, to allow data to be sent to the BIOMASS Data Centre. To cope with the range and complexity of the data collected, the formats were of necessity complex and, as a consequence, difficult to use. Because of this, the BIOMASS format was a disincentive to transfer data to the BIOMASS Data Centre. Also, scientists did not always understand benefits they would receive by transferring their data to the data centre.

Although most of the BIOMASS data were validated during data analysis workshops, some underwent validation only at the end of the programme, up to 10 years after collection. In addition, the biological data required special skills to validate and the accuracy of these data depended on the technical skill and taxonomic competence of the scientists involved.

It was initially decided that the BIOMASS dataset would be made freely available to all BIOMASS investigators. However, this open access protocol was changed at the insistence of some BIOMASS nations. The restricted access protocol, in place until 1990, made it difficult for data to be accessed outside of data analysis workshops as it required the permission of the data collector to be sought in order for the data to be used. This greatly restricted the potential for scientific use of the BIOMASS data and resulted in lost opportunities for research.

Many of the problems with the BIOMASS database, which required extensive restructuring, revalidation and documentation, were due to the way the BIOMASS Data Centre was managed. This was a result of a misunderstanding between the BIOMASS Data Centre, its host (BAS) and the BIOMASS programme. BAS and BIOMASS each assumed that the other had taken the responsibility for overseeing the work of the BIOMASS Data Centre and ensuring that key activities had been carried out.

Recommendations

A number of recommendations can be made that should be incorporated into the design of future programmes. These include:

(i) A better integration of information management of science, with information management being planned into programmes from the beginning. The information management strategy and its implementation must be reviewed at regular intervals throughout the lifetime of a programme to ensure that scientific objectives are met;

(ii) Although information management systems must be upgraded to keep abreast with advances in computing technology, migration to new systems should only be undertaken with good reason. Time spent in system migration is time not available for science;

(iii) The structure and implementation of any database must be well thought out and full use should be made of commercially available tools and techniques for its design, maintenance and documentation;

(iv) Transfer of data to a data centre must be made as easy as possible, with data being accepted in the scientists own format;

(v) Data validation must be given a high priority and carried out as data are loaded. Validation requires the full participation of the scientists who collected the data. Biological data require special skills to validate;

(vi) Full supporting documentation (meta data) must be supplied with the data;

(vii) There should be no restrictions on access to data;

(viii) A data centre requires a clearly defined management structure with allocated roles and responsibilities.

Ultimately, the scientific community is responsible for ensuring that their requirements are met, that standards are adhered to and that the overall management of the data centre is being carried out in accordance with agreed plans.

Conclusions

The BIOMASS programme was innovative and revolutionary, both in how it carried out co-operative scientific research and also in how it managed the data collected. With the benefit of hindsight, valuable lessons have been learned from the running of the BIOMASS Data Centre for the management of data from a large scale, multi-national, co-operative programme. These lessons should be taken into consideration by future programmes. The reinventing of wheels can be expensive and mistakes can be difficult to correct.

Review of the Bay of Bengal Oceanography

M.P. Tapaswi, NIO, Goa, India

The Aquatic Sciences and Fisheries Abstracts (ASFA) database on compact disk was used to review the Bay of Bengal Oceanography. Five-year data (1988-1992) were searched from January 1988 - June 1994. Among the Indian Ocean studies, the Bay of Bengal ranked second - next to the Arabian Sea. It constituted nearly 22% of the total Indian Ocean literature. Of the Bay of Bengal-bordering countries, India alone contributed about 76% of the literature, whereas Thailand (5.14%), Bangladesh (2.78%) and Sri Lanka (1.34%) ranked second, third and fourth position, respectively. Contributions from Myanmar were not noticed. All other countries not bordering the Bay contributed to the tune of 14%. An increasing trend was noticed over the period by all countries except Bangladesh.

The trend analysis showed that the scientists preferred to publish in Indian Journals and Monographs. Around 13% of the Indian contributions on the Bay of Bengal were published in foreign sources, whereas 17% of foreign contributions were in Indian sources.

Fisheries was considered to be the area of most interest. Ecology and Biology among the living resources and Physical/Chemical and Geological/Geophysical Oceanography among non-living resources ranked next in order in Indian publications. An increasing trend is noticed in a number of references in non-living resources over a period.

Possible reasons for a large gap between Indian and other countries literature on this database were checked. Large research and development set up with various programmes and projects in India were thought to be one of the important reasons. Besides, it was also thought that the literature from other countries may not be available for input to this database. An urgent need for the development of input centres (either collaborating or co-ordinating) in these countries was highlighted. Considering the information flow in a cycle, the concept of a regional information exchange network was put forward. The activities of a regional information exchange and external information supply were considered to be of prime importance in the region. Successful efforts in some other regions, except the northern Indian Ocean in this direction, were pointed out.

French Cruises in the Indian Ocean from 1980 until 1994

A. Poisson, Paris, France

More than 100 cruises sponsored by the 3 main oceanographic institutes of France (ORSTOM, IFREMER and IFRTP) have been undertaken in the Indian Ocean since 1980. Scientists from ORSTOM used two ships (*Coriolis* and *Alis*) in Indonesia and the Central Western Pacific zones, and were interested with Geophysics and Halientic studies. Other geological and geophysical cruises were done using the IFREMER ships - *Jean-Charcot*,

Noroit and *L'Atalante*, but it is on board the *Marion-Dufresne*, the supplier ship of the French Sub-Antarctic Islands (Crozet, Kerguelen, Amsterdam) that main geophysical studies in the northern part and physical, chemical, biological and geological studies in the southern part of the western Indian Ocean have been made. Geophysicists were interested to study the geological and geophysical zones of the central Indian ridge and to understand the evolution of the northern basins and the Mozambique Channel.

In the framework of SINODE programme, an XBT section between Cape Guardafui and La Reunion Island was regularly performed in order to study seasonal variability of the equatorial current system due to monsoon influence. Physicists were also interested to understand the oceanic circulation through the Indonesian Archipelago and estimate the corresponding volumes of heat transport. This was implemented by JADE, a joint French-Indonesian programme. Another programme related to JADE was implemented as a component studies of CO_2 transfer from the region to the atmosphere. Most of the biological programmes were performed jointly with physical and chemical programmes in the Southern Ocean. The aim of these programmes was to study the krill and its environment (SIBEX, ANTIPROD) and the carbon, silicon and nitrogen cycles (ANTARES/JGOFS).

Several programmes were taken up in the Indian sector of the Southern Ocean to reconstruct the climate history and the oceanic circulation during the last hundreds of thousands of years, using $^{18}0/^{16}0$ and $^{13}C/^{12}C$ ratios in the calcite of foraminifera and Si in the diatoms. The same scientific teams as those involved in the JADE programme have planned a 3-year programme (INDIGO) for all the Western Indian Ocean, using several tracers to study the general circulation in this region by reoccupying several GEOSECS stations. This programme is now continuing in the Southern Ocean. France has the responsibility to implement two WOCE sections in the western zone of the Indian sector of the Southern Ocean.

One station near the Kerguelen Archipelago (KERFIC/ANTARFIX) was occupied monthly for 4 years to study the temporal variation of the hydrological structure and the influence of various parameters on the variation of CO_2 concentration in surface water. Underway measurements of the CO_2 concentration in surface water (Minerve) together with related parameters are performed in the Indian Ocean since 1982, to estimate the flux of CO_2 between the Indian Ocean waters and the atmosphere.

It is in physical oceanography and carbon chemistry that the most data were collected during this period. Amongst the most important results in hydrography are certainly the quantification and the location of the mass flux between the Pacific and the Indian Ocean through the Indonesian Straits: the core of the flux (estimated at 13 SV) is close to the Indonesian coast and is in the upper layer of water. The data of the SINODE programme provide an opportunity to study seasonal variations of the equatorial current system and up-welling characteristics along the Somali coast and thus help to develop a very realistic model of this system.

All the CO_2 data collected on board the *Marion-Dufresne* show the great spatio-temporal variability of pCO_2 in surface water; the development of a combined model taking into account processes which influence the CO_2 concentration in surface water has been implemented. This model was applied to a 2^o x 2^o grid using measured pCO_2 and climatological data all over the Indian Ocean Basin in order to obtain a continuous and monthly field of pCO_2. This is necessary for obtaining estimations of the mean air-sea flux of CO_2 at the Indian Ocean basin scale.

Biological Processes in the Indian Ocean

A.H. Parulekar, NIO, Goa, India

A major problem in evaluating and quantifying the biological processes in the ocean, is the inability to understand and predict variability in space and time. So far, the mechanisms responsible for such variability remain less understood. As many marine species, directly or indirectly comprise the food supply and are extremely sensitive to effects and impacts of environmental and man-made changes, the cause and predictability of variability in biological processes are both of societal and scientific concern.

Most practiced protocol to study the biological processes is through studies on different link and/or trophic levels of the marine food chain. As elsewhere, in the Indian Ocean too, quite a substantial information is available on an "*ecosystem-biota*" basis for primary, secondary, benthic and tertiary production. Estimates for primary

production vary from 3-6.6 x 9 billion tonnes of carbon per year. Zooplankton biomass ranges from 0.52 x 10 to 0.58 billion tonnes/year with secondary production projected to be 69.3 million tonnes of carbon per year. While the average benthic biomass varies from 20.4 gm $^{-2}$ in shelf to 3.2 gm^{-2} along a slope to 1.6 gm^{-2} in abyssal plain, the production is estimated to be 58 million tonnes of carbon per year. In case of microbial production, efforts and methods, so far employed, are too inadequate to generate any reliable information. Fishery potential estimates have a low of 10.2 million tonnes/year and a high of 45 million tonnes/year, as against the present yield of 4.7 million tonnes/year.

Some of the inference and the stumbling blocks are:

(i) Evidently there is a close coupling of physical processes and biological production mechanisms in the coastal and neritic waters;

(ii) As mechanism of regeneration of nutrients and its availability of euphotic region still remains far from being explained, it is imperative to differentiate between recurring and new production;

(iii) Better insight into the dynamics of transport of high coastal production to subsurface water is a prerequisite;

(iv) Magnitude of secondary production; rates of grazing and predation; faecal pellet production and its fate/utilization, poses imminent information gaps;

(v) Lack of information about the role of microbes in the formation of acute oxygen depletion of subsurface waters, is a serious handicap in understanding and quantifying the biological processes in the Indian Ocean;

(vi) Inadequacy in using standard and well-accepted methodologies for production estimates, has generated incomparable, and at times, unrealistic projections about potential and sustainable marine living resources.

Some Aspects of Carbon and Nitrogen Cycling in the Northern Indian Ocean

S.W.A. Naqvi, NIO, Goa, India

The northern Indian Ocean is a region of unusual transformations within the coupled carbon-nitrogen system and consequently it makes important contributions to global bio-geochemical cycles that are far in excess of what is expected from its size. A pronounced depletion of dissolved oxygen occurs within a large body of intermediate waters in the region, but the sub-surface oxygen concentrations do not show a direct correlation with the productivity of the overlying surface waters. Enzymatic measurements involving the activity of the respiratory electron transport system (ETS) indicate much higher respiration rates in the Arabian Sea as compared to the Bay of Bengal, in conflict with the sediment trap data which show higher sinking fluxes of the particulate organic carbon. This may result from the incorporation of organic matter into the rapidly-sinking particulate aggregates favoured by the massive inputs of lothogenic matter into the Bay. This seems to prevent the development of reducing conditions in the northeastern Indian Ocean. In the northwestern Indian Ocean, on the other hand, the high respiration rates lead to widespread denitrification at intermediate depths.

