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Guide for establishing a National Oceanographic Data Centre

(Second revised edition)

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TABLE OF CONTENTS

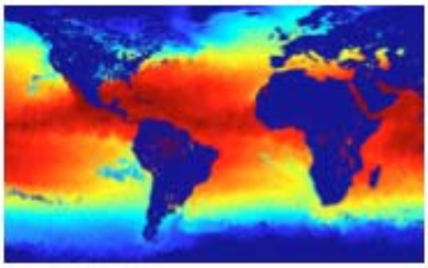
FOREWORD

This Document is the second revision of the IOC Manuals and Guides No.5. The first edition was published in 1975 and the first revision in 1997. This document deals mainly with oceanographic data management but, as data and information management are increasingly complementary, some attention is also given to marine information management.

This Guide is intended as a tool for policy makers at the national level to assist them with the decision-making related to the establishment of national facilities for the management of oceanographic data (and information). It is also intended to be a reference document for national organizations involved in, or planning to be involved in, oceanographic data and information management.

1. IMPORTANCE OF DATA MANAGEMENT

Ocean, or marine, data underpin many of the activities we undertake encompassing scientific research, modelling, monitoring and assessment. These data are precious; they are fundamental to the understanding of the processes that control our natural environment. The data help provide answers to both local questions (such as the likelihood of coastal flooding) and global issues (such as the prediction of the impact of global warming). The better we can predict these events, the better we can protect ourselves into the future. This not only affects us, but the quality of the lives of future generations.



Additionally, whilst the data collected will be used operationally or manipulated by the scientist or researcher to provide material for scientific publications, the data are a resource in their own right. Properly managed and preserved, they can be used and re-used by future researchers, exploited commercially or used by educators and the general public. Such further uses, often not envisaged in the first instance, will make an additional contribution to scientific advance and knowledge.

Oceanographic data are obtained by diverse means: nets are dragged; traps are set; instruments are lowered from ships, set adrift, or moored on cables and platforms; satellites scan the oceans from space; and laboratories are constructed on the seafloor. Measurements are made for a wide variety of purposes by individuals and sensors supported by many different kinds of institutions, including governments, private industry and non-governmental organizations. These data come in many different forms, from a single variable measured at a single point (e.g., a species name) to multivariate, four-dimensional collections of data that may be millions of gigabytes in size.

These data are often irreplaceable; they are always unique, if only in the timing of collection. Even when considering all of the data collected, spatial and temporal coverage of the global ocean is quite sparse. Marine data can also be extremely expensive to collect. Over many years a variety of databases have been compiled bringing together data from many different sources. More recently there has been need for access to more multidisciplinary and integrated data sets to further our knowledge and understanding and to better manage the marine environment, including taking an ecosystem approach to living marine resources.. In addition there is an increasing requirement for operational data in near-real-time for forecasting marine conditions and weather prediction.

> Within the context of this document we use the following definitions for data and information:
> - ***Data***: numbers (as in observations of temperature)
> - ***Information***: text (as in scientific publications)

The social relevance of measurement and sampling at sea, and the need to disseminate the results as widely and in as user-friendly a manner as possible, cannot be overestimated. More services and products useful to industry, the general public and policy makers, could, and should, be extracted from databases. The oceans cover about 72% of the Earth, and about half of the world’s population live in coastal areas, so monitoring the health, resources and ‘tantrums’ of the global ocean is no luxury. There are many applications of data-management that relate to climate and weather, safety at sea and along the coast, fisheries, offshore activities, management of the seas, etc.

From all the above it is abundantly clear that oceanographic data have to be professionally managed at the national and international level.

2. COORDINATION OF DATA AND INFORMATION MANAGEMENT AT THE NATIONAL LEVEL

Until the late 1980s oceanographic data were mostly managed in a centralized national facility, i.e. a **National Oceanographic Data Centre (NODC)**. Data consisted mostly of research cruise data or research projects, provided by research scientists to the data centres in delayed-mode. The delay between the observation and the submission to the data centre could be days to years depending on the data type. Often data would be submitted to the data centre only when the scientist had finished with it, often when a scientific paper was published.

The task of the data centre, once the data were received, was to assess the quality of the data through a number of tests and procedures (e.g. valid temperature readings). Data were then archived for use by other "secondary users".

Sometimes research projects would be organized at a regional level, involving several countries. In such a case one national centre would carry out data management tasks for the entire project or, alternatively, a dedicated data centre was established.

Today's picture is very different. Since the development of **operational oceanography** and the establishment of the **Global Ocean Observing System (GOOS)** the number of data types and volumes of data have grown greatly. In addition, many projects and programmes have developed their own data management systems, often without coordinating with existing NODCs. The national data centres are therefore often unaware of new data streams and these are often not included in the NODC data systems. In some cases when a project ends, large volumes of data were simply left unattended and have been lost.

Operational oceanography is important to:

- Monitor, understand and predict weather and climate
- Describe and forecast the state of the ocean, including living resources
- Improve management of marine and coastal ecosystems and resources
- Mitigate damage from natural hazards and pollution
- Protect life and property on coasts and at sea

It is therefore essential that, at the national level, all ocean observation and research is properly coordinated and a data management plan prepared as part of every initiative. The NODC should be involved during the drafting of these data management plans. The following key national outcomes can have a fundamental dependence on an effective national oceanographic management system and should be considered when developing the data management plan:

- Detecting and forecasting oceanic components of climate variability and change,
- Facilitating safe and efficient marine operations,
- Ensuring national security,
- Managing marine resources for sustainable use,
- Preserving and restoring healthy marine ecosystems,
- Mitigating natural hazards, and
- Support for the marine research community.

The rapid expansion of the number and capability of observation platforms, the number of data types and the volume of data collected means that NODCs are unlikely to be able to take responsibility for the management of all data types. Data management at the national level will therefore often move from a single centralized centre to a distributed system composed of a number of data centres. These centres can be permanent or may be project-based and are thus limited in time.

