United Nations
Educational, Scientific and
Cultural Organization

Intergovernmental
Oceanographic
Commission

Manuals and Guides 51

IOC strategic plan

for oceanographic data and information management (2008–2011)

UNESCO 2007

Oostende, 22 October 2007

For bibliographic purposes this document should be cited as follows:
IOC Strategic Plan for Oceanographic Data and Information Management (2008-2011). Paris, Intergovernmental Oceanographic Commission of UNESCO, 42 pp.
(IOC Manuals and Guides No. 51) (English)

Printed in 2008
By the United National Educations, Scientific and Cultural Organization
7, place de Fontenoy, 75352 Paris 07 SP

Printed in France

(IOC/2008/MG/51)

Table of Contents

EXECUTIVE SUMMARY

The IOC Data and Information Management Strategy is for all data and information collected in 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.

1. INTRODUCTION

The Intergovernmental Oceanographic Commission (IOC) of UNESCO provides its Member States with an essential mechanism for global cooperation in the study of the ocean. **The IOC promotes international cooperation and coordination of programmes in research, observing systems and services, and capacity-building, in order to learn more about the nature and resources of the ocean and coastal areas and to apply that knowledge for the improvement of management, sustainable development, the protection of the marine environment, and the decision making processes of its Member States**.

Within the context of IOC we use the following definitions for data and information:

- ***Data***: numbers (as in observations of temperature)
- ***Information***: text (as in scientific publications)

Most of the IOC programmes involve the collection of data. 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 publication, the data are a resource in their own right. Properly managed and preserved, they can potentially be used and re-used by future researchers, and exploited commercially or educationally. 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 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. In addition there is an increasing requirement for operational data in near-real-time for forecasting marine conditions.

Marine Science Libraries hold an important role in promoting information about the marine environment: scientific knowledge is exchanged between

scientists through scientific publications; information provision to the policy makers is crucial in order to enable them to make the best decisions regarding the protection and use of the marine environment; marine research information contributes to educating the next generation of environmental stewards; research literature and public information tools attract a future environmentally concerned workforce and generates an ocean literate public that understands the value of the ocean and can make appropriate decisions to protect it.

Research literature is increasingly produced and disseminated electronically (e-repositories). This creates challenges to the traditional publishing model but provides easier access to information to more people. Similarly marine libraries play an important role as clearing house systems for factual information (e.g. directories of institutions and researchers). On an international scale, networks of Marine Information Management (MIM) Centres, collaborating to develop products and services, strengthen our global understanding of ocean processes and conditions. The IOC/IODE's Marine Information Management activities and its main expert base, i.e. the Marine Librarians play a vital role in this knowledge cycle.

The scope of this Data and Information Strategy is comprehensive and **across all of the disciplines within the mandate of IOC**. There is no *a priori* separation of functions based on the lead time for data delivery (e.g., real-time versus delayed mode) or in the type of data. Different strategies might be employed to satisfy global, regional and local requirements, and to meet timeliness needs. At the present time, no coherent data management and communications strategy exists for effectively integrating the wide variety of complex marine environmental measurements and observations across disciplines, institutions, and temporal and spatial scales. As a result, we are denied important benefits that might otherwise be derived from these data, such as improved climate forecasts and more effective protection of coastal marine ecosystems.

This strategy has been developed **to ensure that those projects and programmes which come under the auspices and guidance of IOC are all covered by a common set of goals**. It takes into account those strategies already developed or under development, by for example, global GOOS, coastal GOOS and JCOMM (IOC-WMO), and also is in accordance with the developing GEO/GEOSS data and architecture concepts. In addition, programmes and projects sponsored or co-sponsored by IOC, which have developed data and information strategies have also been taken into account. These may include, for example, projects under the International Council for Science (ICSU). It is also compatible with other initiatives, for example, the Ocean Biogeographic Information System (OBIS) of the Census of Marine Life (CoML). The strategy covers all aspects of oceanographic data and information management including the marine information management undertaken by marine librarians, which provides the crucial link between data, information and the dissemination of knowledge.

The information technology required to meet most of the requirements of the IOC Data and Information Strategy, whilst challenging, can be developed from existing capabilities through relatively straightforward software engineering. The **greatest challenge** to be faced is one of **coordination and cooperation** among partners and user communities. It can succeed only if the participants devote increased resources to cooperation and actively use the data and metadata standards, communications protocols, software, and policies that will knit the parts into an integrated whole. The creation of a successful international data and information system will require a sustained effort, a commitment across the marine community, and continual coordination with other international bodies.

This document outlines the strategy for the next four years (2008-2011) and will be reviewed again after four years. The implementation of this Strategy is not addressed in this document.

2. OCEANOGRAPHIC DATA AND INFORMATION MANAGEMENT AND EXCHANGE IN THE IOC

2.1 THE INTERNATIONAL OCEANOGRAPHIC DATA AND INFORMATION EXCHANGE PROGRAMME (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 NODCs (National Oceanographic Data Centres) and DNAs (Designated National Agencies) and it collaborates closely with the ICSU system of World Data Centres (WDCs) of which there are now 51 with 4 WDCs dealing with marine data: Silver Spring, USA; Bremen, Germany; Obninsk, Russian Federation; and Tianjin, China. During the past 46 years, IOC Member States have established **65 oceanographic data centres** in IOC Member States (Figure 1).

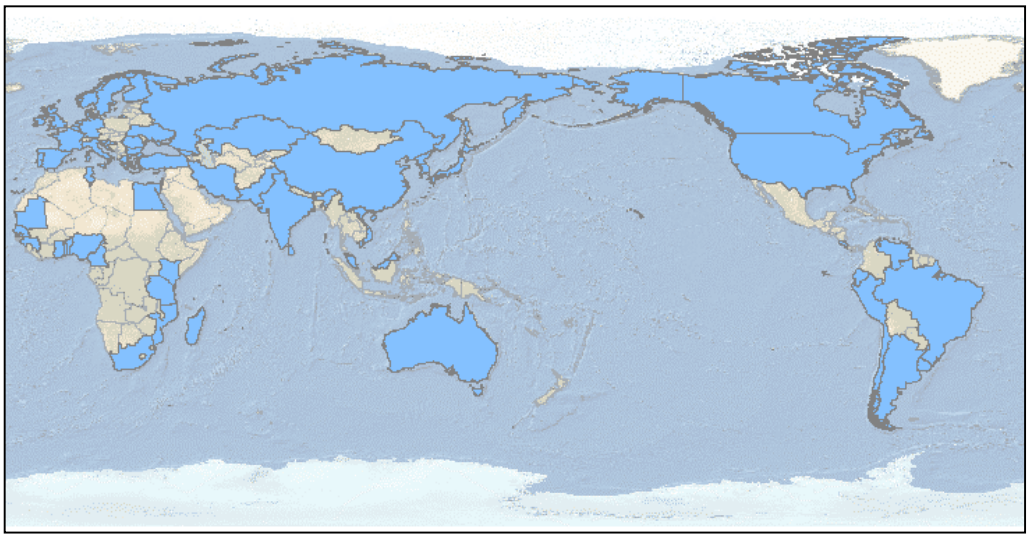

Figure 1: The IODE network of National Oceanographic Data Centres (2007)

The main objectives of the IODE Programme are (as *updated through Recommendation IODE-XVIII.1)*:

(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 now 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). A major and long-term commitment of the IODE Programme is to provide long term accessibility and archival of oceanographic data and the national level (through the NODCs) and to facilitate a global archive in cooperation with the ICSU World Data Centre system.

2.2 THE IODE REVIEW (2005)

The seventeenth Session of the IODE Committee (2003) recommended that a review of the IODE Programme be implemented. A review team was established, composed of seven international experts and chaired by Mr Dieter Kohnke. The report of the Review was submitted to the eighteenth Session of IODE (2005). The report includes 17 recommendations. They include, *inter alia*, a revision of the IODE objectives, revision of number of IODE Officers, overhaul of the IODE Groups of Experts, abolishing the Responsible National Oceanographic Data Centres (RNODCs), increased focus on quality control/quality assurance, increased focus on collaboration with scientific programmes, development of a global data set for long-term archival, abolishing of IODE regional coordinators.

As this was the first review of IODE since its creation in 1961, the review has had a considerable impact on the IODE programme and has substantially revitalized the programme. It is noted that an additional IODE Review was commissioned by UNESCO in 2007 (the report will be available by the end of 2007).

Within IODE the application of new information and communication technologies (ICT) for data and information management and dissemination has become fully mainstream. The traditional model with centralized data centres at national or global scale, is gradually being replaced by a distributed network of data centres accessible and searchable over the internet. Thanks to this distributed model scientists can participate more actively in the data management chain, and can also access data and information more easily. The model also enables a wider range of user communities to access data, data products and information. The global application of the new model and its inherent technology related to oceanographic data and information management requires the continuing development and fine-tuning of new standards and applications.

There are good examples of distributed national systems under development, for example in Australia, the Netherlands, Russia and the USA, and also regional systems (e.g. SeaDataNet). Additionally the data system for the components of the open ocean component of GOOS are well established. If cooperative programmes are developed around the pilot projects where research and data management organisations work together to design and build the data and information systems then considerable progress can be made, even in the existing financial climate. However it must be recognised that there is need for significant additional resources to be devoted to international data and information management for this strategy to be successful. Some of these resources will have to be new resources.

2.3 IODE AND CAPACITY BUILDING

Since its creation in 1961, IODE has always had a strong focus on capacity building. The reason for this can be found in the lack of formal training possibities in ocean data management; traditionally data management expertise is acquired in-house in the NODCs and passed on through generations. In comparison information management training is part of Librarian formal education. Training of national experts has been the driving force that has resulted in the establishment of 65 NODCs and DNAs (as at 2007) as well as the nomination of 32 National Coordinators for Marine Information Management, associated with national oceanographic libraries.

Traditionally IODE has undertaken capacity building through the organization of national, regional or global training courses; through the funding of internships and the funding of participation in international conferences and workshops related to ocean data and information management.

Since the late 1990s IODE designed a new way to develop capacity in (developing) member states. This new "strategy" is based upon four elements:

- providing equipment
- providing training
- providing seed funding for operational activities of newly created data centres and marine libraries
- working in a regional context, addressing common (regional) as well as individual (national) goals

This strategy has been implemented as **"Ocean Data and Information Networks" or ODINs**. The first region where the new strategy was tested was Africa (ODINAFRICA) (See Box 1). Similar networks in the Caribbean/South America (ODINCARSA), Indian Ocean (ODINCINDIO), European countries in economic transition (ODINECET), Western Pacific -WESTPAC region (ODINWESTPAC) and Black Sea region (ODINBlackSea) have subsequently been established.