A decoupling of denitrification from primary production, unique of this region, is revealed by nitrite, ETS activity and bacterial production data. Results of both enzymatic and microbiological investigations show that the sinking flux of carbon cannot support the subsurface carbon demand, indicating a major role of organic carbon other than that sinking from the surface layers in supporting denitrification. Although an intermediate nepheloid layer is found to be associated with denitrification, it seems unlikely that the excess carbon comes with particles re-suspended along the continental margins and transported quasi-horizontally into the ocean interior. Instead, the particle maximum may be caused by a proliferation of denitrifying bacteria with the dissolved organic matter as their major nutrient.

The Arabian Sea serves as a significant source of greenhouse gases such as carbon dioxide, nitrous oxide and methane to the atmosphere. The fluxes of these gases from the Bay of Bengal are considerably smaller due to

weak up-welling and strong stratification. Due to the prevalence of oxygen deficient conditions, extremely rapid turnover of nitrous oxide occurs in the northern Indian Ocean.

4. NATIONAL REPORTS

AUSTRALIA

The Australian Oceanographic Data Centre (AODC) was formed in 1964 and in 1965 established a relationship with the IOC. The AODC presently has 12 people comprising 3 sections which are:

(i) Data Management Group - responsible for the acquisition of data from national and international sources, data quality and database integrity. They also provide digital data to clients on request.

(ii) Products and Services - provide hard copy information reports on ocean areas on request.

(iii) Information Technology Group - responsible for system development, research into computing technology and project specification.

The AODC operates a specifically developed computer system that incorporates a commercial Geographic Information System (GIS) software package which uses the ORACLE Relational Database Management System (RDBMS). The system has been optimized to manage oceanographic data, providing data management, analysis and visualization capabilities within a single package. The system is commercially available and is now being used in Malaysia within their Designated National Agency.

The AODC is presently managing almost 1,000,000 observations within the database system. Many megabytes of additional data are also held on CD-ROMs including TOGA data, bathymetry, etc.

Marine Science in Australia

The Head of Marine Agencies (HOMA) comprises some 14 agencies involved in national scale marine science. State and university groups are not co-ordinated through HOMA. Earlier this year HOMA created a Data Management Group. This group is now advised by the Technical Advisory Group on oceanographic data management. A recent meeting of the Technical Group defined a range of parameters that should be managed in the national interest. The parameters were allocated to specific agencies with an operational or research interest in those particular data types. While the AODC plays a co-ordinating role some data types are the responsibility of other agencies with relevant expertise.

The Technical Group also has made a number of recommendations including:

(i) The importance of oceanographic data archaeology and rescue was recognized and all HOMA members encouraged to undertake appropriate steps within their own agencies.

(ii) The importance of developing a comprehensive national oceanographic data inventory was stressed. Funding is being made to undertake the development of this inventory which will be made available in hard copy form and on Internet via the AODC'S World Wide Web Mosaic Server.

(iii) The importance of monitoring data from the moment of collection was noted. It was agreed that the use of Cruise Summary Reports would be encouraged by each agency. Software provided by the International Council for the Exploration of the Seas (ICES) is being used for this purpose and is being circulated by AODC.

National Data Inventory

A pilot project is now underway in the State of Tasmania to collect data using a form developed by AODC. The suitability of the survey technique and the content of the form will be reviewed on completion of the pilot project. For the description of ocean data holdings in different national institutions of Australia, see the Summary Report of GODAR-II Workshop, published in 1994, in the IOC Workshop Report Series N$^{o.}$ 100.

Summary

(i) Australia recognizes the importance of GODAR and the major contribution it is making to global oceanographic activities. Australia fully supports this very successful project.

(ii) Major efforts are underway to develop a national oceanographic data inventory that will assist in identifying data previously unavailable nationally and internationally.

(iii) The HOMA Data Management Group is improving the co-ordination of data management in Australia which will assist in improving Australia's contribution to IOC programmes such as IODE.

FRANCE

General

SISMER - the French NODC is a service of IFREMER for the National Scientific Community at Nantes and Brest. While the SISMER missions are: 1) to design and operate scientific information systems and databases in the marine domain; 2) to set the standards of quality to be respected for data banking; 3) to maintain an inventory of existing marine datasets in France; 4) to represent IFREMER for the scientific data/management; and 5) to provide training in its field of competence. The overall objectives include: 1) to compile time-series data and the associated meta-data including methodology and formats; 2) to insure their safeguard, quality and accessibility; 3) to assist the preparation of new field programmes; and 4) to facilitate the access to foreign data sets for the national community.

Banking Requirements

Cover: heterogeneous data types, underway records, vertical profiles, etc., in varied disciplines (fisheries, biology, geophysics, marine physics and chemistry) and presented in varied media (computer disks, books, videos, etc.); control of data quality and easy but controlled access to data files. To ensure data quality, SISMER undertakes upstream data validation and standard control according to IOC recommendations *viz.* computerized automatic and visual manual control and flagging. The centre also provides free use of catalogues.

Present Activities

The important activities of the centre are: to design software for scientific data management; 2) to assist the french scientific teams in data management; 3) to archive data; and 4) to answer data requests.

Facilities

The following hardware and software are available in the centre:

(i) SUN/UNIX workstations;
(ii) DOS/WINDOWS 3.1 PC;
(iii) Relational Database Software (ORACLE);
(iv) Fast network link - National RENATOR and International Internet.

The centre has achieved *inter alia* the following tasks in the database development:

(i) TOGA/WOCE upper layer thermal dataset - This contains worldwide temperature data (0-1000m), about 250000 profiles (in real-time and delayed mode);

(ii) SISMER SERVER - This is an information activity using relational database and a tool for data management. Included in this are: (a) information on catalogues, cruises, chief scientists, laboratories, instruments, etc.; (b) access to data files with user-friendly interfaces; (c) software library, reformatting, plotting, specific processing; and (d) data management which includes data access control, request follow-up and statistics.

Data Management Programmes

The French NODC Centre operates the following data banks/bases: French sea cruises inventory; National monitoring network for seawater quality databases (RNO); National Geophysical Data Bank; National Physical and Chemical Data Bank; European MEDATLAS Hydrographic Data Bank; European EDMED Inventory of Marine Datasets for France and the International TOGA/WOCE Centre of Sub-surface Temperature Data.

The centre holds, at present, the following data: 3,600 sea cruises reports (extended ROSCOP); 8,000 CTD profiles (115 cruises); 789 bottle cruises; 1,200 current meter time-series (106 experiments); 235,000 XBT profiles (TOGA/WOCE Centre); 300,000 coastal stations of the RNO coastal network; geophysical data collected underway on board the *Jean Charcot* and *Atlante* research vessels and data products from other data centres: WDCs and RNODCs.

In 1993 alone, 96 data requests were received and data supplied. The discipline-wise breakup is as follows:

(i) Physical oceanography data (excluding XBTs) - 24;
(ii) XBTs - 20;
(iii) Geophysical data - 41; and
(iv) Sea cruises and miscellaneous information - 11.

French Cruises in Indian Ocean

Since 1952, 190 cruises to the Indian Ocean have been reported covering all disciplines of oceanography. The area-wise coverage is as below :

118 in the open Indian Ocean;
37 in the Mozambique Channel;
12 in the Oman Sea;
12 in the Indonesian and the Singapore Straits; and
11 in the Red Sea and Gulf of Aden.

In addition to these, since 1980, major oceanographic projects like JADE, INDIGO, SINODE, CORINDON and the geophysical cruise on board the RV *Marion Dufrense* have been undertaken.

As a result, the following information on historical datasets for the Indian Ocean is available in the French NODC: reports of 190 sea cruises; 7 CTD cruises (623 profiles in the open Indian Ocean and 24 in the Indonesian Straits); 29 bottle cruises; 5 current meter time-series and one thermistor time-series; 42,166 upper temperature profiles from TOGA/WOCE Centre and 10 geophysical cruises (multibeam bathymetry, gravity, magnetism) collected underway on board the R/Vs *Jean Charcot* and *Atlante*.

The data from other major oceanographic projects are being analyzed by the scientific laboratories and will be archived in the NODC.

INDIA

The concept of oceanographic data centres was included in the plans for the NIO since its inception in 1966. The data processing was first carried out manually and later with desk calculators, IBM accounting machines and hiring of computer time. The usage of computer in the data centre itself came into operation in 1979 and RDBMS usage came in 1992.

The collection of oceanographic data is being done by several ships of many organizations. These includes the NIO's R.V. *Gaveshani*, DOD's *Sagar Kanya, Sagar Sampada*, GSI's R.V. *Samudra Manthan* and two coastal research vessels. In addition to these main vessels, there are others of ONGC, Navy, Survey of India, permanent stations, IMD, FSI, universities, the Merchant Navy, etc.

Objectives

The INODC of NIO, Goa, is a national facility for the oceanographic data and information management. The main objective of the centre is to acquire oceanographic data from various sources including IODE centres, NODCs, RNODCs and WDCs, and to act as a national focal point for the oceanographic data of the Indian Ocean. INODC ensures that the user gets good quality and accurate data which can generate useful information and to enhance scientific knowledge of the oceans for their exploitation.

The Government of India have initiated a major programme under the title "*National Oceanographic Information System*" under which the INODC is the largest and the only multi-disciplinary centre. INODC is also one of the 5 centres working on the Marine Remote-Sensing Information System (MARSIS) that includes management of remote-sensing data, coastal zone information system and identification of Potential Fisheries Zones along the Indian coast.

Quantum of Data Holding

INODC is holding the ocean data pertaining to Indian Ocean which includes Gulf of Oman, Persian Gulf, Laccadive Sea, Andaman Sea, Mayanmar Sea, Mozambique Channel, Malacca and Singapore Straits, Arabian Sea, Bay of Bengal, Gulf of Aden, Red Sea and Gulf of Aquba. The quantum and type of data available at INODC is as follows:

DATA HOLDINGS

A. DATABASE IN INGRES RDBMS			
a. Inventory	**No. Cr.**	**No. Stn.**	**No. Rec.**
a1. Station Inventory Information	306	12,173	12,173
a2. Time-Series Inventory Information	184	2,616	3,516
a3. Geological Sample Inventory Information	19	1,060	1,060
b. Physical Oceanographic Data	**No. Cr.**	**No. Stn.**	**No. Rec.**
b1. CTD	30	1,130	213,548
b2. MBT	50	1,612	90,904
b3. XBT	18	564	38,000
b4. Nansen Cast	96	2,808	35,970
b5. Waves			1,431
b6. SST			4,922
b7. SST Satellite (weekly avg: since Dec. '91)			1,079
c. Meteorological Data	**No. Cr.**	**No. Stn.**	**No. Rec.**
c1. Sea-surface Met.			3,312
d. Chemical Data (Water)	**No. Cr.**	**No. Stn.**	**No. Rec.**
d1. Oxygen	96	2,266	24,219
d2. Phosphate	87	2,161	23,242
d3. Silicate	87	2,161	23,230
d4. Nitrate	87	2,161	23,240
d5. Nitrite	87	2,161	23,245
d6. Ammonia	87	2,160	23,241
d7. Alkalinity	47	772	3,560
e. Biological Data	**No. Cr.**	**No. Stn.**	**No. Rec.**
e1. Primary Production	47	772	3,560
e2. Chlorophyll a	60	1,043	4,376
e3. Pigments (other)	31	383	1,843
e4. Zooplankton Biomass	68	1,616	2,383
e5. Zoobenthos Biomass	46	918	1,257
f. Geological Data	**No. Cr.**	**No. Stn.**	**No. Rec.**
f1. Geochemistry of Sediments	24	730	730

f2. Particle Flux of 20 Foraminifera (sedimentary traps)		6	
g. Geophysical Data	**No. Cr.**	**No. Stn.**	**No. Rec.**
g1. Marine Bathymetry, Magnetics & Gravity	over 1,000/000 line km		117,739