In order to manage the distributed architecture it is recommended to establish a **National Oceanographic Data and Information Coordination Committee** composed of all stakeholders involved in data collection and management. The tasks of the Committee should be:

- to identify all ocean observation and research activities at the national level and their data management needs,
- to agree on the distribution of responsibilities for data management responsibilities, and
- to ensure the use of standard methods by all facilities involved in oceanographic data and information management.

Examples of **relevant stakeholders** include:

- national universities involved in marine and coastal research/observation (public or private),
- national research organizations (public or private),
- projects related to marine and coastal research/observation (national or representing the country in a regional project),
- operators of research vessels,
- commercial enterprises involved in work at sea, and
- other national government or private bodies involved in marine and coastal research/observation.

It is recommended that the National Oceanographic Data and Information Coordination Committee meets at least once a year and elects a Chair to coordinate and monitor the activities of the Committee. In view of the increasing complementarities and application of similar system and technological solutions, it is recommended that the coordination committee deals with both oceanographic data management and information (libraries) management.

It is recommended that a national facility be assigned the role of **IODE National Oceanographic Data Centre** (NODC) and will form part of the IODE global network of NODCs. The responsibilities of an NODC are defined in Section 3. In some cases it may be preferred to have more than one IODE NODC in a country (this may be the case in a federal state structure where each state or region has extensive autonomy).

Marine Information. Within the IODE programme, Marine Information focuses on the implementation of national information centres. An IOC Manual and Guide to assist member states in establishing and operating a National Oceanographic Information Centre will be made available as a separate publication.

3. TASKS OF A NATIONAL OCEANOGRAPHIC DATA CENTRE

The mission of a National Oceanographic Data Centre is to provide access and stewardship for the national resource of oceanographic data. This effort requires the gathering, quality control, processing, summarization, dissemination, and preservation of data generated by national and international agencies

The full range of data management tasks to be carried out by a national oceanographic data management "system" can be summarized as follows:

- receiving data from national, regional and international programmes collecting oceanographic data;
- verifying the quality of the data (using agreed upon standards)
- ensuring the long term preservation of the data and associated information required for correct interpretation of the data; and
- making data available, nationally and internationally.

National Responsibilities include:

1. Receiving data from researchers, performing quality control, and archiving;
2. Receiving data from buoys, ships and satellites on a daily basis, processing the data in a timely way, and providing outputs to various research and engineering users, forecasters, experiment managers, or to other centres participating in the data management plan for the data in question.
3. Reporting the results of quality control directly to data collectors as part of the quality assurance module for the system.
4. Participating in the development of data management plans and establishing systems to support major experiments, monitoring systems, fisheries advisory systems;
5. Disseminating data on the Internet and through other means (and on CD-ROM, DVD, etc);
6. Publishing statistical studies and atlases of oceanographic variables.
7. Providing indicators for the different types of data being exchanged in order to track the progress.

International Responsibilities include

1. Participating in the development of international standards and methods for data management through the IODE and JCOMM;
2. Participating in international oceanographic data and information exchange through the IODE and JCOMM, the Joint Commission for Oceanography and Marine Meteorology;
3. Assisting with data management aspects of global or regional programmes or pilot projects through IODE and JCOMM and in the framework of, *inter alia*, the IOC's Strategic Plan for Oceanographic Data and Information Management;
4. Operating as a data assembly and quality control centre for part of an international science experiment;
5. Operating regional, specialized or World Data Centre (WDC) on behalf of the international science community.

Data Indicators

The NODC should provide indicators on the data flow within the centre which are comparable across other data centres. To develop such indicators the data should be identified within three categories:

1. Data received from data providers. This is the unprocessed, or raw, data
2. Data processed and archived by the NODC. This includes data quality control, metadata description, and storage in databases
3. Data delivered to users

These three categories of data should be expressed in terms of the data type, which could include the following disciplines:

- Physical Oceanography
- Chemical Oceanography
- Marine Contaminants/pollution
- Marine Biological/Fisheries
- Marine Geology/Geophysics
- Marine Meteorology

To assess the data volumes of the different data categories and data types, two complementary procedures could be used:

- Provide the count by data unit. The unit will be dependent on the data type and the data provider and could be expressed by parameter, profile, station, cruise, samples per net tow, etc.
- Provide the count by data volume. This could be expressed by units or bytes.

These steps could be summarised in the following table:

	Data category*		
	Data Unit	*Data (count/unit)*	*Data Volume (mb/data unit)*
Physical Oceanography			
Chemical Oceanography			
Marine Contaminant/ Pollutant			
Marine Biology/ Fisheries			
Marine Geology/Geophysics			
Marine Meteorology			
Other			
Total			

* Data category will be Data Received, Data Archived or Data Delivered

4. ESTABLISHING A NATIONAL OCEANOGRAPHIC DATA CENTRE

The most important requirement in establishing an NODC is to secure the support and cooperation of the oceanographic and in some cases meteorological organizations that collect and use oceanographic data. Without this cooperation the new centre will have great difficulties in acquiring data for its databases and will lose its first and most natural group of clients, i.e. the ones who supply the data. A centre that is designed with the collaboration of the collectors of the data will be off to a much better start.

There is always a danger that the new centre will be seen as an additional burden on the data collectors. They may not see benefits for themselves while having to do additional work to supply the centre with data. There is no universal solution to this problem. There are, however, some initiatives that can be taken to show mutual benefits:

- The centre should plan and demonstrate that it will have data management and other related expertise that is more specialized and focussed than that available to the data collectors. Thus, the data collectors can expect to receive benefits from working with the centre. The centre must then establish this expertise by recruitment or training and maintain it.
- The centre must also relieve the collecting organizations of some existing responsibilities. For example, if a collecting organization has to deal with the international community as well as local requests for data, the centre can take on that work for them.
- The centre must demonstrate that it can provide information on standards and on hardware and software technologies that will be useful to the collectors in improving their own data management.
- The centre must demonstrate that it will not be a roadblock in the data flow, but will improve efficiency.

