

**Intergovernmental Oceanographic Commission**  
*Workshop Report No. 178*



**International Global  
Oceanographic Data  
Archaeology and Rescue  
(GODAR) Review Conference**

**Silver Spring, Washington MD, USA**  
12-15 July 1999

The International Global Oceanographic Data Archaeology and Rescue (GODAR) Review Conference took place in Silver Spring, MD, USA from 12-15 July 1999. The Conference marked the end of the first phase of the GODAR project and was attended by more than 70 data managers and scientists. The Conference summed up the results of the first phase and provided guidance for future GODAR activities. Substantial amounts of additional historical data that still reside only in manuscript form have been identified by Member States as a result of the 6 regional GODAR meetings that have been held to date. The meeting concluded that the GODAR project should be continued and extended to possibly include additional variables such as sea level and ocean bathymetry.

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## 1. OPENING

The GODAR Project Leader, Mr. S. Levitus, opened the Conference on 12 July 1999 at 10:00, thanking all participants for their efforts to attend the meeting.

Mr. Levitus reminded participants of the history of the project and identified the Conference objectives as follows:

- Sum up the results of the First Phase of the GODAR project;
- Identify the need for extending the archaeology and rescue efforts to cover other types of oceanographic data;
- Identify priorities and ways of assisting Member States of IOC in oceanographic data archaeology and rescue operations; and
- Develop tactics for funding the Second Phase of GODAR.

He stressed that the discipline of ocean data management is rapidly evolving and has become a serious issue in the context of many scientific groups. Mr. Levitus called on the participants to share their knowledge and experience in meeting the Conference objectives and to formulate the recommendations, which can help in creating an effective data management service to a wide scientific community. He urged the participants to fully participate in the discussions and contribute to the Conference success.

Dr. Jim Baker, Under Secretary and Administrator of NOAA, and Dr. Susan Zevin, Deputy Assistant Administrator for Data Centers, greeted participants and pointed out that the GODAR Conference is a milestone in the project implementation. They highlighted the needs of the scientific community and other users for oceanographic data products. The success of GODAR and the development of the World Ocean Database earmarked a turning point in the attitude of scientists to IODE. The IODE system, through the implementation of such projects as GTSP and GODAR, has gained a high reputation as a valuable and useful system.

Dr. Baker and Dr. Zevin expressed belief that the second phase of GODAR based on the experience gained by the project in past years and on the existing national and international facilities, will help in solving many scientific uncertainties related to studies of the World Ocean. They said that the NOAA Administration, as in the past, will be responsive to the project needs and provide required support.

In his welcome address, Dr. I. Oliouline, Deputy Executive Secretary of the IOC, speaking on behalf of the IOC Executive Secretary, Dr. P. Bernal, pledged IOC commitment to the GODAR project. He emphasized that the Conference marked a milestone for GODAR, as it would sum up the results of the First Phase of the international project, which started in 1993. The quality of the GODAR products was ensured by having the project run by highly qualified personnel of the IODE data centres. He complimented Mr. Levitus and his staff for their leading role in managing the GODAR project and expressed thanks to the WDC-A, Oceanography and NODC of the United States for the Conference arrangements. He hoped that the Conference would bring forward new ideas and initiatives and wished the participants every success.

### 1.1 BACKGROUND AND GODAR PROJECT OBJECTIVES

Data archaeology and rescue activities began at the three World Data Centres 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, following the decisions of the Workshop held in September 1990 at the US National Oceanographic Data Centre (NODC), Washington, DC.

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 the expansion of this *ad hoc* multi-lateral effort into an international data rescue and recovery project (IOC Workshop Report N<sup>o</sup> 78, 1992).

This is how the experience gained by the above-mentioned activities laid the foundation for the international Global Ocean Data Archaeology and Rescue project, known as GODAR, which was given strong endorsement by the IOC Committee on IODE at its Fourteenth Session (Paris, France, 1-9 December 1992).

The GODAR Project Proposal received full support of the IOC Assembly at its Seventeenth Session (Paris, France, 25 February – 11 March 1993). In response to the Recommendation of IOC-XVII, the Secretary of IOC appointed Mr. S. Levitus, Director WDC-A, Oceanography as the Project Leader.

The project was aimed bridging the gaps in the long time series of ocean observations, which are of the utmost importance, especially for climate-change studies. Efforts in the context of the preparation for UNCED, including assessments of the state of the environment, the SWCC, the IPCC activities 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 for national decision making. Vigorous ocean data archaeology efforts helped to significantly enhance the ocean data record from past decades. These efforts have relied on data exchange of the IOC IODE and the ICSU WDC systems.

The project has endeavoured 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 a two-part process of first identifying and locating data and then performing the steps required to merge them into a digital database.

The following definitions are useful for understanding the reason for, and goals of, this project:

**Data Archaeology:** the process of seeking out, restoring, evaluating, correcting, and interpreting historical data sets;

**Data Rescue:** the effort to save data at risk of being lost to the science community by digitizing manuscript data, copying on electronic media and archiving these data into an internationally available electronic database.

The first phase of GODAR focused on searching for data holdings in different regions, which have not yet been available to the international marine science community; assessing the state of these holdings; and making them widely available through GODAR products, such as the World Ocean Atlas 1994 (WOA94) and World Ocean Database (WOD98). Since 1993, six regional GODAR workshops have been implemented in Europe, Asia, South America and Africa. Reports have been produced for each workshop describing results of the workshops and in particular, describing the amount of data held in manuscript and digital form in each of more than 60 participating countries.

## 1.2 PROGRAMME

The programme, formulated with the advice of the GODAR Project Leader, is given in [Annex I](#). The programme may be viewed as having five parts:

- (i) Review the progress of GODAR and GODAR-type projects: a session focused on the presentation of the achievements in data rescue and archiving made within the oceanographic data system as well as in other data-and-information holdings of the earth science system.
- (ii) Science and its needs for historical data: a new perspectives session specified a continuing need for oceanographic data and information by governments, industry, science, and the public to deal with such issues as the effects of the ocean upon climate, ocean pollution, and biodiversity studies. This session demonstrated how GODAR is able to respond to the changing needs in the ocean science and marine-operational communities.
- (iii) GODAR future – New data types and regional implementation – Plans and reality: a session demonstrating case studies and presenting plans for the inclusion of new data types, such as sea-level, chemical and biological data, geological, and geophysical data in future GODAR efforts.
- (iv) Five sessional working groups were established to deal with specific issues emanating from the presentations and related to the future of GODAR:
  - future parameters for GODAR;
  - regional implementation;
  - declassification of naval, fisheries and industrial data;
  - proposal for a “World Ocean Database project”;
  - search for funding.The groups deliberated on the issues and proposed recommendations that need to be implemented during the Second Phase of GODAR. These recommendations were considered by a wrap-up panel and presented as approved in Chapter 3 of this report.
- (v) Poster sessions were organized during the Conference to give participants an opportunity to complement the information contained in the key presentations and to share their national and regional experiences.

### 1.3 WORKING ARRANGEMENTS

Seventy-four scientists and data centre managers from 26 countries attended the Conference. They came from many different oceanographic and atmospheric disciplines and interest groups. They were from international, government, private, and academic organizations (Annex II). Discussions of various selected items were produced through presentations by invited speakers.

During the 4 days of the Conference, a total of 23 key talks and 24 complementary presentations were given during the different sessions. The available abstracts of presentations are given in section 2 of this report. A ten-minute questions-and-comments session followed each presentation. At the end of each session, general discussions were organized and the results of the discussions summed up.

The last day of the Conference culminated with an open-forum discussion of sessional working group reports, recommendations, and their adoption.

## 2. SCIENTIFIC PRESENTATIONS

### 2.1 SESSION 1: REVIEW OF THE PROGRESS OF GODAR AND GODAR-TYPE PROJECTS

Mr. S. Levitus – Director WDC-A, Oceanography, GODAR Project Leader, USA. “IOC/IODE GODAR Projects – Results to Date”

The Global Oceanographic Data Archaeology and Rescue (GODAR) project was established in 1993 by the Intergovernmental Oceanographic Commission of the UNESCO.

Before electronic computers came into general use, oceanographic data were recorded in manuscripts, data reports, and card index files. With the advent of electronic data storage, oceanographic observations were increasingly recorded on magnetic media such as tapes and disks. Unfortunately, all these media are subject to degradation over time with subsequent loss of unique data. This has occurred in some cases. The goal of the GODAR project has been to identify oceanographic data that are at risk of being lost due to media decay and to "rescue" as many of these data as possible by digitizing them and integrating them into international historical archives. The final step was to distribute these archives internationally without restriction via write-once media such as CD-ROMs and via on-line servers as well.

The idea of digitizing historical oceanographic data from manuscripts did not originate with the GODAR project. There have been several efforts that we know of that began with the advent of electronic computers. What the GODAR project has accomplished was the establishment of a formal, internationally organized effort to support such activities and to make available all data in one integrated database.

A few Workshops have been implemented in search for data:

1. September, 1988: Workshop on Ocean Data Files held at NODC, Washington, D.C.  
Subject: ocean data archiving and distribution  
Participants: scientists and data managers from the U.S. and Japan  
Conclusion: following a suggestion by Mr. S. Levitus, the meeting recommended the establishment of a "Historical Data Validation Project" to "recover as much historical data as possible".
2. September, 1990: Ad hoc meeting held at NODC, Washington, D.C.  
Subject: state of historical oceanographic data  
Participants: scientists and data managers from the Soviet Union, Japan, Chile, the Republic of Korea, the United States, the International Council for the Exploration of the Sea, and Australia  
Conclusions: substantial amounts of oceanographic data exist only in manuscript form and are thus unavailable to national and international research communities. Data are at risk of being lost due to media degradation or neglect; substantial amounts of oceanographic data exist in digital form and are not available to national and international research communities.
3. June, 1990: NOAA support for data archeology and rescue at NODC, Washington, D.C. The US Global Change Research Programme (USGCRP) provided the intellectual support for "data archeology and rescue activities" in the U.S. and began funding archeology and rescue activities at NODC, Washington.
4. February, 1992: IOC Workshop on Ocean Climate Data, Greenbelt, Maryland. The Workshop demonstrated progress of national and international "Data Archeology and Rescue" projects. It was recommended to institute an international data archeology and rescue project.
5. December, 1992: 14th session of the IOC Committee on IODE, Paris, France. IODE recommended the formation of a "Global Oceanographic Data Archeology and Rescue" (GODAR) project to IOC. In March, 1993 the IOC Assembly accepted the proposal and decided to establish an international project with this name.
6. Six Regional GODAR Workshops were held worldwide during the period 1993-97, which encompassed all countries that make oceanographic measurements. In total, the attendance at these meetings was approximately 150 oceanographic data managers and scientists. The dates and locations of these meetings were:
  - GODAR I, Obninsk, Russia, May 1993, for the countries of Eastern and northern Europe;

- GODAR II, Tianjin, China, March 1994, for WESTPAC countries;
- GODAR III, Goa, India, December 1995, for the countries of the Indian Ocean;
- GODAR IV, Malta, April 1995, for the Mediterranean countries;
- GODAR V, Cartagena, Colombia, April 1996, for Central and South American countries;
- GODAR VI, Accra, Ghana, March 1997, for African countries.

These meetings have resulted in the identification of substantial amounts of data that are at risk of loss due to media decay. A meeting report for each meeting is available from the IOC.

As of January 1999, data in the following amounts have been processed and made available as part of "World Ocean Database 1998" (WOD98):

- a) 803,000 SD cast profiles
- b) 946,000 MBT profiles
- c) 34,000 XBT profiles
- d) 92,000 CTD profiles
- e) 120,000 chlorophyll profiles
- f) 600,000 plankton observations.

The availability of oceanographic profile data over time is shown in Table 1. Several countries have declassified naval data, which has made an important contribution to the historical ocean profile archives. These data were processed as part of the GODAR project and also as part of the NODC "Global Ocean Database" project. The first data resulting from the GODAR project were released as part of the World Ocean Atlas 1994 (WOA94). More than one million temperature profiles previously unavailable were distributed as part of the atlas CD-ROM series. More than 900 sets of WOA94 Atlases and 450 WOA94 CD-ROM sets were distributed internationally without restriction since the release of WOA94. A second set of data resulting from the GODAR project was released as part of the World Ocean Database 1998 (WOD98). More than 250 sets of Atlases and CD-ROMs have been distributed since the release of WOD98.

WOD98 is an integrated database containing physical and chemical oceanographic profile data as well as data of plankton observations. The database has been distributed via CD-ROM. The second version of WOD98, which is expected to be available in February 2000, will be made available online as well as via CD-ROM. The online version will be available with data sorted by time as well as geographically.

Products based on WOD98 include the World Ocean Atlas 1998 series, which contain objectively analyzed fields of temperature, salinity, oxygen, nutrients, and chlorophyll. In addition, statistics of standard-level values for climatological compositing periods (seasons and months) are presented for both one-degree and five-degree grid boxes. A novel feature of this series is that it includes more than 41,000 color figures (GIF images), which are available on CD-ROM and on-line via the NODC/WDC-A home page ([www.nodc.noaa.gov](http://www.nodc.noaa.gov)).

The availability of GODAR products has been advertised through the World Wide Web as well as in numerous journals, newsletters and bulletins.

Support for data archaeology and rescue activities in oceanography and meteorology and specifically for the GODAR project has come from many sources with support increasing with time, particularly from the CLIVAR program (WCRP, 1995; 1999) and IPCC (1996).

The IOC has provided important support in the form of staff time and resources. The NOAA Climate and Global Change Program and the NOAA ESDIM Program have provided crucial support for U.S. participation, for meeting support, visits by scientific and data management personnel, and for digitization of many data sets for the world ocean. The European Community has provided support for



the MEDAR/MEDATLAS project and for GODAR meetings; and individual countries and international institutions (e.g. ICES) have provided support for different elements of the GODAR project.

TABLE 1

	Climatological Atlas of the World Ocean (1982)	World Ocean Atlas 1994	World Ocean Database 1998
Station data temperature profiles (*)	425,000	1,194,407	1,491,117
CTD temperature profiles	N/a	89,000	192,859
MBT temperature profiles	775,000	1,922,170	2,070,235
XBT temperature profiles	290,000	1,281,942	1,544,514
TOGA-TAO moored buoy temperature profiles	N/A	N/A	107,450
Total number of temperature profiles	1,490,000	4,533,968	5,226,285
Surface only temperature data			128,117

(\*) The station data file contains some older STD and CTD data that were placed there before NODC developed a separate CTD file.

Mr. A. Saulesleja - WMO expert. "Rescuing and Retrieving Climate and Impacts Information - the WMO Experience and Outlook"

Historical climate data are under threat from natural events such as hurricanes and earthquakes as well as human actions, such as fire and war but, sometimes, simply due to poor management. The World Meteorological Organization aims to preserve and make available information on climate and its impacts both on land and sea. In addition to their expertise in the climate of the atmosphere, WMO Members have contributed expertise and resources toward the compilation and digitization of marine observations for the Marine Climatological Summaries Scheme and, more recently, to the Comprehensive Ocean Atmosphere Data Set - COADS.

WMO has encouraged digitizing and exchange of climatological data through its CLimate COMputer (CLICOM) project. Under CLICOM, computers, software and expertise are contributed by several developed countries so that meteorological services in less-developed countries may extend their capabilities to managing digital data sources.