BOX 1: THE OCEAN DATA AND INFORMATION NETWORK FOR AFRICA (ODINAFRICA)

The Ocean Data and Information Network for Africa (ODINAFRICA) brings together more than 40 marine related institutions from twenty five (25) Member States of the Intergovernmental Oceanographic Commission of UNESCO from Africa. The initial focus of ODINAFRICA was enabling member states from Africa to get access to data available in other data centres and scientific literature, develop skills for manipulation of data and preparation of data and information products, and develop infrastructure for archival, analysis and dissemination of the data and information products. Each of the participating institutions has developed a suite of data and information products that have been quality controlled, merged and availed through project website (*www.odinafrica.org*). These include: Directories of marine and freshwater professionals, Catalogues of marine related data sets, Marine Species data bases, library catalogues, catalogue of marine related publications from/about Africa.

The network has now broadened its scope to encompass upgrading of the coastal observation network, though installation of sea level stations, as well as development of data and information products required to address the key coastal management issues that have been identified by countries participating in the initiative. These include (i) coastal erosion, (ii) management of key ecosystems and habitats, (iii) pollution, (iv) sustainable use of living resources, and (v) tourism. Specialized training has been organized to equip the staff of the data centres with skills in the use of decision support tools such as modelling, remote sensing and GIS to develop scenarios and display results of data analyses.

An African Marine Atlas (www.africanmarineatlas.net) providing access to a wide range of marine related data and information, including maps and images was launched in February 2007. The atlas has over 800 downloadable data products derived from the fields of marine geo-sphere, hydrosphere, atmosphere, biosphere, geopolitical and the human socio-economic dimensions.

ODINAFRICA has harnessed the expertise available in the IODE network of data and information centres, together with the generous support provided by the Government of Flanders, Belgium to develop a network of data and information centres in Africa addressing the needs of a diverse user community.

It is important to note that ODINs do not focus just on the development of ocean data and information management capacity. **ODINs are end-to-end capacity development platforms which seek close collaboration with IOC ocean observation programmes (GOOS), IOC ocean science (Harmful Algal Bloom programme), IOC coastal management (ICAM), as well as with the WMO/IOC JCOMM and regional programmes such as NEPAD, CPPS and of course the GOOS regional alliances**.

ODINs are medium to large-scale projects that take 5-10 years to develop and come to fruition, and are dependent on extra-budgetary support from IOC Member States as well as donors. ODINAFRICA has received considerable financial support from the Government of Flanders (Belgium).

Training activities of the IODE Programme are organized either at the IOC Project Office for IODE in Ostend (Belgium) - since 2005 - or are hosted by IOC Member States who then often cover a substantial part of the cost (including participants' cost).

The success of the ODIN projects is widely recognized as an excellent model for capacity building at the regional level. **It is therefore recommended to utilize the ODIN model as the capacity building mechanism for the IOC Data and Information Management Strategy,** supplementing and contributing to the **"**IOC Principles and Strategy for Capacity Building" (Document INF-1211).

2.4 DATA MANAGEMENT IN IOC AND OTHER INTERNATIONAL PROGRAMMES

A strategy for IOC data and information management should cover a wide diversity of data and spatial and temporal scales, including operational data flows to the latest scientific research. It also needs to cover countries that are highly technically

developed alongside those that may have little infrastructure for managing and utilising data, data products and information.

Over the past forty seven years since the creation of the IOC, many ocean science and observation programmes and projects have been established. In 1961, the IOC established the IODE programme. Whereas the IODE, and especially its national oceanographic data centres (NODCs), has assumed responsibility for the data management tasks of many national and international ocean science and observation programmes and projects, many programmes and projects have developed their own data management activities, often without linkages to the IODE and its NODCs. In addition, other international organizations, programmes and projects have also developed data management programmes and activities with national, regional or global focus. The IOC Data and Information Management Strategy cannot be developed or implemented in isolation.

All programmes within IOC should have a data management component, which is developed within the programme and should be implemented in close collaboration and consultation with the IODE and its NODCs, so the considerable expertise available in these national structures, can be fully exploited. The IOC Data and Information Strategy will provide the framework in which these plans can be developed, and recommend the use of standards and the data centres where the data can reside.

The task of building a global, distributed ocean data system is complex and will require a culture change leading to a level of international cooperation that has not yet been seen. Every participant will need to make changes in their present practices to conform to the larger view. But the payoff would be large and shared by all. The key to this process is **agreement on standard practices and protocols.** Starting afresh is not an option, and the current systems need to evolve into an interoperable system. New technologies and ideas will be exploited to handle and deliver data to a wide range of users or clients. As with GEOSS, a system of systems is required

ANNEX I lists a (non-exhaustive) number of IOC programmes and related organisations that play a role in the collection and management of marine data and information.

2.4.1 JCOMM DATA MANAGEMENT

JCOMM was formed in 1999 with the merging of the activities of the WMO Commission for Marine Meteorology (CMM) and the Joint IOC/WMO Committee for the Integrated Global Ocean Services System (IGOSS). JCOMM is responsible for the development, implementation and maintenance of operational data collection and dissemination systems to meet the needs of traditional clients, the needs of GOOS and GCOS, and the needs of global science experiments such as CLIVAR. It is structured into three Programme Areas (PAs), one of which is the Data Management Programme Area (DMPA).

JCOMM has recently published its Data Management Strategy which covers elements in common with the IOC data and information management strategy, for example, data and information exchange, data processing and data access. There must be close collaboration between JCOMM and IODE to ensure that there is no duplication of effort and that synergies develop by sharing knowledge. JCOMM is concentrating on systems that deliver parameters for which a defined need has been established for global or regional programmes, and for which some international standards have been agreed for both coverage and accuracy.

Thus JCOMM DMPA and IODE have a number of similar objectives, though the range of types of data presently handled by JCOMM is more restricted. Because of these similar objectives, there are similar issues to address. There is overlap in both the kinds of data managed by JCOMM and IODE and the time scales on which those data are handled. Depending on national organization, there can be a high degree of cooperation between IODE and JCOMM. This cooperation is vital. The full suite of oceanographic and meteorological measurements is large and the work needed to manage the data is diverse. Where there is a high degree of overlap of interests in types of data, it is important to consider streamlined operations. In this spirit, IODE and JCOMM share the Expert Team on Data Management Practices (ETDMP) and coordinate its activities. Likewise, certain data management programmes of IODE, such as the Global Temperature and Salinity Profile Project (GTSPP), are jointly supported by JCOMM and IODE. There are other examples and it is important to identify and recognise these joint programmes.

2.5 THE IOC OCEANOGRAPHIC DATA EXCHANGE POLICY

The IOC Data and Information Management Strategy builds on the IOC Oceanographic Data Exchange policy (see Box 2), which promotes the free and open access to data, metadata and products. It will also be compatible with other international relevant data exchange policies which promote free and open access to data, for example, **WMO Resolution 40** which provides for the free and unrestricted sharing of data. Other examples are ICSU (including the World Data Centres) data sharing principles, ICES Data Exchange Policy, IPY Data Policy, Ocean Biogeographic Information System (OBIS), and the emerging GEO/GEOSS data policy. It is important to note that GEO/GEOSS asserts that the societal benefits of earth observations cannot be achieved without data sharing.

A variety of other programme, project, national and organisational data exchange policies also exist and as far as possible they should be encouraged to provide 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. Against this, it is important to ensure intellectual property rights are not compromised and scientific papers produced by those responsible for the data collection. In addition it is important to give proper credit to the data collectors and data must be properly referenced or cited.

BOX 2: 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.

3. THE STRATEGIC PLAN

3.1 WEAKNESSES IN EXISTING SYSTEMS

There are a number of shortfalls within the existing systems to deal with the broad range of applications, the operational requirements for data and information, the integration of satellite and *in situ* data, and an increased variety of physical, chemical, and biological parameters.

We can identify the following **needs**:

(i) There is a need to improve our ability to integrate regional and global data systems.
(ii) There is a need to improve the state of data management software in the centres now managing ocean data and information. Many of the software systems that are now operational in the data centres are not adequate to the job, although this is improving.
(iii) There is a need to take advantage of more sophisticated algorithms and software technologies to increase the amount of automation for data processing and quality control.
(iv) There is a need to provide the centre staff processing the data with graphic presentations and the power to interact effectively with the presentation and the databases behind them to significantly increase the sophistication of the processing and the volume of throughput. Progress in this area will allow increases in the volume of data handled with a minimum of increase in resources.

Some of the **problems** which currently exist include:

(i) There is no common way to **discover** data of interest no matter where in the world they are housed. Consequently users cannot exploit the full extent of knowledge embodied in these data.
(ii) Data and information are **duplicated** over and over again when we exchange our holdings with our partners. Each exchange often embodies a transcription of content with unplanned mistakes and losses. Users may well receive the same data from different places and they look different. This is confusing and wasteful.
(iii) There is no universal, common way for assessing or indicating the **quality of data** in our archives. What is more, it is still uncommon for detailed information about quality assessment procedures to be available. The result is that we and our users do not know how to judge the data that arrive and therefore usually reassess the data with our own procedures.
(iv) There is no common way to **name variables and attributes** of data. This means that when we exchange data, or data from two centres are delivered to a user, they have different labels. The client is forced to reconcile these differences in order to use the data.
(v) There is no universal, common **way to handle data from the variety of disciplines** that constitute our data holdings. Even worse, there is **no common way of handling data from the same disciplines**. For example, ocean profile data not only have different data formats in different centres but the underlying data structures are different. The result is that we even have problems mapping exchanged data and information from common instruments across data centres.

(vi) There are many standards in use; but these are often numerous and incompatible: there is no standardization between the data centres (metadata, data formats, quality control procedures,…).

Data management at this time, especially through GEOSS, has a high profile in the international area and, in some member states of IOC, at the national level. The willingness of other national and international organizations to participate in cooperative ventures is also at a high at this time.

It is therefore a good time for JCOMM and IODE to take a highly active role in expanding the capabilities and role of the existing systems by:

- Working more closely with remote sensing agencies, preparing integrated data products, implementing improved metadata directories and improved services on the web, and handling a broader suite of physical, chemical and biological parameters;
- Developing cooperative programmes with the research community to implement end-to-end systems for all the modules of GOOS; and
- Developing improved capacity building programmes in cooperation with other agencies such as the World Bank, UNEP, and UNDP.