B. DATA ON CD-ROMs	
b1. Global Temperature & Salinity (2 Nos)	1,200 MB
b2. TOGA Dataset on Temperature, Salinity & Surface Meteorology (7 Nos)	4,200 MB
b3. Global Stations Time-Series Profiles (1 No)	500 MB
b4. Global Geophysical Dataset (GEODAS) on Bathymetry, Magnetics, Gravity & Seismic (2 Nos)	4,000 MB
b5. Global Relief Dataset (1 No)	600 MB
b6. Digital Atlas (1 No)	600 MB
b7. First WCRP SRB on Short Wave Radiation (1 No)	600 MB
C. DATA ON HARD COPIES	
c1. International Indian Ocean Expedition (1969-65) data on physical, chemical and biological parameters	10,000
c2. INS Darshak Expedition (1973-75) data on chemical & biological parameters	241
D. DATA FROM INTERNATIONAL PROGRAMMES	
d1. Indo-USSR Monsoon Study	600
d2. Indo-German Programme in Marine Sciences (sediment traps)	10 (time-series)
d3. JGOFS Programme	45
d4. COADS dataset surface meteorological data from NCAR, USA	1,428 MB

Oceanographic Data Organization

The INODC has designed, discipline-wise and parameter-wise, data formats for acquisition. The Centre recommends sending data in fully processed form, on magnetic media and in prescribed formats.

For the purpose of management, oceanographic data is classified as:

1. Station data : From a stationary research ship/platform
2. Underway data : From a moving ship (geophysical data)
3. Time-series data : From moored and drifting buoys
4. Satellite data : Remote-sensing data

Data Treatment

The data submitted to INODC is reviewed to ensure that it is accurately described to characterize the data type and to determine whether it is suitable for processing and conversion into INODC formats. Analog charts are screened for obvious errors or omissions and then digitized for computer storage.

The Data Centre at present, does not have an absolute check on the data accuracy. However, certain methods are employed to point out the coding errors and the suspected data. The centre has developed a quality control method for MBT data which works at low levels at present. The suspected or erroneous data are flagged and some data are even omitted if necessary. The datasets are assigned INODC reference numbers that are recorded in an inventory database as an index key. INODC identifies oceanographic information at 4 levels:

I. Inventory Level Information;
II. Parameter Level Information;
III. Documentation Level Information;
IV. Actual Numerical Data.

I. Inventory Level Information

The inventory level information is further classified into the following 3 types of information:

I.1 Station Inventory Level Information

The information includes geographic location of the stations, cruise details, INODC reference numbers as a key field. It also includes the date, time, originator's reference numbers, depth to bottom, and number of parameters observed. At present it contains the information from about 306 cruises and 12,172 stations since 1976 to date.

I.2 Time-Series Inventory Level Information

The common time-series inventory level database contains the information on ship, station, cruises, date, time, observational time interval, latitudes, longitudes, unit, mooring type, INODC reference number and parameter's name. This database contains time-series measurements at 3,516 stations covered in 140 cruises from 1976 to 1993 on mainly on waves, currents and meteorological parameters. Two reports on time-series station inventory level have been published by the centre as a catalogue information for the end users.

I.3 Geophysical Fixes Inventory Level Information

The purpose of computerization of the geophysical inventory data is to make available basic information related to geophysical coverage as part of the national programme. This inventory level database contains the information for 25,540 line km. bathymetry, 45,000 line km. magnetics, 19,068 line km. seismic and 5,041 line km. for side scan sonar covered by 22 cruises. It also contains the information of about 25,000 line km. navigational fixes.

II. Parameter Level Information

The parameter level database contains information on the parameters observed at each station and the field is filled with ROSCOP (Report on Samples/Observations collected during Oceanographic Programme) codes. Each record of the parameter has the index key field of INODC reference number. All the 3 inventories *viz.* station, time-series and geophysical fixes, have the ROSCOP-based codes as a parameter level information.

III. Documentation Information

This database has been designed to have cruise-wise or station-wise instruments and calibration details, and the sample analysis method used to determine the particular parameter. This database will also be having an INODC reference number to link these information with inventory level and data level information.

IV. Actual Numerical Data

This database contains information at two levels which is the actual database for all the oceanographic and marine parameters. This database is divided into 4 categories *viz.* station, time-series, remote-sensing and geophysical databases. Station and time-series databases are multi-disciplinary in nature whereas the geophysical database contains information about bathymetry, magnetics and gravimetry, and remote-sensing database contains information about SST.

Database Management Systems

The Data Centre has developed the following systems and sub-systems for the management of various types of data:

(i) Oceanographic Station Inventory Information System (SIIS);
(ii) Integrated File System (IFS) for numerical data storage;
(iii) Geophysical Data Management System (GPDMS);
(iv) Oceanographic Data Management using INGRES RDBMS;
(v) Biological Data and Information Management System (BIODIMS).

Software Development for Data Processing

The following software programmes have been developed for the processing of oceanographic data on the AViiON-4000 computer system.

A. In INGRES (RDBMS)

(i) Unix shell script programme for transferring data from NORSK data spooler tape to the Unix directory;

(ii) Unix shell programmes (DD.Sh and CD.Sh). This script enables the user to retrieve/copy data from spooler tape and compact disc (CD-ROM);

(iii) Twelve VIFRED forms have been developed using various modules of INGRES (RDBMS) for editing, updating and easy retrieval of data;

(iv) Five report writing programmes have been developed using various modules of INGRES report writer for creating user oriented reports.

B. Menu-Based Data Retrieval System

Menu-based data retrieval system using 4GL and Ingres data tables has been developed. Using this system, any user can retrieve the data as per requirement without advance knowledge of computer software.

C. C-Shell Programmes

Seven programmes in C-shell have been developed for data analysis and treatment.

D. Coastal Zone Information System

The development of the Coastal Zone Information System (CZIS) has been initiated. Various parameters are recognized and structure development is in progress. This system will be developed using GIS software.

Regional Role

The INODC assists in developing and enlarging the country's competence in marine sciences and has a mandate to promote good relations with neighbouring countries, through participation in regional projects and by becoming a nodal point in an international network for the exchange of data and information. The Indian Ocean region has 27 countries with 4 National Data Centres and one Designated National Agency. In some countries marine sciences have just started, therefore the Indian National Oceanographic Data Centre can help them if requested. In the countries bordering the Indian Ocean, considerable data have been collected and are available in various forms which are not accessible to the scientific community. The INODC would like to take the initiative under the GODAR project to rescue and archive these data. The task can be accomplished with the co-operation of IOC, national institutions in the region and IODE data centres.

International Involvements

The NIO is actively participating in various international projects which includes JGOFS, TOGA, WOCE, IGBP, Climate Project, etc. Analyzed data, generated from these projects, are being received by the Data Centre from time to time. The Data Centre is exchanging and also receiving oceanographic data from WDC-A, WDC-B, US NODC, NGDC, JODC, UK-NODC, etc.

Oceanographic Data Products

The following products have so far been brought out for user's convenience:

Inventory reports

Fifteen inventories (stations and cruises) have been published. One inventory report pertains to 13 geophysical cruises and 6,480 fixes of R.V. *Gaveshani* for the years 1983 to 1988.

Data reports

Twenty-two data reports have been prepared from data collected on board R.V. *Gaveshani* and O.R.V. *Sagar Kanya* and others. The data reports are mainly on the following datasets:

(i) Mechanical Bathythermograph Data;
(ii) Surface Meteorological Data;
(iii) Nansen Cast Data;
(iv) Chemical Data;
(v) Zooplankton Biomass Data;
(vi) Geochemistry of Sediments - Data;
(vii) Sea-Surface Temperature Data;
(viii) Wind Data;
(ix) Geophysical Data.

Oceanographic Atlas

Six oceanographic atlases have been prepared. Oceanographic Atlas of EEZ of India incorporates physical, chemical and biological data collected during 1976-1980 and shows the general annual distribution at different depths. The atlas of Mechanical Bathythermograph data gives composite plots of seasonal variation of temperature profiles drawn against depth, in each square degree grid. The Geophysical Atlas of the eastern Arabian Sea displays Bathymetry, Magnetics and Gravity data as maps, anomaly maps, profiles and 3-d sea

bottom topography plots. The zooplankton atlas of the northern Indian Ocean gives a comprehensive picture of zooplankton biomass in the surface and water column, the seasonal distribution based on day and night samples and latitudinal and longitudinal variability both in neritic and oceanic waters. The Atlas of the Indian Ocean surface temperature contains the seasonal and monthly SST charts for the Indian Ocean. Chlorophyll a atlas for the northern Indian Ocean includes the distribution of chlorophyll a at 8 standard depths and 4 water columns with annual and seasonal variation. This has recently been prepared using facilities at WDC-A.

Technical Reports

Four technical reports have been prepared for the end users. These reports pertain to oceanographic tables, EEZ data, inventory information system and geophysical databases.

Research Papers

The scientific staff of INODC have published 50 papers in national and international journals in the field of oceanographic and marine sciences since 1976. Also, 14 papers were presented at the national and international conferences.

SST Database at the National Remote-Sensing Agency

The National Remote Sensing Agency of Space Department has initiated and stored SST database for the northern Indian Ocean since February 1991 except for monsoon (June-September) period. Other AVHRR data available are: high resolution time composited (1.1 sq. km) image data; $15' \times 15'$ daily grid averages generated for images; and 1 x 1 day weekly composited averages for users. NRSA also have ships and drifting buoys data collected by other agencies. NRSA has also acquired the SST atlas from the Meteorological Office, UK.

Archival of Marine Data at India Meteorological Department[1]

The India Meteorological Department (IMD) is responsible for collecting, keying, processing and archival of surface marine data collected over Indian Ocean under its area of responsibility north of latitude 15°S and longitude 20°E to 100°E.

The observations are recorded in the standard ship logs by the ships registered as Volunteer Observing Fleet crisscrossing the Indian Ocean. The Indian Volunteer Observing Fleet logs are received by the Marine Climatological Division at Pune where the logs (marine data) are scrutinized manually for all the elements like pressure, dry bulb temperature, dew point temperature, sea-surface temperature, wind, wave, swells, wind speed/direction, etc., as per the ship code and guidelines provided by World Meteorological Organization. After scrutiny, the data are keyed in on floppy disks and sent to the National Data Centre for electronic processing. While processing the marine data, several checks are made *viz.* sequence, multi-punch, duplicate, missing data, invalid character checks, etc. After the data are processed, some quality control checks for different elements as per the guidelines provided by WMO are done to clean the data. After correcting the data, a master dataset is created for permanent archival.

The marine data is archived on hard disk and magnetic tapes available with a very fast and modern electronic computer system VAX-4000/300 (Dual system) recently installed at NDC, Pune. Data from 1961 to 1981 are in IMMPC format (80 bytes per rec; 50 recs/block) and from 1982 marine data are in IMMT format (124 bytes/rec; 50 recs/block) approved by WMO.