An important step in the process is to build confidence that the centre will be established to serve, that it will have the expertise to fill a leading role in national oceanographic data management, and that it will work in a co-operative manner to ensure that the organizations that supply data will receive commensurate benefits for the work involved in supplying data to the centre.

Given the above ideas and principles the following steps are suggested as an outline on proceeding to establish an NODC.

Step 1. Recruit a team of interested parties (including potential clients and partners) to propose a mission and organizational model for the centre. This team should examine the missions of the organizations in the Member State or region that collect or use oceanographic data. Some of these organizations may be examined as a class (e.g., coastal engineering firms designing shore-based facilities of various sorts). This examination will also provide information on the potential client base. At this stage it is important to ensure that effective consultation occurs with all potential stakeholders including all levels of government (local, state and federal), industry, the science community, community interest groups, etc. Workshops may provide a suitable forum for the generation of ideas and directions.

Step 2. From this study construct a draft mission for the centre and review the opportunities for useful partnerships with existing organizations. Also review the needs of the centre for specific types of expertise and make a first attempt at defining a client base. This document should basically be a preliminary proposal for a national centre including a draft cost proposal. If possible look for some sort of governmental approval in principle pending a final formal proposal for the centre so that meaningful negotiations can be taken under Step 3 below.

Step 3. Conduct negotiations with the potential partners as to the possibilities for mutually beneficial partnerships or at least support for the establishment of the centre. During these negotiations the mission can be revised to reflect the partnerships. The expertise proposed for the centre can be modified as well.

Step 4. Do a study of the computer and communications hardware required and a final plan for the staff needed. Prepare a draft administrative organization. It will probably be necessary to have assistance from appropriate specialists for this step. Contracting for some of the experts is an option.

Step 5. Having a more final version of the mission and information on partnerships, prepare a final proposal for the centre for final approval. This proposal should include a high-level national data management plan for ocean data. Recruit the appropriate team to prepare it. Include a more detailed budget.

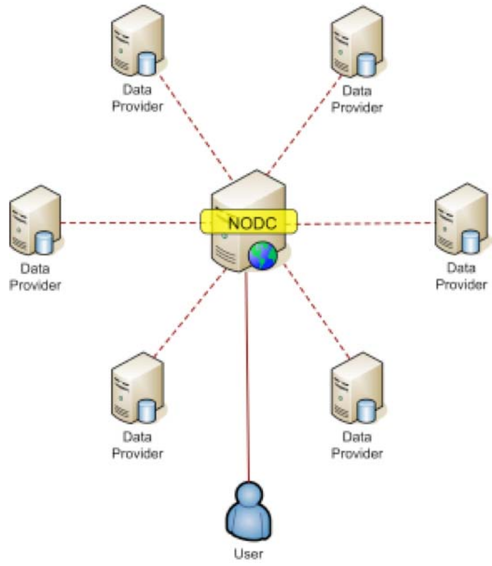
Step 6. Develop in consultation with the partners clear written agreements on the responsibilities of both sides. This will ensure that expectations are met in the future. If expectations are not met due to misunderstandings there will be difficulties in maintaining productive partnerships.

These steps and principles are suggestions for guidance only. Depending on the circumstances and administrative arrangements in the organization establishing the NODC, modifications may have to be made, or a completely different approach taken. Directors of NODCs in other countries could help with this process based on their experiences. Member States should not hesitate to contact NODCs in other countries or the IOC Secretariat for advice in developing their NODC.

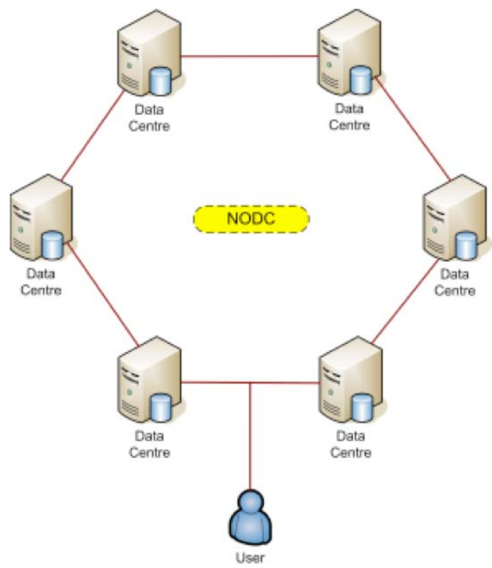
After the centre is approved and staffing is complete there will be an appreciable time before routine operation is achieved. There should be two main thrusts. The first will be to acquire and implement the computer and communications hardware and software. The second will be to make the centre visible to the client community.

In implementing the systems it is important to choose some goals that can be achieved earlier rather than later. There will be significant expectations within a broad community. It is not a good idea to implement a new centre and then not see anything produced for two years or more. It is important that visible progress becomes evident quickly. Even small steps that nevertheless show distinct progress will keep up interest in the centre. It is important not to promise more than can be delivered. This will maintain confidence in the client community and among partners.

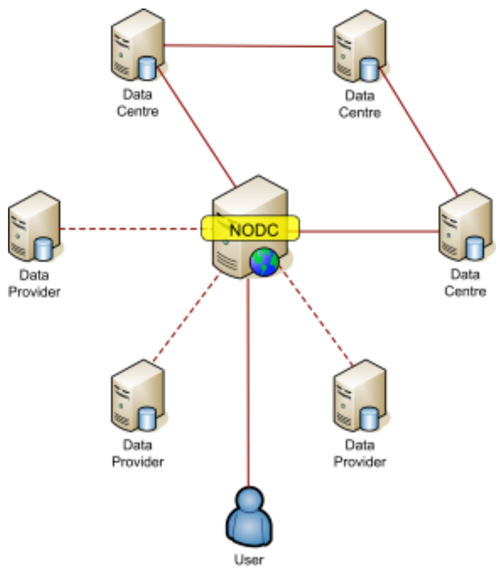
When considering the establishment of an NODC, there are different conceptual models that can be adopted. Figure 1 shows different conceptual models for national ocean data and information management arrangements.