3.2 THE NEED FOR A STRATEGY

Why is a strategy needed? The data and information system will make available the data and information needed to:

- Provide well described and accessible scientific data and information on ocean, coastal and inland waters and ecosystems in support of integrated resource management and conservation and sustainable use of marine resources;
- Support the information and data requirements for marine services, transportation, and navigation;
- Establish and enhance cooperation within and between IOC programmes and IOC partners towards the creation of a fully integrated data system;
- Ensure connectivity of, and encourage synergies between regional and global initiatives in data and information management;
- Undertake marine assessments and routinely provide indices on the “health” of the marine environment;
- Predict and mitigate the impact of natural and man-made hazards;
- Manage risk for operations in the coastal and open ocean, including the oil and gas industry;

What will the strategy deliver? 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”);
- Deliver *ad hoc*, as well as routine requests for data and products ("pull" as well as "push");

- 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;
- Integration of diverse data sets;
- Secure access to data;
- Coordination long term and reliable data preservation, archiving and accessibility;
- Collaboration with other intergovernmental bodies to ensure greater flexibility in timely and cost-effective access to data and information;
- Support IOC's commitment to its member countries and international organizations;
- Capacity in all IOC Member States to fully participate in, and benefit from IOC programmes and projects;
- Equitable access to data and information by all.

In a practical sense, the objective should be to make this future ocean data and information management system the system of choice for all ocean activities, particularly those of research programs. However, we are not starting from a clean sheet and it is essential that the future system is built around already existing and operational national, regional, and international systems.

3.3 VISION

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 service for the "**global ocean commons**" (i.e. global public good) is central to this vision. As with Global Earth Observation System of Systems (GEOSS), 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.

IOC is a participating organization within GEOSS, thus **it is essential that the IOC Data and Information Management Strategy is properly harmonized with GEOSS**, and that mutual benefit is gained from cooperation and interaction. Data management is a crucial cross cutting and underpinning activity across a broad range of the environmental sciences. IOC is also contributing to GEOSS through its involvement through IOC/WMO JCOMM involvement in WIS. WIS is a major component of GEOSS for ocean and marine meteorology.

3.4 OBJECTIVES

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

3.5 SCOPE

The scope of this Data and Information Management Strategy is **comprehensive and across all of the disciplines within the mandate of IOC**. All types of data and all time scales for data delivery (e.g. real-time versus delayed mode) are included. Different strategies might be employed to satisfy global, regional and local requirements, and to meet timeliness needs. We must move towards a coherent data management and communications strategy to enable us to integrate the wide variety of complex marine environmental measurements and observations across disciplines, institutions, and temporal and spatial scales.

4. IMPLEMENTING THE STRATEGY

4.1 STRUCTURE AND GOVERNANCE

There are existing governance structures in place for IODE and JCOMM, noting that JCOMM, being formed in 1999, has a new structure. IODE's structure has recently been revised as a result of the 2005 review. The IOC Strategic Plan for Oceanographic Data and Information Management will avoid destructive interference in the present arrangements but, at the same time, intends to provide a mechanism for an seamless interoperability of the now separate ocean data management activities. The Strategy recognises a broad set of requirements from the IOC and as such will need careful guidance, both in terms of management and in terms of technical and scientific guidance. The future ocean data and information system is ambitious and will need access to expert advice.

4.1.1 ADVISORY GROUP

In order to provide a coherent yet open ended governance system for the IOC's data and information management system, it is proposed to establish an "**IOC Data and Information Management Advisory Group**". This body will bring together the various programme elements of IOC (GOOS, IODE, tsunami, HAB, Ocean Carbon, ICAM, Capacity Development, GOOS GRAs, IODE ODINs,…) as well as of bodies and organizations collaborating closely with IOC (JCOMM, WMO, ICES, ICSU WDCs Oceanography,…). **Its main objective and responsibility will be to oversee the implementation of this Strategy.**

Figure 2 shows the proposed organogram, linking the various programmes and projects and their involvement in the Advisory Group.

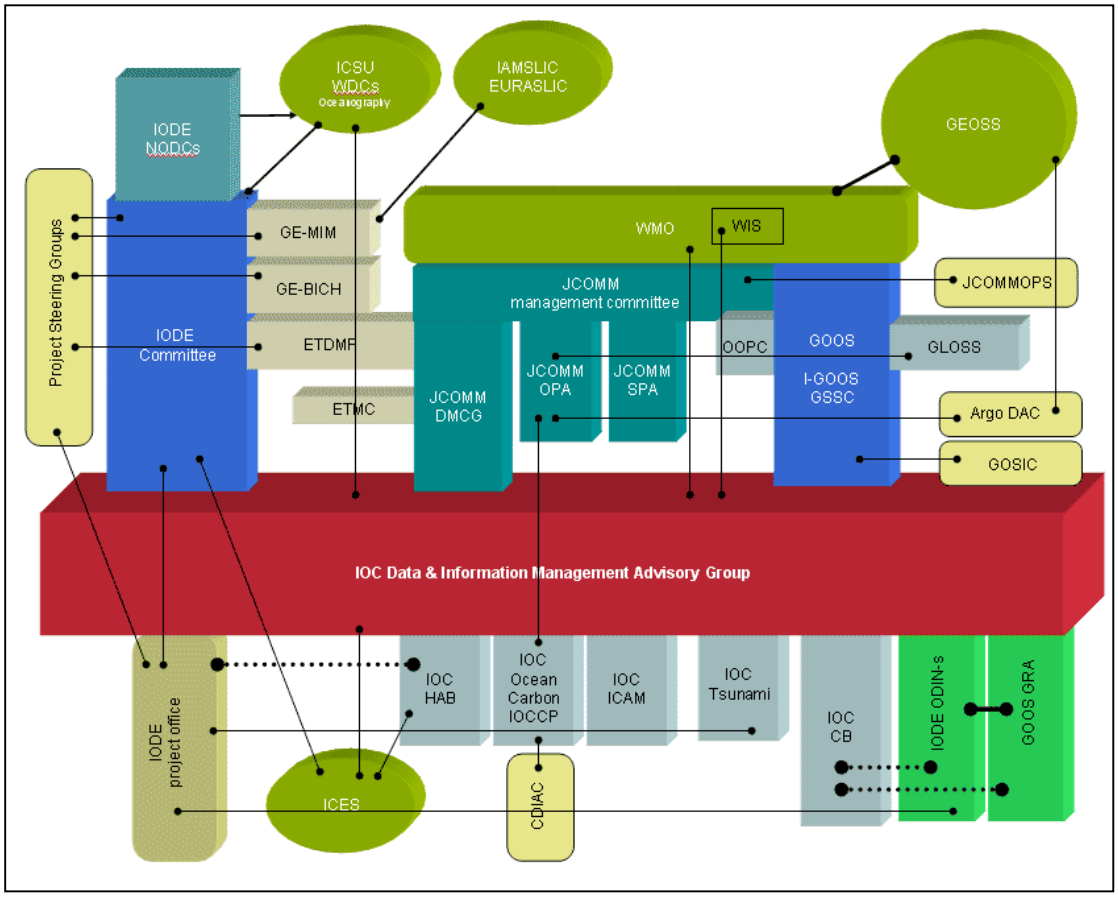

Figure 2: Organogram of the IOC Data and Information Management System

Note: For reasons of clarity the diagram in Figure 2 does not aim at completeness in terms of projects as there are many other projects that are not displayed here.

The following observations are made to further clarify the proposed architecture:

Input from IOC Programmes. The IOC Data and Information Management Strategy seeks to cover all data and information collected by IOC programmes. Thus it is crucial that there is input to the Advisory Group and evaluation and feedback on the progress towards delivery from the IOC Member States and from IOC Programmes.

Non-IOC Organizations and Programmes. The IOC Data and Information Management Strategy can not exist in isolation. It must take account of those other activities already in place and planned, not only within JCOMM and WMO, but also with other international initiatives such as GEO/GEOSS, ICSU, ICES, IAMSLIC, FAO, UNEP and others, as well as national or regional initiatives such as SeaDataNet, IOOS, Australia's Ocean Portal, etc., and encourage synergies between these initiatives.

Advisory Group. It is important that there be an efficient Advisory Group that reviews and endorses the activities of the data and information management program. The Advisory Group will "own" the Data and Information Management Strategy and be responsible for both its development and execution. This Advisory Group will be small (10-12) in order to be efficient, and able to draw in expertise as required.
Initial membership could include:

- Co-Chairs of IODE
- JCOMM DMPA Coordinator
- Representative WMO (WIS, CBS,..)
- Representative GOOS (GSSC, I-GOOS)
- Representatives IOC ocean science programmes (HAB, Ocean Carbon, ICAM, tsunami)
- Representative IOC capacity development programme
- Representative GOOS GRAs
- Representative IODE ODINs
- Representative ICSU WDCs Oceanography
- Representatives Project Offices (IODE project office, JCOMMOPS, GOSIC, CDIAC,…)

The membership may be revised by the Group.

It is important to note that the Advisory Group should be established as an e-group (electronic discussion group), preferably moderated, which will avoid costly meetings and provide sufficient flexibility to carry out its tasks in a timely and organized fashion.

Coordination and Support. The **IOC Project Office for IODE** has been established to provide a creative environment facilitating the further development and maintenance of IODE and partner data and information management projects, services and products with emphasis on improving the efficiency and effectiveness of the data and product/service stream between the stage of sampling and the user. The Project Office assists in strengthening the capacity of Member States to manage oceanographic data and information and to provide ocean data and information products and services required by users.

Implementing the IOC Data and Information Strategy will need coordination and secretariat support. This can be provided effectively by the IOC Project Office for IODE. A staff member of the Project Office should be included in the Advisory Group to act as **Secretary to the Group**, to ensure smooth dissemination of Advisory Group meeting reports, information on progress in implementing the strategy, metrics, etc. Additional support could be supplied by:

- The **JCOMM *in situ* Observing Platform Support Centre (JCOMMOPS)** which was established by JCOMM in 2001 to provide international coordination for oceanographic and marine observations from drifting buoys, moored buoys in the high seas, ships of opportunity, and sub-surface profiling floats. JCOMMOPS provides support to programme planning, implementation, and operations including information on: (i) observational data requirements, (ii) technology, instrumentation, and costs, (iii) operational status of observing networks, and (iv) deployment opportunities. JCOMMOPS is thus in a good position to provide metrics on the status of observing systems.
- **Global Observing Systems Information Center (GOSIC).** GOOS, along with GCOS and GTOS have established the Global Observing Systems Information Center (GOSIC) to provide on-line information about the collection, flow, and availability of data from the three global observing systems. This information is intended for use by the data collectors and data managers, by those evaluating the effectiveness and performance of the systems, and most importantly, by those who need the data for operational or research and engineering studies. GOSIC can provide further metrics via the IOC Project Office for IODE to the Advisory Group for wider dissemination.