[1] This report was presented by Dr. S. Dixit, Indian Meteorological Dept., Pune

The marine data availability with NDC is as follows:

Period	Types of Data	Remarks
1961-1988	MCSS[2]	IVOF and VOF
1989-1992	MCSS	Only VOF

There are approximately 215 ships registered under IVOF. Marine data observed by VOF ships over our area of responsibility and received from other responsible Member countries are also integrated with the data received from IVOF ships. The IMD publishes Annual Marine Climatological Summaries containing monthly means, frequency tables and annual means. Annual summaries from 1961 to 1969 have been published.

The IMD, in exchange, is supplying marine data to other responsible Member countries for their areas of responsibility. The marine data archived at NDC is supplied to users on request against payment on magnetic tapes, floppy diskettes, cartridge tapes or in printout forms as desired.

IRAN, ISLAMIC REPUBLIC OF

Background

In reference to Resolution N$^{o.}$ 127 submitted by the Islamic Republic of Iran and adopted by the General Conference of UNESCO at its 26th Session, an IOC-UNESCO mission visited the Islamic Republic of Iran in April 1992. This mission formulated a number of recommendations, two of those were: the need to establish a National Centre for Oceanography and to create a National Oceanographic Data Centre.

As a follow-up of the first recommendation, an Iranian National Centre for Oceanography (INCO) was established in 1992 to provide national support for marine studies and for co-ordinating research activities among national marine scientific organizations and administrative bodies.

Regarding the second recommendation on the creation of an NODC in the Islamic Republic of Iran, a feasibility study mission (25 August - 1 September 1994) was arranged which recommended ways and procedures for the establishment of a National Oceanographic Data Centre in the Islamic Republic of Iran (IRINODC). The IRINODC when established will serve as an archival and referral centre in collecting oceanographic data.

Marine National Data Holders

Meteorological Organization of the Islamic Republic of Iran (IRIMO)

The IRIMO was established in 1951. In 1965, it started collecting marine meteorological data along the coastline of the Oman Sea, Persian Gulf and Caspian Sea. Four synoptic marine stations are located at Chah Bahar, Jask, Bushehr Ports and Siri Island in the Persian Gulf and Oman Sea in the South and 5 coastal synoptic stations located in the Caspian Sea in the North. These stations make 8 observations a day since 1951. Measurements on wave, sea temperature, etc. from 8 VOS ships owned by the organization are registered in the log books.

From 1951 to 1992, meteorological data are collected in a digitized form and stored as a 12 million record database on tapes and disks, together with another database with 6 million records of synoptic, climatological and rainfall data and upper-air conditions.

The IRIMO conducts the quality control of collected data according to the WMO standards. Since 1982, data on weather conditions have been received from Meteosat. These data, due to lack of data processing equipment, are not stored.

[2] Marine Climatological Summary Scheme

Department of Environment (DOE)

The Department for Marine Environmental Studies was established in 1991. However, the data bank of the Department includes data collected during 1975-1979, under a joint project with the ex-Soviet Union on "*Prevention of the Caspian Sea from Pollution*"; and in 1977, through participation of Iranian experts on board a German R/V *Atlantis II*.

Different types of marine data at coastal research stations in the Caspian Sea (Sari, Chaloos and Anzali Port) and in the Persian Gulf (Hormoz Island, Bushehr), are being collected since 1991 by DOE experts.

For the period 1991-1993 microbiological, oceanographic and meteorological data from 21 stations along the Caspian Sea have been collected.

During 1989-1994, the following data were collected along the coastline of the Persian Gulf:

(i) Ecological data (benthos) at 21 stations in Khamir Port (from 1989-1991);

(ii) Sedimentological, oceanographic and meteorological data at Siri, Lavan, Khark and Hormoz Island (from 1989-1991);

(iii) Oceanographic data at Kish Island (from 1993-1994 only);

(iv) Sedimentological, ecological and oceanographic data at 12 stations along Bushehr Coastline (from 1993-1994 only).

In 1991, pollution studies were carried out by NOAA in the Persian Gulf and the data are available on TH, TOC, TIC and TC. Ecological, oceanographic and sedimentological data collected by NOAA in 1992 are also included in the data bank.

Iranian Fisheries Industries Centre (Shilat)

In 1990, Shilat was established by the Iranian Fisheries Research and Training Organization (IFRTO). IFRTO conducts research in the waters of the Persian Gulf and Oman Sea in the south and the Caspian Sea in the north, and also in inland waters. The Hydrology Department of IFRTO makes studies on different marine ecosystems, investigates physico-chemical properties of the water as well as marine pollution sources.

No scientific data at present is arranged in a central data bank. Some oceanographic data (physical, chemical and biological) are available in Shilat research facilities for the years 1990-1993. All these data are digitized in a house format.

Long time-series of hydro-biological observations, for almost 50 years are available for the area of Anzali in the Caspian Sea.

Iranian Remote Sensing Centre (IRSC)

This centre was established in 1973 and has a Ground Satellite Receiving Station (GRS) located at Mahdasht. The GRS was designed to collect and process data from LANDSAT 1,2,3 and NOAA satellites. The centre has already obtained and stored 10 years of NOAA AVHRR data. This dataset is archived on magnetic tapes with the resolution of at least one image per day. A one year complete coverage of the Islamic Republic of Iran by LANDSAT (for the year 1991) is also available.

National Cartographic Centre (NCC)

The NCC was established in 1961. In 1979, NCC started hydrographic surveying and mapping projects. NCC has published the following nautical charts:

(i) South Coast P.G. 3001 in the scale of 1:25000
P.G. 3003 in the scale of 1:40000, and

(ii) Caspian Sea C.S. 4001 in the scale of 1:10000
C.S. 4002 in the scale of 1:10000

In 1989, NCC established sea-level stations on the southern coast of the Islamic Republic of Iran. Tidal data are collected from each station and sent to the central office. Data, after correction, are stored on a personal computer and filed on floppy disks. NCC collects some current data (speed and direction) with the help of the Valeport current meters.

KENYA

The Kenyan coastline is 640 km. long. A number of activities take place in the coastal waters: tourism, shipping and fishing being the prominent ones playing a very significant role in the coastal and national economy. The need for ocean data especially with regard to management of ocean-based resources is therefore great. There are a number of government organizations in the country that deal with oceanographic data, acquiring such data primarily or secondarily through national, bilateral or international programmes. The Kenya Marine and Fisheries Research Institute (KMFRI) is mandated by the Science and Technology Act to carry out research on marine fisheries, aquatic biology, chemical and physical oceanography among other things. The Kenya Wildlife Services (KWS) in the Ministry of Tourism and Wildlife is responsible for the protection and management of wildlife, marine national parks and reserves, the Department of Fisheries is responsible for the management of the country's marine fisheries. The Kenya Ports Authority (KPA) ensures that there are proper and adequate facilities to enable ships to dock in the Kenyan Ports. The Department of Meteorology has its weather observatories and voluntary observing ships for the coastal climatic regimes and oceanographic data collection respectively. The Department of Meteorology's observatories in Mombasa and Malindi is vital source of coastal climate data.

Specific projects, some of which are continuing, have contributed substantial quantities of oceanographic data. The Kenya-Belgium Project in Marine Sciences - KBP (Belgium-KMFRI) started in 1985, has participated in mangrove and estuarine ecological studies. The Coastal Marine Systems in Africa - COMARAF (UNESCO) project carried out studies on mangrove ecology. The coastal hydrodynamics project (SAREC-KMFRI) started in 1991, is integral in investigating the hydrodynamics of near-shore and estuarine areas. The programme on sea-level observations is part of the GLOSS network and has tide-gauge stations in Lamu and Mombasa. The STD-3 project on Inter-linkages between the Coastal Ecosystems (EEC-KMFRI) is a regional project presently investigating the nutrient dynamics in the coastal ecosystems. The Coastal Erosion Inventory and Monitoring project is concerned with the worrying threat to the hotel industry and general loss of beach line. Birds as bio-indicators of the environment project started in 1994 and is involved on ecological monitoring work along the Kenyan Coastal area. The KWS has its management authority in the marine parks and reserves. Its research department set up in 1992, collects data used in park management decisions.

A lot of data has been obtained from international programmes. Most of these data are in digital form and already prepared to be circulated to institutions and individuals. The KMFRI is a recipient of such data through the TOGA and GLOSS programme. This is mainly on sea state and covers the following parameters: temperature, sea-level, waves, pigments and salinity. The Department of Fisheries has over the years done resource surveys to determine fish stocks. Apart from the biological resources (trawl surveys) which form the gist of these surveys, a lot of oceanographic data were also gathered (temperature, salinity, density and oxygen content, nutrient). However, data holdings are unavailable for public domain. Oceanographic data collected by VOS are deposited with the meteorology office within the precincts of Kilindini Port.

A number of measures have been initiated towards management of data. The IOCINCWIO-III meeting resolved to initiate a network for oceanographic data exchange in countries of the Western Indian Ocean region. The Regional Dispatch Center of the RECOSCIX-WIO project (IOC-UNESCO) at Mombasa, Kenya was designated to provide the focal point. The first phase has been implemented and concentrates on the IOCINWIO-GLOSS network. The Ocean Data and Information Network in Eastern Africa Project-ODINEA (IOC-UNESCO) seeks to establish a broad-based data exchange programme. This project will seek to provide

access to regional and international networks and data centres and establish databases on sea-level data, sea state data collected in the region (individual scientists, visiting research vessels, international research programmes, voluntary observing ships and ships-of-opportunity) and data collected within the framework of the IOC-SAREC Nutrient and Water Quality project.

One of the requisite inputs in the UNEP-sponsored Regional Seas Programme EAF/5 on coastal resource management is data. KMFRI has been the lead collaborator and focal point for the Kenyan phase of resources and environment database and Atlas. Most of the data were collected from existing sources. The digital database and the Atlas will constitute some of the efforts now being made in management of oceanographic data.

Most of the work going on within the KMFRI fraternity yield quantities of data which end up in the cabinets of individual scientists or project secretariats. This is also true of marine scientists in other organizations and universities in the country. A pilot data identification procedure organized along the same lines as the MEDI Catalogue, has been established.

A well-defined national center for oceanographic data is necessary. Such a center should have a well recognized mandate to look into matters of storage, standards, processing and liaison with other oceanographic institutions. This center should also harmonize data management efforts in individual oceanographic programmes and also be a country focal point for regional and international data programmes.

As already noted, there have been activities in the regional waters dating several years back. There should be a very well focussed effort in data rescue especially with concern for the following groups:

(i) Past R.V. cruises, ships-of-opportunity, voluntary observing ships. Most of this data is now not readily available;

(ii) Rescue data in possession of individual scientists;

(iii) Form an information task force to promote awareness on the benefits of having an NODC, and on available data.

SAUDI ARABIA

Historical Oceanographic Data

(i) Early contributions

First contributions were made by fishermen, merchants and traders in search of new trade routes. Pre-islamic arabs had a good knowledge of wind direction, seasonal weather variations and ocean currents.

The "*Voyage of Sulayman the Merchant*" written by Ibn-Wahab in 851 gives a description of the maritime routes to India and China. The ships from Arabia (Muscat in Oman) covered the one-way route in about 4 months. During this long voyage the pilots described places of fresh water, tides, typhoons and volcanoes.

In 905, Ibn-Shabyar wrote a book "*Agayab-al-Hind*" (Wonders of India) which not only mentions stories of treasure islands but also describes observations at sea and information on nautical matters.