On 1 January 1989, WMO, through the generous support of Belgium, instituted the DAta Rescue (DARE) project to rescue and preserve meteorological and hydrological data. Due to deteriorating conditions and massive volumes of data stored on paper, the priority was given to microfilming. The DAta REscue project for Africa (DARE 1) was transferred from Belgium to ACMAD (Centre Africain pour les Applications de a Météorologie au Développement) in Niamey, Niger. Concerns have been raised that nearly five million microfilm/fiche forms from 42 countries are not easily accessible and that these should be digitized as a major priority under CLICOM, but this cannot be accomplished without further support from donor countries. If the pilot project is successful, the information on DARE 1 microfiches could be transferred to CD-ROM or DVD with the added benefit that they can be accessible through the INTERNET.

It has been proposed that digital-camera technology be examined as an alternative to microfilm and scanning of images under DARE: this awaits a suitable donor. In a DARE IV ( WMO Region IV - North and Central America) pilot project, the Caribbean Meteorological Institute in Barbados has

agreed to put their 30 or so microfilms onto a CD-ROM. For the interim, data holdings are being microfilmed, and some charts are being digitized through scanning.

There is vital climate data and information, which predate official meteorological services. This information is held in such diverse locations as museums, colonial and company archives, and the Vatican. The Archival Climate HISTory Survey (ARCHISS) project determines the location, extent and relevance of such information, and makes it available in digital form. This jointly sponsored WMO, UNESCO, ICSU, International Council of Archives project completed successful searches for such data in the archives of Mexico and Cuba in 1996/97. A significant amount of serial instrumental data from Mexico for the period 1753 to 1894 from about 30 stations was retrieved in digital form during 1997. In mid-1998, the USA contributed funds towards the search for El Niño climate data in the archives of relevant countries in South America. Further coordination is sought with other El Niño climate projects in the region.

*Dr. G. Boehlert, F. Schwing and R. Parrish – NOAA/NMFS Pacific Fisheries Environmental Laboratory, USA. "Impacts of Environmental Variability on Marine Fisheries"*

Worldwide fisheries have expanded to recent catch levels of some 120 million metric tons per year. Within this increasing catch, however, there are several disturbing trends. As old fisheries become fully utilized or overexploited, new fisheries develop in other areas, often on faster growing, smaller species, which are, in many cases, lower on the food chain. Concerns about declining stocks and habitat destruction lead many to fear impending declines in world fish production.

Marine fish populations fluctuate in abundance on a wide range of time and space scales, a fact of life for virtually all segments of the fishing industry. On short time scales (daily to seasonal), weather or thermal conditions may change behavior of fish, altering availability to fishermen. On intermediate time scales (interannual to El Niño), environmental variability may cause changes in geographic distribution patterns of fish populations; further, changes in reproductive success or survival of young stages affect recruitment of new fish to the population. On decadal to centennial time scales, changes in ocean climate may change entire ecosystems, resulting in regional changes in species distributions and production.

Species have evolved life-history characteristics that allow population persistence in response to the normal range of environmental variability. Human-induced changes, however, can lead to reduced resilience; drastically reduced population size from overfishing or marked changes to the environment may threaten continued production in many species and decrease the likelihood of population rebuilding when environmental conditions are good.

A great deal of evidence demonstrates the role of environmental variability in fluctuations of marine resources, even in the absence of fisheries. This provides support for improving the incorporation of environmental variability in stock-assessment models and fishery-management decisions. Understanding how longer time scales of variability impact fisheries requires longer time series of both environmental and biological data. While new data and instrumentation provide exciting opportunities for research, retrospective studies have benefited from improving ocean data of the kind provided by GODAR. New fisheries research developing ecological indicators of production capacity will depend, in part, on these and other innovative sources of retrospective data.

*Dr. H. Dooley - ICES Oceanographer. "Did GODAR Meet its Objectives? An ICES Perspective"*

The International Council for the Exploration of the Sea (ICES) hosted the original oceanographic data centre when the organization was formed in 1902. The indirect result was the safe archival of almost all of North Atlantic oceanographic data for the first half of the 20th Century. Thanks to GODAR, these

data are now in the public domain. Throughout this century ICES' expectations have always been the acquisition of oceanographic observations collected from research vessels, ships of opportunity, etc., within 12 months of their collection. These expectations were mostly fully realized during the first half of the 20th Century, but since then, very few data are made available on this time scale. GODAR has done little to help meet these expectations. Indeed recent evidence suggests that, in spite of an increase in data production via project-oriented activities containing data management entities, data flow remains fitful at best. Today, much less than 50% of the data are being submitted in a routine way. Thus, there remains a continual threat of data collections being lost forever. Because of these problems, it is clear that GODAR is here to stay.

The presentation analyzed what needed to be done to allow us to make GODAR a project of the past sometime during the 21st Century.

*Dr. V. Mamaev - Woods Hole, USA. "GIS for the Black Sea"*

The Geographic Information System has become a valuable tool for management of environmental resources. Recent applications to the marine realm have shown how a variety of diverse types of information can be presented simply and clearly, bringing together political, social, economic, scientific, and management data in a visual format. The Black Sea GIS was developed as part of the Black Sea Environmental Programme of the Global Environmental Facility, taking some two years to develop with assistance of all Black Sea country specialists. The goal of the GIS was to present data in a graphic form, using a sophisticated navigator to allow computer non-specialists to access a myriad of graphical data types.

The IBM-compatible platform was chosen as the most frequent in the region, and a "home-grown" GIS was developed to be distributed free to users, to preclude the need for users to acquire expensive GIS software. The expense of GIS software is a specific impediment to its widespread use, particularly in the cash-poor Black Sea region where economic shifts inhibit free access to sophisticated software. The results of GIS consist of some 600 individual maps and layers, which provide information on a variety of data of importance to the Black Sea region, for managers, policy-makers, students, and scientists alike. It is a model for application to other regions where expensive software, poor access to sophisticated computer facilities, and slow transition to telecommunications inhibit free data availability.

*Dr. I. Oliounine - Deputy Executive Secretary IOC, GODAR Co-ordinator, France. "Declassification of Naval Data – Logic of Détente"*

Much of what is presently known about the sea and many of the most significant ocean engineering advances have come about as a consequence of naval research and development for strategic military and security applications. Most of these technological developments, along with masses of sensitive data, have traditionally been classified and have thus not been able to be used in civilian scientific research.

With the end of the cold war, this situation has slowly started to change. An encouraging willingness appeared to release information and to make military technology available for civilian purposes. From the start of the GODAR project, the military was considered as one of the partners in retrieval and safety of historical oceanographic data, as it was understood that naval data management capabilities can provide an important contribution to the GODAR objectives.

Seven countries (Argentina, Australia, New Zealand, Turkey, Russia, UK, and USA) have declassified their data and submitted it for inclusion in the World Ocean Database. The total number of MBT, XBT and CTD profiles was more than one million observations (Table 2). The data have global coverage, are

of good quality and help to close gaps in information during the years, e.g., WW-I and WW-II, when data collection by civilian ships was temporarily suspended.

**TABLE 2**

Country	Total	XBT	MBT	CTD	Station Data
Argentina	7,844	1,493	6,351	0	0
Australia & NZ	40,162	28,471	11,571	0	120
Russia	172,482	0	138,903	0	33,579
Turkey	864	0	0	0	864
UK	171,898	108,407	63,187	0	304
US	757,297	430,176	302,811	17,757	6,553
US (Coast Guard)	235,000	0	235,000	0	0

There are, however, still large volumes of data in possession of many naval data centres or in the archives of naval ministries in Germany, Japan, Canada, France, Latin American countries, India and China.

It was recommended to consider declassification of data as an absolute necessity for the sake of international scientific co-operation as well as for the sake of confidence building between Member States. It was recommended that a pilot scheme be put into operation to build worldwide support for the declassification process. Some mechanisms to achieve the objective were proposed.

*Dr. M.E. Conkright - Ocean Climate Laboratory, National Oceanographic Data Center, USA.  
"Chemical and Biological Oceanographic Data made Available as a Result of the GODAR Project"*

To date, the US NODC/WDC-A archives of historical oceanographic data have grown dramatically as a result of data located and rescued by the Global Oceanographic Data Archaeology and Rescue project (GODAR) from institutions around the world. GODAR (and the Global Database Project) resulted in the addition of over 152,000 stations containing phosphate data; 13,000 stations containing chlorophyll observations; and 61,000 stations containing biomass data and plankton taxa (600,000 observations within these stations).

Some of the activities at the Ocean Climate Laboratory related to GODAR have been:

- Expansion of the World Ocean Database to include chlorophyll and plankton biomass and taxonomic data. These data have been published as part of World Ocean Database 1998 and distributed to the scientific community without restriction on CD-ROM.
- Development of a spreadsheet program for the digitization of physical, chemical, and biological variables in one common format. This format was developed with the co-operation of scientists at the Murmansk Marine Biological Institute and was distributed globally.
- Digitization of plankton and pigment data from various international sources (e.g. Japan, Russia). To date, 20,234 stations containing chlorophyll have been digitized; 15,511 containing plankton; and 4,976 containing nutrient data.
- Metadata requirements for chlorophyll, primary productivity, and plankton data were defined as a result of a workshop "International Management of Biological and Chemical Oceanographic Data" held in Hamburg, Germany in 1998 co-sponsored by IOC.
- Development of quality-control procedures for pigment and plankton data.

The addition of chemical and biological data has enabled the expansion of the World Ocean Atlas to include analyzed seasonal nutrient fields to 500 m depth, annual chlorophyll fields to 100 m depth, and

seasonal chlorophyll fields for the surface. Additional data are required in order to improve and expand on these products.

## 2.2 SESSION II: SCIENCE AND NEEDS FOR HISTORICAL DATA – NEW PERSPECTIVES

Mr. S. Levitus - Director WDC-A, Oceanography, GODAR Project Leader, USA. "Scientific Results made Possible by the GODAR Project"

There are a number of general reasons for building comprehensive, global, historical, electronic *in situ* oceanographic profile-plankton databases:

- the international scientific community advises national and international bodies on such issues as climate change. Historical data are required to support such studies, particularly to establish whether variability is due to natural or anthropogenic induced causes;
- to determine the role of the ocean as part of the earth's climate system, the international scientific community must have access to the most complete oceanographic databases possible. These data bases must be accessible in digital form and available internationally without restriction;
- ocean measurement programs are expensive. Scientists planning such programs should have access to all available data in order to make the most efficient use of scarce scientific resources, such as ships;
- pollutants flow across boundaries. The international community must have access to all historical data for pollution transport studies. This is particularly important for studies of the coastal environment-
- to develop and improve long-range weather forecasts and climate forecasts on interannual-to-decadal time scales. Statistical forecasting and hindcasting studies require historical ocean data.

There are a number of specific uses for ocean profile data and products derived from such data, including, but not limited to:

- Diagnostic studies describing role of the ocean as part of the earth's climate system;
- Boundary and Initial conditions for numerical models;
- Verification for ocean and atmosphere simulations;
- "Sea truth" for satellite ocean-altimetry measurements;
- Initial state for acoustic tomography inversions;
- Establishing fields of temperature and salinity for paleoclimatic studies (e.g. CLIMAP).

Although remotely observed data from satellites are providing a revolutionary view (and data) about the variability of the World Ocean, satellite data have limitations including:

- Short record length;
- Inability to provide data on variables as a function of depth, such as for temperature and salinity. Such data are required for initializing models, preparing diagnostic studies, verification of models, etc.
- Estimation of vertically integrated changes in temperature and salinity. Density-compensating changes in temperature and salinity cannot be detected via altimetry. Such changes have been documented to occur over large areas of the North Atlantic Ocean (Levitus, 1989).

Data acquired as a result of the GODAR project, and distributed as part of the World Ocean Atlas 1994 series and the World Ocean Database 1998 series, have been used in numerous scientific studies and results published in the scientific literature. One example of a new scientific result made possible by the data acquired as a result of the GODAR project is the decadal variability of upper ocean temperature in the subarctic gyre of the North Atlantic Ocean (Levitus et al, 1994). Another example is the warming of the World Ocean (Levitus et al, 2000). This result is of critical importance for better understanding the role of the ocean in climate change, especially with respect to the current scientific debate about the affect of increasing greenhouse gases in the atmosphere on the Earth's climate system.

Prof. J. Woods - Imperial College, London, UK. "Biological Oceanographic Data Requirements for Biogeochemical Modeling Studies"

Biological oceanography has two goals: to describe the geographical and temporal distributions of plankton and to explain those distributions in terms of the laws of nature.

The classical empirical approach to addressing those goals involves massive collections of observations of the environment and samples of plankton for identification and counting. Well known examples are data from the continuous plankton recorder, time series at Bermuda and Hawaii, research cruises, and collaborative experiments such as JGOFS and GLOBEC. Those data are then analyzed statistically.

This empirical approach suffers from four problems: advection, patchiness, plankton biology, and biodiversity. Advection by the permanent circulation causes changes in the ambient climate to which the ecosystem takes several years to adapt, so it is always influenced by earlier conditions upstream. This greatly reduces the value of Bermuda data. The Azores would be a much better site. Mesoscale turbulence (Rossby Number order one) causes patchiness in plankton concentration of a factor of ten on scales less than 100 km. This poses severe problems in collecting representative values of ecosystem variables.

Because of their small size and abundance, it is not possible to track individual plankters or their lineages; this means that observations alone do not have the information needed to explain plankton distributions. Although some 10,000 plankton species can be identified taxonomically, marine biologists have experimental data on the physiology and behavior of only a few.

The solution to these problems is to switch from the classical empirical approach to Virtual Plankton Ecology, in which the data to be used to address the goals of biological oceanography are generated by a mathematical model based on primitive equations (which are derived from reproducible experiments). This new approach is helped by the fact that plankton act like automata: their brains control their physiological and behavioral functions including adaptation, which use rules encoded in their genes. This makes biological oceanography a problem in physics. The primitive equations for single species plankton functions are as securely based on reproducible laboratory experiments as physical phenomena like turbulence and optics. The only biological problem arises from biodiversity: many species have not yet been documented by laboratory experiments.

To address the problems of biological oceanography, a Virtual Plankton Ecosystem (VPE) must contain information about all three elements of the ecosystem: the environment, the individual plankters, and the populations of plankton. For each simulated year, the VPE typically contains a gigword of environmental data and a teraword of data for a million individual plankters. The model used to generate a VPE must internalize the processes that control and link these three elements. Such a model is complex and large: about ten thousand lines of C code. A CASE tool was developed, the "Virtual Ecology Workbench," to automate the creation and analysis of VPEs.

In order to address the problems of biological oceanography by virtual plankton ecology there is a need for observations of the natural ecosystem for two purposes: (i) to initialize model integrations, and (ii) to verify (test) the model. Initialization depends only on observations of the chemical environment, in particular nutrients including nitrate, phosphate, silicate, and iron. The model is initialized at the end of the cooling season, just as the growing season is beginning. The nutrient data are needed for that time of year only. Verification of the model is based on the ecological Turing test. This compares features of the ecosystem as revealed by the VPE and by observations. Typical examples are temporal changes during the spring bloom and during the transition to oligotrophy (when the limiting nutrient is depleted in the

mixed layer). Observations are needed of the physical and chemical environment and of plankton concentrations (or surrogates provided by biomarkers or acoustics). A Turing test is valid only if the uncertainties in the simulation and in the observations are less than the difference between them. This provides a basis for specifying the accuracy of the observations. Patchiness due to mesoscale turbulence provides the largest source of uncertainty in the observations. This will be illustrated with SeaWiFS data.