4.1.2 TECHNICAL GUIDANCE

The Advisory Group is responsible for overseeing the implementation of the Strategy. To aid them in this task, a **Technical Task Team** may be required to provide expert advice on a number of technical issues relating to standards, including interoperability, web services, transport protocols and formats, metadata, vocabularies and ontologies, quality control, etc. Within both JCOMM and IODE, activities are either underway or in the process of being developed, to improve the efficiency and effectiveness of data management, including working more closely together, for example the joint JCOMM/IODE Expert Team on Data Management Practices (ETDMP). This strategy seeks to increase the impact and utility of this effort, building on the current developments and to provide a link with the WMO Information Service (WIS). This could be developed from the ETDMP. In addition to providing expert advice to the Advisory Group, the Technical Task Team will keep abreast of new standards and technological developments.

IODE has a number of global projects and technical working groups (e.g. ETDMP, GE-BICH, GE-MIM, SG-MEDI, SG-MarineXML, SG-OceanTeacher). These groups will carry out specific tasks as required to contribute to the implementation of the IOC Data and Information Management Strategy.

4.2 DATA CENTRES

National Oceanographic Data Centres (NODCs) form the backbone of the IODE system, and act as the national focal points for archiving, stewardship and dissemination of marine data. The NODC system has contributed greatly to the management of oceanographic data. NODCs can be either centralized or distributed facilities. Although they operate to the same main objectives of IODE, the NODCs have widely varying national remits and vary in size considerably.

It is also clear that **at the national level, there is a merging and blending of the formerly separate activities of ocean data exchange and archiving, as represented by the system of NODCs, and those associated with operational ocean and climate prediction**. The latter are often, but not always, associated with National Meteorological and Hydrological Services (NMHS). The IOC does not yet have the equivalent of National Ocean (prediction) Centres. This lack of a national focal point is an issue in terms of communication and in terms of organising and rationalising the activities of IOC. There is a gap between the technological advances and the products they make available, and the national arrangements to exploit this capability. This situation is beginning to change and, in terms of data management, there is the emergence of a framework within JCOMM of operational ocean data and product services. In some cases, nations have already taken steps that would realise more focussed structures.

Regional aspects of data and information management are extremely important. Consistent with the rationale outlined earlier, there appears to be a continuing need for regional and specialised centres, for both **data collection and assembly** and **product and information distribution**.

There are a number of different drivers for creating regional and specialised data and information centres:

- To serve the data and information management requirements of a GOOS Regional Alliance;
- To satisfy the requirements of an IOC-defined region or Regional Subsidiary Body;
- To satisfy the data and information requirements of other regional programs, e.g. a Large Marine Ecosystems (LME) or Regional Seas program;
- To satisfy a specialist requirement, e.g. a science program, a specific data service (e.g. sea level);
- Geopolitical, geographic or other forms of regional affinity (as noted in the UNESCO approach);
- To satisfy the requirements of WMO regional associations.

It is therefore a challenge for the data and information management strategy to determine an approach that is optimal in terms of regional effectiveness and efficiency. It is conceivable that the IOC could use its regional groups (regional subsidiary bodies, GOOS regional alliances, and/or ODINs) as a way of organising its regional approach, implementing procedures similar to those used by WMO. Under such an arrangement, there would be increased responsibility compared with the present circumstances. and, all data and information management activities would be given a home(s) within this structure.

The regional aspects of data and information management should derive from:

- A prominent, organised project or regional programme with a unique need for a specialised regional (or specialised) data and information service; or
- Demonstrable gains in efficiency and/or effectiveness in meeting the collective data and information service needs of a region; or
- Strong geographic or geopolitical drivers (support and needs) for a regional (specialised) ocean data and information service.

A **Regional Oceanographic Data Centre** would normally provide routine, long-term functionality in terms of data service. A **Specialised Oceanographic Data Centre** may be either long-term or finite, meeting a specific one-off need. In the latter case, there must be a clear strategy for transition of the functionality, including archived data, of a finite-term Specialised Oceanographic Data Centre in to a permanent system – for example a World Data Centre.

The World Data Centre System was created by the International Council for Science (ICSU) to safeguard a wide range of data for use by future generations. Among the many centres for different scientific disciplines, there are four World Data Centres for Oceanography: Obninsk (Russia), Silver Spring (USA), Tianjin (China) and Bremen (Germany). The World Data Centres for Oceanography receive oceanographic data and inventories from IODE NODCs, marine science organisations, and individual scientists. These data are collected and submitted voluntarily from national programmes, or from international co-operative ventures. It is important that the WDC system is maintained and operated as a permanent (long-term) archive**.**

Final data archives should be identified for all data sets whilst establishing the end-to-end data management systems, whether for operational data streams or research project data. As far as possible pre-existing centres should be built upon; this includes **IODE NODCs, ICSU WDCs and the Data Assembly Centres established by WOCE (and continued as CLIVAR, developed for Argo, and built on for GOSUD and OceanSites)**. If there are no suitable centres available, then new data centres can be established, according to pre-established guidelines and standards for data assembly (including metadata), quality control, archiving, and data dissemination (including data transport). Data can be of any type, i.e. not restricted to biological, chemical or physical, and of any latency although not all data centres will handle all types or latency of data. Links should be maintained with other non-marine data centres (e.g. those involved with or established by GEO/GEOSS, WMO/WIS, IPY, etc) and with CoML/OBIS.

Development of common archiving practices and standards with GOOS, JCOMM, IODE and the ICSU World Data Centre System will ensure IOC data and information are available for future needs.

Centres who take on the responsibility of an archive centre will be expected to take on the responsibility for the medium to long term. Perhaps centres should sign a memorandum of understanding (as some centres did for WOCE) making a commitment to certain activities for a certain period of time.

The minimum responsibilities for a permanent archive are generally that the archive agrees to:

- accept the data and all available supporting metadata
- to store it either in its original form or in a form from which all the original data and metadata can be recovered
- to refresh or update the medium on which the data and metadata are stored so that both are readable in the future
- to provide the data and all supporting metadata to users on request, free of charge or at the cost of reproduction
- to store the data sets so that it can be distinguished by programme, project, experiment, etc., and recovered separately from similar data.

A goal for the IOC Data and Information Management Strategy is that there should be a permanent long-term data archiving centre for all data, which operates to agreed standards. Those accepting the responsibility of permanent archives should adhere to a Data Archive Policy. An example policy is the proposed IOOS Data Archiving Policy (see Box 3).

BOX 3: IOOS Data Archive Policy

All facilities that participate as official archive centres in the Archive System will agree to adhere to data archiving guidelines that will be established in the phased implementation of the DMAC. A few key points that will be part of the guidelines are:

- Data distribution policies will follow the international recommendations of the IOC and WMO.
- Generally, the policy will call for full and open sharing of data and products. As a possible extension, the ability to provide restricted access for limited periods of time may be provided in certain cases;
- Data will be made accessible, to the greatest extent practical, on line and at no cost to the user.
- Data from off-line sources will similarly be available at no more than the cost of providing the service;
- Centres in the Archive System will make the data and metadata available using the DMAC transport protocols, metadata standards, and data discovery interfaces. The details of the transition from existing access systems to systems using the DMAC standards remain to be determined;
- The archive centres in the Archive System will have a data and metadata migration plan to accommodate media and system evolution and assure long-term preservation of irreplaceable data;
- All data collected and prepared under IOOS funding shall be submitted (or, in appropriate cases, notification of its availability shall be submitted) to the IOOS Archive System;
- As new versions (upgraded or changed) of a data set become available the versions will be distinguishable through standard metadata. Old versions can be deleted only under restrictive circumstances — when all relevant IOOS data policies and federal regulations are met.

4.3 OCEAN DATA PORTAL

The IODE is developing the Ocean Data Portal to facilitate and promote the exchange and dissemination of marine data and services. The Ocean Data Portal will **provide seamless access to collections and inventories of marine data from the IODE NODCs and other data centres in the network** and will allow for the discovery, evaluation (through visualisation and metadata review) and access to data via web services. The system architecture will use Web-oriented information technologies to access non-homogeneous and geographically distributed marine data and information.

The Ocean Data Portal will be developed in close cooperation with existing and developing initiatives such as the IODE/JCOMM E2EDM Pilot Project, SeaDataNet, WIS, Australian Oceans Portal, IOOS, Russian ESIMO and others. The Ocean Data Portal will also support the data access requirements of other IOC programme areas, including GOOS, JCOMM, HAB and the Tsunami warning system. The Ocean Data Portal development will also work closely with other international initiatives including WIS and GEOSS to ensure interoperability with other domains.

The Ocean Data Portal will deliver a standards-based infrastructure that provides the integration of marine data and information from a network of distributed IODE NODCs as well as the resources from other participating systems, as shown Figure 3 below.

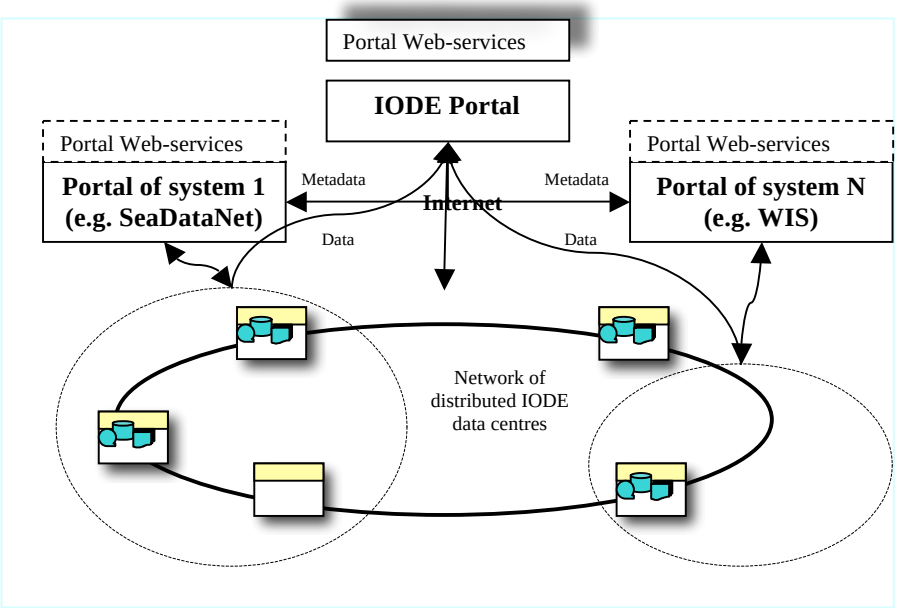

Figure 3. Proposed IODE Ocean Data Portal

The Ocean Data Portal will provide on-line access to the marine data and information resources of the participating data centres including:

(i) operational and delayed-mode data
(ii) data and services from the oceanographic and marine meteorological domains
(iii) data from multiple source formats and local data systems (DBMS, data files, GIS, electronic documents)
(iv) data from multiple providers in different geographic regions

The Ocean Data Portal will not create a new data system. The key principles of the Portal will be **interoperability with existing systems and resources**. It will serve to coordinate the view of ocean data resources so that WIS and GEOSS see a single entry point for ocean data rather than multiples. Participating data centres will need to accept and implement a set of agreed interoperable arrangements including the technical specifications and Web-services for the integration and shared use of the metadata, data and products. This interoperability will be achieved through the use of internationally endorsed standards (such as SOA, ISO and OGC) and it will not be a requirement for data centres to change their internal data management systems. The interoperability arrangements will be developed in close cooperation with existing and developing systems and will follow international standards and best practices.