Turkish Admiral Pine Rais (1470-1554), wrote a book on navigation called "*Bahria*" (i.e., Mariner). Turkish navigators depended on Indian Ocean Arabic nautical directions.

Ibn-Majid (1475) and Sulayman Al-Mahri wrote books on astro navigation. They described in detail the latitudinal corrections for positioning at sea. Arabs also developed altitude sailing which is a measure of the distance travelled, calculated from the measurements of the difference in altitude of the Polar star at the beginning and end of a navigational cycle. Ibn-Majid improved a magnetic compass. He attempted to measure

longitudes by the method of lunar distance. He prepared a map of the Indian Ocean. It is presented in his book Mohit (1554). He also discussed monsoon winds.

(ii) Documented Research Cruises

The recorded history of research cruises in the Red Sea dates back to the late 19th Century when the Russian R.V. *Vitiaz* collected hydrographic data in the year 1894, followed by British and American R.V.s H.M.S. *Stork* and *Valdivia* respectively, in the years 1898 and 1900. A list of the research cruises and the nature of the data collected is given in Table 1.

Table 1: Research Cruises in the Red Sea

N°.	Year	Vessel	Nationality	Studies	Results	Remarks
1.	1894	Vitiaz	Russian	Hydrographic	Hydrographic Data	
2.	1898	H.M.S. Stork	British	Hydrographic	Hydrographic Data	
3.	1900	Valdivia	American	Hydrographic	Hydrographic Data	
4.	1901	S.S. Pola	Austrian	Hydrographic	Hydrographic Data	
5.	1923-24	Ammiraglio Magnaghi	Italian	Hydrographic	Hydrographic Data	
6.	1927-28	H.M.S. Ormonda	British	Hydrographic	Hydrographic Data	
7.	1932	R.V. Willebrod Snellius	Dutch	Hydrographic	Hydrographic Data	
8.	1988-94	H.E.M.S. Mababiss	British	Hydrographic	Hydrographic Data	Jointly with Egypt
9.	1937	R.V. Willebrod Snellius	Dutch	Hydrographic	Hydrographic Data	
10.	1909	H.E.M.S. Mababiss	British	Hydrographic	Hydrographic Data	
11.	1940	H.E.M.S. Mababiss	British	Hydrographic	Hydrographic Data	
12.	1948	M.S. Albatross	Swedish	Temperature and Salinity	Trace of brine	The first evidence of higher temperature and salinity of the deep water (Albatross Deep)
13.	1949-50	Commandant Charcot	French			
14.	1950-51	R.R.S. Discovery II	British	Hydrographic	Hydrographic Data	
15.	1957	Norsel	French	Hydrographic	Structure of water masses	
16.	1959	R.V. Atlantis II	American	Hydrographic	Hydrographic Data	The first data on higher than usual salinity in Atlantis II Deep

It is also worth mentioning that data collection by the British voluntary observing scheme of merchant ships started in 1855.

The findings in 1947-1948 of abnormally high-temperature water in the Red Sea by the Swedish R.V. "*Albatross*" later attracted the attention of international geoscientists around the world and led to more research ships from different countries. Some extensive scientific programmes for the exploration of the Red Sea were launched. These resulted in the discovery of several deeps in the central part of the Red Sea containing extensive ore deposits that have motivated preparations for sea floor mining.

In 1974, the Saudi-Sudanese Red Sea Commission (SSRSC) was established for the dual purpose of efficiently retrieving these resources while providing adequate protection of the marine environment. It was in the service of these objectives that several studies were undertaken by SSRSC (Nwwab, 1980, Moammar, 1981 and 1985). The results of such studies are now available with the Directorate-General of Mineral Resources in Saudi Arabia.

Though a good deal of scattered hydrographic and oceanographic data is available for the Red Sea, there is no comprehensive database for the Red Sea until now. These data are with several governmental agencies and scientific institutions. Therefore, these data cannot be used in an efficient manner and these do not serve the ambition of the scientific community.

In 1993, MEPA (Meteorology and Environmental Protection Administration - Jeddah, Saudi Arabia), the meteorological and environmental protection authority in the Kingdom of Saudi Arabia, established a Scientific Information and Documentation Center (SIDC). The main objectives of this center are to facilitate the establishment of a MEPA data bank, data analyses as well as national and international data and information exchange. At the core of the center is distributed computing network for data entry, data archive, analyses and exchange. State-of-the-art tools include a geographic information system (GIS), remote-sensing and image processing facilities and a relational database management system.

Currently, the SIDC in MEPA is developing a National Coastal Zone Management Information System. The purpose of this comprehensive computerized database and analysis system is to support Saudi Arabia's efforts to effectively co-ordinate and mediate ever increasing demands for its terrestrial and marine natural resources especially in coastal environment. Rapidly increasing economical and industrial developments and fast growing urban centres along the Red Sea and the Arabian Gulf require a co-ordinated use of space and natural resources. The basis for decision and recommendations in environmental management are comprehensive and timely information is needed.

In the future, the SIDC in MEPA will provide national and international user groups with comprehensive coastal zone management databases and information.

To effectively co-ordinate, manage and protect environmental as well as economical national and international interests, countries around the Red Sea require a well-established organized information exchange. Being part of PERSGA (Programme for the Environment of the Red Sea and Gulf of Aden - Jeddah, Saudi Arabia), the SIDC in MEPA is able to provide assistance in the creation, compilation, archiving and analysis of relevant information. The technology currently available at the center and anticipated for the future will facilitate comprehensive analysis and access to data and information, both nationally and internationally.

There is an urgent need for implementing the following actions:

(i) to establish a comprehensive data bank for the Red Sea as part of SIDC;
(ii) to make an inventory of existing Red Sea oceanographic data and prepare relevant documents;
(iii) to collect oceanographic data on a continuous basis from different sites in the Red Sea;
(iv) to establish permanent stations which would be used for collection of meteorological and oceanographic data.

The historical hydrographic and oceanographic data when systematically arranged and preserved will help in achieving the numerous scientific objectives without any further need for extensive field surveys, e.g., mapping

of the seasonal variation of temperature, salinity, density and oxygen of the Red Sea. Tunnell (1963) used the sea surface temperature observations made by vessels participating in the British observing voluntary scheme over the period 1855-1943. Approximately 65,000 observations were analyzed and the results are presented in a table with monthly mean temperatures for 2° band of latitude along the length of the Red Sea. A revised version of Tunnell's original table is found in Morcos's paper (1970) and this needs to be updated in view of the more recent oceanographic data available.

The comprehensive data bank and documentation will be helpful in any future oceanographic and marine environmental studies related to the Red Sea, such as developing an integrated Coastal Zone Management Plan.

SOUTH AFRICA[3]

The South African Data Center for Oceanography (SADCO) archives marine data within its target area (the southern hemisphere between 30°W-70°E), and disseminates this data mainly to the organizations providing the financial support for the data centre's existence (they include virtually all the marine scientists of South Africa and Namibia). The data are mainly physical (sea temperature from XBT, CTD, etc., salinity, nutrients) and a large amount of sea-surface observations (from voluntary observing ships).

SADCO is trying all possible avenues to ensure that:

(i) Physical marine data collected by South African organizations are deposited in the data centre. Although these efforts (estimated) are 90% successful, SADCO does not seem to be able to get hold of all the data. The latter can be ascribed to donor "propriety", and to data that cannot be processed due to manpower shortages;

(ii) Other data of relevance to South African organizations are obtained and either accessioned into the database or be made available to the local community. In this case, SADCO scouts for foreign data in the target area and regularly requests data from foreign organizations. Good links are established with the World Data Center 'A' (Washington), and the national ocean data centres of Britain (BODC), Germany (DOD) and France (SISMER).

As SADCO seems to be the only marine data centre of its kind in the South African region, SADCO will play a leading role to ensure that data from the neighbouring countries are deposited and archived in the data centre. This has met with limited success, again because of apparent manpower and financial constraints presently in South Africa.

TANZANIA, UNITED REPUBLIC OF

It is only a few years ago that the Government of the United Republic of Tanzania has given the necessary attention to the importance of Marine Environmental data.

It is now very clear that information (data) is required to guide the planning and implementation of the development, conservation and management activities in the marine environment.

The main question is what data are available? Who collected it? Where is it stored and how can it be retrieved? Two national seminars were organized with the purpose of identifying institutions holding data within the country. The first seminar was organized by the Ministry of Science and Technology in co-operation with the bio-diversity project (United Republic of Tanzania). It was agreed that institutions holding data must send information on the type of data they hold and how can it be accessed to the database in the Ministry of Science and Technology. The second seminar was organized by the Central Bureau of Statistics of Tanzania and the Department of Environment. All sectors of the Government involved in data collection were argued to publish

[3] This report from M. Grundlingh was presented *in absentia*.

their data so that people can know the existence and availability of all data collected. A database for environmental statistics was proposed during the seminar.

At the moment archives are open. However, we are not sure how long it will take to have all the data digitized in an accessible form.

Institutions Holding Oceanographic Data

(i) Ministry of Natural Resources, Tourism and Environment

Tanzania Fisheries Research Institute;
Tanzania Fishing Co-operation;
Zanzibar Fishing Co-operation;
Fisheries Training Institutes;
Fisheries Division (Fisheries Statistics Section, Zanzibar and Dar-es-Salaam);
National Environmental Management Council (NEMC); and
National Meteorological Department.

(ii) Ministry of Science and Technology

Inventory of Tanzania Marine Scientists and their published and unpublished reports;
Workshop and Seminar Reports;
Reports of all government funded projects and database of scientific data holdings.

(iii) University of Dar-es-Salaam

Zoology and Marine Biology Department, Ph.D and M.Sc thesis, Workshop and Seminar Project Reports;
Institute of Marine Sciences (IMS).

Considerable amount of data are held by individual scientists.

In general, there were no systematic and continuous data collection programmes, but only hit and run programmes.

Data on temperature, salinity, oxygen, currents, nutrients, plankton are little and scattered. The absence of a large research vessel in the United Republic of Tanzania has prevented Tanzanian scientist from collecting oceanographic data beyond the territorial waters. Consequently, oceanographic data have been collected by visiting foreign vessels, e.g., *Dr. Fridtjof Nansen* (Norwegian R.V., 1984), *Prof. Matyesev* (Russian R.V., 1978) etc.

Efforts are also going on to establish an Oceanographic Data Centre in the United Republic of Tanzania. However, lack of resources (personnel and funds) is slowing down the process.

Current Efforts to Generate More Oceanographic Data at IMS, Zanzibar

The Institute of Marine Science, Zanzibar is making all efforts to generate more and more data through various programmes and projects. IMS has plans to acquire a research vessel with the help of the Canadian Government. IMS is also linked to an information exchange network in Mombasa.

Recommendations

Developing countries (including the United Republic of Tanzania) must be encouraged and supported in their efforts to collect data and establish oceanographic data centres.

5. SOFTWARE DEMONSTRATION

In the afternoon of 8 December 1995, a demonstration at the Data Centre was arranged by the scientists of INODC for the participants of the workshop. This included the explanation of databases, software under INGRES RDBMS and 4GL and the activities of the Indian NODC. The recently received CD-ROMs for global ocean data set and GEBCO were also read out. The participants were apprised of quantum and nature of data and functional utilities available for processing, archiving, retrieving, presenting and dissemination of data. The organizational structure and menu driven retrieval system were also shown with examples.

Mr. B. Searle from Australia demonstrated the BT datasets and other data from Australia which he brought with him.

The demonstration was well received and appreciated by all.