In conclusion, data are needed to initialize model integrations and to test the model. The highest priority is to acquire nutrient data collected at the end of the cooling season. Research is needed to design sampling schemes that will reduce errors due to patchiness.

*S. Woodruff - NOAA/ERL/Climate Diagnostics Centre (CDC), USA; J. Elms - NOAA/NESDIS/National Climatic Data Center (NCDC), USA; S. Worley - US National Center for Atmospheric Research (NCAR), USA. "International Cooperation in Building the Comprehensive Ocean-Atmosphere Data Set (COADS)"*

The Comprehensive Ocean-Atmosphere Data Set (COADS) is the most extensive set of surface marine meteorological data presently available for the World Ocean, covering the period 1854-1997. Data from ships and, for more recent years, from extensive arrays of drifting and moored buoys have been supplemented since around 1900 using near-surface sea temperatures derived from the uppermost levels of oceanographic profiles. These oceanographic data (and available meteorological observations) have been obtained from NOAA/NODC, including the World Ocean Database 1998 (WOD98).

COADS, produced through a continuing cooperative project since 1981 between NOAA (CDC and NCDC) and NCAR, continues to benefit from extensive international cooperation. Ship logbook data exchanged among maritime countries under WMO Resolution 35 (1963) provided a key ingredient in recent decades. For earlier years, large collections of historical ship data (e.g., punched card decks) from countries including Denmark, Germany, Japan, the Netherlands, Norway, South Africa, UK, and the former USSR, were exchanged during the 1940s-1960s under bilateral agreements. Data also were obtained as a result of the internationally organized Historical Sea Surface Temperature (HSST) Data Project.

Since the start of the COADS project, additional data have been obtained from these or other countries including Canada, Russia, and Ukraine. U. S. ship data basically extend in COADS only back to World War II; thus, extensive efforts have been made over the last several years to digitize earlier US merchant marine data. China, under cooperative data-exchange agreements, digitized the US Maury Collection (1792-1910), and is digitizing US Marine Meteorological Journals (1879-1893). These and other international marine data archaeology efforts, which COADS has helped foster, will be described in an upcoming WMO publication. COADS products are distributed openly and without restriction; this has been a critical element in developing broad international participation.

*Prof. G.T. Mitchum - Florida State University, USA. "Scientific Rationale and Prospects for Sea-Level Data Archeology"*

The presentation was organized into four main sections: the scientific need for sea level-data; how sea-level data are used in conjunction with satellite altimetry; the present status of the sea-level database and prospects for improving it; and a set of recommendations.

The scientific utility of sea-level data comes mainly from the fact that the sea-surface height responds to surface currents via the geostrophic relationship and to vertically integrated density changes via the hydrostatic balance. Several examples of interesting signals were given, including possible gyre-gyre

interaction in the Pacific related to the El Niño/Southern Oscillation (ENSO) phenomenon, subtropical gyre changes in the North Pacific, and decadal variations in the Atlantic.

It was stressed that, now when altimetry is nearing operational status and has proven its reliability with the accumulation of over six years of high-quality data from TOPEX/Poseidon, tide-gauge data collection must take into account the probable availability of satellite altimetry from the early 90's into the foreseeable future.

It is argued that the two data sources are highly complementary and, in fact, that sea-level data archaeology is more useful for satellite altimetric applications than for more traditional uses of sea-level data. The consideration of satellite altimetry, along with the requirements necessary to improve the quality of the existing database, leads to the conclusion that emphasis should be placed on the recovery of high-frequency data (i.e., hourly heights) at stations where only monthly mean records are currently available at the international data centers.

The present status of the sea-level database was not reviewed in complete detail, but an idea of the status was given by examining the data available in the Atlantic in some detail. It was quickly seen that long records are particularly scarce at island stations and in the southern hemisphere, which is also true on a global basis. The prospects for improving the database by recovering the hourly data from tide gauges that have been in existence for several decades, but which have only produced monthly mean data, were briefly explored by identifying stations in the Atlantic where significant additions could be made. It was immediately apparent that the availability of hourly heights was very poor, and any effort would likely result in a large improvement.

The presentation concluded with a set of three recommendations. First, initial efforts should focus on recovering hourly data from gauges known to exist from the presence of monthly mean data. This is a higher priority than searching for existing gauges that have never sent data of any sort to an international data center. Second, efforts should first be aimed at island stations and at stations in the southern hemisphere. This is where the current database is weakest and also where the data is most likely to be lost if not recovered. Finally, it was noted that significant expertise in sea-level quality control and processing already exists, and linkages with many countries are available through the GLOSS program and IOC. These resources should be fully exploited in order to make a sea-level data archaeology effort most efficient.

### 2.3 SESSION III: GODAR FUTURE – NEW DATA TYPES AND REGIONAL IMPLEMENTATION – PLANS AND REALITY

#### *Dr. V.S. Shcherbakov - WDC-B, MGG, Russian Federation. "Availability of and Need for Historical Marine Geological and Geophysical Data"*

Marine geological and geophysical (MGG) data have not yet been covered by the first phase of the GODAR project. However, these data are of interest and importance to different scientific programmes, like those on Climate Change, OSNLR, COASTS, JGOFS, LOICZ, Ocean Mapping, and others.

During the last 40 years, a great deal of MGG data has been collected by ships, satellites, aircraft, buoys, and submarines. Different methods have been used for measurements: bathymetry and multi-beam echo-sounding, gravity and magnetic profilers, sidescan, long-range and narrow-beam sonar profilers, seismic, seismoacoustic, and deep-seismic sounding. There have also been measurements by near-bottom and deep-towed systems as well as measurements of sediments and rock properties *in situ* and in on-shore laboratories.



A description of data sets available in the MGG WDC-B was given, and a proposal was made to include geological and geophysical data in the priority list of parameters of the second phase of GODAR. It was recommended to include the following types of data:

- bathymetry including multi-beam echo-sounding, magnetic and paleomagnetic data, gravity and seismic and, seismoacoustic, deep seismic sounding, heat flow and radiometry data;
- TV and photo images, sidescan sonar profilers;
- sediment and rock cores and specimen descriptions including chemical, physical, age, and other properties;
- remotely sensed primary and processed data, images, and information.

Dr. T. Aarup - IOC, UNESCO, France. "Transparency Climatology for the North Sea and Baltic Sea as Determined from Secchi Disc Measurements – Data Archeology in a Coastal Region"

The depth of the euphotic zone,  $Z_e$ , is an important parameter for many oceanographic studies. It is used in modeling heat storage, in physical-biological modeling of primary production, and in calibration and validation of satellite ocean-color algorithms. Time series of  $Z_e$  can also provide evidence of long-term eutrophication effects.

Seasonal and regional climatologies (atlases) of  $Z_e$  could be used for the modeling tasks mentioned above. However, until recently, only few specialized laboratories measured  $Z_e$ , which are scarce and have traditionally not been archived at the national and regional data centers. In contrast, Secchi disc measurements are more plentiful both on a spatial and temporal scale. It is natural to attempt to derive a surrogate  $Z_e$  climatology from Secchi-disc climatological fields by using the relationship,  $Z_e = k \times SD$ , where  $k \sim 2$ .

The results of a Secchi data archeology study for the North Sea – Baltic Sea region were presented. About 40,000 observations were gathered from various sources. The results of this effort were presented in terms of climatological maps of the depth of  $Z_e$ .

The study demonstrated that: (i) there were vast amounts of unreported Secchi-disk data residing in paper archives and with individuals. WDC-A, Oceanography, had about 1,800 reported observations, and the ICES data center had about 200 reported observations for the study region; (ii) the ROSCOP database was very useful to pinpoint cruises where Secchi observations might have been gathered, though information regarding optical measurements (recorded under ROSCOP parameter fields H16 or H17) generally was lacking or incompletely reported; (iii) the spatial distribution of Secchi-disk observations in the North Sea is very uneven, and it appears that the Secchi disk has been a more useful tool among oceanographers of other countries than in the UK.

On a worldwide scale, there appears to be significant amounts of Secchi data that are unreported or not fully accessible. Prof. Voitov from Russia (Relative transparency, *Optica Okeana*, 2, pp. 21-26, 1983) estimated that his research group held about 320,000 observations. In 1988, Dr. Lewis et al (JGR – Oceans) presented a study that was based on all the observations held at WDC-A (120,000 in total). In November of 1997, the WDC-A worldwide holdings were about 160,000 Secchi observations. Based on inquiries at WDC-B, it appears that there is a large set of observations (on the order of 60,000) in the archives that could be used to improve the current Secchi-disk climatology.

In conclusion, it was proposed that the next phase of the GODAR project should be extended to include the rescue of Secchi-disc observations for both the coastal and open oceans.

Dr. C. Maillard - MEDAR/MEDATLAS Project Leader, SISMER, France. "MEDAR/MEDATLAS – EU-IOC/GODAR-type Project in the Mediterranean and Black Seas"

The objective of the MEDAR/MEDATLAS II project is to rescue, safeguard, and make available a comprehensive data set of oceanographic parameters collected in the Mediterranean and Black Seas, through a wide co-operation of the Mediterranean and Black Sea countries. The MEDAR consortium involves 20 organizations of 17 countries as well as scientific advisers from international organizations.

The project aims to increase the use of the data collected within scientific programmes, to enhance exchange of information and data between projects, and to improve the overall level of data quality. It also aims to enhance the existing data-management structures through job training and workshops about data quality, processing, mapping, exchange, and, finally, to contribute to develop sustainable, regional capacity building for the Mediterranean countries.

The project tasks are:

- to compile, safeguard and make available historical data sets of parameters presented in Table 3:

**TABLE 3**

Temperature	Salinity	pH
Oxygen	Nitrate	H <sub>2</sub> S
Nitrite	Ammonia	Alkalinity
Total Nitrogen	Phosphate	Chlorophyll-a
Total Phosphorus	Silicate	

These parameters are requested by modelers, and sufficient preliminary knowledge on their distribution is available through GODAR to allow quality checks to be performed. The data compilation was done in each country by the National Coordinator for International Oceanographic Data and Information Exchange. Special attention was given to the east, south, and coastal regions of the Mediterranean and Black Seas.

- to make the archived data sets comparable and compatible by using the common MEDATLAS protocol for formatting and quality checking, in accordance with the internationally agreed standards published by UNESCO/IOC, ICES and MAST;
- to prepare and disseminate qualified value-added products by using an efficient gridding and mapping methodology developed with the Variational Inverse Model of MODB ;
- to publish the observed data, gridded data, maps, and related documentation on CD-ROM for further scientific, educational, industrial, and governmental use.

For quality assurance, all of the data sets were first transcoded in the common MEDATLAS format. The data sets were then checked for quality (QC) in regional qualification centres by implementing automatic (objective) and visual (subjective) checks. These checks are based on a preliminary knowledge of the distribution of the parameters. As a result, the observations have not been modified, but a quality flag was attached to each numerical value.

The observed and analyzed climatological data and maps, on a 114 x 114 degree grid and at 28 vertical levels, from the MEDATLAS 1997 and MODB 1996 releases are available on CD-ROM and on WWW for the gridded data (<http://www.ifremer.fr/medar/>).

The updated database, the climatological statistics, and the methodology implemented to process and exchange these data will constitute a basic capacity of the Mediterranean and the Black Sea NODCs/DNAs to meet the requirements of the forthcoming operational oceanography.

*Mr. L. Awosika - IODE-IOCEA Regional Co-ordinator, Nigeria. "GODAR and Strategies for Ocean Data and Information Networking in West Africa (ODINAFRICA)"*

Oceanographic research in the Central Eastern Atlantic (IOCEA) region has, over decades, generated moderately large volumes of data, most of which are not easily available to the international scientific community. Most of these historical oceanographic data were collected by institutions, government agencies, United Nations agencies, private prospecting companies, and individuals.

Historical data are essential for the validation of results of on-going projects like Global Ocean Observing System (GOOS), World Ocean Climate Experiment (WOCE), a study of Climate Variability and Predictability (CLIVAR), and other projects to predict seasonal-to-interannual and decadal-to-centennial changes in the global ocean-atmosphere-land system. Such validations will enhance the effective formulation and implementation of an integrated coastal and marine management plan in the IOCEA region.

Implementation of archiving and rescue of historical data in the region should include the following stages: (i) establishment of an institutional and organizational framework ;(ii) description of data holdings; (iii) data search stage; (iv) verification of data inventories with WDCs; (v) compilation of data and planning of data digitizing and evaluation;.(vi) digitizing of data and (vii) production of IOCEA - GODAR database on CD-ROM and its inclusion in the World Ocean Database. Technical assistance in the form of training, provision of equipment and development of infrastructure will be required to ensure the successful inclusion of historical oceanographic data from the IOCEA region in the World Ocean Database.

The volume of historical marine environmental and geophysical data available at different institutions in the region is enormous. Much of these data are not presently available to the scientific world because they have not been included in the international data archives. To make these data available, there is a need now to archive and rescue these data not only for scientific purposes but also to serve as benchmarks for understanding coastal and marine changes in the past, for the effective prediction of future marine changes, and for the management of coastal zones and their resources.

In the past, the IOCEA region has been lacking behind in the implementation of global oceanographic projects like TOGA, WOCE, and newly established CLIVAR . The region cannot afford to lag behind the developed world in any future global project, especially in a GODAR-type project. GODAR may help to diminish the gap between developed and developing countries.

*Dr. P. Geerdens – Netherlands. “GODAR Project for the Caribbean Region”*

The IOCARIBE region is confronted with the consequences of phenomena such as El Niño and La Niña, climate change, sea-level rise, and increasing pressures on the coastal zones. Historical data contributes to the study of changes and trends and to the development of models. Finally, the planned establishment of the IOCARIBE-GOOS will require historical data and models for tuning, sampling, and monitoring frequencies.

During the GODAR-V meeting in Cartagena de Indies, Colombia, in 1996, representatives from ten countries from the region presented their needs and requirements concerning historical data. While many valuable data sets were identified, much data are still in a manuscript form and recorded in an out-of-use format. There is a lack of documentation metadata, and, finally, there is insufficient manpower and technical infrastructure available for data processing.

The idea for an IOCARIBE-GODAR type project was presented at the Sixth Session of the IOC Sub-Commission for IOCARIBE in San Jose, Costa Rica, in April 1999 where it was well received and moral support was offered. As a first step, a small drafting group of experts, led by P. Geerdens, will develop a first draft of a project proposal. This will be finalized during a small workshop at the IOCARIBE Secretariat. Subsequently, funding should be sought and identified. In principle, several

options exist - IADB, IOC, World Bank, NOAA, GEF, EU. When adequate funding is obtained, the drafting group will be converted into a Project Steering group to initiate and guide the project. An inventory of metadata will be compiled of relevant *in-situ* as well as remote sensing data. This inventory will take 8-12 months to develop. It will be published on CD-ROM and on a web site. It is most probable that data of interest will be found not only within the region but also elsewhere, e.g. in the US, Russia, and Europe. The relevant NODC's within and outside the region will be involved in the data search and rescue. Recovery and digitization will be done taking into account national and regional priorities, including the requirements of the IOCARIBE-GOOS project.

Mr. S. Sato - Deputy-Director of JODC, Japan. "Historical Data for Meeting the Needs of WESTPAC and NEAR-GOOS"

The Japan Oceanographic Data Center (JODC) has accepted the responsibility for data management in the WESTPAC region. Some of the Center's activities were presented.

As a pilot project of the Global Ocean Observing System (GOOS), the "North-East Asian Regional GOOS (NEAR-GOOS)" project, is being implemented covering the northeastern Asian region with four participating countries: China, Japan, Republic of Korea, and Russia. Since October 1997, a delayed-mode database (DMDB) has been operational in JODC to provide data to oceanographic researchers.