The Ocean Data Portal will provide the full range of processes including data discovery, access, and visualization. The following functionality is envisaged:

- Data centres will generate discovery metadata about their datasets for distributed data search and retrieving.
- The Portal will periodically harvest these metadata, monitor the accessibility of a remote data sources and update the portal metadata catalogue.
- Users can access the system via a web browser and search for single or multiple data types from a distributed set of sources.
- Data requests will be sourced from the appropriate data centre and returned to the Portal.
- Portal tools will fuse the aggregated data and services in real time to produce a new product or service of value to the user.

The Ocean Data Portal will conform to open standards service-oriented architecture (SOA) and will include the following components:

(i) **Data providers.** Participating NODCs will form nodes on the IODE data centres network and will provide data and metadata to the Portal. Discovery metadata will be harvested from the contributing nodes to populate the Catalogue.
(ii) **Data Portal**. An interface to provide the ability to search for data from contributing data centres which will make available data discovery, visualization, content management and administration tools.
(iii) **Catalogue.** The metadata catalogue will provide a registry of existing data and services available from the data providers.

4.4 OCEANDOCS

Scientific publications of research findings are increasingly produced and disseminated electronically, either by commercial publishers, by research organizations or specialized research groups, or by research institutions. This creates challenges for the commercial publishers of (peer reviewed journals) as there is an increasing demand for, and access to, free on-line publications. However this changed publishing model also offers considerable opportunities to scientists and research organizations. The advances in technology now make it possible to search amongst thousands of e-repositories and to retrieve publications full-text and instantenously.

The objective of **OceanDocs** is to **make publications of marine science and oceanography more easily and freely accessible** to the ocean (and coastal area)

research and management community, to enhance scientific cooperation communication at the regional level. In particular to:

- Promote marine science and oceanography research at the regional and global level;
- Facilitate publishing of research findings by scientists (with special attention to scientists in developing countries);
- Ensure secure archival of marine science and oceanography publications.

OceanDocs enables researchers to **deposit the full text of their works**: articles, conference papers, technical reports, working papers, thesis and more. The information managers and librarians of the participating institutes will help the researchers with the submission of their publications.

OceanDocs is a service to enhance scientific communication in marine science and oceanography and will not interfere with the classical book and journal publishing methods. Researchers can publish in a scientific journal and at the same time submit their publication to OceanDocs. Nearly 90% of the international scientific journals accept the posting of the author's version of an article on a personal or institutional website even after it is accepted for publication.

OceanDocs is being developed as a distributed network of national repositories, hosted by Member States, as well as regional or international repositories (e,g, Aquatic Commons developed by IAMSLIC) and harvesters (e.g. IFREMER's Avano). Technical advice on requirements, technical implementation and management is provided by the IODE's GE-MIM.

Researchers in developing countries have a wealth of information available that often has not been published in widely available journals: e-repositories can be extremely powerful tools to expose this wealth. Capacity building to create the necessary expertise in all Member States to create institutional, national or regional e-repositories will be provided through ODINs.

A second service to be further developed and expanded is **OceanExpert**: the global directory of marine and freshwater professionals. This system is a "clearing house" providing professional information on ocean researchers and institutions.

4.5 STANDARDS AND BEST PRACTICES

The IOC Data and Information Management Strategy will encourage the adoption of existing and new standards to support broader data and information usability. Throughout IOC a number of effective single-purpose data and information systems exist. Such individual systems become even more effective and efficient when they are designed to work together - to be "interoperable". The focus of this interoperability should be the use of existing international standards organisations where ever possible.

The success of the Data and Information Strategy will depend on the acceptance and implementation of a set of interoperability arrangements, including technical specifications for collecting, processing, storing, and disseminating shared data, metadata and products. Interoperability should be based on non-proprietary standards, with preference given to formal international standards. As with GEOSS, interoperability will be focused on interfaces, defining only how system components

interface with each other and thereby minimising any impact on affected systems other than where such systems have interfaces to the shared architecture.

Data transport protocols. Various mechanisms are available or under development for data transfer and access via the internet. Improved handling of data and information is still required with better tools to manage received data. Computer security and firewalls are still an issue as is bandwidth and management of large data files. The IOC Data and Information Management Strategy should review the available transport mechanisms and adopt the most appropriate to its needs for each situation.

Web services. The development of a distributed network of oceanographic data centres will provide access to existing datasets in an interoperable environment using web services. Web services provide a standards-based interface for automated machine-to-machine, customized requests for access to distributed datasets. These standards include the Web Map Service (WMS) to compose and display map images from underlying data sources, as well as the Web Feature Service (WFS) and Web Coverage Service (WCS) to provide direct access to oceanographic data. The deployment of web services will provide seamless integration of data across a wide range of data providers.

Discovery Metadata. The importance of metadata attached to the observations in long term data sets has been recognised for some time. Most observation programmes now provide for metadata that describe data collection methods, instruments, quality control procedures applied, analyses done, etc. Metadata must be stored with the data and included when the data are provided to users. The development of effective metadata standards has been much improved by having both the scientists and data mangers involved in their specification. “Parent-child” hierarchies of metadata must be supported, since marine data are often managed as collections of observations that require description both as inventories and as individual observations. The IOC Data and Information Management Strategy must promote standardisation of discovery metadata, converging to the use of ISO19115/19139, and recommend suitable metadata tool(s).

Common vocabularies/ontologies. Controlled keywords (standardised topic names) and controlled vocabularies (standardised technical terminology) need to be adopted or developed. The breadth of scientific disciplines that are covered by the IOC Data and Information Management Strategy guarantees the existence of overlapping terminology, and therefore tools and techniques to perform translation among these controlled vocabularies are needed. The Strategy will promote the use of common standardised vocabularies and ontologies (guided by the Marine Metadata Interoperability project, including SeaVox).

Formats for data delivery. At present there are many data formats and more are created as required. The same data can appear in different forms with varied content. There is no “universal” data structure, although there is evidence of a slow convergence to a small number of data structures. This variety of formats and structures impedes combining different data in cross discipline analyses. Thus closer cooperation between different programmes is required and this will foster more rapid convergence of data structures. The need is to converge to a small number of “capable” data formats. The IOC Data and Information Management Strategy will promote exchange of data in an agreed small number of formats (e.g. netCDF, BUFR for GTS, ASCII (CSV), XML and OGC compliant web service output).

Quality control/assurance procedures. Assessing the quality of data is the act of judging how trustworthy are the observed values to represent what was measured. Good quality research depends on good quality data and good quality data depends on good quality control methods. Data quality control essentially and simply has the following objective:

> *"To ensure the data consistency within a single data set and within a collection of data sets and to ensure that the quality and errors of the data are apparent to the user who has sufficient information to assess its suitability for a task." (IOC/CEC Manual, 1993)*

The IOC Data and Information Management Strategy recommends best practice for quality control, documented (including a standard suite of automatic quality control tests), scientific (agreed by appropriate experts) quality control and a single quality flag scheme) that is easily accessible and available.

4.6 CAPACITY BUILDING

As already discussed under 2.3, the IODE Programme has a long and respected track record in capacity building. It is therefore recommended to utilize the ODIN model as the capacity building mechanism for the IOC data and information management strategy, supplementing and contributing to the **"**IOC principles and strategy for capacity-building".

Capacity building and sustainability are important aspects of the IOC Data and Information Strategy and IODE's record on capacity building includes the building of ODINs in the regions. It is essential that basic infrastructure is in place to allow data management to function effectively. It is also recommended to employ low-cost, mass-market technology for linking components wherever possible. An emphasis on "main-stream" rather than "special purpose" or "cutting edge research" technology can help to assure the cost-effectiveness and sustainability of implementations.

ODINs provide a valuable mechanism for assessing the current and potential state of development of national data centres and to create the means for mutual capacity building in a region. ODINs develop a cooperation network for managing and exchanging oceanographic data and information within the regions including contributing to ocean sciences, operational oceanography development and integrated coastal management and disaster reduction programmes at the regional level. ODINs also contribute to improving the provision of ocean data and information products and services to different users by sharing of expertise, knowledge transference and capacity building and aim to become useful platforms for other programs and organizations such as GOOS (including GOOS Regional Alliances), GCOS, LME, IAMSLIC, IAI, CPPS, JCOMM, ASFA and ICAM. They form the basis of a regional distributed data centre.

The IOC Project Office for IODE in Ostend, Belgium, is an excellent facility for capacity building activities. Its use should be encouraged for capacity building in data and information management across IOC and its collaborators. Already joint courses with JCOMM have taken place and this type of activity needs to be expanded. Fundamental to the IODE capacity building activities is **OceanTeacher.**

The objective of OceanTeacher is to provide training tools for Oceanographic Data and Information management. These tools are used traditionally during IODE Training Courses but can also be used for self-training and continuous professional

development. Since 2006 OceanTeacher has also been used as a repository for knowledge and training materials related to operational oceanography (GOOS) and marine meteorology (JCOMM). The OceanTeacher system is comprised of two components: (i) the Digital Library which contains a wide range of data and information management reference materials, including software, quality control and analysis strategies, and documents, and (ii) the Training Modules, a collection of outlines, notes, examples, and miscellaneous documents used in conjunction with the Digital Library during group training courses

The IOC Data and Information Management Strategy will continue to develop ODINs backed up by OceanTeacher as a capacity building tool, whilst extending OceanTeacher through cooperation with WMO, JCOMM and other programmes as appropriate.