6. CONCLUSIONS AND RECOMMENDATIONS

The Workshop was arranged at a time when the awareness of countries of the region of the importance of oceanographic data for different scientific and application purposes is increasing and the need for national oceanographic data management infrastructures becomes vital.

The Workshop was considered by all participants as a very successful endeavour, in spite of the fact that due to different reasons, only 7 countries of the region had been able to take part in the meeting.

There are only 4 NODCs and one DNA in the Indian Ocean region which is bordered by more than 20 Member States. The lack of the IODE National Co-ordinators in these countries prevents establishing effective links of communication, information and data flow. Not only the general public but also many decision makers, scientists and even data managers themselves are not aware of the IOC activities, of its IODE programme and the benefits which will accrue through participation in IODE, such as access to large environmental databases.

The Workshop strongly endorsed the proposal to bring to the attention of marine policy makers and the marine scientific community the importance of data archaeology and rescue. The Workshop recognized the high cost of collecting marine data and the inability to go back in time to recollect data that have been lost. The Workshop further recognized the value of historical data in global climate change research activities.

The Workshop stressed the need to co-ordinate and harmonize methods of data collection, exchange and analysis. This work should be started immediately.

Taking all this into account, **the Workshop formulated** the following recommendations:

(i) **The Workshop urged** Member States to consider the establishment of NODCs and the nomination of IODE National Co-ordinators as a priority action in developing national ocean data management infrastructures. In this regard, the requests of Kenya and Saudi Arabia for the establishment of NODCs were especially noted and the decision of the Islamic Republic of Iran to establish an NODC was appreciated. One of the responsibilities of IODE National Co-ordinators will be to increase awareness of decision makers, scientific institutions, individual scientists and the general public of the importance and benefits of IODE. The IOC Secretary was requested to take appropriate action through providing advice and support, and sending study missions on request.

(ii) **The Workshop noted** that much data are in the possession of different national institutions and individual scientists. Information about the volumes and types of data in their possession and their accessibility in many Member States (except Australia) is very scarce. Lack of this type of information does not give an opportunity to prepare a comprehensive and well-documented plan for data rescue operations under the GODAR project for the region.

The Workshop noted the progress made by IOC, the European Council, India and Australia in preparation of marine environmental data inventories. The Workshop also noted that the Directory of Marine Scientists in the Western Indian Ocean region is now available in printed form and computer searchable form. The Workshop acknowledged the importance of these studies and recommended to start the development of national directories of marine institutions and individual scientists and inventories of data holdings on a country-to-country basis. **The Workshop requested** the IOC/UNESCO Regional Offices concerned and the GODAR Project Leader to help Member States of the region in making this survey.

(iii) **The Workshop noted** the implementation of an electronic data and information exchange system (RECOSCIX-WIO) for countries bordering the western Indian Ocean. Noting the value of such a system for exchanging bibliographic information and data, the Workshop recommended the establishment of a similar system to support such functions for the countries bordering the northern part of the Indian Ocean region. It was recommended that all NODCs and DNAs become part of Internet with dedicated data links as soon as possible. Funding for the data links will be included in the proposal by ROSTSCA.

The Workshop noted that UNESCO, through the Regional Office of Science and Technology for South and Central Asia (ROSTSCA), has in fact prepared such a proposal for this area that includes the Islam ic Republic of Iran, Pakistan, India, Sri Lanka, the Maldives, Myanmar and Bangladesh. **The Workshop urged** that Member States indicate to UNDP the great importance of this project through formal letters of support.

(iv) **The Workshop recommended** the UNESCO Regional Offices and the IOC national contacts to make marine policy makers in each country aware of the GODAR project and to request them to provide assistance in its implementation.

The Workshop considered that the success of GODAR in the Indian Ocean region could be improved by the digitization of analog data at a national level. This could be accomplished through the GODAR Project Leader by providing appropriate computing resources to national agencies with an interest in undertaking such an effort. **The Workshop felt** that regionally-based digitization would be beneficial in demonstrating the importance of GODAR to IOC Member States.

The Workshop recommended the increased use of the Cruise Summary Report to ensure that data are identified at a national and international level as soon as possible. The Workshop recognized the need to ensure that in the future, data would not be lost to the international community. The use of the ROSCOP Data Entry and Retrieval software developed by ICES was recommended as an excellent mechanism for this purpose.

(v) **The Workshop strongly recommended** the establishment of an RNODC to support IOC Member States within the Indian Ocean region. It was recognized that an RNODC will play an important role for improving data management and exchange and also provide a focal point for scientists in the region as a source of both data and information.

It was recognized that a commitment to establish an RNODC, requires strong national support through the provision of appropriate resources for the centre to operate effectively within the IODE system. A strong commitment from Member States within the region to support the RNODC through the submission of national data in a timely manner in accordance with IODE guidelines was seen as the only way an Indian Ocean RNODC could function effectively. A primary responsibility of the RNODC would be to facilitate the "free exchange" of all types of data between countries of the region. This RNODC should establish links of co-operation with already existing data centres in the region.

The Workshop acknowledged that the establishment of RNODCs should be in accordance with the IODE procedures documented in IOC Guide N$^{o.}$ 9, Annex II, 1982.

(vi) **The Workshop noted** the request by IODE-XIV for Member States to declassify oceanographic data archived by their respective navies. The Workshop acknowledged actions undertaken by the navies of the

United Kingdom, Russian Federation, the United States, Australia and New Zealand. In particular, the declassification of data from EEZ regions by these navies was noted. **The Workshop recommended** that the IOC Secretary acknowledge by a Circular Letter, the efforts of these countries and distribute information about the status of such declassification to IOC Member States.

The Workshop further encouraged governments within the region to review their data classification policies in an effort to increase the availability of national oceanographic data to support scientific activities.

In order to make IOC Member States of the Indian Ocean region more aware about the declassification of oceanographic data by various navies, **the Workshop recommended** that the Chairman of the IOC Committee on IODE in co-operation with the Director of WDC-A, Oceanography, should inform IOC Member States on available details and the status of declassification of oceanographic data by navies.

(vii) **The Workshop noted** the unique nature of the data collected by the Biomass programme and also the resources provided by the British Antarctic Survey for their final validation, documentation and distribution. **The Workshop recommended** that the British Antarctic Survey and SCAR, in co-operation with the RNODC-SOC, consider publishing the BIOMASS dataset and documentation on CD-ROM.

(viii) **The Workshop noted** the geographical and oceanographic uniqueness of the Red Sea and **recommended** that a GODAR Workshop be convened for this region by IOC and ROSTAS in co-operation with the PERSGA Project.

(ix) **The Workshop recognized** the importance of the GIS project for the area from the Red Sea to Mozambique and of the UNEP project for the Eastern Africa Coastal and Marine Environment Resources Database and Atlas. **The Workshop recommended** that efforts be made by the UNESCO Regional Office in Kenya and the Secretary IOC to improve links with these projects for the benefit of the IODE system and the GODAR project in particular.

(x) **The Workshop recognized** the need, importance and value of training within the region. The plans of IOC and UNESCO to arrange training courses in the region (India, Islamic Republic of Iran, Kenya) were acknowledged with appreciation. **The Workshop felt** that the establishment of NODCs and an RNODC would help to improve training opportunities. **The Workshop urged** UNESCO through regional offices and IOC to increase training both inside and outside the region through new courses and seminars and by providing fellowships for individual experts.

(xi) **The Workshop noted** that the global change research community is developing a programme of regional capacity building in areas such as training and development of computer infrastructure including networks, through the START programme of IGBP, WCRP and HDP. The programme has been successful in attracting substantial funds from the GEF for its work in developing regions.

Aware of its own recommendations to develop a regional network for the countries of the northern Indian Ocean region and on the importance and value of training, **the Workshop recommended** that the Secretary IOC and the Chairman of the IOC Committee on IODE liaise with the Director of START, to see if there are areas of common interest for which joint co-operation and liaison would be of benefit, especially in ensuring that scarce resources are not wasted due to duplication of effort.

ANNEX I

WORKSHOP PROGRAMME

6 December

09:00 - 10:00 **Registration**

10:00 - 10:45 **Official Opening**

10:45 - 12:45 **Lecture 1**
Subject
Regional Programmes of IOC and UNESCO: General Policy and Status of Implementation in the Indian Ocean Region.
Speaker
I. Oliounine, Head, Ocean Services Unit, IOC.
L.A. Mandalia, Programme Specialist in Water Sciences, ROSTA/UNESCO, New Delhi, India.

Lecture 2
Subject
Scientific Results made Possible by the GODAR Project.
Speaker
S. Levitus, Director, WDC-A, Oceanography, GODAR Project Leader, USA.

12:30 - 14:00 Lunch

14:00 - 17:00 **Lecture 3**
Subject
Red Sea Pollution Transport Studies and Need for Oceanographic Data.
Speaker
M.O. Moammar, King Abdulaziz University, Jeddah, Saudi Arabia.

Lecture 4
Subject
General Circulation of the Indian Ocean.
Speaker
N. Bahulayan, National Institute of Oceanography, Goa, India.

19:30 - 22:00 Social Event

7 December

09:30 - 12:30 **Lecture 5**
Subject
Status of the IODE/GODAR Project.
Speaker
S. Levitus, Director, WDC-A, Oceanography, GODAR Project Leader, USA.

Lecture 6
Subject
Indian Participation in International Programmes.
Speaker
B.N. Krishnamurthy, Director, Dept. of Ocean Development, New Delhi, India.

National Report of Australia.
National Report of France.

12:30 - 14:00 Lunch

14:00 - 17:30 **Lecture 7**
Subject
GIS Project for the Area from Red Sea to Mozambique.
Speaker
H. Ong'Anda, Kenyan Marine Fishery and Research Institute, Mombasa, Kenya.

Lecture 8
Subject
The BIOMASS Project.
Speaker
M. Thorley, British Antarctic Survey, Antarctic Environmental Data Centre.

National Report of India.
National Report of the Islamic Republic of Iran.

Lecture 9
Subject
Review of the Bay of Bengal Oceanography.
Speaker
M.P. Tapaswi, National Institute of Oceanography, Goa, India.

17:30 - 20:00 Social Event

8 December

09:30 - 12:30 **Lecture 10**
Subject
French Cruises in the Indian Ocean from 1980 until 1994.
Speaker
A. Poisson, Laboratoire de Physique et Chimie Marines, Université Pierre et Marie Curie, Paris, France.

Lecture 11
Subject
Biological Processes in the Indian Ocean.
Speaker
A.H. Parulekar, Head, Biological Oceanography, National Institute of Oceanography, Goa, India.

National Report of Kenya.
National Report of Saudi Arabia.

12:30 - 14:00 Lunch

14:00 - 17:30 **Lecture 12**
Subject
Some Aspects of Carbon and Nitrogen Cycling in the Northern Indian Ocean.
Speaker
S. Naqvi, National Institute of Oceanography, Goa, India.

National Report of South Africa.
National Report of the United Republic of Tanzania.

Demonstration at Indian NODC.

9 December

9:30 - 12:30 Round Table Discussions: Adoption of the Implementation Plan, Conclusions and Recommendations.

12:30 - 14:00 Lunch

14:00 - 17:30 Round Table Discussions (cont.)

Closure of the Workshop.

