



IOC/INF-1337
Paris, 9 May 2016
English only

INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION
(of UNESCO)

INFORMATION DOCUMENT

**SYNTHESIS OF IOC DEVELOPMENT, WORK AND RESULTS:
OPPORTUNITIES AND COINCIDENCES 1960–2015**

Summary. This overview of the IOC development reflects on the role of the IOC as an intergovernmental organization for: ocean research and basic science responsible for cooperation and coordination of international oceanographic activities; capacity development; elucidating the importance of the ocean in climate, weather, global cycles, fulfilment of basic human needs and social security; creation of observing and warning systems, data exchange and forecasting; and application of oceanography in operational oceanography. It is presented in order to provide an indication for the pathways which could be followed in the Post-2015 navigation.

The document, authored by Gunnar Kullenberg (past Executive Secretary of IOC from 1989 to 1998), is a contribution to a thorough reflection the Commission started in 2013 about its future developments and role as an intergovernmental body. Suggestions for improvements to the author are welcome at gkullenberg@gmail.com.

THE ORIGIN OF THE IOC

The creation of the IOC goes back to the conclusion and results of World War II, with its technological developments, and the subsequent economic development with increasing demands for cheap energy in form of fossil fuels, of commodities of various kinds, of food and nutritional material from the marine environment, increasing transportation across the ocean, together with the need for related ocean observations, data exchanges and cooperation in ocean research with backing of governments. Political tensions, growing arms production and armament with concern for security and need for avoidance of armed conflict also played a role through calling for exchange of information and international cooperation. The oceanographic research after the war was initiated by the Scandinavian countries through several large expeditions around the world, like the Swedish *Albatross* expedition 1947–48 and the Danish *Galathea* expedition 1950–52. The increasing interest for planetary research was subsequently manifested through the successful International Geophysical Year 1957–58; the creation of SCOR by ICSU in the same period. The need for cooperation involving also the governments in such global efforts became clear. The intergovernmental need in relation to ocean research was evaluated already soon after the War through UNESCO by a committee of oceanographers and biologists meeting in spring of 1947 at the UK Royal Society. They expressed strong support for creation of an organized platform for such cooperation. The meeting was followed up by another one in 1950. However, it took a decade until the intergovernmental UNESCO Conference in Copenhagen in July 1960 reached agreement on the establishment of the IOC. Over the subsequent five decades the number of Member States increased from 40 to 148.

THE NEED AND THE COPENHAGEN CONFERENCE

The scientific community had expressed its support and the Conference was needed to confirm the commitment and involvement of the governments. UNESCO had accordingly prepared a draft agreement which was accepted with minor amendments. The support of the major powers at the time USA, UK and Soviet Union was secured with participation of the leaders Drs Deacon, Revelle, and Zenkevitch. The leader of the *Galathea* expedition, Dr Anton Bruun referred to the acceptance from the governments as “the largest milestone in the history of ocean research”. The ocean research had so far been mainly supported by private efforts. The research community had problems to obtain support from and get the attention of governments. It was necessary to bring the governments to participate in an organization they had accepted. UNESCO was ready to provide the required financial resources. From the UNESCO perspective the main interest was the need for education and training of human resources to do ocean research and be able to use the results. The lack of human resources had been identified as one primary reason for the limited development of ocean research. The need was management and proper utilization of ocean resources and in particular the marine living resources, although large amounts of non-living resources had also been found on and in the sea floor.

The new body was called upon to cooperate with other relevant bodies, in particular SCOR, but also regional organizations like ICES. It should coordinate projects already planned by UNESCO in cooperation with SCOR, which was an advisory body to the IOC from the start. In particular, the Indian Ocean investigation was to become a flagship undertaking through the International Indian Ocean Expedition project.