JODC has plans to develop two sets of marine chemistry data for the Northern Pacific. The first set includes data collected by the Hokkaido University. Since 1957, its faculty of fisheries has carried out oceanographic observations in the Northern Pacific, the Sea of Okhotsk, and the Bering Sea. Various data types, e.g. CTD, ocean colour, nutrients, and zooplankton, were obtained. JODC collaborates with the Hokkaido University in processing and analyzing these data to create a marine chemistry data set. The second set includes data collected as part of the Northwest Pacific Carbon Cycle Study (NOPACCS) project. This project aimed at conducting research on the absorption of CO<sub>2</sub> by the ocean and the behavior and cycle of carbon in the ocean. The JODC and organizations involved in the project developed a data set on CD-ROM and have started its distribution.

Dr. J. Fischer - EuroGOOS Secretariat, Southampton Oceanography Centre, UK. Operational Oceanography and Data Requirements in Europe

Operational oceanography can be defined as the activity of systematic and long-term routine measurements of the seas, oceans, and atmosphere and their rapid dissemination. Important products derived from operational oceanography are nowcast, forecast, and hindcast. Data archaeology can be potentially helpful in all three categories of products as it can be used in model validation, trend analysis, and in understanding long-term biological fluctuations (among other uses).

EuroGOOS is an association of European national agencies for developing operational oceanographic systems and services in European seas and for promoting European participation in the Global Ocean Observing System (GOOS). EuroGOOS was set up in December 1994. In 1999, there were 30 Members from 16 countries and Associate Membership from several key European multi-national bodies. The primary purpose of EuroGOOS consists in promoting and supporting the continuing development of operational oceanography in Europe, providing regional benefits for Europe, helping to implement GOOS objectives and activities, and contributing to them.

An important aspect of operational oceanography is its close connection to customers. The recently published EuroGOOS Data Requirements Survey represents a first step to assess the demands regarding

marine data forecasts and models for a wide range of potential users of oceanographic data and products in Europe (e.g. marine research, governmental services, commercial marine businesses). Results reveal that although physical variables are in high demand by a majority of respondents, some biogeochemical variables dominate in the environment sector and feature strongly in the food sector. There can be no attempt to discover or define the ideal or "average" product; thus, products from operational oceanography must be targeted to applications.

The economic and social benefits of operational oceanography is now well proven in GOOS and EuroGOOS. The benefit that GOOS products could derive from long-term physical and biogeochemical data records gives an added incentive for supporting the important work of GODAR.

## 2.4 POSTER AND COMPLIMENTARY PRESENTATIONS

### Dr. Z. Aziz – Malaysian Navy Oceanographic Centre, Malaysia. “Oceanographic Data Management and GODAR Activities at RM NODC – an Update”

The Royal Malaysian Navy Oceanographic Data Centre (RMNODC) was established within the Hydrographic Directorate of the Royal Malaysian Navy (RMN) in late 1993. With the purchase of the HydroComp System from Australia in early 1994, the RMNODC's capacity to manage oceanographic data on a larger scale was enhanced, sufficient to sustain the need of a National Oceanographic Data Centre (NODC). With this new capability, by mid-1994 it was recognized as the Designated National Agency (DNA) for Malaysia under the IOC-IODE system. As a DNA, RMNODC has taken the initiative to rescue all available data collected by other governmental and non-governmental agencies and archive them for future use by marine scientists. Seminars and meetings were held to educate data gatherers on the importance of archiving historical data. In fact, this is an ongoing effort by RMNODC under the GODAR activities. With the recent approval by the Malaysian government for RMNODC to create new posts, the RMNODC is now set to step ahead into new territories and to become the NODC for Malaysia.

### E. Balopoulos, A. Iona, A. Lykiardopoulos, P. Karagevrekis, A. Souvermezoglou, E. Krassakopoulou – NCMR/IO-HNODC, Hellinikon, Athens, Greece; C. Maillard, M. Fichaut – IFREMER/DITI/SISMER, Centre de Brest, Plouzane, France. “Recent Advances in Oceanographic Data Rescue and the Development of an Oceanographic Data Archive for the Eastern Mediterranean Sea”

The Eastern Mediterranean Sea has been the subject of intensive oceanographic research activity during the last 15 years. This was due to the implementation of large-scale research projects (e.g., POEM, Mediterranean Targeted Project, etc.) designed within the framework of international organizations such as IOC, EU, etc.; to the improvement and increased availability of marine research means in several countries of the region; and, finally, to the increased amount of financial resources made available for marine research by various national and international agencies and, in particular, by the Marine Science and Technology Programme of the European Union (EU/MAST).

Research activities provided comprehensive data sets and enhanced our understanding of oceanographic processes and phenomena in the region. At the same time they revealed the need for historical observational data. The interpretation and systematic study of such data plays a decisive role for the proper planning and design of marine research projects (e.g. oceanographic cruises) and facilitate the synthesis of the results of recent studies. This view is fully supported by the experience gained from the study of important climatological changes [increase of temperature and salinity of the deep layers (>2,000m) by 0.5° C and 0.1‰, respectively] occurring during the recent years in the water masses of the region.

Several efforts have been made within the recent years to develop an archive of historical data and to make an inventory of climatological fields of the Mediterranean Sea (Miller et al., 1970; Guibout, 1987; Picco, 1990, Levitus, 1982; Brasseur et al., 1996a, 1996b). More recently, the MEDATLAS Project provided an updated, quality-controlled data set of temperature and salinity profiles of the Mediterranean Sea and produced revised climatological statistics for the region (MEDATLAS Consortium, 1997). This initiative is currently supplemented by the MEDAR/MEDATLAS Project and extended to other data types (chemical and biological data). Within the framework of the last two Projects, an effort is underway by the Hellenic National Oceanographic Data Centre (HNODC) to rescue oceanographic data and develop an oceanographic data archive of the Eastern Mediterranean region (defined as the sea area to the east of the Sicily Strait).

At present, the hydrological data set consists of 32,000 temperature and salinity profiles of which 11,000 are CTD data and 21,000 are water bottle data, collected during 892 cruises. Of these, around 2,500 bottle data and 7,500 CTD profiles were made available to the HNODC by Hellenic marine research laboratories and, in particular, by the Institute of Oceanography of the National Centre for Marine Research in Athens. Historical data sets were obtained from various data sources, such as ICES, WDC-A, MODB, etc. In addition to the above, a total of 40,000 MBT and 42,000 XBT profiles have been obtained. These were collected by the Hydrographic Service of France, from the navies of various countries, and made available to the MEDATLAS Project.

Chemical data have been obtained from 170 cruises. These were made available to the HNODC by various Hellenic laboratories, which participated in different national and international projects. During the cruises, measurements of oxygen were made at 2,914 stations; nitrates at 860 stations; phosphates at 1,236 stations; and silicates at 918 stations. The total number of measurements is 9,530 for oxygen; 7,867 for  $\text{NO}_2$ ; 8,742 for  $\text{NO}_3$ ; 8,532 for  $\text{NH}_4$ ; 9,008 for  $\text{PO}_4$ ; and 8,643 for  $\text{SO}_4$ . These data, originally being in hard copy form (paper), have now been digitized. For both hydrological and chemical data, inventories have been developed.

All the data sets have been transcoded to the MEDATLAS Format (MAILLARD et al., 1995; MEDATLAS Group, 1996). In addition, the hydrological data sets have been subjected to quality control using a computer programme (SCOOP) for UNIX, developed by IFREMER/SISMER (Cure et al., 1995). To manage the various data sets, an oceanographic database has been developed at the HNODC. The ORACLE RDBMS, related development tools (DEVELOPER-2000, pro-C, etc.), and third-generation programming languages (C, FORTRAN) have been used for the database development. A programming interface, now under development, will enable access through the WWW and will provide the scientific community with a fast, reliable, and efficient way for accessing the database.

*C.A. Biney and E.R. Anang - Water Research Institute, Accra, Ghana. "Global Oceanographic Data Archeology and Rescue – A Review of Ghana's Participation"*

The Republic of Ghana lies along the Gulf of Guinea in West Africa. Different kinds of oceanographic data are collected by various institutions for research and /or commercial purposes. The Research and Utilization Branch of the Fisheries Department has, since 1962, carried out oceanographic research with respect to the development of coastal fisheries in Ghana. This includes studies on water temperature, currents, salinity, oxygen, turbidity, and nutrient concentration. Most of the data are still stored in manuscript form.

From the annual temperature cycle observed, three main oceanographic regimes have been identified, namely, the thermocline periods and major and minor upwelling seasons. An annual cycle of phytoplankton and zooplankton production, influenced by coastal upwelling and stability periods, has

also been observed. While tuna resources are under-exploited, small pelagic and demersal species are being over-exploited.

More recent studies by the Water Research Institute and other university departments have focused on the increasing impact of anthropogenic activities on the resources of the coastal zone. These are normally confined to the immediate nearshore areas and associated wetlands, lagoons, and estuaries. On the basis of information gathered, the state of marine and coastal ecosystems was reviewed. This covered urban development, erosion, climatic change, and pollution.

In general, more efforts are required for the effective participation of Ghana and other West African countries in the GODAR Project.

G.W. Boehlert, Phaedra Green – NOAA-NMFS, Southwest Fisheries Environmental Laboratory, 1352 Lighthouse Avenue, Pacific Grove, CA 93950-2097, USA; Daniel P. Costa, Daniel E. Crocker, Games Ganong – Department of Biology, University of California, Santa Cruz, CA 95064, USA; Syd Levitus – NOAA-NESDIS, E/OC5, 1315 East West Hwy., Silver Spring, MD 20910-3282, USA. "Autonomous Pinniped Environmental Samplers (APES); Using Instrumented Animals as Oceanographic Data Collectors"

The ability to conduct research on the behavior and movements of oceanic animals has been markedly improved by miniaturization of electronic components and sensors. Electronic tags have been used in several biological applications. Data recording or archival tags record and store data for later retrieval. These small electronic tags, with their continually improving measurement accuracy, can return valuable information including habitat preferences, physiological data, environmental data, and movement patterns. If properly instrumented, calibrated and archived, data from these tags can add to the oceanographic data stream for parts of the ocean where data are sparse or lacking.

As part of a project designed to evaluate the incorporation of such "biological autonomous" data into the World Ocean Database, existing and new data from northern elephant seals are being used. Elephant seals offer a unique system to carry instrumentation as they range widely over the northeastern Pacific to the Aleutian Islands on foraging trips that last from 2 to 9 months. The seals dive continuously on these trips, exhibiting long duration dives (mean = 22 min) with short surface intervals (typically 1-3 min). Dives are routinely made to depths of 400 - 600 m. Animals are instrumented with time-temperature-depth recorders and ARGOS platform terminal transmitters.

Data have been evaluated from 12 females and 3 males tagged between February 1996 and March 1998 at the Aflo Nuevo rookery in Central California. Valid data from ARGOS averaged 1.9 positions per day. Temperature and depth were measured and stored every 30 sec and retrieved after the animals returned to the rookery months later. The 15 animals from this study were tracked an average of 119 days and traveled an average distance of 2,436 km. A comparison of the profiles from seal TTDR and ARGOS data with existing MEDS subsurface data showed very good agreement. For the time period from March - May 1998, only 52 MEDS subsurface observations exist in the region bounding the migratory area of five tagged female seals. By comparison, these five seals made 22,131 dives during the same period. Thus, even combining adjacent dives to generate profiles or subsetting the data in some other way, the available data quantity is impressive.

Biologically autonomous sampling systems clearly have the potential to improve oceanographic sampling. The northern elephant seal example described here represents but one species covering portions of the northeast Pacific Ocean. Research programs presently exist on a variety of species, including southern elephant seals, tunas and bilifish, sharks, seabirds, marine turtles, and whales. With improving technology, such tags will be applied to even more marine animals and the innovative approach described here will markedly improve ocean data availability.

L. Botluk - Environmental Data Rescue Programme, USA. "NOAA Environmental Data Rescue Program"

The National Oceanic and Atmospheric Administration (NOAA) is responsible for archival, storage, and management of environmental data and information for the United States. These records, stored on paper, film, and digital media, are of great value to researchers, to private industry, and to the general public. Access to these data is limited and, as the media deteriorate with age, records are in danger of being lost.

The goals of the NOAA Environmental Data Rescue Program are to preserve the meteorological, climatological, geophysical, and oceanographic data stored by the NOAA National Data Centers and throughout NOAA, and to make this information more accessible to researchers and the general public. The EDRP inventory of data sets requiring some rescue activity currently lists over 130 data sets from the data centers and line offices. The inventory is reviewed, prioritized, and updated annually.

To date, the NOAA EDRP has rescued the following data sets by converting them to more stable storage media:

- 732,000 paper-based oceanographic surface and profile observations
- 13.5 million paper-based meteorological forms
- 131,000 pages of paper-based scientific publications of coastal data
- 250 paper-based bathymetric maps
- 4,000 paper-based geophysical observations
- 440,000 microfiche-based meteorological observations
- 1,000 pages of microfilm-based meteorological observations
- 88,000 reels of microfilm containing meteorological data.

K. Bryan - AOS Programme, Sayre Hall Princeton University, USA. "The Role of the Ocean in Climate"

Climate is usually associated with the long-term behavior of the atmosphere, but it has long been recognized that the ocean, with its enormous capacity to store heat, plays a dominant role. Broadly, the interactions of the ocean and the atmosphere can be divided into two categories: first, the interactions which determine the steady-state climate; and second, the interactions which are involved in climatic fluctuations. The presentation provided some historical perspective on the science discussed at this conference and some appreciation of the relative abundance of data available today as compared to what was available to oceanographers a few decades ago.

Primary ways in which climate is modified by the ocean are through seasonal heat storage and through the poleward transport of heat from low to high latitudes. It was possible in the early post World War II period to make indirect estimates of heat storage using marine meteorological data, but the scarcity of measurements made it extremely difficult to make direct measurements of heat storage. An important step forward was the development of the bathythermograph. The routine use of this instrument provided a database that allowed a rough map of seasonal heat storage in the North Atlantic. A comparison of these results with the estimates based on heat balance indicated large discrepancies, suggesting that there were serious flaws in the data or that seasonal changes in the wind and non-local advection by the ocean circulation played an important role.

Marine meteorological observations were also used by Sverdrup and other pioneers to estimate the poleward heat transport by the ocean circulation. The estimates made by Sverdrup published in the 1950's for the Northern Hemisphere agree qualitatively with the most recent measurements, based on



much more detailed oceanographic and meteorological data. The early heat balance estimates predicted that the Atlantic transfers large amounts of heat across the equator from the southern to the Northern Hemisphere, a very special and remarkable feature of the global heat balance.

In spite of the very small amounts of historical data available at the time, J. Bjerknes was able to come up with some remarkable insights on the role of the oceans in variations of climate from an equilibrium state. Although his work on the El Niño is best known, his pioneering analysis and interpretation of the historical marine meteorological record for the Atlantic was also an amazing and far-reaching contribution.

There appears to have been a strong connection between Bjerknes's ideas on Atlantic variability and Sverdrup's research on global heat balance. In retrospect, many of the most important contributions to the study of large-scale air-sea interaction with improved data sets and models have been to provide more quantitative details in terms of additional data and models to the broad conceptual ideas of Bjerknes.