ANNEX II

GODAR PROJECT PROPOSAL

Recommendation IODE-XIV.3

DATA ARCHAEOLOGY AND RESCUE PROJECT

The IOC Committee on International Oceanographic Data and Information Exchange,

Noting that historical observations of oceanographic parameters are not repeatable if lost,

Acknowledging that substantial amounts of historical ocean observations are at risk of being lost due to media degradation or neglect,

Recognizing that the international scientific and engineering communities need the most comprehensive oceanographic multi-decadal databases possible for research purposes, particularly for use in studies describing the role of the world ocean as part of the earth's climate system as well as for Global Change research,

Emphasizing that in order to make sound policy decisions national governments and intergovernmental advisory groups need scientific observations of the state of the world ocean and for understanding of the role of world ocean as part of the earth's climate system,

Recommends that:

(i) IOC establish a Global Oceanographic Data Archaeology and Rescue Project under the IOC Committee on IODE as presented in the Annex to this Recommendation subject to the condition that additional funds be made available;

(ii) A project leader be designated by the Secretary IOC in consultation with the Chairman of the IOC Committee on IODE to supervise its implementation;

(iii) IOC invite Member States and international organizations to participate in and support this project, including the possibility of direct funding ear-marked for this purpose within the IOC Trust Fund.

Annex to Recommendation IODE-XIV.3

Introduction

All countries of the world have a concern about climate change because of the global impact of climate variability, whether natural or anthropogenic,

If international agreements are to be implemented due to concern about climate change, the science on which these agreements is based must be international in scope. All data on which these studies are based must therefore be available to the international scientific community without restriction.

Historical oceanographic data is of fundamental importance of scientists studying the role of the ocean as part of the earth's climate system. Regardless of any particular view an individual scientist or nation has on these issues, it is necessary that scientific assessments and national and international actions be based on the most complete environmental databases possible.

Recognizing that oceanography is an observational science and that the world ocean is a major component of the earth's climate system it is suggested that the IOC sponsored activities will result in more complete global

oceanographic databases. These activities should be viewed as an enhancement of existing IODE activities. The new and enhanced oceanographic databases will be available without restriction to the international science community. We call this effort the "*Global Oceanographic Data Archaeology and Rescue Project*" (GODAR). To do the most thorough job possible this project must have a lifetime of 5 to 10 years. Funds to support the activities of this project will be obtained through as many sources independent of IOC as possible, including foundations.

"Data Archaeology" is the term used to describe the process of seeking out, restoring, evaluating, correcting and interpreting historical datasets.

"Rescue" refers to the effort to save data at risk from being lost to the science community.

Physical, chemical and biological oceanographic data as well as surface marine meteorological observations are the specific types of data this project will focus on. These are the data types of greatest concern to IODE and climate research activities. Advances in computer technology both hardware and software (e.g., Relational Database Technology) now allow for the construction of integrated global oceanographic databases that included widely disparate types of oceanographic data from different oceanographic disciplines.

The data gathered as a result of this project will be of particular benefit to developing countries. The international availability of comprehensive global oceanographic datasets represent a policy of both, information sharing, as well as knowledge and technology transfer since the data can be used to study regional environmental oceanographic problems.

Rationale

Many oceanographic data are at risk of being lost to future use because of media degradation, hence the need for a "data rescue" effort in conjunction with the data archaeology effort. Sole copies of manuscript data are easily lost due to environmental damage or catastrophe such as fire. In addition, manuscript data are of minimal use to researchers who require data in digital form with all pertinent meta-data in order to perform the most comprehensive studies possible. It is the international scientific community which must advise national and international bodies on such issues as climate change. Thus, the most complete well-documented database possible must be available to the international community. Data archaeology and rescue activities at WDC-A, Washington; WDC-B, Obninsk; WDC-D, Tianjin; ICES, Denmark; The Japanese Oceanographic Data Center, and other institutions all have identified major oceanographic databases that exist only in manuscript form. Efforts sponsored by the institutions have resulted in digitization of some of these data and further digitization ("data rescue") is planned. For example, the US NODC has located 150,000 MBT profiles in manuscript form and is contracting to have these data digitized. All the above institutions are already closely co-operating on archaeology and rescue activities to avoid duplication of effort and to maximize their resources.

Purpose

To facilitate the creation of global oceanographic databases for use by the international research community for the study of the role of the world ocean as part of the earth's climate system.

Main Emphasis

Specifically the project will emphasize:

(i) Digitization of data now known to exist only in manuscript and/or analog form. This effort will have highest priority of all activities.

(ii) Ensuring that all oceanographic data available for international exchange is archived at two or more international data centers in digital forms.

(iii) Preparing catalogues (inventories) of:

(a) Data now available only in manuscript form;
(b) Data now available only in analog form; and
(c) Digital data not presently available to the international scientific community.

(iv) Making all data accessible on various media including CD-ROMs as well as standard magnetic tape.

These efforts represent implicit acknowledgement of the value of the ICSU-IOC International Oceanographic Data and Exchange (IODE) system but also recognize the need to enhance and expand the existing scope and efforts of this system, as well other international exchange mechanisms such as bilateral agreements. In fact, this International Data Archaeology and Rescue Programme will build on existing data archaeology programmes at WDC-A, WDC-B, and ICES.

The enhanced databases will be made available as ASCII files on CD-ROM disks as this is the technology that represents the least expensive and most efficient means of distribution of large datasets.

The World Data Center-A for Oceanography (WDC-A) volunteers its services for these activities. WDC-A will work with data centers and research institutions around the world to compile the most complete oceanographic databases possible and will arrange for the production and distribution of the resulting databases on CD-ROMs and magnetic tapes.

Proposed Activities

(i) The IOC Secretary in consultation with the Chairman of the Committee on IODE appoint a project leader to direct the project (March 1993) - no funds required.

(ii) A project leader with the assistance, if necessary, of selected experts, will prepare an implementation plan and identify priorities (April 1993) - no funds required.

(iii) A Workshop on GODAR will be arranged in Russia for Eastern Europe countries (May-June 1993) - 20K from IOC RF and 40K from extra budgetary sources.

(iv) IOC will mobilize and provide resources to sponsor series of regional and international meetings on the formation of global oceanographic databases for international distribution as part of GODAR (1994..) funds from IOC RF and extra-budgetary sources.

(v) IOC provide support via its VCP and by using extra-budgetary sources for the delivery of hardware/software required, and by arranging contracts with the staff of data centres to implement specific projects (1993...) funds from extra budgetary sources.

(vi) IOC requests its Member States to declassify as much militarily-restricted oceanographic data as possible for international distribution.

Data Types of Interest

(i) Hydrographic casts including all chemical and biological observations;
(ii) Salinity/Conductivity Temperature-Depth casts;
(iii) Expendable Bathythermograph casts; and
(iv) Mechanical Bathythermograph casts.

ANNEX III

LIST OF PARTICIPANTS

AUSTRALIA

Mr. B. Searle
Head, Australian Oceanographic Data Centre
Maritime Headquarters
Meteorological & Oceanographic (METOC) Services
MHQ Annex Level 2, Potts Point
NSW 2011
AUSTRALIA
Tel: <61> (02) 563 48 01
Fax: <61> (02) 563 48 20
E-mail: ben@aodc.gov.au

FRANCE

Mr. A. Poisson (**Lecturer**)
Laboratoire de Physique et Chimie Marines
Université Pierre et Marie Curie, Case 134
4, place Jussieu
75252 Paris Cedex 05
Tel: <33> (1) 44 27 48 69
Fax: <33> (1) 44 27 49 93
E-mail: apoisson@ccr.jussieu.fr

INDIA

Mr. L.A. Mandalia
Programme Specialist in Water Sciences, UNESCO
Regional Office of Science & Technology for South & Central Asia
8, Poorvi Marg. Vasant Vihar
New Delhi 110057
Tel: <91> (11) 67 73 10/67 62 85
Fax: <91> (11) 687 33 51
E-mail: uhman@frunes21.bitnet
Tlx: (81) 3165896 ROST IN
Tlg: UNESCO, New Delhi

Shri K.H. Rao
Scientist `SE' (Oceanography Group)
National Remote Sensing Agency
Balanagar
Hyderabad 500037 (A.P.)
Tel: <91> (40) 27 86 17
Fax: <91> (40) 27 98 69

Dr. S.K. Dikshit
Director, India Meteorological Dept.
Pune 5
Tel: <91> (212) 32 52 11 Ext. 270
Fax: <91> (212) 32 32 01
Tlx: 1457225

Cmdr. V.K. Verma
Deputy-Director
Directorate of Naval Oceanology & Meteorology
Naval Headquarters
R. No. 130, A-Wing Sena Bhavan
DHQ Post Office
New Delhi 110011
Tel: <91> (11) 301 09 49 Office

Shri V.B. Joshi
Senior Research Officer
Central Water & Power Research Station
Pune 411024
Tel: <91> (212) 47 78 11-25
(212) 438031 Residence
Fax: <91> (212) 44 52 68
Tlx: 1457390 CWPRS IN
Cbl: CEWAPORES
E-mail: uunet!nicnet!wapis!root

Dr. R.R. Rao
Scientist `F'
National Physical Oceanographic Laboratory
Cochin 682021
Tel: <91> (484) 85 88 11
Fax: <91> (484) 85 82 97

Dr. V.N. Sankaranarayanan
Scientist-in-Charge
National Institute of Oceanography, Regional Centre
Providence Rd.
Kochi 682018
Tel: <91) 36 03 06 Office
31 93 84 Residence
Tlx: 8856399 NIO IN
Tlg: OCEANOLOGY ERNAKULAM

Cmdr. P. Jayapal
Naval Hydrographic School
Vasco da Gama
Goa 403802
Tel: <91> 51 39 50 Ext. 218/242

Dr. P.S. Swathi
Scientist, C-MMACS
National Aerospace Laboratory, Belur Campus
Bangalore 560037
Tel: <91> (80) 527 46 49
Fax: <91> (80) 526 03 92
E-mail: swathi@cmmacs.ernet.in

Dr. B.N. Krishnamurthy (**Lecturer**)
Director, Dept. of Ocean Development
Mahasagar Bhavan, Block 12
CGO Complex, Lodi Rd.
New Delhi 110003
Fax: <91> (11) 436 07 79/436 03 36
Tlx: 3161535 DOD IN/3161984 DOD IN

Shri A. Chakraborty
Scientist, International Scientific Collaboration
Council of Scientific & Industrial Research
Anusandhan Bhavan, Rafi Marg.
New Delhi 110001
Fax: <91> (11) 371 47 88/371 06 18

Dr. A.H. Parulekar (**Lecturer**)
Dr. N. Bahulyan (**Lecturer**)
Dr. S.W.A. Naqvi (**Lecturer**)
Shri M.P Tapaswi (**Lecturer**)
Dr. R.M.S. Bhargava
Sh. J.S. Sarupria
Sh. G.V. Reddy
Sh. Aravind Ghosh K.
Sh. T. Pankajakshan
Sh. P.D. Kunte
National Institute of Oceanography
Dona Paula
Goa 403004
Tel: <91> (832) 22 62 53-56
Fax: <91> (832) 22 33 40/22 13 60
E-mail: bic_nio@dbt.ernet.in
Tlx: 194216 NIO IN/194316 MGG IN

IRAN, ISLAMIC REPUBLIC OF

Dr. B. Amini
Iranian National Center for Oceanography
P.O. Box 14155-4781
Tehran 19877
Tel: <98> (21) 641 65 56
Fax: <98> (21) 641 99 78
E-mail: amini110@irearn.bitnet

KENYA

Mr. H. Ong'anda (**Lecturer**)
Kenya Marine & Fisheries Research Institute
P.O. Box 81651
Mombasa
Tel: <254> (11) 47 11 29
Fax: <254> (11) 47 22 15