Model 1: Centralized data centre model. Data providers (researchers, projects, research cruises, observation platforms) do not have data management capabilities. All data is sent to a central national oceanographic data centre (IODE NODC).



Model 2: Distributed data centre model. Each data provider has a data management capability. Data holdings remain with the originating data centre. The data are dynamically accessed through the internet rather than through a central repository. This model provides improved inter-agency cooperation and coordination with uniform data and metadata standards and protocols.



Model 3: Mixed data centre model. Some data providers do not have a data management capability and provide data to a central national oceanographic data centre (IODE NODC), Other data providers with a data management capability, link their data centre through a distributed network.

Figure 1: Conceptual models for national ocean data and information management arrangements

The choice of which model to adopt will be based on a variety of considerations. The distributed data centre model has several potential advantages. The first advantage is that data can be managed within the data centre where the expertise exists. For example, if the NODC is to maintain a database table of taxonomic protocols, this table could be maintained in a location where the national expertise is located. The second advantage is that the work required maintaining a distributed system can be shared amongst the partner organizations. There may also be savings in operating costs by not having to duplicate specific expertise.

The distributed model also takes into consideration the considerable volume of data that can be generated by operational oceanography programmes. These high volumes can no longer be managed by a single data centre. Using a web services approach, such as a data portal, to build a distributed network of data providers will also improve the ability to share and integrate oceanographic data and reinforce the concept of distributed data custodianship where each agency is responsible for providing access to datasets.

While the distributed model provides several advantages, it could present some constraints as it requires:

- High level of technology and coordination to setup the network and ensure its efficient functioning.
- Adoption of accepted standards and protocols to ensure interoperability across the different components of the distributed system.

The choice of a conceptual model should take into consideration the available technology and human resources to ensure the efficiency and sustainability of the system. The extensibility of the adopted model should also be considered.

5. THE IOC COMMITTEE ON INTERNATIONAL OCEANOGRAPHIC DATA AND INFORMATION EXCHANGE (IODE)

The IOC's International Oceanographic Data and Information Exchange (IODE) was established in **1961** to "*enhance marine research, exploitation and development by facilitating the exchange of oceanographic data and information between participating Member States and by meeting the needs of users for data and information products*". Formally the IODE started out as a Working Group on Oceanographic Data Exchange which was created by the First IOC Assembly (19-27 October 1961) through Resolution I-9. The Working Group became a Working Committee in 1973 through Resolution VIII-31, adopted by the 8th Session of the IOC Assembly (5-17 November 1973).

The IODE system forms a **worldwide service oriented network** consisting of DNAs (Designated National Agencies) and NODCs (National Oceanographic Data Centres), of which there are now 69 (in May 2008) (Figure 2). IODE collaborates closely with the ICSU system of World Data Centres (WDCs) that includes 4 WDCs dealing with marine data: Silver Spring, USA; Bremen, Germany; Obninsk, Russian Federation; and Tianjin, China.

Figure 2: The IODE network of National Oceanographic Data Centres (2008)

The objectives of the IODE Programme are:

(i) to facilitate and promote the exchange of all marine data and information including metadata, products and information in real-time, near real time and delayed mode;

(ii) to ensure the long term archival, management and services of all marine data and information;

(iii) to promote the use of international standards, and develop or help in the development of standards and methods for the global exchange of marine data and information, using the most appropriate information management and information technology;

(iv) to assist Member States to acquire the necessary capacity to manage marine data and information and become partners in the IODE network; and

(v) to support international scientific and operational marine programmes of IOC and WMO and their sponsor organisations with advice and data management services.

The IODE network has been able to collect, control the quality of, and archive millions of ocean observations, and makes these available to Member States. Whereas in the past IODE data centres focused mainly on physical oceanography data, the IODE Programme now gives attention to all ocean related data including physical oceanography, chemical, biological, etc.

IODE closely collaborates with, and services the needs of the other IOC and related programmes such as Ocean Sciences, GOOS and the Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM). IODE provides the data dissemination and archiving functions required to build an integrated ocean observing system.

Another major and long-term commitment of the IODE Programme is the long-term accessibility and archival of oceanographic data, metadata and information to safeguard present and future holdings against loss or degradation.

6. FORMAL PROCEDURE TO JOIN THE IODE NETWORK OF NATIONAL OCEANOGRAPHIC DATA CENTRES

The formal procedure to join the IODE network of National Oceanographic Data Centres includes the following steps:

1. At the national level a data centre should be designated as the IODE National Oceanographic Data Centre (IODE NODC). This centre should respond to the minimum requirements as defined in Chapter 4;
2. At the national level an IODE National Coordinator for Oceanographic Data Management should be nominated. This person should work at the IODE NODC;
3. A formal letter should be sent by the IOC Action Address[1] of the concerned IOC Member State to the IOC Executive Secretary, with a copy to the IODE Technical Secretary. This letter should inform the IOC Executive Secretary that the Member State wishes to join the IODE network of data centres. The letter should include the name and address of the data centre that is submitted for inclusion in the IODE network of data centres, as well as the name and full contact information of the nominated IODE National Coordinator for Oceanographic Data Management. In an annex to this letter there should be a report that documents the compliance of the submitted centre with the minimum requirements mentioned in (1).
4. A response will be sent by IOC, confirming the acceptance of the submission, or reasons why the submission could not be accepted.