4.7 COMMUNICATION AND OUTREACH

Communication and outreach must be a key element in the IOC Data and Information Management Strategy and it must 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 organisations with similar interests and goals is essential. This must include explaining the strategy and convincing others to become a part of it. Thus it is important for representatives to attend meetings of other organisations undertaking similar initiatives and encourage even greater cooperation. Dissemination of information via the web is a further essential method 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.

For the IOC Data and Information Strategy to succeed it must achieve acceptance and recognition by both data providers and data user communities. The only effective mechanism for this to succeed will be by methods of gentle persuasion which allow those working in pursuit of their organisation specific goals to perceive that being part of the strategy will lead to a net gain toward achieving those goals. Thus, one of the greatest challenges for initial acceptance and adoption of the Strategy and its implementation are in the areas of community outreach and organisational behaviour (the factors that enable a community to agree upon and use standards) rather than in technology.

There will also need to be a continuous, vigorous outreach process addressing all levels of users of marine data and information, emphasising the benefits of participation and helping to identify and remedy difficulties encountered by those who are participating. In addition, this process will identify and address changing user requirements. True end users are generally not information technology specialists, but professionals who rely on information that has been developed from data by other professionals.

The users of marine information include research scientists, policy makers, students at all levels, educators, industry and businesses. Marine information management centres interact with marine data managers to deliver information products, for example, data that has been processed and interpreted. The data may be repackaged in the form of electronic citation databases, internet bibliographies, regional repositories of stored and accessible scientific research, online catalogues of specialised collections, or digitised collections of difficult to find scientific studies.

In order to reach the highest possible effectiveness and impact it will be appropriate to create partnerships with other organizations (governmental, non-governmental and international).

ANNEX I

DATA MANAGEMENT IN IOC AND OTHER INTERNATIONAL PROGRAMMES

International Oceanographic Data and Information Exchange (IODE)
The International Oceanographic Data and Information Exchange (IODE) programme has established 65 National Oceanographic Data Centres (NODC) since it was established in 1961. Although they operate to a set of common principles, the NODCs have widely varying national remits and vary in size from one person to well over one hundred. The NODC system has contributed greatly to the management of oceanographic data. Most NODCs receive data from government and academic agencies and a smaller proportion (approximately one-third) also receive data from privately funded research institutions and/or from industry. Most centres provide quality controlled delayed-mode data. In addition, over half of these offer on-line data. They are increasingly handling a wide range of data types, including physical, chemical and biological data, marine meteorology and atmospheric data, geological and geophysical data and some handle real-time data and data relevant to GOOS. (URL: http://www.iode.org)

Ocean Data and Information Networks (ODINs)
Since the late 1990s a new IODE capacity building strategy was developed: the Ocean Data and Information Network (ODIN). The ODINs bring together marine institutions from a region, to provide capacity building, establishing and maintaining national oceanographic data centres and improving collaboration. ODINs link training, equipment and operational support in a regional context and provides a regional networking platform that can be used by IOC programmes, such as, GOOS, IODE, ICAM, tsunami, HAB, etc. ODINs are highly focused 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 inter-personal and institutional networking. Communication and outreach play a significant role.

Open ocean component of GOOS (implemented through JCOMM)
GOOS is a permanent global system for observations, modelling and analysis of marine and ocean variables to support operational ocean services worldwide. Data management systems exist for a number of the data streams for the open ocean part of GOOS. Examples include the ship of opportunity programme (including GTSPP), data buoys (through DBCP), sea level (through GLOSS) and Argo.

- **Global Temperature Salinity Profile Project.** The Global Temperature Salinity Profile Project (GTSPP) is a cooperative international project. It seeks to develop and maintain a global ocean Temperature-Salinity (T-S) resource with data that are both up-to-date and of the highest quality possible. Making global measurements of ocean T-S quickly and easily accessible to users is the primary goal of the GTSPP. Both real-time data transmitted over the Global Telecommunications System (GTS), and delayed-mode data received by the U.S. NODC are acquired and incorporated into a continuously managed database. (URL: http://www.nodc.noaa.gov/GTSPP/gtspp-home.html)
- **Data Buoy Cooperation Panel.** The Data Buoy Cooperation Panel (DBCP) is an official joint body of the WMO and the IOC which was formally established in 1985. The principal objectives of the DBCP are: to

(i) review and analyse requirements for buoy data, (ii) co-ordinate and facilitate deployment programmes to meet requirements, (iii) initiate and support action groups, and (iv) improve the quantity and quality of buoy data distributed onto the Global Telecommunication System (GTS). Drifting buoy data is currently managed by Integrated Science Data Management, Department of Fisheries and Oceans, Canada. (URL: http://www.dbcp.noaa.gov/dbcp/index.html)

- **Global Sea Level Observing System.** The Global Sea Level Observing System (GLOSS) is an international programme conducted under the auspices of JCOMM to establish high quality global and regional sea level networks for application to climate, oceanographic and coastal sea level research. GLOSS, in collaboration with IODE, has initiated a data archaeology project aimed at the rescue of sea level information available only in paper form and its conversion into computer-accessible form. (URL: http://www.gloss-sealevel.org/)
- **Argo Data System.** Argo is an international project to collect information on the temperature and salinity of the upper part of the world's oceans. Argo uses a global array of 3000 robotic floats to measure temperature and salinity and will provide a quantitative description of the evolving state of the upper ocean and the patterns of ocean climate variability. Argo has an international Steering Team and a Data Management Team made up of scientists from countries involved in Argo. (URL: http://www.argo.ucsd.edu/)

Coastal component of GOOS (implemented through GOOS Regional Alliances)
The coastal module of GOOS will contribute to the understanding of the effects of human activity, climate change and natural disasters in coastal systems. Coastal GOOS will develop a data communications and management subsystem (DMS) for the discovery and delivery of data within GOOS and for interoperability with other relevant observing systems and research programmes. The development of the coastal GOOS DMS will be facilitated by the formation of a planned Data Management Working Group (DMWG)[1] in collaboration with the IODE and the JCOMM Data Management Programme Area. The DMWG will formulate guidelines for system development, promote the establishment of standards and protocols, define metrics and encourage pilot projects. (URL: http://www.ioc-goos.org/content/view/14/28/)

The IOC Harmful Algal Bloom Programme
The Harmful Algal Bloom Programme (HAB) seeks to foster the effective management of, and scientific research on, harmful algal blooms in order to understand their causes, predict their occurrences, and mitigate their effects. Over the past 10 years, IOC HAB has established a number of data products including (i) Harmful Algal Event Database (HAE-DAT), (ii) IOC Taxonomic Reference List of Toxic Plankton Algae, (iii) International Directory of Experts in Harmful Algae and Their Effects on Fisheries and Public Health, and (iv) IOC Bibliographic HAB Database. (URL: http://ioc.unesco.org/hab/).

Working Group on Coral Bleaching and Local Ecological Responses
The goal of this Group is to integrate, synthesize and develop global research on coral bleaching and related ecological impacts of climate change on coral ecosystems, and further new research findings into development of tools and techniques for improved observations, predictions and management interventions at national and global scales. (URL: http://ioc.unesco.org/coralbleaching/).

[1] From: An Implementation Strategy for the Coastal Module of the Global Ocean Observing System, (2005), GOOS Report No 148

IOC Study Group on Benthic Indicators
The aim of this study group is to develop robust indicators of benthic health. The expected output will be a series of indicators, such as geo-chemical markers which reflect biological conditions, that is easy to use and broadly applicable in detecting stress of benthic communities. An online database with synoptic data on macroinfaunal communities and environmental conditions from different coastal regions of the world is currently under development. (URL: http://ioc.unesco.org/benthicindicators/)

Large Marine Ecosystems
Large Marine Ecosystems (LME) are regions of ocean and coastal space that encompass river basins and estuaries and extend out to the seaward boundary of continental shelves and the seaward margins of coastal current systems. LMEs have been delineated according to continuities in their physical and biological characteristics, including *inter alia*: bathymetry, hydrography, productivity and trophically dependent populations. The LME as an organizational unit facilitates management and governance strategies that recognize the ecosystem's numerous biological and physical elements and the complex dynamics that exist amongst and between them. (URL: http://www.lme.noaa.gov/Portal/)

Global Ocean Ecosystems Dynamics
Global Ocean Ecosystems Dynamics (GLOBEC) is an international response to the need to understand how global change will affect the abundance, diversity and productivity of marine populations comprising a major component of oceanic ecosystems. The primary goal for GLOBEC is to advance the understanding of the structure and functioning of the global ocean ecosystem, its major subsystems, and its response to physical forcing so that a capability can be developed to forecast the responses of the marine ecosystem to global change. GLOBEC uses a decentralised data management system where metadata is held in a central database and individual projects are responsible for quality control and archiving their data. The GLOBEC Data Policy focuses on data and metadata sharing, the responsible archiving of data and inventory and cataloguing activities. It gives National and Regional GLOBEC programmes a framework from which to construct their own detailed data management policies and to address issues such as long term archival of the data to ensure that GLOBEC makes a lasting contribution to marine science. (URL: http://www.globec.org/)

World Climate Research Programme
The World Climate Research Programme (WCRP) is sponsored by ICSU, WMO and IOC. The two main objectives of the WCRP are (i) to determine the predictability of climate; and (ii) to determine the effect of human activities on climate. The WCRP covers studies of the global atmosphere, oceans, sea- and land-ice, the biosphere and the land surface. WCRP has established a task force on data management to develop common data management activities, to ensure availability of data for assimilation, and to develop new assimilation techniques. (URL http://wcrp.wmo.int/)

Ocean Observations Panel for Climate
The Ocean Observations Panel for Climate (OOPC) is a scientific expert advisory group charged with making recommendations for a sustained global ocean observing system for climate in support of the goals of its sponsors. The OOPC is sponsored by GCOS, GOOS and WCRP. The Panel also aids in the development of strategies for evaluation and evolution of the system and of its recommendations, and supports

global ocean observing activities by interested parties through liaison and advocacy for the agreed observing plans. (URL: http://ioc.unesco.org/oopc/)

International Ocean Carbon Coordination Project
The International Ocean Carbon Coordination Project (IOCCP), co-sponsored by IOC and SCOR, promotes the development of a global network of ocean carbon observations for research through technical coordination and communication services, international agreements on standards and methods, advocacy, and links to the global observing systems. (URL: http://www.ioc.unesco.org/ioccp/)