Dr. G. Kitaka
UNESCO Nairobi
P.O. Box 30592
Nairobi
Tel: <254> (2) 62 23 64
Fax: <254> (2) 21 59 17
Tlx: 22275 UNESCO

SAUDI ARABIA

Dr. M.O. Moammar (**Lecturer**)
Faculty of Marine Science
King Abdulaziz University
P.O. Box 1540
Jeddah 21441
Tel: <96> (2) 695 23 92 Office
694 10 51 Home
Fax: <96> (2) 651 98 68

Dr. R.D. Williams
Oceanographer, Saudi Arabian Oil Company
Saudi Aramco
P.O. Box 1484
Dhahran
Tel: <96> (3) 876 82 93
878 73 03 (Residence)
Fax: <96> (3) 876 66 57

TANZANIA, UNITED REPUBLIC OF

Mr. C.A. Muhando
Institute of Marine Sciences
P.O. Box 668
Zanzibar
Tel: <255> (54) 32128
Fax: <255> (54) 33050

UNITED KINGDOM

Mr. M. Thorley (**Lecturer**)
Antarctic Environmental Data Centre
British Antarctic Survey
Natural Environment Research Council
High Cross, Madingley Rd.
Cambridge CB3 OET
Tel: <44> (1223) 25 15 94
Fax: <44> (1223) 62616
Tlx: 817725 BASCAM G
E-mail: m.thorley@bas.ac.uk

USA

Dr. S. Levitus
(**Project Leader/Lecturer & Co-Chairman**)
Director, WDC-A Oceanography
National Oceanographic Data Center
Ocean Climate Lab, NOAA/NESDIS
1825 Connecticut Av, NW
Washington, DC, 20235
Tel: <1> (202) 606 45 07
Fax: <1> (202) 606 45 86
E-mail: slevitus@nodc.noaa.gov

Dr. P.H. Dwivedi
Chief, ADP Support Division
National Oceanographic Data Center
1825 Connecticut Av, NW, Room 403
Washington, DC, 20235
Tel: <1> (202) 606 45 18
Fax: <1> (202) 606 45 86
E-mail: pdwivedi@nodc.noaa.gov

IOC SECRETARIAT

Dr. I. Oliounine (**Lecturer & Co-Chairman)**
Head, Ocean Services Unit
Intergovernmental Oceanographic Commission
UNESCO
1, rue Miollis
75732 Paris Cedex 15
FRANCE
Tel: <33> (1) 45 68 39 63
Fax: <33> (1) 40 56 93 16
E-mail: i.oliounine@unesco.org
Tlx: 204461 PARIS
Cbl: UNESCO PARIS

ANNEX IV

GODAR PRODUCTS

* ATLAS SERIES

- Conkright, M.E., S. Levitus & T.P. Boyer, 1994. World Ocean Atlas 1994, Vol. 1: Nutrients. NOAA Atlas NESDIS 1. US Dept. of Commerce, NOAA, NESDIS.

- Levitus, S. and T.P. Boyer, 1994. World Ocean Atlas 1994, Vol. 2: Oxygen, NOAA Atlas NESDIS 2. US Dept. of Commerce, NOAA, NESDIS.

- Levitus, S., R. Burgett & T.P. Boyer, 1994. World Ocean Atlas 1994, Vol. 3: Salinity. NOAA Atlas NESDIS 3. US Dept. of Commerce, NOAA. NESDIS.

- Levitus, S. & T.P. Boyer, 1994. World Ocean Atlas, 1994, Vol. 4: Temperature NOAA Atlas NESDIS 4. US Dept. of Commerce, NOAA, NESDIS.

* QUALITY CONTROL DOCUMENTATION

- Boyer, T.P. & S. Levitus, 1994. Quality Control & Processing of Historical Oceanographic Temperature, Salinity & Oxygen Data. NOAA Technical Report NESDIS 81. US Dept. of Commerce, NOAA, NESDIS.

- Conkright, M.E., T.P. Boyer & S. Levitus, 1994. Quality Control & Processing of Historical Nutrient Data. NOAA Technical Report 79. US Dept. of Commerce, NOAA, NESDIS.

* DOCUMENTATION FOR NON-ARCHIVED DATA

- Levitus, S., R. Gelfeld, T. Boyer & D. Johnson, 1994. Results of the NODC & IOC Oceanographic Data Archaeology & Rescue Project. Key to Oceanographic Records Documentation N$^{o.}$ 19, NODC, Washington, DC.

* DOCUMENTATION FOR ARCHIVED DATA

- Levitus, S. & R. Gelfeld, 1992. NODC Inventory of Physical Oceanographic Profiles. Key to Oceanographic Records Documentation N$^{o.}$ 18, NODC, Washington, DC.

* DISC 1

- Objectively Analyzed Temperature Fields.

* DISC 2

- Objectively Analyzed Salinity Fields.
- Five Degree Square Statistics.

* DISC 3

- Objectively Analyzed Oxygen, Apparent Oxygen Utilization, Oxygen Saturation, Phosphate, Silicate & Nitrate Fields.

* DISC 4

- Observed Level Profile Data for the North Atlantic (0-40^{o}N), Northern Indian & Southern Indian Oceans.

* DISC 5

- Observed Level Profile Data for the North Atlantic (40°- 90°N) & South Atlantic Oceans.

* DISC 6

- Observed Level Profile Data for the North Pacific (0.30°N) & South Pacific Oceans.

* DISC 7

- Observed Level Profile Data for the North Pacific (30°N-90°N).

* DISC 8

- Standard Level Profile Data for the Atlantic & Indian Oceans.

* DISC 9

- Standard Level Profile Data for the Pacific Ocean.

* FUTURE DISC 10

- Upper Ocean Thermal Structure (1942-1990).

ANNEX V

LIST OF ACRONYMS

AODC	Australian Oceanographic Data Centre
ASFA	Aquatic Sciences and Fisheries Abstracts
AVHRR	Advanced Very-High Resolution Radiometer
BAS	British Antarctic Survey
BIODIMS	Biological Data and Information Management System
BIOMASS	Biological Investigations of Marine Antarctic Systems & Stocks
BODC	British Oceanographic Data Centre (UK)
BT	Bathythermograph
CEC	Commission of European Communities
COMARAF	Regional Project for Research and Training on Coastal Marine Systems in Africa
CSIR	Council of Scientific and Industrial Research (India)
CTD	Current, Temperature, Depth
CZIS	Coastal Zone Information System (India)
DOD	Deutsches Ozeanographisches Datenzentrum (Germany)
EACC	East African Coastal Current
EAF	East African Action Plan
ECC	Equatorial Countries Current
EDMED	European Marine Datasets
EEC	European Economic Community
EEZ	Exclusive Economic Zone
EJ	Equatorial Jet
EMC	Eastern Madagascar Current
ETS	Electron Transport System
FCCC	Framework Convention on Climatic Change
FIBEX	First International Biomass Experiment
GEBCO	General Bathymetric Chart of the Oceans
GEF	Global Environment Facility
GEODAS	Geophysical Data System
GEOSECS	Geophysical Oceans Sections Study
GIS	Geographical Information System
GLOSS	Global Sea-Level Observing System
GODAR	Global Oceanographic Data Archeology and Rescue Project
GOOS	Global Ocean Observing System

GPDMS	Geophysical Data Management Systems
GRS	Ground Receiving Satellite
HOMA	Heads of Marine Agencies (Australia)
ICSU	International Council of Scientific Unions
IFREMER	Institut Français de Recherche pour l'Exploitation de la Mer (France)
IFRTO	Iranian Fisheries Research and Training Organization
IGBP	International Geosphere-Biosphere Programme
IGOSS	Integrated Global Ocean Services System
IMD	Indian Meteorological Department
IMMPC	International Maritime Meteorological Punch Card
IMMT	International Maritime Meteorological Tape
IMS	International Marine Science Newsletter
INCO	Iranian National Centre for Oceanography
INODC	Indian National Oceanographic Data Centre
IOC	Intergovernmental Oceanographic Commission
IOCARIBE	IOC Sub-Commission for the Caribbean and Adjacent Regions
IOCEA	IOC Regional Committee for the Central Eastern Atlantic
IOCINCWIO	IOC Regional Committee for the Co-operative Investigation in the North and Central Western Indian Ocean
IOCINDIO	IOC Regional Committee for the Central Indian Ocean
IODE	International Oceanographic Data and Information Exchange
IPCC	Intergovernmental Panel on Ocean Climate
IRIMO	Islamic Republic of Iran Meteorological Organization
IRINODC	Islamic Republic of Iran National Oceanographic Data Centre
IRSC	Iranian Remote-Sensing Centre
JGOFS	Joint Global Ocean Flux Studies
JODC	Japan Oceanographic Data Centre
KBP	Kenyan-Belgium Project
KMFRI	Kenya Marine and Fisheries Research Institute
KPA	Kenyan Ports Authority
KWS	Kenyan Wildlife Services
MARSIS	Marine Remote-Sensing Information System
MBT	Mechanical Bathythermograph
MDC	Marine Data Centre
MEDI	Marine Environmental Data Information Referral System
MEPA	Meteorological and Environment Protection Administration (Saudi Arabia)
METOC	Meteorological and Oceanographic Services (Australia)

MZC	Mozambique Current
NCAR	National Centre for Atmospheric Research (USA)
NCC	National Cartographic Centre
NDC	National Data Centre
NEMC	National Environmental Management Council (United Republic of Tanzania)
NGDC	National Geophysical Data Centre (USA)
NIO	National Institute of Oceanography (India)
NOAA	National Oceanic and Atmospheric Administration (USA)
NODC	National Oceanographic Data Centre
NOIS	National Oceanographic Information System (India)
NRSA	National Remote-Sensing Agency
ORSTOM	Office de la Recherche Scientifique et Technique Outre Mer (France)
ORV	Oceanographic Research Vessel
PERSGA	Red Sea and Gulf of Aden Environment Programme
RECOSCIX-WIO	Regional Co-operation in Scientific Information Exchange in the Western Indian Ocean
RNODC	Responsible National Oceanographic Data Centre
ROSCOP	Report of Observations/Samples Collected by Oceanographic Programmes
ROSTA	Regional Office for Science and Technology for Africa
ROSTAS	Regional Office for Science and Technology for the Arab States
ROSTSCA	Regional Office for Science and Technology for South and Central Asia
SADCO	South African Data Centre for Oceanography
SAREC	Swedish Agency for Research Co-operation with Developing Countries
SIBEX	Second International Biomass Experiment
SIDC	Scientific Information and Documentation Centre
SIIS	Station Inventory and Information System
SINODE	Surface Indian Ocean Dynamic Experiment
SISMER	Marine Scientific Information Systems (France)
SOC	Specialized Oceanographic Centre
SRB	Surface Radiation Budget
SSRSC	Saudi-Sudanese Red Sea Commission
START	Global Change System for Analysis, Research & Training
STD	Salinity, Temperature, Depth
SUMED	Suez-Mediterranean Pipeline
SWCC	Second World Climate Conference
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNCED	United Nations Conference on Environment and Development
UNCLOS	United Nations Convention on the Law of the Sea

UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
VCP	Voluntary Co-operation Programme
VOS	Voluntary Observing Ship
WCRP	World Climate Research Programme
WDC	World Data Centre
WESTPAC	IOC Sub-Commission for the Western Pacific Region
WMO	World Meteorological Organization
WOCE	World Ocean Circulation Experiment
XBT	Expendable Bathythermograph

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