Relevant Addresses:

IOC Executive Secretary
Intergovernmental Oceanographic Commission (IOC) of UNESCO
1, rue Miollis
75732 Cedex 15
France
Fax: +33 1 45 68 58 12
URL: http://ioc.unesco.org

IODE Technical Secretary
IOC Project Office for IODE
Wandelaarkaai 7
8400 Oostende
Belgium
Fax: +32 59 34 01 52
URL: http://www.iode.org

[1] The List of Action Addresses can be obtained from the IOC Secretariat. It is also available from the IOC web site (http://ioc.unesco.org)

7. DEVELOPING CAPACITY FOR DATA AND INFORMATION MANAGEMENT

The IODE has developed a capacity building strategy based on the Ocean Data and Information Network (ODIN). An ODIN links training, equipment and operational support in a regional context and provide a regional networking platform that can be used by all IOC programmes, such as, GOOS, IODE, ICAM, tsunami, HAB, etc.

The ODIN strategic approach involves the following elements:

(i) **provision of infrastructure** (equipment): whereas one should aim to involve national institutions that have the basic infrastructure that enables participation in the activities, certain specialized equipments (e.g. computer equipment, observation instruments, communication equipment….) may be provided to reinforce existing facilities;

(ii) **provision of training**: organization of regional training courses; providing travel and study grants;

(iii) **provision of operational support**: although one should aim to involve national institutions that have a clear mandate and related funding for the national government to undertake activities directly related to the activities, some supplementary funding can be provided to “jumpstart” project activities and develop demonstration products/services;

ODINs are highly focussed on the development of data and products and involve a multi-stakeholder approach. There is also a strong focus on the end-to-end process linking observations, data management and product development ensuring that the data centres fill existing needs. In addition, there is a focus on interpersonal and institutional networking where communication and outreach play a significant role. The ODINs bring together marine institutions from a region, to provide capacity building, establishing and maintaining national oceanographic data centres and improving collaboration.

The objectives of ODINs are:

(i) to provide assistance in the development of National Oceanographic Data Centres and regional networking;

(ii) to provide training opportunities in marine data and information management applying standard formats and methodologies as defined by IODE;

(iii) to assist in the development and maintenance of national, and regional metadata, information and data holding databases; and

(iv) to assist in the development and dissemination of marine data and information products and services responding to the needs of a wide variety of user groups using national and regional networks.

The success of the ODIN projects is widely recognized as an excellent model for capacity building at the regional level and the IOC Strategic Plan for Oceanographic Data and Information Management (see Section 9) recommends the ODIN model as the capacity building mechanism for the IOC Data and Information Management Strategy.

The ODIN network covers the following the following regions:

- **ODINAFRICA**. This network consists of marine related institutions from twenty-five IOC Member States from Africa (Algeria, Angola, Benin, Cameroon, Comoros, Congo, Cote D'Ivoire, Egypt, Gabon, Ghana, Guinea, Kenya, Madagascar, Mauritania, Mauritius, Morocco, Mozambique, Namibia, Nigeria, Senegal, Seychelles, South Africa, Tanzania, Togo, Tunisia).

- **ODINCARSA**. This network was established to create the means for mutual capacity-building in South America and the Caribbean and to develop a network for managing and exchanging oceanographic data and information within the regions. This network comprises nineteen IOC Member States (Argentina, Bahamas, Barbados, Belize, Brazil, Colombia, Chile, Cuba, Dominica, Ecuador, Haiti, Jamaica, Mexico, Nicaragua, Panama, Peru, Saint Lucia, Trinidad and Tobago, Venezuela).
- **ODINCINDIO**. This network aims at promoting and assisting with the development of data and information management capacity in national ocean research institutions in the Central Indian Ocean region. This network comprises sixteen IOC member states from the Central Indian Ocean region (Bangladesh, India, Indonesia, Iraq, Islamic Republic of Iran, Kuwait, Malaysia, Maldives, Myanmar, Oman, Pakistan, Qatar, Saudi Arabia, Sri Lanka, Thailand, United Arab Emirates).
- **ODINWESTPAC**. This network aims to develop products and services that will promote communication and collaboration between member states in the Western Pacific region and comprises twenty member states (Australia, China, Fiji, France, Indonesia, Japan, Malaysia, New Zealand, Philippines, DPR of Korea, Republic of Korea, Russian Federation, Western Samoa, Singapore, Solomon Islands, Thailand, Tonga, UK, USA, Vietnam).
- **ODINECET**. The network for European countries in economic transition constitutes a capacity building strategy for Eastern and Central European countries linking training, equipment and operational support in a regional context. The network is composed of six IOC Member States and one observer country (Bulgaria, Croatia, Estonia, Poland, Russia, Ukraine, Latvia (observer)).
- **ODINBlackSea**. The network for the Black Sea region will develop a capacity building instrument for further development of the NODC structure in the region and will support BlackSeaGOOS and other regional initiatives. The network comprises six member states (Bulgaria, Georgia, Romania, Russia, Turkey, Ukraine).
- ***ODIN-PI:*** *a new network is being prepared for small islands states in the Pacific region (starting 2008)*

Figure 2: The Ocean Data and Information Network (2008)

8. IOC STRATEGIC PLAN FOR OCEANOGRAPHIC DATA AND INFORMATION MANAGEMENT: IMPORTANCE FOR NODCs

The IOC Data and Information Management Strategy covers all data and information collected by IOC programmes. The vision is for:

"A comprehensive and integrated ocean data and information system, serving the broad and diverse needs of IOC Member States, for both routine and scientific use."