In parallel to the process of establishing the IOC, efforts were underway to lay the foundation for an international law for the ocean, the uses of its resources and other services. This was triggered by the increasing “terraneization” of ocean space through offshore extension of the national sovereignty and jurisdiction. In the beginning the IOC acted within the legal framework of the four Geneva Conventions on the Law of the Sea of 1958. These covered the continental shelf, the high seas, the territorial sea, fishing and conservation of the living marine resources of the high seas, with little attention to marine science or observations. This was not an integrated approach, and from this perspective the First and Second Law of the Sea Conferences in 1958 and 1960 were not successful. Another decade was to pass before the newly independent developing island State Malta brought

up the matter in such a convincing way that the UN General Assembly took action. The development and negotiations for the Third UN Law of the Sea Conference was strongly pushed by the new developing States resulting from the decolonization process. The successful completion, signing in 1982 and entering into force end of 1994, was very much due to the united, cooperative efforts of these developing countries. These were not much involved in the creation of the IOC, but came gradually to understand its importance in the 1970s and 1980s. The negotiations for the Law of the Sea played a large role in this process and so did UNESCO. The scientific community and UNESCO saw the coincidence of the need and the opportunity of the combined interest of scientific enquiry, development and economy. The UNCLOS of 1994 provides for the legal framework within which the IOC acts.

THE INITIAL DECADES

The initial relevance test: The very important warning and forecasting system of the IOC for natural hazards driven from the ocean was initiated through the tsunami warning system. This system was started by the USA in 1948, and was first brought up at IOC at the second session in 1962. The tsunami of May 1960, which killed 1600 people along the Pacific rim, generated by a large earthquake off southern Chile, led to the establishment five years later, following a comprehensive study by a working group, of the International Pacific Tsunami Warning System through an offer by the USA, accepted by the IOC, to expand its existing Tsunami Warning Centre in Honolulu. The meeting in Honolulu in 1965 created the International Tsunami Information Center (ITIC) and the International Coordination Group for the Tsunami Warning System. This model with respect to building warning systems for tsunami and other hazards originating from the ocean has been followed ever since. The development is an example of the use of science and technology for risk reduction, saving lives, infrastructures, enhancing security overall.

Traditional programmes: Charting of the sea floor was included as a service in the Long-term Expanded Programme on Ocean Exploration, LEPOR, as one of the eight major programmes. The IOC realized the importance of having regularly updated bathymetric charts of the world ocean, and thus became associated with the General Bathymetric Chart of the Oceans project (GITC by, 2003). Following advice by SCOR, the joint IOC-IHO Guiding Committee for GEBCO was created in 1977. The historical development of GEBCO illustrates the development over 100 years in data gathering and synthesizing: going from lead lines for deep sea sounding to use of ultra-sound, and from hand to digital contouring and production. The Centenary Edition of *GEBCO Digital Atlas* (IOC, IHO, and BODC, 2003) from 2003, marking the 100th anniversary of the initiation of the GEBCO chart series by Prince Albert I of Monaco, is currently used by almost 1,000 organizations in almost 100 countries. The IOC role with respect to studies of the sea-bed has been acknowledged also through the research programme on Ocean Sciences and Non-Living Resources. This contributed to global change research through paleo-oceanographic mapping and studies of boundary processes along margins of active plates. These efforts were part of the Past Global Change Programme of the International Union of Geological Sciences/Commission on Marine Geology, and also a contribution to the IGBP.

TEMA: Training and education were parts of IOC concern from the start, these matters also being essential interests of UNESCO. Elaborations on the most appropriate way to proceed were going through the IOC meetings during the first decade. The result was the creation of two different groups to deal with mutual assistance, training and education in oceanography. In the process it was realized that a global approach was not appropriate due to the different needs in the regions. In 1973 the activities were joined into one Working Committee for Training, Education and Mutual Assistance in the Marine Sciences, TEMA was born. It was understood that TEMA components need be part of all IOC science programmes. A priority of the action plan was the assessment of the training needs of the developing States. These were elucidated through a series of regional TEMA meetings in the years 1975–78. The role of the IOC is to promote, coordinate and advice in context of training and education. Operational activities were parts of the ICSPRO Agencies work. An additional mechanism in support of TEMA was created in 1977 in the form of a Voluntary Assistance Programme, providing for a supplementary source of support to the training through technical assistance.