International Ocean Colour Coordinating Group
The main objectives of the International Ocean Colour Coordinating Group (IOCCG) are to develop consensus and synthesis at the world scale in the subject area of satellite ocean colour. Specialised scientific working groups are established by the IOCCG to investigate various aspects of ocean-colour technology and its applications, and to publish IOCCG Monographs on their findings. The IOCCG also has a strong interest in capacity building, and conducts and sponsors advanced training courses on applications of ocean-colour data in various developing countries. (URL: http://www.ioccg.org/)

Integrated Coastal Area Management
Integrated Coastal Area Management (ICAM) is an interdisciplinary activity where natural and social scientists, coastal managers and policy makers focus on how to manage the diverse problems of coastal areas. The objectives of ICAM are to address coastal zone problems through activities of a more cooperative, coordinated and interdisciplinary nature, and ensure good coordination among existing IOC efforts related to the coastal zone. The programme also aims to provide a mechanism to promote interaction between IOC programmes related to ICAM and those of other international organisations, between marine natural scientists and social scientists, as well as between scientists and coastal managers and policy-makers. (URL: http://ioc.unesco.org/icam/)

Joint IOC/WMO Technical Commission for Oceanography and Marine Meteorology
The Joint IOC/WMO Technical Commission for Oceanography and Marine Meteorology (JCOMM) coordinates, regulates and manages a fully integrated marine observing, data management and services system that uses state-of-the-art technologies and capabilities, is responsive to the evolving needs of all users of marine data and products, and includes an outreach programme to enhance the national capacity of all maritime countries. It works closely with partners including IODE, GOOS and GCOS. The Data Management Programme Area (DMPA) will implement and maintain a fully integrated end-to-end data management (E2EDM) system across the entire marine meteorology and oceanographic community. The DMPA provides expertise to assist other groups to specify and implement their own data management requirements, with the overall goal of integrating their data management into the E2EDM system. (URL: http://ioc.unesco.org/jcomm/)

WMO Information System
The WMO Information System (WIS) is an overarching approach and a single coordinated global infrastructure for the collection, distribution, retrieval of, and access to data and information of all WMO and related programmes. It will help WMO to avoid data incompatibilities, and problems in the sharing of data between various programmes. It will ensure interoperability of information systems between WMO programmes and outside of the WMO community. JCOMM is closely linked with the development of WIS and the DMPA had already taken some steps that

compliment the work of WIS through its support of the E2EDM (End to End Data Management) pilot project (a joint IODE-JCOMM activity). (URL: http://www.wmo.ch/web/www/WISweb/home.html)

Global Earth Observation System of Systems
The intergovernmental Group on Earth Observations (GEO) is leading a worldwide effort to build a Global Earth Observation System of Systems (GEOSS) over the next 10 years. The purpose of GEOSS is to achieve comprehensive, coordinated and sustained observations of the Earth system, in order to improve monitoring of the state of the Earth, increase understanding of Earth processes, and enhance prediction of the behaviour of the Earth system. GEOSS will meet the need for timely, quality long term global information as a basis for sound decision making, and will enhance delivery in nine societal benefit areas.

To manage data, GEOSS will facilitate the development and availability of shared data, metadata, and products commonly required across diverse societal benefit areas. GEOSS will encourage the adoption of existing and new standards to support broader data and information usability. GEOSS will draw on existing Spatial Data Infrastructure (SDI) components as institutional and technical precedents in areas such as geodetic reference frames, common geographic data, and standard protocols. IOC can benefit from collaborating closely with GEOSS, in particular with the Data and Architecture Committee as it develops. IOC should be at the forefront in contributing to the marine data component of GEOSS. (URL: http://www.earthobservations.org/)

International Council for Science (including World Data Centres)
The International Council for Science (ICSU) is a non-governmental organization representing a global membership that includes both national scientific bodies and international scientific unions. ICSU has established a number of bodies that specialize in scientific data and information issues at an international level. The World Data Centre (WDC) system comprises 52 centres in 12 countries that provide access to geophysical and environmental data to all scientists for free or for the cost of reproduction. The centres also assure the long-term archiving and preservation of data and work with data to improve their quality. The WDC mandate has been to act as the global archive for data, and as such, rely on data exchange agreements with national data centres. There are three WDCs for oceanography located in the USA, Russia and China. In addition, more recently a WDC for Marine Environmental Data has been set up in Germany. Besides ensuring the safe keeping and dissemination of the data, they are also in a position to create or collaborate on the production of climatologies. (URL: http://www.ngdc.noaa.gov/wdc/)

International Polar Year
The International Polar Year 2007-2008 (IPY 2007-2008) is one of the largest international scientific programmes with over 50,000 scientists, technicians, crew members and other participants from 60 nations participating in scientific activities in both polar regions. IPY has a total of 170 coordination projects with 39 of these projects being oceanographic projects, in both polar regions. The dataflow generated by these projects will be large and will continue after the IPY period. The IOC is a strong supporter of the International Polar Year. Involvement has come at the level of IOC governing bodies, programs, secretariat and member states. The IODE Committee has endorsed the data management activities for the oceanographic IPY projects and all NODCs from countries active in the polar regions have been requested to coordinate activities with the national IPY committees and provide oceanographic data management assistance where possible. IPY may very well act as a stimulus to increase the awareness for the importance of data management and be

an opportunity for NODCs to obtain additional resources. (URL: http://ioc.unesco.org/ipy/)

International Council for the Exploration of the Sea

International Council for the Exploration of the Sea (ICES), initiated in 1902, is the oldest international treaty organization and the oldest intergovernmental oceanographic agency. Data are kept in the areas of biology/fisheries, marine pollution and classical hydrography. ICES is principally concerned with providing scientific support for international ocean management. ICES has developed a new data strategy to cope with much broader, larger sets of data in its future work and has an important data management role to play both as a data steward and provider of access to distributed data. Three strategic data management goals have been identified as (i) ICES will remain a focal point for marine data in the North Atlantic, (ii) ICES will create a portal serving as a hub for distributed data, and (iii) the ICES web portal will become more attractive to the science community**.** ICES and the IOC have entered into a Memorandum of Understanding which specifically emphasises "co-operation in the field of data and information management, including development of marine information technologies". IOC collaborates with ICES to ensure that common standards are in place. (URL: http://www.ices.dk/datacentre/data_intro.asp)

Ocean Biogeographic Information System

The Ocean Biogeographic Information System (OBIS) is the data management programme of the Census of Marine Life (CoML). OBIS is a web-based provider of global geo-referenced information on marine species containing expert species level and habitat level databases and provides a variety of spatial query tools for visualizing relationships among species and their environment. OBIS assesses and integrates biological, physical, and chemical oceanographic data from multiple sources. The OBIS Portal accesses data content, information infrastructure, and informatics tools - maps, visualizations, and models – to provide a dynamic, global facility in four dimensions. (URL: http://www.iobis.org)

Global Climate Observing System

The Global Climate Observing System (GCOS) was established in 1992 to ensure that the observations and information needed to address climate-related issues are obtained and made available to all potential users. It is co-sponsored by WMO, IOC, UNEP and ICSU. GCOS is intended to be a long-term, user-driven operational system capable of providing the comprehensive observations required for monitoring the climate system, for detecting and attributing climate change, for assessing the impacts of climate variability and change, and for supporting research toward improved understanding, modelling and prediction of the climate system. GCOS will build, to the extent possible, on existing operational and research observing, data management and information distribution systems, and further enhancements of these systems. It will provide an operational framework for integrating, and enhancing as needed, observational systems of participating countries and organizations into a comprehensive system focussed on the requirements for climate issues. (URL: http://www.wmo.ch/web/gcos/gcoshome.html)

Integrated Global Observing Strategy

The Integrated Global Observing Strategy (IGOS) seeks to provide a comprehensive framework to harmonize the common interests of the major space-based and in-situ systems for global observation of the Earth. IGOS is a strategic planning process, involving a number of partners linking research, long-term monitoring and operational programmes, as well as data producers and users, in a structure that helps determine observation gaps and identify the resources to fill observation needs. IGOS focuses primarily on the observing aspects of the process of providing environmental

information for decision-making and is intended to cover all forms of data collection concerning the physical, chemical, biological and human environment including the associated impacts. IGOS has adopted a set of Data and Information Systems and Services (DISS) principles and these principles will be applied to all IGOS implementation activities. The IGOS principles for data and information systems and services should be consistent with an integrated global strategy allowing the integrated use of data sets from multiple sources. (URL: http://www.igospartners.org/)

ANNEX II

LIST OF ACRONYMS

ASCII	American Standard Code for Information Interchange
ASFA	Aquatic Sciences and Fisheries Abstracts
BUFR	Binary Universal Form for the Representation of meteorological data
CB	Capacity Building
CBS	Commission for Basic Systems (WMO)
CDIAC	Carbon Dioxide Information Analysis Center
CLIVAR	Climate Variability and Predictability (WCRP)
CoML	Census of Marine Life
CPPS	Comisión Permanente del Pacífico Sur/ Permanent Commission for the South Pacific
CSV	Comma-Separated Values
DBCP	Data Buoy Cooperation Panel (JCOMM)
DBMS	Data Base Management System
DISS	Data and Information Systems and Services
DMAC	IOOS Data Management and Communications (USA)
DMCG	JCOMM Data Management Coordination Group
DMPA	JCOMM Data Management Programme Area
DMWG	Data Management Working Group (GOOS)
DNA	Designated National Agency
E2EDM	End-to-end data management
ESIMO	A unified system of information on the World Ocean (Russian Federation)
ETDMP	Joint JCOMM/IODE Expert Team on Data Management Practices
FAO	Food and Agriculture Organisation
GCOS	Global Climate Observing System (WMO)
GE-BICH	IODE Group of Experts on Biological and Chemical Data Management and Exchange Practices
GE-MIM	IODE Group of Experts on Marine Information Management
GEO	Group on Earth Observations
GEOSS	Global Earth Observation System of Systems
GIS	Geographic Information System
GLOBEC	Global Ocean Ecosystem Dynamics
GLOSS	Global Sea Level Observing System (JCOMM)
GOSUD	Global Ocean Surface Underway Data
GOOS	Global Ocean Observing System
GOSIC	Global Observing Systems Information Center
GRA	GOOS Regional Alliance
GSSC	GOOS Scientific Steering Committee
GTOS	Global Terrestrial Observing System
GTS	Global Telecommunications System (WMO)
GTSPP	Global Temperature and Salinity Profile Programme
HAB	Harmful Algal Blooms programme
HAE-DAT	Harmful Algal Event Database
IAI	Inter-America Institute for Global Change Research
IAMSLIC	International Association of Aquatic and Marine Science Libraries and Information Centers
ICAM	Integrated Coastal Area Management
ICES	International Council for the Exploration of the Sea
ICSU	International Council for Science
ICT	Information and Communication Technology