The concept of delivering a data and information service for the "**global ocean commons**" (i.e. global public good) is central to this vision

The objectives of the Strategy are to develop:

- A system that can receive data collected by all IOC programmes and projects and deliver them in a uniform and transparent way to all users
- A system that can collect bibliographic and factual information from all IOC programmes and projects and deliver them in a uniform and transparent way to all users

The IOC Data and Information Management System resulting from the strategy will deliver the following:

- Assembled, quality controlled and archived data on a diverse range of variables according to scientifically sound and well-documented standards and formats;
- Timely dissemination of data on a diverse range of variables (observations and model outputs) depending on the needs of user groups and their technical capabilities (automatic dissemination as well as "on demand"); and will
- Facilitate easy discovery and access to data on a diverse range of variables and derived products (including forecasts, alerts and warnings) by users who have a broad range of capabilities.

The IOC Data and Information Management System will, like that of the Global Earth Observing System of Systems (GEOSS), be a system of systems. Each of these should be an end-to-end system, handling data from the point of collection, through processing and quality control, to archival and dissemination. There is no "one size fits all", but by use of standards interoperability between the systems can be achieved. A fundamental concept is that, like GEOSS, the ocean or marine "system of systems" must be built on existing systems and initiatives with sufficient flexibility to encompass future systems. One system will not be suitable for all requirements and thus it is envisioned that a number of complementary end-to-end data systems will best address the vision. Increasingly standards are available, which have been designed elsewhere but which are applicable to ocean or marine data. These include those developed by the International Organization for Standardization (ISO), the World Wide Web Consortium (W3C) and the Open Geospatial Consortium (OGC).

The major elements of the Strategy are:

- Adherence to the IOC Oceanographic Data Exchange Policy;
- Acceptance and implementation of agreed interoperability arrangements including technical standards and specifications for processing, quality control, storing and disseminating shared data and information;

- A global network of data centres and related national distributed networks, and permanent long term data archiving centre(s) for all data, which operate to agreed standards, providing seamless access to data and information;
- Capacity building through continued development of Ocean Data and Information Networks (ODINs) whilst extending the OceanTeacher capacity building tool through cooperation with WMO, JCOMM and others as appropriate;
- Governance by an Advisory Group that brings together the various programme elements of IOC as well as of bodies and organizations collaborating closely with IOC

Communication and outreach must be a key element in the Data and Information Strategy, which will be addressed at various levels. Communication within and between IOC programmes, and with IOC's partners, is essential to ensure that a fully integrated data system rather than the current multitude of systems results. But IOC does not exist in isolation and cooperation and collaboration with other organizations with similar interests and goals is essential. Participation in meetings of other organisations undertaking similar initiatives and dissemination of information via the Internet are both essential methods of communication and outreach. Information about the IOC Data and Information Strategy, its development, data centres, standards, and implementation progress must be made available in an easy to understand form.

There are many IOC and IOC-related programmes and projects with a data management component. Presently there are also many mechanisms to coordinate the various individual ocean and marine data systems. Whilst these are essential to the continued operation of data management and exchange of the various data streams, an overarching coordination must be put into place to encourage adoption of standards, protocols, technologies, etc. IODE and the JCOMM Data Management Coordination Group (DMCG) should coordinate this effort, through the suggested Data and Information Management Advisory Group, and develop the implementation plan, building on the existing expert groups and continuing close links with groups external to IOC.

Indeed already there are many initiatives, which are making progress on the goals identified. This includes the development of the ISO19115 marine community profile for metadata and work on developing common vocabularies and ontologies. Increasingly there are moves towards service-oriented architecture and use of W3C, OGC and ISO standards. These should be continued. Further work is necessary on quality control. New technical groups may be required to solve some of the issues raised. Data assembly and archiving centres must be strengthened and properly resourced. A suite of metrics needs to be developed to enable assessment of the progress of the overall system and some over all data information unit or centre established, building on those which already exist.

The IOC Data and Information Management Strategy will build on existing systems, and will make every attempt not to re-invent the wheel. A fundamental concept is that, like GEOSS, the ocean or marine "system of systems" must be built on existing systems and initiatives with sufficient flexibility to encompass future systems.

The greatest challenge to be faced in developing and implementing the IOC Data and Information Management Strategy is one of coordination and cooperation among member countries, partners and user communities. There are currently still major barriers to the efficient use and re-use of data and to overcome these, and make the best use of the new technologies available, a culture change is required. The information technology required to meet most of the requirements of the strategy, whilst challenging, can be developed from existing capabilities through relatively straightforward software engineering. But the strategy will only succeed if all participants devote increased resources to cooperation, actively use the data and metadata standards, communications protocols, software, and policies that will knit the parts into an integrated whole.

The “IOC Strategic Plan for Oceanographic Data and Information Management” was adopted by the 24th Session of the IOC Assembly (2007) and is available as IOC Manuals and Guides No. 49 from the IODE web site (http://www.iode.org/strategy).

9. IOC DATA EXCHANGE POLICY

The exchange of oceanographic data is central to the mission of IODE and the free and unrestricted exchange of oceanographic data will ensure the maximum use is made of all available data. Open access to data and derived products can contribute to the beneficial public use and protection of the ocean environment, resources, protection of life and property and for the prediction of weather and climate.

The IOC Oceanographic Data Exchange policy, which was adopted as Resolution IOC-XXII-6 at the 22nd Session of the IOC Assembly in 2003 (see Box 1), promotes the free and open access to data, metadata and products, and aims to maximize the amount of data exchanged without infringing the rights of data originators.

The policy describes the recommended practices and associated institutional arrangements for the exchange of oceanographic data. This policy states that Member States shall provide timely, free and unrestricted access to all data, associated metadata and products generated under the auspices of IOC programs. The Policy aims to maximise the amount of data exchanged and promotes the use of National Oceanographic Data Centres as long-term repositories for data and metadata, and encourages capacity building.