*Capt. O. Malaver Calderon - Comision Colombiana de Oceanografia, Colombia. "Oceanographic Data Collected in Colombia since 1969"*

Since 1969, the Colombian Navy has been collecting oceanographic open sea and coastal data in the Pacific Ocean and Caribbean Sea. During the last 30 years, large volumes of oceanographic data were collected on physical, chemical, and biological parameters. These data still exist either in manuscript or analogue form. It is planned to carry out the recovery of these data and, after applying internationally agreed quality control and formatting procedures, make the data available to users and for international exchange. These data are very important to detect changes in hydrological conditions of coastal waters.

*S. Cisse - CNDOR CERESCOR, Conakry, Republic of Guinea. "Basis of Integrated Data as Tool of Integrated Management of Coastal Zone"*

The integrated management of the coastal zone is a present concern for many researchers, engineers, and managers as well as for people living in the coastal zone and for the authorities who take the responsibility for its management.

The Guinean coast is 300 km long and conceals many estuaries, bordered by marine forests. Its ecosystem is parcelled out and various, and the environment is influenced by the effects of human-development activities taking place in the coastal areas.

A knowledge of the evolution of the coasts, the abiotic factors and their variability, and an inventory of peoples' needs in endogen technologies and others are needed to find effective solutions for the protection and management of coastal zones. The centralized approach to scientific studies and research, data collection, and management constitute important aspects of the integrated management of the coastal zone.

The presentation was focused on the Guinea capacity to collect and archive marine and coastal data and information. The problems were presented and discussed and the perspectives in increasing efficiency in data management formulated. An architecture of an integrated data base was suggested which takes into account all the essential elements of the ecosystem, includes various parameters and contains methods for their management. The importance of oceanographic and coastal data for sustainable development was stressed and problems related to the oceanographic data management common to all West African countries were identified. It emphasized the importance and necessity of creating national and regional IODE infrastructures.

M. Fichaut -- IFREMER/SISMER, France. "New Development in Quality Assurance at IFREMER/SISMER"

Usually, the scientific laboratories have the responsibility for validating their data. However, it is recognized that some further cross-checks for quality are necessary before archiving and dissemination. According to the international recommendations from IOC, MAST, and ICES, automatic/objective and visual/subjective checks should be performed and a quality flag assigned to each numerical value. In case of an outlier in recent data sets, the originator is contacted to validate/correct/eliminate the value.

The present challenges of data management include increasing the volume of data and its diversity, including new biochemical parameters for which very limited number of standards exists and the need for real-time data management.

To meet these requirements, IFREMER/SISMER has developed expert tools to assist a data manager to implement QC procedures. The software, SCOOP, has been designed to QC vertical profiles. It was used first to meet the objectives of MEDATLAS and then in other projects. A new version exists now for time series. Similar software tools have also been developed to process underway geophysical data.

The automatic part of the QC tools can be used to process real-time data of operational oceanography. However, the fully automatic procedure still requires further improvement.

A. Klepikov - Arctic and Antarctic Research Institute, St. Petersburg, Russian Federation. "The Southern Ocean Oceanographic Dataset"

The Arctic and Antarctic Research Institute, St. Petersburg, Russia, is currently involved in creating the most complete digital database of oceanographic observations for the Southern Ocean.

The oceanographic data generated from the archives that were collected at the AARI and at the RIHMI-WDC National Oceanographic Data Center (Obninsk) prior to 1985, served as a basis for the data set. The data set was supplemented with data obtained from different national and other sources (including 1985-1998 observational data). Not only were the missing expedition data entered into the data set but the available expedition data were also supplemented with additional characteristics.

The database, to date, contains physical and chemical oceanographic data from approximately 40,000 stations made south of 30° S from 1924 to 1998. The AARI database was also used as a source for compiling and publishing the Russian-German "Oceanographic Atlas of the Southern Ocean." Different methods of data quality control were applied during the preparation of this Atlas with the aim of rejecting unreliable data used in the calculation of climatic fields. The subsequent analysis has revealed that the methods applied were not quite effective. The AARI efforts are now focused on supplementing the database and on a careful comparison of the data entered with the source data as well as on developing more efficient approaches and methods for formal and expert data quality control. The paper analyzed the quality-control procedures and use of the data collected by different data holders.

S. Lakkis - Laboratory of Marine Ecology and Ecology and Plankton, Lebanese University and LNCSR, Lebanon. "Long Time Series of Hydrological Data from Offshore Lebanese Waters (Eastern Mediterranean)"

The Levantine Basin of the Eastern Mediterranean, including the Lebanese sector, is situated within the Mediterranean temperate region, which has a certain subtropical affinity.

Long time series of hydrological data, including temperature, salinity, and oxygen, collected monthly and seasonally during 1968-98 from Lebanese offshore waters, showed regular seasonal variations and interannual fluctuation patterns with a slightly increasing trend.

The annual thermic cycle consists of two phases. The first is a cool phase during winter (December-March), marked by homothermic conditions in which the temperature profile is mostly linear through the water column with an average surface value of  $16^{\circ}\text{C}$ . The second, a warm phase lasting from May through November, is characterized by high surface temperatures rising as high as  $30^{\circ}\text{C}$  and a sharp thermocline between the surface and 75 m, accompanied with a water-layer stratification. This creates a thermic barrier against deep-water ascent from the depth to the surface.

The seasonal variations of surface salinity are not highly significant. In summer, the strong evaporation and the shortage of freshwater input induce a high salinity of 39.65‰. During winter, the salinity drops down to 39.20‰ following rainfall and freshwater input in the sea. Interannual fluctuations of temperature and salinity are generally regular from year to year.

The average surface temperature during the last 30 years was  $23.28^{\circ}\text{C} \pm 1.45$  and salinity  $39.28\text{‰} \pm 0.38$ ; the average surface temperature values ranged between a minimum of  $16^{\circ}\text{C} \pm 1.67$  in February and a maximum of  $29.75^{\circ} \pm 1.25$ . Interannual variability during the long period of survey showed a slightly increasing trend of temperature and salinity in the entire Levantine Basin. The average increment in surface temperature during the last 30 years was  $0.45^{\circ}\text{C}$ . This is probably due to a certain global climate change. While the increase in salinity was 0.25‰ due to the shortage of Nile flood after the construction of the Aswan High dam. The reduction of freshwater input from local small rivers, following the diminish of rainfall rate during the last decade contributed to increasing sea surface salinity.

*G. Matishov, A. Zuyev, V. Golubev, N. Androv, V. Slobodin – Murmansk Marine Biological Institute, Russian Federation; S. Levitus, I. Smolyar – National Oceanographic Data Center, USA. "Climatic Atlas of the Barents Sea 1998: Temperature, Salinity, Oxygen"*

The Barents Sea, owing to its unique natural characteristics, is outstanding among the seas of the Arctic Ocean. Penetration of warm Atlantic waters to the Barents Sea produces climatic conditions within this area which are anomalous for the Arctic Ocean. These anomalous climatic conditions have various forms of manifestation.

The Barents Sea is the only Arctic sea that remains unfrozen throughout the year. During some years, the winter ice boundary is along  $75^{\circ}\text{N}$ . The inflow of warm Atlantic waters makes the climate of the Kola Peninsula and adjacent regions more benign during the winter. Rain in January and February is a typical phenomenon for Murmansk. At the same time, the proximity to the Arctic can result in snowstorms, which may occur in any summer month.

The Barents Sea is renowned for its biological riches. Hundreds of vessels from different countries fish in this area for valuable fish species and invertebrates. Sea products harvested in the Barents Sea are a significant dietary supplement for the population of Europe and Asian Russia. The Barents Sea biological productivity is largely dependent on the variability of the inflow of the Atlantic waters. The anomalous oceanographic characteristics of the Barents Sea make the sea a natural laboratory for studying a large number of problems related to the ocean effect on climate and the distribution of marine life.

The anomalous climatic conditions also result in diversified human activities. The Russian city of Murmansk is a large base for research, fishery, and transport vessels. Nuclear-powered icebreakers (a part of the Northern Maritime Shipping Company based in Murmansk) have permitted annual trips to the North Pole to be conducted on a routine basis. During the past decade, interest in the Barents Sea has

dramatically increased due to the discovery of oil and natural gas and due to concerns about radioactivity waste disposal dumped in the sea.

During the 19th and 20th centuries, the Barents Sea was the most studied area of the Arctic basin. Many countries implemented scientific expeditions to the Barents Sea. The results of Norwegian, English, Swedish, and German expeditions were published and became available to scientists from different countries. Research results written by Russian scientists, in most cases, were published only in Russian and were, therefore, inaccessible to many English-language readers. Thus, while preparing the atlas, the main focus was on Russian expeditions.

The Climatic Atlas of the Barents Sea contains oceanographic data collected by the Murmansk Marine Biological Institute and World Data Center-A for Oceanography (Silver Spring, USA) and is a part of the Global Oceanographic Data Archaeology and Rescue (GODAR) project. Based on the objective analysis of these data, the monthly mean fields of temperature (T) and salinity (S) at standard levels of 0, 30, 50, 100 and 200 m were plotted. The initial data (74,256 stations for the period 1898-1993) are on CD-ROM in a format convenient for electronic use.

Oceanographic data used for this publication were obtained from the following sources:

- World Data Center-A (WDC-A) for Oceanography: WDC-A receives oceanographic data from many marine institutions and organizations including WDC-B Obninsk, Russia, and WDC-D, Tianjin, China.
- Murmansk Marine Biological Institute (MMBI), Russian Academy of Science: The oceanographic database of the Murmansk Marine Biological Institute consists of data measured by MMBI scientists, data found in libraries, and data acquired during joint scientific work with other marine organizations such as PINRO, North Fishing Reconnaissance, and Murmansk Hydrometeorological Service.
- CD-ROM on Eastern Arctic Ice, Ocean and Atmosphere Data, Volume 1, 1991: National Snow and Ice Data Center (CIRES-1), University of Colorado, USA.

Initially, the database was created for the region 66° - 82° N and 5° -105° E, which was slightly beyond the Barents Sea proper. For this region, the WDC-A files contain 104,370 stations, of which 47,863 are within the Barents Sea. The CD-ROM from the University of Colorado, containing data for the Barents Sea and the region adjacent to Spitsbergen, contains 2,148 stations. The Murmansk Marine Biological Institute files contain 42,654 stations, of which 36,203 are within the Barents Sea.

After merging all data, rejection of duplicate stations and implementing other data processing steps, 74,280 stations within the Barents Sea were put on the CD-ROM.

The distribution of data indicated that the Barents Sea is one of the regions of the World Ocean that is well covered by observations. An objective analysis was used to construct climatic fields of temperature and salinity. The results agree well with existing qualitative notions about basic features of variability of the Barents Sea thermohaline fields. However, they were insufficient to describe the effect of river discharge on the coastal zone of the southern part of the Barents Sea and for ice melting in the northern latitudes. To a large degree, these features are manifested during the summer months within the layer of 0-30 m.

In the future, it is planned to supplement the available data with new measurements within the upper layer as well as with deep-sea stations by digitizing manuscript data. It is also planned to improve the data quality control and objective-analysis procedures.

N. Michailov - WDC-B, Russian NODC, Russian Federation; S. Levitus - WDC-A, USA. "Integrated Marine Environmental DataBase for the North Atlantic: Testing Case of GODAR Future"

The progress in the development of the Integrated Marine Environmental DataBase (IMEDB) was presented. This database will include marine data for the northern part of the Atlantic Ocean to help in studying different components of the integrated climate system (ocean, atmosphere). IMEDB will be constructed to support complex climate studies and climate modeling and to support the needs of users who want access to environmental information.

IMEDB will be a multi-level marine environmental database, which will include observational, derived (time series), calculated (statistics and grid fields), and metadata data sets. The following principles were considered as a basis for the creation of IMEDB:

- collection of data from various sources, including national and international collections;
- use of the World Ocean Database 1998 formats for exchange and archiving of data and transformation into a unified format;
- development of quality control procedures (QCP), which should be applied to all observational data. QCP should be more advanced than those used for individual types of data;
- in parallel with the development of observational data sets, the metadata, derived, and calculated data sets will be developed and supported;
- an inventory database will be developed and updated on a regular basis;
- development of mechanisms and software for access to data sets of IMEDB including the publication of data on CD-ROM along with PC software for the retrieval, calculation of simple statistics, and visualization of data; and maintenance of an on-line version of the metadata and databases available from Internet via ftp or the World Wide Web.

Y. Nagata and T. Suzuki - Marine Information Research Centre, JHA Mishima Ginza, Chuo-ku, Tokyo, Japan. "Archive and Quality Control of the Oceanographic Data collected by Japanese Agencies of Fisheries"

Much of the data obtained by fishery agencies, which belong to local prefectural governments, have not yet been archived. As one of the main activities of the Marine Information Research Center of the Japan Hydrographic Association, these data have been collected, managed, and transferred to JODC. The collecting procedures and the problems found in quality control were presented and discussed.

G.V. Reddy and J.S. Sarupria - Indian Oceanographic Data Centre, National Institute of Oceanography, India. "Hydrographic Database of the Indian Ocean: An Objective Analysis for the Estimation of Climatological Characteristics"

A hydrographic database at the Indian Ocean Data Centre (IODC) contains a large number of vertical profiles of temperature, salinity, nutrients, and chemical parameters obtained using various oceanographic instruments (Nansen cast, CTD/STD, MBT, XBT etc.) onboard Indian research vessels: RV Gaveshani, ORV. Sagar Kanya, and FORV Sagar Sampada. This database also includes historical data acquisitions.

The regional workshop for the Indian Ocean, GODAR III, held at the IODC (NIO) in Goa in 1994, added a new dimension to the efforts to archive and rescue data. As a follow up to the workshop, IODC has taken up analysis of about 800 MBT profiles, which were originally available on coated-glass slides. After certain quality checks adopted by IODC, the vertical profiles of physical and chemical parameters have been finally stored on an INGRES relational database for generating various climatological statistics and to answer routine queries.

The presentation contained results obtained from the distribution maps of in-situ temperature and salinity data at standard oceanographic levels. Using objective analysis, data were spatially interpolated onto a regular  $1^\circ \times 1^\circ$  grid by choosing a relatively smaller influence radius in order to achieve better results. This was possible due to the enhancement of data rescued or otherwise acquired, mainly from programmes like GODAR. These gridded fields have wide applications particularly in modeling studies of the Indian Ocean and in studies aimed at exploiting ocean resources.

R.L. Rojas - CENDOC-SHOA, Chile. "Status of GODAR Activities in Chile"

As a follow up to the IOC Regional Workshop for Member States of the Caribbean and South America, GODAR-V held in Cartagena, Colombia in October 1996 several recommendations were given to NODCs of the region in order to improve the data archeology and rescue efforts of Member States of South America..

In Chile, the National Oceanographic Data Center (CENDOC) located at Servicio Hidrográfico y Oceanográfico de la Armada (SHOA), took over those tasks and implemented a number of activities to meet the goals of the GODAR Project. These activities included: (i) compilation of data and application of quality control procedures to facilitate archiving and exchange of data; (ii) production of catalogs and inventories to be shared with national scientists in order to show the benefit of sending their data to CENDOC as a safe repository that diminish the risk of data loss; (iii) establishment of a permanent task team (GT-IODE) with the participation of the national scientific community to promote data and information exchange between national marine science institutions; (iv) implementing training on data formats and Ocean PC software for data holders and universities; (v) organization of a search for new data sets at the national level and providing assistance required for data recovery.

The results of these activities were presented, as well as an updated data set was demonstrated which will be transferred to the World Data Center A, Oceanography.