IGOS	Integrated Global Observing Strategy
I-GOOS	Intergovernmental IOC-WMO-UNEP Committee for GOOS
IOC	Intergovernmental Oceanographic Commission (of UNESCO)
IOCCG	International Ocean Colour Coordination Group
IOCCP	International Ocean Carbon Coordination Project
IODE	International Oceanographic Data and Information Exchange
IOOS	Integrated Ocean Observing System (USA)
IPY	International Polar Year
ISO	International Organization for Standardization
JCOMM	Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology
JCOMMOPS	JCOMM *in situ* Observing Platform Support Centre
LME	Large Marine Ecosystem
MEDI	Marine Environmental Data Inventory
MIM	Marine Information Management (IODE)
NEPAD	New Partnership for Africa's Development
netCDF	Network Common Data Form
NMHS	National Meteorological and Hydrological Services
NODC	National Oceanographic Data Centre (IODE)
OBIS	Ocean Biogeographic Information System
OceanSites	OCEAN Sustained Interdisciplinary Timeseries Environment Observation System
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
OOPC	Ocean Observations Panel for Climate
RNODC	Responsible National Oceanographic Data Centre (IODE) [abolished]
SOA	Service Oriented Architecture
SDI	Spatial Data Infrastructure
SG-MarineXML	IODE Steering Group for the MarineXML project
SG-MEDI	IODE Steering Group for the MEDI project
SG-OceanTeacher	IODE Steering Group for the OceanTeacher project
TEMA	Training Education & Mutual Assistance (IOC)
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United National Educational, Scientific and Cultural Organisation
W3C	World Wide Web Consortium
WCRP	World Climate Research Programme
WCS	Web Coverage Service
WDC	World Data Centre (ICSU)
WFS	Web Feature Service
WIS	WMO Information System
WMS	Web Map Service
WMO	World Meteorological Organisation
WOCE	World Ocean Circulation Experiment
XML	eXtensible Markup Language

IOC Manuals and Guides

No.	Title
1 rev. 2	Guide to IGOSS Data Archives and Exchange (BATHY and TESAC). 1993. 27 pp. (English, French, Spanish, Russian)
2	International Catalogue of Ocean Data Station. 1976. *(Out of stock)*
3 rev. 3	Guide to Operational Procedures for the Collection and Exchange of JCOMM Oceanographic Data. Third Revised Edition, 1999. 38 pp. (English, French, Spanish, Russian)
4	Guide to Oceanographic and Marine Meteorological Instruments and Observing Practices. 1975. 54 pp. (English)
5 rev. 2	Guide for Establishing a National Oceanographic Data Centre. Second Revised Edition, 2008. 27 pp. (English) *(Electronic only)*
6 rev.	Wave Reporting Procedures for Tide Observers in the Tsunami Warning System. 1968. 30 pp. (English)
7	Guide to Operational Procedures for the IGOSS Pilot Project on Marine Pollution (Petroleum) Monitoring. 1976. 50 pp. (French, Spanish)
8	*(Superseded by IOC Manuals and Guides No. 16)*
9 rev.	Manual on International Oceanographic Data Exchange. (Fifth Edition). 1991. 82 pp. (French, Spanish, Russian)
9 Annex I	*(Superseded by IOC Manuals and Guides No. 17)*
9 Annex II	Guide for Responsible National Oceanographic Data Centres. 1982. 29 pp. (English, French, Spanish, Russian)
10	*(Superseded by IOC Manuals and Guides No. 16)*
11	The Determination of Petroleum Hydrocarbons in Sediments. 1982. 38 pp. (French, Spanish, Russian)
12	Chemical Methods for Use in Marine Environment Monitoring. 1983. 53 pp. (English)
13	Manual for Monitoring Oil and Dissolved/Dispersed Petroleum Hydrocarbons in Marine Waters and on Beaches. 1984. 35 pp. (English, French, Spanish, Russian)
14	Manual on Sea-Level Measurements and Interpretation. (English, French, Spanish, Russian)
	Vol. I: Basic Procedure. 1985. 83 pp. (English)
	Vol. II: Emerging Technologies. 1994. 72 pp. (English)
	Vol. III: Reappraisals and Recommendations as of the year 2000. 2002. 55 pp. (English)
	Vol. IV: An Update to 2006. 2006. 78 pp. (English)
15	Operational Procedures for Sampling the Sea-Surface Microlayer. 1985. 15 pp. (English)
16	Marine Environmental Data Information Referral Catalogue. Third Edition. 1993. 157 pp. (Composite English/French/Spanish/Russian)
17	GF3: A General Formatting System for Geo-referenced Data
	Vol. 1: Introductory Guide to the GF3 Formatting System. 1993. 35 pp. (English, French, Spanish, Russian)
	Vol. 2: Technical Description of the GF3 Format and Code Tables. 1987. 111 pp. (English, French, Spanish, Russian)
	Vol. 3: Standard Subsets of GF3. 1996. 67 pp. (English)
	Vol. 4: User Guide to the GF3-Proc Software. 1989. 23 pp. (English, French, Spanish, Russian)
	Vol. 5: Reference Manual for the GF3-Proc Software. 1992. 67 pp. (English, French, Spanish, Russian)

No.	Title
	Vol. 6: Quick Reference Sheets for GF3 and GF3-Proc. 1989. 22 pp. (English, French, Spanish, Russian)
18	User Guide for the Exchange of Measured Wave Data. 1987. 81 pp. (English, French, Spanish, Russian)
19	Guide to IGOSS Specialized Oceanographic Centres (SOCs). 1988. 17 pp. (English, French, Spanish, Russian)
20	Guide to Drifting Data Buoys. 1988. 71 pp. (English, French, Spanish, Russian)
21	*(Superseded by IOC Manuals and Guides No. 25)*
22	GTSPP Real-time Quality Control Manual. 1990. 122 pp. (English)
23	Marine Information Centre Development: An Introductory Manual. 1991. 32 pp. (English, French, Spanish, Russian)
24	Guide to Satellite Remote Sensing of the Marine Environment. 1992. 178 pp. (English)
25	Standard and Reference Materials for Marine Science. Revised Edition. 1993. 577 pp. (English)
26	Manual of Quality Control Procedures for Validation of Oceanographic Data. 1993. 436 pp. (English)
27	Chlorinated Biphenyls in Open Ocean Waters: Sampling, Extraction, Clean-up and Instrumental Determination. 1993. 36 pp. (English)
28	Nutrient Analysis in Tropical Marine Waters. 1993. 24 pp. (English)
29	Protocols for the Joint Global Ocean Flux Study (JGOFS) Core Measurements. 1994. 178 pp . (English)
30	MIM Publication Series:
	Vol. 1: Report on Diagnostic Procedures and a Definition of Minimum Requirements for Providing Information Services on a National and/or Regional Level. 1994. 6 pp. (English)
	Vol. 2: Information Networking: The Development of National or Regional Scientific Information Exchange. 1994. 22 pp. (English)
	Vol. 3: Standard Directory Record Structure for Organizations, Individuals and their Research Interests. 1994. 33 pp. (English)
31	HAB Publication Series:
	Vol. 1: Amnesic Shellfish Poisoning. 1995. 18 pp. (English)
32	Oceanographic Survey Techniques and Living Resources Assessment Methods. 1996. 34 pp. (English)
33	Manual on Harmful Marine Microalgae. 1995. (English) [superseded by a sale publication in 2003, 92-3-103871-0. UNESCO Publishing]
34	Environmental Design and Analysis in Marine Environmental Sampling. 1996. 86 pp. (English)
35	IUGG/IOC Time Project. Numerical Method of Tsunami Simulation with the Leap-Frog Scheme. 1997. 122 pp. (English)
36	Methodological Guide to Integrated Coastal Zone Management. 1997. 47 pp. (French, English)
37	Post-Tsunami Survey Field Guide. First Edition. 1998. 61 pp. (English, French, Spanish, Russian)
38	Guidelines for Vulnerability Mapping of Coastal Zones in the Indian Ocean. 2000. 40 pp. (French, English)
39	Manual on Aquatic Cyanobacteria – A photo guide and a synopsis of their toxicology. 2006. 106 pp. (English)
40	Guidelines for the Study of Shoreline Change in the Western Indian Ocean Region. 2000. 73 pp. (English)
41	Potentially Harmful Marine Microalgae of the Western Indian Ocean

No.	Title
	Microalgues potentiellement nuisibles de l'océan Indien occidental. 2001. 104 pp. (English/French)
42	Des outils et des hommes pour une gestion intégrée des zones côtières - Guide méthodologique, vol.II/ Steps and Tools Towards Integrated Coastal Area Management – Methodological Guide, Vol. II. 2001. 64 pp. (French, English; Spanish)
43	Black Sea Data Management Guide ***(Under preparation)***
44	Submarine Groundwater Discharge in Coastal Areas – Management implications, measurements and effects. 2004. 35 pp. (English)
45	A Reference Guide on the Use of Indicators for Integrated Coastal Management. 2003. 127 pp. (English). *ICAM Dossier No. 1*
46	A Handbook for Measuring the Progress and Outcomes of Integrated Coastal and Ocean Management. 2006. iv + 215 pp. (English). *ICAM Dossier No. 2*
47	TsunamiTeacher – An information and resource toolkit building capacity to respond to tsunamis and mitigate their effects. 2006. DVD (English, Bahasa Indonesia, Bangladesh Bangla, French, Spanish, and Thai)
48	Visions for a Sea Change. Report of the first international workshop on marine spatial planning. 2007. 83 pp. (English). *ICAM Dossier No. 4*
49	Tsunami preparedness. Information guide for disaster planners. 2008. (English, French, Spanish)
50	Guidelines on Hazards Awareness and Risk Mitigation in Integrated Coastal Area Management. ***(Under preparation)***
51	IOC Strategic Plan for Oceanographic Data and Information Management (2008–2011). 2008. 46 pp. (English)

Intergovernmental Oceanographic Commission (IOC)

United Nations Educational, Scientific and Cultural Organization (UNESCO)
1, rue Miollis, 75732 Paris Cedex 15, France
Tel: +33 1 45 68 39 83
Fax: +33 1 45 68 58 12
http://ioc.unesco.org