Data centres that are part of the IODE network of National Oceanographic Data Centres are expected to comply with the IOC Oceanographic Data Exchange policy. The IOC Data Exchange Policy should be considered when developing a national policy that covers the exchange of oceanographic data. A variety of other programme, project, national and organisational data exchange policies also exist and as far as possible these should encourage the free and open access to data. Argo is a good example of a project with free and open access to all the data collected; real-time data are available within 24 hours and quality controlled data on a longer time scale.

The complete Resolution is available from the IODE web site at http://www.iode.org/policy .

BOX 1. IOC OCEANOGRAPHIC DATA EXCHANGE POLICY

Preamble: The timely, free and unrestricted international exchange of oceanographic data is essential for the efficient acquisition, integration and use of ocean observations gathered by the countries of the world for a wide variety of purposes including the prediction of weather and climate, the operational forecasting of the marine environment, the preservation of life, the mitigation of human-induced changes in the marine and coastal environment, as well as for the advancement of scientific understanding that makes this possible.

Recognising the vital importance of these purposes to all humankind and the role of IOC and its programmes in this regard, the Member States of the Intergovernmental Oceanographic Commission agree that the following clauses shall frame the IOC policy for the international exchange of oceanographic data and its associated metadata.

Clause 1: Member States shall provide timely, free and unrestricted access to all data, associated metadata and products generated under the auspices of IOC programmes.

Clause 2: Member States are encouraged to provide timely, free and unrestricted access to relevant data and associated metadata from non-IOC programmes that are essential for application to the preservation of life, beneficial public use and protection of the ocean environment, the forecasting of weather, the operational forecasting of the marine environment, the monitoring and modelling of climate and sustainable development in the marine environment.

Clause 3: Member States are encouraged to provide timely, free and unrestricted access to oceanographic data and associated metadata, as referred to in Clauses 1 and 2 above, for non-commercial use by the research and education communities, provided that any products or results of such use shall be published in the open literature without delay or restriction.

Clause 4: With the objective of encouraging the participation of governmental and non-governmental marine data-gathering bodies in international oceanographic data exchange and maximising the contribution of oceanographic data from all sources, this Policy acknowledges the right of Member States and data originators to determine the terms of such exchange, in a manner consistent with international conventions, where applicable.

Clause 5: Member States shall, to the best practicable degree, use data centres linked to IODE's NODC and WDC network as long-term repositories for oceanographic data and associated metadata. IOC programmes will co-operate with data contributors to ensure that data can be accepted into the appropriate systems and can meet quality requirements.

Clause 6: Member States shall enhance the capacity in developing countries to obtain and manage oceanographic data and information and assist them to benefit fully from the exchange of oceanographic data, associated metadata and products. This shall be achieved through the non-discriminatory transfer of technology and knowledge using appropriate means, including IOC's Training Education and Mutual Assistance (TEMA) programme and through other relevant IOC programmes.

Definitions

"Free and unrestricted" means non-discriminatory and without charge. "Without charge", in the context of this resolution, means at no more than the cost of reproduction and delivery, without charge for the data and products themselves.

"Data" consists of oceanographic observation data, derived data and gridded fields.

"Metadata" is "data about data" describing the content, quality, condition, and other characteristics of data.

"Non-commercial" means not conducted for profit, cost-recovery or re-sale.

"Timely" in this context means the distribution of data and/or products sufficiently rapidly to be of value for a given application.

"Product" means a value-added enhancement of data applied to a particular application.

10. LONG-TERM ARCHIVAL: THE ICSU WORLD DATA CENTRE SYSTEM

The ICSU World Data Centre (WDC) system consists of over forty designated World Data Centres, which collect, manage, and distribute a wide range of defined geophysical, solar and environmental data. The World Data Centre program was created during the International Geophysical Year of 1957-1958, and in 1968, ICSU (International Council for Science) established a Panel on World Data Centres to coordinate and monitor the activities of the centres. The WDC holdings include a wide range of solar, geophysical, environmental, and human dimensions data. These data cover timescales ranging from seconds to millennia and they provide baseline information for research in many ICSU disciplines, especially for monitoring changes in the geosphere and biosphere.

The World Data Centre system is decentralized and consists of largely discipline-specific data centres. It is the policy of the WDCs to make data freely open and available for scientific research. All World Data Centres are committed to the long-term retention of their holdings. Individual World Data Centres generally comply with national and international standards and work with suppliers and users to define preferred formats.

Among the many WDCs for different scientific disciplines, there are three WDCs for Oceanography and one for Marine Environmental Science. These are:

(i) World Data Centre for Oceanography, Silver Spring (USA)
(ii) World Data Centre for Oceanography, Obninsk (Russia)
(iii) World Data Centre for Oceanography, Tianjin (China)
(iv) World Data Centre for Marine Environmental Sciences, Bremen (Germany)

(i) World Data Centre for Oceanography, Silver Spring, (USA)

URL: http://www.nodc.noaa.gov/General/NODC-dataexch/NODC-wdca.html

Maintained by: U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA). The WDC for Oceanography, Silver Springs is operated by, and collocated with, the National Oceanographic Data Center (NODC).

Summary of Data Held: A variety of oceanographic sets, collected during international projects and routine observational programs. Examples are: International Geophysical Year: IGY and IGC oceanographic data 1957-1959; International projects: Data from the Tropical Atlantic (ICITA), Indian Ocean (IIOE) Programs, and the first GARP Global Experiment (FGGE). Data sets from Climate Research Programs (TOGA, WOCE, and JGOFS); Routine observations: Data from fixed stations and ship cruises since 1900; Nansen cast and salinity/ temperature/depth (STD/CTD) data, bathythermo-graph data, biological data, current measurements.

User Services: Open to visitors during normal working hours. Advance notice is recommended. NODC data processing facilities and data management services are available to users of the WDC-USA.

Data Publications: Annual reports of Oceanographic Data Exchange data catalogue to 1975, with Change Notices from 1975 onward; Accessioned Publications, 1957-1967 with biennial supplements; data reports and special catalogs for international oceanographic programs.