V.V. Sapozhnikov, Russian Federal Research Institute of Fisheries and Oceanography (VNIRO), Russian Federation. "On the Outcome of Systematization of Hydrochemical Data in Russia from 1993-1998"

During the last five years, joint efforts of VNIRO and the US NODC have resulted in publishing the Hydrochemical Atlas of the Sea of Okhotsk, which includes data sets on salinity, oxygen, oxygen saturation, phosphate, silicate, nitrate,  $\text{NH}_4$ ,  $\text{N}_{\text{org}}$ , and  $\text{P}_{\text{org}}$  and will be available to users as a CD-ROM product. The authors used recent highly accurate data from approximately 1,000 stations. These data have been obtained with the help of a Neil Brown CTD sounder equipped with sensors for measuring oxygen and chlorophyll and a set of Go-Flo sample bottles. Measurements of phosphates, nitrates, and silicates have been made with an ALPKEM autoanalyzer on board the ship.

The Atlas presents maps of hydrochemical characteristics at several levels (0, 20, 50, 75, and 100 m) as well as their vertical distribution at seven sections within the Sea of Okhotsk. This information provides a sound background for the determination of major regularities of the spatial distribution of nutrients, for the identification of quasi-stationary mesoscale eddies, and for the assessment of their influence on biological productivity of the basin. These highly accurate data can be used as the benchmark for rejection of erroneous data of the hydrochemical database in WDC-B, Oceanography (Obninsk).

The Hydrochemical Atlas of the Sea of Okhotsk will be made available via the Internet. VNIRO is developing a supplement to the Atlas, which will include the following materials: maps of the distribution of primary production in the surface layer ( $\text{mg cm}^{-3} \text{ day}^{-1}$ ) and in the entire euphotic layer

( $\text{mg cm}^{-2} \text{ day}^{-1}$ ); maps of "new" primary production and production developed on nutrient recycling; maps of chlorophyll a, b, c, phaeophytin, and carotenoids; and maps of the distribution of dissolved and particulate organic matter, proteins, lipids, carbohydrates, and nucleic acids.

The Hydrochemical Atlas of the Sakhalin Shelf Zone is almost finished and includes maps of  $\text{S}\%$ ,  $\text{O}_2$ ,  $\text{O}_2$  (%), pH, Alk,  $\text{PO}_4$ ,  $\text{SiO}_3$ ,  $\text{NO}_2$ , phenols, and hydrocarbons for the period 1948-1993. The Hydrochemical Atlas of the Black Sea has been finalized. It presents a collection of four season maps of  $\text{S}\%$ ,  $\text{O}_2$ ,  $\text{O}_2$  (%), pH, Alk, and  $\text{PCO}_2$  data distribution at various depths (0, 20, 50, 75, 100, 150, 200, 500, 1,000, 1,500, and 2,000 m). These data were collected for the period 1897-1995.

There were problems associated with developing an isoline image of spotty patterns characterizing spring and winter periods. Using Surfer, specialists had to average available data on a 0.5 x 0.5 grid before drawing a map.

Special measurements made with a diving Aquashuttle CTD that was towed by a ship making a sinusoidal trajectory, provided a 72-hour survey of the shelf zone. The results proved the existence of meso- and microscale eddies on the main Black Sea Current shelf side.

The presented atlases need further improvements. However, they are useful for the identification of meso- and microscale eddies during complex studies of temperature, salinity, and nutrients; for the calculation of "new" primary production by finding differences between winter and summer nutrient stocks in the euphotic layer; for the determination of processes limiting primary production on the complete uptake of nitrogen or phosphorus; and for the identification of coastal upwelling zones; and for resolving many other oceanographic problems.

*T. Suzuki, Y. Nagata and K. Odate – Marine Information Research Centre, JHA Mishima Ginza, Chuo-ku, Tokyo, Japan. "New Zooplankton Database Collected in the Western Subarctic Area of the North Pacific Ocean in the Period from 1951 to 1990"*

The western subarctic area (especially the mixed water region between the Kuroshio and Oyashio fronts) of the North Pacific Ocean is one of the most productive fishing grounds in the world. The Tohoku National Fisheries Institute has conducted a special program to collect zooplankton biomass data in this area. More than 17,000 observations have been made, and a zooplankton database was created (Odate, 1994). The database was sent to JODC. The Marine Information Research Center (MIRC) is conducting additional quality control, and preparing the metadata information for this database for general users. The outline of this database, and related activities of MIRC were presented.

*A.M. Suvorov - Marine Information Systems and Technologies Dept., Marine Hydrophysical Institute, Ukraine National Academy of Sciences, Ukraine. "Marine Information Resources of Ukrainian Marine Centers and Participation of Ukraine in GODAR Project"*

TABLE 4

Ukrainian Marine Centers	Type of Archived Data
Marine Hydrophysical Institute (MHI), Ukraine National Academy of Sciences, Sevastopol	All types of oceanographic, geophysical, and satellite data
Institute of Biology of Southern Seas (IBSS), Ukraine National Academy of Sciences, Sevastopol	Biological, physical, and chemical data
Southern Scientific Research Institute of Marine Fisheries and Oceanography (SSRIMFO), State Committee of Fisheries of Ukraine, Kerch	Fishery, biological, physical, and chemical data

Ukrainian Scientific Center of Ecology of the Sea (UkrSCES), Ministry of Nuclear Safety and Environment, Odessa	Physical, chemical, and pollution data
Institute of Geological Sciences (IGS), Ukraine National Academy of Sciences, Kiev	Geological data
Institute of Geophysics (IG), Ukraine National Academy of Sciences, Kiev	Geophysical data
Experimental Branch of the MHI, Katsively (Crimea)	Oceanographic data
Hydroacoustical Branch of the MHI, Odessa	Hydroacoustical data
Marine Geological Branch of the Natural Museum of the Ukraine National Academy of Sciences, Kiev	Geological data
Marine Branch of the Ukrainian Research Hydrometeorological Institute (MB of UkrRHMI), Sevastopol	Hydrometeorological data
State Scientific and Production Center "Marine Technologies" of the MHI, Sevastopol	Physical data
Scientific and Technological Center "Resources of the Shelf" of the MHI, Sevastopol	Physical, chemical, and biological data

Ukrainian specialists took part in two regional GODAR workshops that were organized: in 1993 at the WDC-B, Oceanography, in Obninsk, Russian Federation, for the Member States of Eastern and Western Europe; and in 1995 at the Foundation for International Studies in Valletta, Malta, for the Member States of the Mediterranean.

After the Regional Workshop for the Member States of Eastern and Western Europe, data archeology and rescue activities were started in the Ukrainian marine centers. The results of these efforts have been presented on CD-ROM which included data from the following Ukrainian marine centers:

- Marine Hydrophysical Institute of the Ukrainian National Academy of Sciences;
- Southern Scientific Research Institute of Marine Fisheries and Oceanography of the State Committee of Fisheries of the Ukraine;
- Institute of Biology of Southern Seas of the Ukrainian National Academy of Sciences;
- Ukrainian Scientific Center of Ecology of Sea of the Ministry of Nuclear Safety and Environment of the Ukraine.

A group of scientists of the MHI, using a climatic temperature and salinity data subset of the GODAR project, identified areas of maximum horizontal thermohaline gradients and climatic frontal zones in the tropical Atlantic and found them to be variable in time and space. It was shown that the northern and southern tropical frontal zones are areas where maximum horizontal temperature, salinity, and density gradients coincide. Results of this research were published in the "Marine Hydrophysical Journal" (Russian version) and "Physical Oceanography" (English version).

*B.G. Trotsenko - World Ocean Fisheries Oceanography Laboratory, Southern Scientific Research Institute of Marine Fisheries and Oceanography, Ukraine. "Some Aspects of Application of GODAR Products and of Development of Oceanographic Databases in Future Project Activities"*

Large amounts of oceanographic data have become available to the world scientific community due to GODAR project activities. This has made it possible to extend considerably the range of existing oceanological atlases. At present, it is possible to create atlases of secondary hydrostructure characteristics that can be obtained on the basis of certain calculations. These are extremely important



indices for evaluation of the state of the World Ocean, in particular, for the estimation of spatial-temporal variability of the structure of water.

In addition to a general description of ocean climate, the hydrophysical and hydrochemical parameters enable scientists to conduct a more specific assessment of marine ecosystems, to define the phenomena that create changes in biodiversity, pollutants distribution and contamination, and to solve many other problems.

It was proposed to include in the list of secondary characteristics, as a priority issue, the vertical and horizontal gradients of water density (highlighting frontal zones of different spatial-temporal scales), coefficients of variability of principal oceanographic parameters such as temperature, salinity, etc., for assessing the stability of oceanographic conditions, and spatial-temporal autocorrelation functions for featuring characteristic scales of the process.

An application of the above approach was illustrated with maps of depths of maximum vertical density gradients designed both for the whole Arabian Sea and, in more detail, for the Gulf of Aden, averaged for the main seasons (northeastern and southwestern monsoon) in accordance with the mean seasonal sea-level atmospheric pressure.

In addition to the development of the atlases of secondary characteristics, it was recommended within the second phase of GODAR to consider development of integrated databases that would incorporate results of oceanographic, hydrometeorological, hydrobiological, and ichthyological studies. These integrated databases will be of great value as elements (or the basis) of multifunctional GISs. In this sense, when extending GODAR activities, it's important to rescue and process other types of ocean data.

*E.D. Vyazilov and N.N. Michailov - RIHMI-WDC of Roshydromet, Obninsk, Russian Federation. "The Global Oceanographic Data Archeology and Rescue Project: Contribution by Russia"*

In spite of the establishment of a centralized oceanographic data acquisition system, part of the data is still only available from ship owners or is held as a single copy and is not archived in the State Holding (RIHMI-WDC). At present, due to a difficult economic situation in the Russian Federation, people who were aware of specific information and were data holders had to leave their positions, and data archiving was eliminated. This may lead to an irreversible loss of information on the ocean for research purposes. From 1993, the Russian NODC has been coordinating the GODAR Project related activities of Russian maritime institutions and has been preparing and making historical oceanographic data available to the World Data Centers A (USA, Washington) and B (Russia, Obninsk), Oceanography.

In 1994-95, using the information database on RN cruises prepared by the Russian NODC, the Center started to produce catalogues for individual geographical regions and types of observations and compiled an inventory of oceanographic observations held in the RIHMI-WDC on paper and other non-standard media. In addition, the Center made a comparison of its data catalogues with those of other Russian maritime institutions of the Roshydromet (Far East RIHMI, State Oceanographic Institute (SOI), Research Institute for Arctic and Antarctic), Academy of Sciences (Shirshov Institute of Oceanology (IO), Pacific Ocean Institute of Oceanology), Ministry of Agricultural Industry (AtlantRIFO), and Ministry of Defense (Research Oceanographic Center) in order to find the cruise data missing from the Russian NODC.

These efforts revealed about 2,000 cruise oceanographic observations on non-standard media in Russian maritime institutions. The analysis of SOI's catalogues showed that more than 300 documents with primary oceanographic data (deep-sea hydrological and hydrochemical data, sea surface temperature, and chemical pollution) are missing from the RIHMI-WDC. The catalogues with data for the open ocean and Far East seas were compiled by the Far East RIHMI in 1993-96. The analysis of these data showed that one-third of them are missing from the State Holding. It was primarily data collected before 1965,

i.e. before a centralized data acquisition approach has been introduced. The missing cruises with oceanographic observations made by the OI RAS were identified from abstracts containing results of the research made. About 70 cruises of RAS R/Vs were identified of which data have never been submitted to the State Holding.

Five issues of cruise catalogues were prepared by the All-Russian RIFO in 1986-1989. A check of the catalogues revealed 943 cruises missing from the State Holding. Large amounts of data have not been received from the northern and Far East basins. The analysis of the materials for the western Atlantic basin as a whole and, particularly, for the southwestern Atlantic, showed that the All-Russian RIFO catalogues do not contain all cruises made by the Fishery Committee organizations. The AtlantRIFO data catalogue contains data from 1,909 cruises of which the data from 94 R/V cruises are completely missing from RIHMI-WDC. The analysis of the PolarRIFO catalogue of oceanographic observations in the Northwest Atlantic for 1954-1993 shows that only 133 out of 205 cruises are available in the State Holding.

The analysis of bibliographical sources made it possible to compile a list of materials with oceanographic observations held in printed copies. More than one hundred cruises data of which were used by Prof. A.M. Muromtsev in his classical works, were included in the list. Thus the following number of observations for the South Atlantic was revealed: deep-sea bottle observations from 943 RN cruises (about 50,000 oceanographic stations); bathythermograph observations from 450 RN cruises (approximately 150,000 soundings); observations by sounding instruments from 37 RIV cruises (about 5,000 soundings); and 3,000 hydrobiological observations (specific composition of zoo and phytoplankton, fish sounding, biological analyses, primary water production).

### **3. CONFERENCE RECOMMENDATIONS**

#### **3.1 FUTURE PARAMETERS FOR GODAR**

Although GODAR's primary aim was to locate and rescue data at risk of being lost, all oceanographic parameters were not addressed with equal effort or success. Because depth-temperature-salinity data forms the basic set of parameters for virtually all studies of oceanographic processes, these parameters are probably the most common of all data emanating from oceanographic expeditions and investigations globally. In addition, these parameters play a decisive role in studies of climate variability and prediction, an aspect presently of universal interest and importance.

Little wonder, therefore, that GODAR has been very successful in recovering a large amount of data within the category of primary parameters from international oceanographic data sets and databases all over the world.

The list of "primary parameters" in GODAR includes:

Temperature	Ammonia DOC
Salinity	Chlorophyll pCO <sub>2</sub>
Oxygen	Phaeophytin tCO <sub>2</sub>
Phosphate	Primary productivity XC0 <sub>2</sub>
Total phosphorous	Biochemistry XC0 <sub>2</sub> sea
Silicate	LightC 14 N0 <sub>2</sub> NO <sub>3</sub>
Nitrite	DarkC 14 Transmissivity
Nitrate	Alkalinity Pressure
pH	POC Conductivity

The order of these parameters is likely to also represent the relative amount of data rescued for each parameter, with temperature at the top of the list (more than 2 million temperature profiles). This large amount can be ascribed to the instruments, such as mechanical bathythermographs (MBTs) and expendable bathythermographs (XBTs), where only temperature is recorded.

The future "portfolio" of parameters that could be addressed in the continuing endeavours of GODAR was considered. It was felt that the following parameters justify consideration during the continuation of GODAR (not in order of priority):

**Temperature, salinity, nutrients.**

These measurements form the basis of our understanding of most oceanographic processes, including climate variability and modeling. It was felt that the existing thrust to collate temperature and salinity profiles and data from "standard" oceanographic stations should continue. It was estimated that a large amount of temperature-salinity profiles (plus related "primary" data") has still not been recovered, and remains at risk of becoming lost.

**Biogeochemistry, CO<sub>2</sub> variables (TCO<sub>2</sub>, alkalinity, pH, pCO<sub>2</sub>)**

A comprehensive database would be useful for a variety of purposes, e.g. to calculate ocean carbon uptake from pCO<sub>2</sub> maps, to determine long-term changes in the dissolved carbon concentrations, to predict future atmospheric CO<sub>2</sub> concentrations through modeling studies, and to develop a better understanding of the carbon cycle on a basin-wide scale

**Primary productivity**

Acquisition of primary productivity is of immediate concern since these data are in danger of being lost due to deteriorating record media; not all data are properly archived in digital form; and metadata, which is critical for this data type, are not always part of a digital record. Manuscript data is of minimal use to researchers who need well-documented, comprehensive digital data. A digital, research-quality global primary production data set is essential for understanding the factors affecting the variability of production in the oceans and its impact on global change.