Data Products: Time Series Data Sets for the World's Oceans. Responsible National Oceanographic Data Center (RNODC) data sets for Integrated Global Ocean Services System (IGOSS), FGGE operational year, Drifting Buoy Data, Southern Oceans WOCE Upper Ocean Thermal Data Set, World Ocean Atlas 1994 (atlases and CDs), Atlas of Surface Marine Data 1994 (atlases and CDs).

(ii) World Data Centre for Oceanography, Obninsk (Russia)

URL: http://www.meteo.ru/nodc

Maintained by: Federal Service of Russia for Hydrometeorology and Monitoring of the Environment.

Summary of Data Held: Data from 15,771 research vessel cruises from 64 countries (including former Soviet Republics). These contain data from over 1,090,000 oceanographic stations, 565,000 bathythermograph profiles, 25,000 CTD profiles, and 4,000 deep sea and surface current meters for 1890-1994. The data are in the form of magnetic tapes, diskettes, CDROMs, and hard copies. Data can be transferred in standard formats to diskettes and magnetic tapes. Long term data series and quality controlled global and regional data sets are available.

User Services: The WDC-Russia provides copies of data and information products, information on incoming data; use of library, e-mail, fax and post.

Publications: Catalogs of data and information, annual reports of WDC-Russia activities and prospects.

(iii) World Data Centre for Oceanography, Tianjin (China)

URL: http://wdc-d.coi.gov.cn

Maintained by: State Oceanographic Administration, collocated with National Oceanographic Data and Information Center.

Summary of Data Held,: Data from domestic and international marine research projects, ships of opportunity, marine research vessels and offshore platforms: Oceanographic station data; Ocean current data; Wave data from coastal stations; T and S data; Cruise and data report of China-U.S.A. Joint Air-Sea Interaction: studies in the Western Tropical Pacific Ocean; Oceanographic observations at coastal stations, 1960-1982; Marine geophysical data; Side analysing marine sediments data; Marine geochemical data; Marine meteorological data from coastal stations; Marine ice data; Oceanic manganese nodule data; Marine biological data; Marine pollution data. User Services: Computer readable data and products on magnetic tape and/or disks are available.

Publications: Pacific Oceanographic Atlas, Atlantic Oceanographic Atlas, Indian Ocean Oceanographic Atlas, China-Japan Joint Research Program on the Kuroshio Oceanographic Atlas, Cruise and Data Report on China-U.S.A. Joint Air-Sea Interaction, Studies in the Western Tropical Pacific Ocean, Oceanographic Observations at Coast Station 1960-1978, Oceanographic observations 1954-1978, Oceanographic Standard Profiles 1960-1982, Tidal Current Table in China Sea, World and China Tide Tables, Oceanographic and Meteorological Observations at China Coast Stations 1960-1969.

(iv) World Data Centre for Marine Environmental Sciences, Bremen (Germany)

URL: http://www.pangaea.de/info

Maintained by: The Center for Marine Environmental Sciences (MARUM) at Bremen University and Foundation Alfred Wegener Institute for Polar and Marine Research (AWI).

Summary of Data Held: The WDC is aimed at collecting, scrutinizing, and disseminating data related to global change in the fields of environmental oceanography, marine geology, paleoceanography, and marine biology. It focuses on georeferenced data using the information system PANGAEA. The WDC stores and handles numeric, string, and image data. Users can retrieve data through the Internet via different gateways. Data are accepted in any format.

User Services: The WDC for Marine Environmental Sciences offers data management services, in particular project data management and data publication. It maintains an inventory of site and sampling locations for all related fields. It provides hosting and mirroring of electronic journals and serves software products for analyzing, visualization, and transformation of data. Visitors are welcome.

In addition, the following World Data Centres could potentially handle ocean science data (*Reference: Second SCOR Summit of International Marine Research Projects, 2006*):

- World Data Centre for Atmospheric Trace Gas, USA
  URL: http://mercury.ornl.gov/cdiac
- World Data Centre for Climate, Germany
  URL: http://wdc-climate.de
- World Data Centre for Marine Geology and Geophysics, USA
  URL: http://www.ngdc.noaa.gov/mgg/aboutmgg/aboutwdcmgg.html
- World Data Centre for Marine Geology and Geophysics, Russia
  URL: http://www.rfimnr.ru/projects/wdcmgg.html
- World Data Centre for Paleoclimatology, USA
  URL: http://www.ncdc.noaa.gov/paleo/datalist.html

ANNEX I

LIST OF ACRONYMS

DMCG	Data Management Coordination Group (JCOMM)
DNA	Designated National Agency
GEOSS	Global Earth Observation System of Systems
GOOS	Global Ocean Observing System
HAB	Harmful Algal Blooms programme
ICAM	Integrated Coastal Area Management
ICSU	International Council for Science
IOC	Intergovernmental Oceanographic Commission (of UNESCO)
IODE	International Oceanographic Data and Information Exchange
ISO	International Organization for Standardization
JCOMM	Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology
NODC	National Oceanographic Data Centre (IODE)
ODIN	Ocean Data and Information Network
ODINAFRICA	Ocean Data and Information Network for Africa
ODINBlackSea	Ocean Data and Information Network for the Black Sea
ODINCARSA	Ocean Data and Information Network for the Caribbean and South America
ODINECET	Ocean Data and Information Network for European Counties in Economic Transition
ODINCINDIO	Ocean Data and Information Network for the Central Indian Ocean
ODINWESTPAC	Ocean Data and Information Network for the Western Pacific region
OGC	Open Geospatial Consortium
UNESCO	United National Educational, Scientific and Cultural Organisation
WDC	World Data Centre (ICSU)
WMO	World Meteorological Organisation

Intergovernmental Oceanographic Commission (IOC)

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