**Sea-ice cover**

Sea ice is an important element of the coupled ocean-ice-atmosphere system. Scientists, sailors, and travelers of the past and present used to record underway sea-ice observations during high-latitude voyages in both hemispheres. With the advent of modern satellite microwave sensors that allow sea ice characteristics to be estimated remotely, the in-situ determinations of sea ice parameters have become even more important as they provide indispensable ground-truth data for calibration of remote sensing measurements.

So far, however, there has been no concerted GODAR-type effort aimed at the rescue of historical and modern sea-ice observational data sets. These data sets are at risk of being lost because most of them have not been digitized yet and exist only in the form of deck logs or sea ice cover maps. Typical examples of such data sets are sea ice observations in the Southern Ocean carried out by national Antarctic expeditions of the former Soviet Union (SAE) and Russia (RAE), South Africa (SANAE), Japan (JARE), Australia (ANARE), United Kingdom (British Antarctic Survey), France, Germany, USA, and other countries. The archeology (search and identification) and rescue (digitization) of the sea ice data collected by the above mentioned expeditions, as well as their Arctic counterparts, falls well within the GODAR Project's mission.

Pertinent protocols and data formats will be worked out in collaboration with national Arctic/Antarctic expeditions and institutes, oceanographic data centres, and ice-data depositories (e.g. NSIDC in Boulder, Colorado), as well as SCAR and International Glaciological Society. Final products (data sets on CD-ROMs) will be disseminated worldwide.

**Geology (sediment)**

It is estimated that there are still about 200,000 - 300,000 geological stations and up to 200,000 specimens at risk of becoming lost. In terms of geological parameters, it was considered that the following are of primary interest:

- a) Geochemical composition - there are approximately 20-30 parameters of interest, namely the main components (NaO, KO, CaO, MgO, TiO<sub>2</sub>, MnO<sub>2</sub>, P<sub>2</sub>O<sub>5</sub>, FeO, Fe<sub>2</sub>O<sub>3</sub>, CO<sub>2</sub>, H<sub>2</sub>O); the content of rare and minor elements (Cd, Ph, St, Ta, Nb, C, etc); and the isotope concentration (O", C", etc).
- b) Sediment properties - primarily grain size (clay, silt, and sand contents) and mineralogy composition (quartz, feldspate, clay minerals, volcano products, etc)
- c) Sediment specimens - actual specimens of sediment will contain the name of the sediment and geological age, with supporting information on the place of collection, water depth, sampling device and the repository).

Information emanating from this data will be useful for the studies of ocean history, paleo-ocean conditions and paleoclimate reconstruction, ocean evolution, climate changes, sediment transport processes, source of sediment material, and sediment quality (for industrial use).

### **Geophysics (seismics)**

Seismic, seismoacoustic profiles, and deep seismic-sounding data are often presented in analog form. The work to rescue these data will comprise of digitizing the profiles (from paper, microfilm, and old magnetic media), scanning of supporting documents, and determining the navigation coordinates and technological means.

These data will assist with the studies of the sedimentation history, earth crust composition, evolution history, sediment layer thickness, fracture zone mapping, compilation of structural thickness maps, oil and gas field prospecting, pipeline routing, as well as some archeological investigations.

### **Optics, secchi disk & suspended sediments**

The depth of the euphotic zone,  $Z_e$ , is an important parameter for many oceanographic studies. It is used in modeling heat storage, in physical-biological modeling of primary production and in calibration and validation of satellite ocean-colour algorithms. Time series of  $Z_e$ , can also provide evidence of long-term eutrophication effects.

Seasonal and regional climatologies (atlases) of  $Z_e$  could be of use for the modeling tasks mentioned above. However, until recently only few specialized laboratories measured  $Z_e$ , and  $Z_e$  data are scarce and have traditionally not been archived at the national and regional data centres. In contrast, Secchi disc measurements are more plentiful both on a spatial and temporal scale. It is natural to attempt to derive a surrogate  $Z_e$  climatology from Secchi disc climatological fields by use of the relation  $Z_e = k \times SI$ , where  $k \sim 2$ . Based on inquiries at WDC-B, it appears that there is a large set of observations (on the order of 60,000 observations) in the archives of WDC-B, which could be used to improve the current Secchi-disc climatology.

On a worldwide scale, there appear to be significant amounts of Secchi-disc data that are unreported or not fully accessible. Voitov (Relative transparency, *Optika Okeana*, 2, pp. 21-26, 1983) estimated that his research group held about 320,000 observations. In 1988, Lewis et al. (JGR - Oceans) presented a study which was based on all the observations held at WDC-A (12,000 in total). In November 1997, the WDC-A worldwide holdings were about 160,000 Secchi observations.

### **Bathymetry**

Bathymetric data have, over the past few years, become a key component for many countries in defining their Exclusive Economic Zones (EEZ). Apart from trying to collect the data as and where required and, thus, construct the coverage and information required to promulgate the EEZ (or other zone) definition, existing (historic) data can contribute considerably to expedite the process. In many cases, developing

countries are unable to undertake the costly expeditions and survey programmes required for this purpose.

Data collected within the marine geophysics domain can assist with the creation and improvement of bathymetric maps. Such bathymetric data should be rescued in coordination with the bathymetric programmes (e.g. GEBCO).

Much of historical bathymetric data may have been collected on recording paper that deteriorates significantly with time, and there may not even be an opportunity to digitize such records.

### **Time series data**

A large amount of time-series data is being collected in coastal and deep-sea areas. Some time-series data are stored by the U.S. NODC (mainly for the USA coastal region). Some other oceanographic data centres also store time series information, but it is surmised that a significant amount of this data type resides with the collecting institutes.

This data, probably similar to the geophysical data, has a higher commercial value than the temperature-salinity profiles. It can be expected that the collation of such data into a central archive, and associated global dissemination, may meet with some resistance from collecting agencies. Nevertheless, experience shows that such data, often stored within organizations who restrict the access or impede cooperation with other research groups, are under most threat of loss. It is important that a concerted effort be undertaken to recover such data.

#### **a) sea level (hourly readings)**

The scientific utility of sea level comes mainly from the fact that the sea-surface height responds to surface currents via the geostrophic relationship and to vertically integrated density changes via the hydrostatic balance. Several examples of interesting signals can be given, including possible gyre-gyre interaction in the Pacific related to the El Niño/Southern Oscillation (ENSO) phenomenon, subtropical gyre changes in the North Pacific, and decadal variations in the Atlantic.

A significant weakness exists in the available sea-level databases due to the fact that, historically, sea-level data were only reported to international data centres as monthly mean values, with the hourly heights retained by the originator. Thus, there is a situation where, in reality, the database consists of a data product for which the original data are not available in any consistent fashion. In some cases, this data can be obtained with some difficulty; in other cases, the original data exist only in paper form and are in some danger of being lost.

It is important to note that since altimetry is nearing operational status and has proven its reliability with the accumulation of over six years of high-quality data from TOPEX/Poseidon, tide gauge data collection must take into account the probable availability of satellite altimetry from the early 90's into the foreseeable future. It is argued that the two data sources are highly complementary. In fact, sea-level data archaeology is more useful for satellite altimetric applications than for more traditional uses of sea-level data. The consideration of satellite altimetry, along with the requirements necessary to improve the quality of the existing database, leads to the conclusion that emphasis should be placed on the recovery of high-frequency data (i.e., hourly heights) at stations where monthly mean records are currently all that exist at the international data centres.

The present status of the sea-level database was not reviewed in detail, but an idea of the status was obtained by examining the data available in the Atlantic in some detail. It is quickly seen that long records are particularly scarce at island stations and in the southern hemisphere, which is also true on a global basis. The prospects for improving the data by recovering the hourly data from tide gauges that have been in existence for several decades, but which have only produced monthly mean data, were briefly explored by identifying stations in the Atlantic where significant additions could

be made. It is immediately apparent that the situation with the hourly heights is very poor, and any effort would likely result in a large improvement.

Initial efforts should focus on recovering hourly data from gauges known to exist from the presence of monthly mean data. This is a higher priority than searching for existing gauges that have never sent data of any sort to an international data center. Efforts should first be aimed at island stations and at stations in the southern hemisphere. This is where the current database is weakest and also where it is judged most likely that the data may be lost first if not recovered. It was noted that significant expertise in sea-level quality control and processing already exists and linkages with many countries are available through the GLOSS program and IOC. These resources should be fully exploited in order to make a sea level data archaeology most efficient.

b) current meter, ADCP data

In many cases, parameters such as temperature and salinity are used to provide some insight into the dynamics of ocean basins, often through the geostrophic approximation.

Over the past 30 years, marine technology has advanced to the level where currents can be measured directly, in the deep sea, shelf and coastal zones, to virtually any depth and for extended periods.

These data are used for a statistical and dynamic insight into ocean currents on a variety of scales and also provide boundary values for numerical modeling of the circulation.

While data such as temperature and salinity are easily shared between researchers, the same does not hold for current-velocity time series. Although it is believed that the data emanating from large programmes, such as those in the Pacific equatorial region, have been deposited with the relevant national data centres, the same cannot be said of other regional or local experiments. In the latter case, it is even doubtful that such data sets have found their way to any data centre but mostly reside on the computers of research organizations that collected the data. The value of such data sets increases with the period of collection as well as areas such as the western boundary currents.

Because data such as current velocity is more useful in the design of maritime structures than, e.g., temperature profiles, the data assumes a greater degree of monetary value. This will represent a definite obstacle in the possible collation of such data.

ADCP (Acoustic Doppler Current Profiler) data represent a sector of the current velocity domain that has grown considerably over the past decade. The deployment of these instruments has proliferated the amount of data because of the larger number of "bins" or strata that can be sampled. These instruments are also used in an underway mode and often produces an amount of data that can only be compared to the thermograph traces in research and merchant vessels.

c) rainfall (islands)

In recent years, the interest in short-term climate variability and in possible anthropogenically forced longer-term variations has led to heightened interest in the global hydrologic cycle. Satellite measurements have begun, and an in situ network of rainfall data has been recognized as an important part of the satellite approach. Given the brevity of the satellite record, however, it will be difficult to address long-term variability of global rainfall distributions without long *in situ* records.

The situation is particularly poor over the oceans where island platforms are scarce and rainfall data, if it exists, have not always been reported in a regular or consistent fashion. Obtaining long records of open ocean rainfall require a data archaeology effort, and the product of a successful effort would be extremely valuable for assessing interannual to decadal modulations in the hydrologic cycle.

d) coastal time series

It is believed that a large amount of time series data is routinely collected all over the world. Excluding the rainfall, sea-level and current-meter data mentioned above, examples of these are the surf temperatures taken daily by lifeguards, beachcombers, and others in the areas of upwelling. It would be misleading to consider this data to be of inferior quality because of the collecting method and areas. In some cases, this data have extended over many years at selected sites. Over the past years, continuously-recording instruments have replaced the manual collection of the past, and the amount of data has increased. Coastal data are very important for developing states to formulate coastal-area management plans.

e) wave and moored buoys data

Wave data are collected by large numbers of wave buoys. In many cases, this data are of high commercial value for oil companies, port authorities, and coastal developers. Much of this data does not follow the route to recognized data centres. Wind and oceanographic parameters from moored buoys can provide a unique insight into coastal processes. It is believed that this data reside with local research organizations or (at best) with national data centres (e.g. a large percentage of the US NODC archives consists of time series data collected from the US coastal water only).

### 3.2 GODAR REGIONAL ISSUES AND ACTIVITIES

It was agreed to use the IOC Regional Subsidiary Bodies structure for the definition of the regions as the ocean basin model (e.g., Atlantic region, Indian Ocean region, etc.) would not allow taking into consideration the specificity and different levels of capacity. The need was stressed to “repatriate” the large volumes of data, which have been collected in the waters of the IOC regions by visiting expeditions and former colonial powers. Special mention was made to the data collected by the former Soviet fleet. Many of these data are now stored in the Marine Hydrophysical Institute (MHI) of the Ukraine. It was proposed to develop a joint project between CERESCOR (Guinea) and MHI with the objective to locate, digitize, and repatriate data relevant to the IOCEA region. A similar proposal was made regarding the establishment of an IOCARIBE – GODAR project.

It was emphasized that existing regional data-management facilities of IODE should be used and strengthened, where necessary, to enable them to respond actively and effectively to GODAR needs. The IODE Regional Coordinators should serve as the main assistants to the GODAR Project Leader in formulating and implementing regional projects. Co-operation with the UN and other international agencies that have similar programs of data search and rescue, should be facilitated through relevant regional structures where applicable and beneficial.

In order to ensure high-quality input as well as to ensure the conservation of original data (either in original or copy form), there is a need for a manual containing the methodology and protocols for all aspects of a data archeology and rescue process. This manual should address such issues as: where to look for data, what to look for, how to deal with the source material (degradation, preservation), what to do with the material (scanning, archiving), formatting of the data, etc. Regional metadata bases should be prepared at the early stages of the regional GODAR projects using the MEDI standard.

Adequate communication facilities, such as access to the Internet are required, especially in developing countries. It was hence recommended that GODAR should pursue activities that includes the provision of communication facilities (e-mail, hardware) for developing nations to facilitate networking and exchange of data.

### 3.3 DECLASSIFICATION OF NAVAL, FISHERIES, AND INDUSTRIAL DATA

A variety of ocean data is collected for proprietary purposes, whether by the military (for national security purposes) or by private entities whose objectives fall under the category of commerce (such as fisheries, offshore energy, or shipping). The reasons for the proprietary nature of the data may involve the need for secrecy in time or space, but the value of the data to those collecting them fades with time. Thus, these data may be held in confidence, and their distribution may be restricted or embargoed for varying periods of time. These data reside in different depositories and data-management systems, and the fate of the data after the embargo period (or after fulfilling its purpose and value for those who collected it) is uncertain, ranging from being made available (referred here under the general term “declassification” for both military as well as commercial data), to being archived or stored, or to being outright discarded.

The issue of declassification and on how to maximize the probability that sources of these data (and associated metadata) will be declassified and ultimately made available to the oceanographic and climate research community through the appropriate data centers of IODE, were under consideration.

Recommendations under this topic were divided into four categories presented below:

### **Communication and Information**

It was noted that communication and information can be improved in both directions. First, IODE and others interested in oceanographic data may lack information on the full scope of data collection by the military and industry. Second, these potential sources of oceanographic data may lack knowledge of the existing needs for oceanographic data.

An effort needs to be made, on a national basis, to identify sources of data in the military and private sector. It is also important to identify contact individuals in these sectors for communication and information exchange. Where possible, an effort should be made to explicitly identify the reasons for restriction or classification under which these restrictions may no longer apply.

Countries will develop national committees on oceanographic and surface marine data, which include key military and industrial contact people to facilitate communication and future information exchange. Key military participants should be invited to be involved in the activities of the IOC Committee on IODE.

### **Education and Awareness**

Holders of oceanographic data in the military and private sectors may not recognize the value of these data to the oceanographic community. In addition, the oceanographic data community may not recognize new sources of data that have been collected by classified or proprietary means.

“Pilot projects” for data declassification for different military and industrial sectors should be developed that can be highlighted as success stories to stimulate future efforts. It is further suggested that educational materials such as brochures or textbooks be developed and training seminars be organized, describing the value of “secondary uses” of oceanographic data collected by military and industrial sectors.

Education programs can be developed targeting unconventional ocean industry segments, for example, cruise ships, to encourage additional data submission and education as well as possible expansion of ships of opportunity programs.

As military technologies are declassified, they should be evaluated as potential and useful sources of environmental and oceanographic data.

### **Assistance and Incentives**



After some time, the value of restricted or classified data becomes of little value to those who collected it, and continued maintenance or archival becomes a cost. In addition to communication and education about the value of secondary uses for the data, technological assistance or other incentives may be needed to encourage submission of data and minimize the likelihood that they will be lost.

Approaches to financial and technical assistance for data rescue should be developed, particularly from the industrial sector, without the appearance of buying oceanographic data. As an extension of this recommendation, technological or instrumentation assistance to industry and fishing sectors should be explored to develop enhanced ships-of-opportunity programs.

Two-way data exchange incentive programs should be explored, for example, value-added oceanographic products (temperature maps, synoptic fields, access to national or GOOS-based data products) in exchange for data submission. Various kinds of non-monetary “rewards” (e.g., certificates, letters of appreciation, data archival services, tax incentives) should be developed as incentives for data submission.

### **Policy**

It may be difficult to develop formal policies and agreements given the often secretive nature of proprietary or classified data, although doing so is deemed a high priority. It is also noted that governments may classify coastal ocean data independent of military or industrial sources.

Significant effort should be expended, with input from military and industrial sectors, to develop guidelines for embargo periods for data that are appropriate to the requirements of the sectors collecting the data.

Development of policies for declassification should be implemented followed by data and metadata submission (after appropriate embargo periods) that are consistent with the IODE policies on data exchange. It was suggested that policies should be sensitive to the difference between historical and future data submission, the latter having explicit language to minimize format and quality control work.

Member States need to explore the degree to which coastal data are restricted and, where possible, policies on submission of these data should be developed.

## **3.4 FUNDING**

The success of the GODAR project, until now, has sparked off interest in more data archeology projects and of wider scope. In order to fund these activities, new national and regional funding sources need to be identified. Besides attractive promotional materials, these new sources will require new arguments explaining the value of the results of GODAR. These encompass not only the scientific applications emphasized until now but should also include arguments related to socio-economic benefits arising from GODAR activities. Historical data serve to develop an understanding of marine and coastal processes and build the corresponding models. These can then serve to forecast events or stimulate the effects of human intervention. As such, the GODAR activities can serve, for instance, to assess the carrying capacity of coastal ecosystems and, thus, contribute to the sustainable development of marine and coastal resources. This also includes the protection of investments in the coastal zone, such as building, infrastructure, industry.

Two specific themes were identified that need to be considered in relation to requests for funding future GODAR activities:

- There is a need to continue and extend the work already undertaken by GODAR. This should include the expansion into other data types and into regional areas in a more focused manner in order to safeguard and make available valuable historical data or data likely to be lost. A GODAR component should be included in the data-management module of science and service programs to

ensure that all existing data are made available. Proposals for future marine research involving data collection activities should include a data-management plan.

- There is a need to introduce processes through GODAR to assist with the tracking and identification of present and future data sets in order to minimize the need for future data archeology and rescue projects. These mechanisms should include existing IODE mechanisms such as properly documenting data through the use of MEDI and Cruise Summary Reports and working through NODCs.

It was agreed that the interests and objectives of potential donors need to be taken into account and be carefully linked to the funding proposal.

Potential donors may include:

- existing GODAR donor organizations, e.g. NOAA, IOC, European Union, etc.
- Global Environmental Facility
- World Bank
- science foundations in Member States
- regional development banks
- funding and aid agencies in Member States
- environmental protection agencies
- insurance, shipping, and off-shore industries

This is a limited list simply to identify possible sources while acknowledging that there are many more potential sources of funds.

In order to attract potential donors, it is important to:

- demonstrate the success of existing GODAR activities using scientific results and cost/benefit analysis;
- identify geographic regions of interest to potential donors and identify issues that donors wish to see resolved;
- identify products and other deliverables such as training and capability development that are of interest to potential donors;
- raise public awareness of the importance of comprehensive global data bases through general public-relations activities including leaflets and the mass media.

During the development and implementation of a GODAR-type project, it is essential that an individual or an agency provide strong leadership and drive.

One mechanism that is available to ensure the effective management and distribution of funds provided in support of GODAR activities is through the use of the IOC Trust Fund. Many other approaches are also possible.

Funding can be directed to a number of areas including:

- purchase of necessary equipment;
- hiring experienced staff to digitize and prepare data sets;
- provide training and ensuring technology transfer in the project region;
- support missions to the regions to help national GODAR efforts.

It is likely that future GODAR-type projects will have slightly different development paths depending on the region or funding mechanism. However, the following general framework for the development of GODAR-type projects was recommended:

- identify interest in a GODAR-type project from the region and identify interested Member States;
- identify interested agencies and individuals;

- establish a small regional working group, including users;
- define regional issues and needs and identify potential GODAR products and outputs;
- identify potential funding agencies at national, regional, and, possibly, global level;
- identify key areas that can be attractive to the funding agencies;
- develop a GODAR-type proposal based on identified issues and needs including social and economic impacts while considering donors requirements and interests;
- identify linkages with other similar environmental activities and programs.

### 3.5 PROPOSAL FOR A “WORLD OCEAN DATABASE PROJECT”

The success of the Global Oceanographic Data Archeology and Rescue Project (GODAR) sponsored by the Intergovernmental Oceanographic Commission (IOC) indicated the willingness of scientists and institutions of Member States of IOC to contribute data to the development of global oceanographic databases through the World Data Centers system. The GODAR project has focused on locating and rescuing historical oceanographic profile and plankton data that are at risk of being lost due to media decay.

There is a pressing need for the international oceanographic and climate communities to have access to the most complete oceanographic databases possible for scientific studies in support of international agreements and treaties such as:

- United Nations Framework Convention on Climate Change of 1992 (FCCC);
- Convention of 1972 on the Prevention of Marine Pollution by Dumping Wastes and Other Matters (London Convention);
- Convention of 1992 on Biological Diversity (Biodiversity Convention);
- The most recent scientific assessment of climate change by the Intergovernmental Program on Climate Change (IPCC, 1996) and the CLIVAR (1995) Science Implementation Plan strongly emphasize the need to understand the role of the ocean in climate change.

During the last 20 years, the international oceanographic community has begun distributing temperature and, more recently, salinity data via the Global Telecommunications System (GTS) as illustrated by the IGOSS and GTSP projects. However, many data types such as CTD and undulating CTD are not sent in on a real-time basis. Such data need to become part of a global ocean database as soon as possible.

It is proposed to establish a new international effort that goes beyond pure international exchange of oceanographic data. The purpose of this effort is to construct the most comprehensive global oceanographic database possible using the World Ocean Database as a model. This database will focus on major oceanographic variables that are measured because some variables and/or information may be restricted for economic or security reasons.

The database will be as inclusive as possible of the data and metadata of commonly measured meteorological variables. Its development will support the standardization of processing of oceanographic data and metadata that are exchanged internationally. Part of the project will be to develop authoritative metadata codes and tables for quantities such as ship names and equipment. Part of the project will be to develop databases of oceanographic cruise reports in which so much valuable data and metadata are located. These documents will be scanned, saved in an image form, managed by a Document Management System, and distributed via electronic means including the Internet, CD - ROM, and DVD technologies.

The database will be available internationally without restriction in accordance with the ICSU/IOC data exchange principles and as exemplified by the distribution of the World Ocean Atlas 1994 and World Ocean Database 1998.

#### **4. CONCLUSIONS**

All participants expressed satisfaction with the Conference as having fully accomplished its objectives and facilitated promising contacts between scientists and data managers.

The Conference was organized at a time when the awareness of the importance of historical oceanographic data for different scientific and application purposes was increasing.

The participants agreed that the Conference was an important turning point in bringing GODAR into a new dimension. Data rescued and exchanged under the First Phase of the GODAR project was invaluable to meet the decisions of UNCED relevant to sustainable development. In particular, developing countries will benefit from the existence of easily accessible marine databases, which may be used to improve their economic potential and to understand the impact of environmental variability on national welfare. A knowledge of the large-scale ocean climatologies and anomalies helps describe the forcing at local and regional scales.

The project gave an impetus to increased interest in oceanographic data collection and management, especially in Africa and South America.

The Conference brought forward new perspectives and initiatives and provided an opportunity for partners in the project to identify objectives for the Second Phase of GODAR. A synthesis was made of the current data gaps, and the Second Phase of GODAR should be launched to close the gaps taking into account the Conference recommendations.

The Conference identified the need for a plan of activities to implement Phase-II of GODAR for future comprehensive management of the wide variety of oceanographic parameters. Based on a sustainable use of resources, this plan will create a platform for the development of national, regional, and global data-management activities.

The Conference also noted that there are a few international bodies and programmes dealing with data search and preservation. The Conference considered it important to stimulate exchange of information and experience between these bodies and programmes and bring them closer together. GODAR should not compete with other organizations in data archiving but rather facilitate, improve, modify and help to co-ordinate.

The Conference stressed that co-operation with other relevant international organizations should be pursued and increased.

The Conference appreciated the efforts of NOAA and WDC-A, Oceanography in operating the project and acknowledged the contributions of the data centres of the IOC/IODE system and numerous institutions to the project.

#### **5. CLOSURE**

In closing the Conference, the Chairman thanked all participants for their constructive input and for the harmonious and positive way in which they had approached the issue of the further development of GODAR. He emphasized that the Conference was just one manifestation of the US NODC commitment to international data management and called on the participants to continue co-operating in meeting new GODAR objectives.

On behalf of the participants, Dr. I. Oliouline thanked the host organization for efficient support and hospitality, which had contributed to the success of the Conference.

The Conference was closed at 18:00 on 15 July 1999.

**ANNEX I**

*INTERNATIONAL GODAR REVIEW CONFERENCE PROGRAMME*

**12 July 1999**

08h30-10h00 Registration

**Session I REVIEW OF THE PROGRESS OF GODAR AND GODAR-TYPE PROJECTS**

10h00-10h15 Official opening

10h15-10h30 *Welcome* - Dr. Susan Zevin - Deputy Assistant Administrator NOAA/NESDIS

10h30-11h00 *IOC/IODE GODAR Projects - Results to date* - Mr. Sydney Levitus - Director WDC-A, Oceanography and GODAR Project Leader

11h00-11h10 Discussions

11h10-11h40 *Status of Data and Information Systems for Earth System Science*- Prof. Ferris Webster, University of Delaware

11h40-11h50 Discussions

11h50-12h20 *Rescuing and Retrieving Climate and Impacts Information - the WMO Experience and Outlook* - Mr. Andrejs Saulesja (Canada)

12h20-12h30 Discussions

12h30-14h00 Lunch

14h00-14h30 *Earth System Monitoring: Past, Present, and Future*- Prof. Francis Bretherton- University of Wisconsin

14h30-14h40 Discussions

14h40-15h10 *Impacts of Regime Shifts on Marine Fisheries* - Dr. George Boehlert, Director of the NOAA/NMFS Pacific Environmental Laboratory

15h10-15h20 Discussions

15h20-15h50 *The Ocean as Part of the Earth's Climate System* - Prof. Kirk Bryan- Princeton University

15h50-16h00 Discussions

16h00-16h20 Break

16h20-16h50 *Declassification of Naval Data - Logic of Detente* - Dr. Iouri Oliounine, Deputy Executive Secretary IOC, GODAR Coordinator

16h50-17h00 Discussions

17h00-17h30 General discussion and sum up of first session

**13 July 1999**

09h00-09h30 *Did GODAR Meet its Objectives? An ICES Perspective* - Dr. Harry Dooley, ICES Oceanographer

09h30-09h40 Discussions

09h40-10h10 *Chemical and Biological Oceanographic Data Made Available as a Result of the GODAR Project* - Dr. Margarita Conkright, NOAA/NODC

10h10-10h20 Discussions

10h20-10h40 Break

**Session II SCIENCE AND NEEDS FOR HISTORICAL DATA - NEW PERSPECTIVES**

10h40-11h10 *Some Scientific Results Made Possible by the GODAR Project* - Mr. Sydney Levitus, Director WDC-A, Oceanography, GODAR Project Leader

- 11h10-11h20 Discussions  
11h20-12h10 Biological Oceanographic Data Requirements for Biogeochemical Modeling Studies - John Woods, Prof. of Oceanography, Imperial College, London, UK  
12h10-12h20 Discussions  
12h20-13h40 Lunch  
13h40-14h10 *Global Observing Systems Information Centre* - Prof. Ferris Webster, University of Delaware  
14h10-14h20 Discussions  
14h20-15h10 *Requirements for Oceanographic Data for Studies of Paleoclimates* - Prof. Warren Prell, Brown University  
15h10-15h20 Discussions  
15h20-15h40 Break  
15h40-16h00 *International Co-operation in Building the "Comprehensive Ocean-Atmosphere Data Set"* - Mr. Scott Woodruff, NOAA/ERL  
16h00-16h10 Discussions  
16h10-16h40 *Scientific Rationale and Prospects for Sea-level Data Archaeology* - Prof. Gary Mitchum, Florida State University  
16h40-16h50 Discussions, summation of second session

**Session III GODAR FUTURE - NEW DATA TYPES AND REGIONAL IMPLEMENTATION - PLANS AND REALITY**

- 16h50-17h30 Creation of working groups (themes, composition)  
17h30-18h00 Discussions  
19h00-22h30 Social event

**14 July 1999**

**Session III** (continued)

- 09h00-09h30 *Availability of and Need for Historical Marine Geological and Geophysical Data* - Dr. Valeri Scherbakov, Director WDC-B, MGG  
09h30-09h40 Discussions  
09h40-12h30 GODAR regional implementation (Case studies)
  - *MEDAR/MEDATLAS - EU/GODAR-type Project in the Mediterranean Sea* - Dr. Catherine Maillard, Project Leader, SISMER, France
  - *GODAR and Strategies for Ocean Data and Information Networking in West Africa (ODINAFRICA)* - Mr. Larry Awosika, IODE Regional Coordinator, IOCEA, Nigeria
  - *GODAR as an ODINEA Component to Help Capacity Building of East Africa* - Mr. M. Odido, Kenya
  - *GODAR Project for the Caribbean Region - Status and Plans* - Mr. Paul Geerders, Project Coordinator, Netherlands
  - *Historical Data for Meeting the Needs of WESTPAC and NEAR-GOOS* - Dr. Yutaka Nagai, JODC Director, IODE Regional Coordinator, WESTPAC
  - *Operational Oceanography and Data Requirements in Europe* - Dr. Johanne Fischer EURO-GOOS Secretariat

Each talk on regional activities will be about 20 min. with 10 min. discussions afterwards. Coffee break will be after the first 3 talks (10h30-11h00)

12h30-14h00 Lunch  
14h00-16h00 Poster session  
16h00-18h00 Working group discussions; Formulation of conclusions

**15 July 1999**

09h00-10h30 Poster session  
10h30-11h00 Break  
11h00-11h30 Dr. D. James Baker - Under Secretary and Administrator NOAA  
11h30-12h30 Open Forum discussion on WG summary reports, conclusions and recommendations  
12h30-14h00 Lunch  
14h00-15h30 Open Forum discussions (continued)  
15h30-16h00 Break  
16h00-17h30 Adoption of conclusions, recommendations and summary report. Plan of follow-up actions  
17h30-18h00 Final comments and official closure of meeting

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