Progress in the TEMA implementation was limited, and in 1980 the Committee concluded that the increase in marine science capabilities in developing countries did not meet expectations. A new mechanism was created in the form of a comprehensive plan for TEMA. This concept was developed together with the Division of Marine science of UNESCO. It resulted in the *Comprehensive plan for a major Assistance Programme to enhance the Marine Science Capabilities of Developing Countries* (UNESCO, 1985), adopted by the Assembly in 1982. A decade later the Working Committee at its 5th session in 1991 understood that the major issues facing society at the time required global scientific efforts with partnerships among States. However, such partnerships could only be achieved with a reasonable level of similarity and harmony in marine science capabilities. This pointed to the regional approach in view of the still large differences in capacity between the regions. A mechanism for the regional TEMA actions existed in the form of regional subsidiary bodies of the IOC. They could help identify specific TEMA needs. The creation of regional training centres was receiving increasing support, whereas the Voluntary Cooperation Programme and the preparation of Marine Science Country Profiles had not developed satisfactorily. It was concluded that a medium-term plan for IOC to define its objectives with respect to TEMA up to the shift of the Millennium was needed also in light of the on-going developments of large-scale ocean research programmes, the upcoming UNCED 1992, the concern for global and climate change, the growing interest in ocean observations and development of the Global Ocean Observing System following the second World Climate conference.

With respect to the implementation of the Comprehensive Plan for TEMA the Committee noted that several extra-budgetary assistance projects were being implemented with UNDP support, in countries and regions. Support from national donor agencies were received for activities in the living resources and marine pollution programmes in the Indian Ocean regions, IOC Regional Committees for the Cooperative Investigation in the North and Central Western Indian Ocean (IOCINCWIO) and for the Central Indian Ocean (IOCINDIO). The combination of the UNESCO Division of Marine Sciences and the IOC Secretariat into one administrative unit called The Office of the IOC and marine science related issues (IOC/MRI) under the authority of the Secretary of the IOC effectuated in 1991 was expected to reinforce and streamline the TEMA activities, meeting also the call by the IOC Assembly in 1987 for joint servicing of the TEMA Committee. The extensive cooperation of IOC with other organizations, within the United Nations system with the ICSPRO Agencies, and outside with several regional and global ones, including ICSU-SCOR, IOI and other NGOs, included much TEMA-related activities. The Committee adopted a TEMA Strategy and Action Plan for 1991–95 together with the Guidelines for the IOC Voluntary Cooperation Programme, which replaced the Voluntary Assistance Programme initiated in 1984.

The Regional perspective: In many ways the IOC during the initial decades followed the path of building participation and interest through regional activities, relating them to societal needs. The International Indian Ocean Expedition model was followed by many others. Thus, during the first decade the IOC in cooperation with the scientific advisory bodies focused on stimulating development, coordination, cooperation and implementation of several international cooperative regional studies. These usually involved all the rim States and were fairly centralized in management. The goals included development of human resources through training-through-research, building of institutions and creating an understanding in governments for the importance of ocean resources, with related needs for research and resource management in partnership with and involvement of science. The scientific work focused on clarifying ocean processes and their interaction in physics, chemistry, biology and geology. The International Indian Ocean Expedition 1959–65 (UNESCO, 1965-1972) yielded many results which are reflected in present day need, for instance as regards the taxonomy of marine organisms in relation to harmful algal blooms. Regional observational programmes were organised e.g. the International Cooperative Investigations of the Tropical Atlantic 1963–64 and the Cooperative Study of the Kuroshio and Adjacent Regions (CSK), 1965–1979. These regional programmes in several cases triggered establishment of regional bodies as parts of the IOC. The cooperation included the existing regional bodies, like ICES in the Eastern North Atlantic and ICSEM in the Mediterranean. A cooperative research programme for the Mediterranean was adopted in 1969, implemented with CIESM and the General Fisheries Council for the Mediterranean of FAO. An International Coordination Group was set up for the CSK with participation

of Member States Coordinators. Several symposia were arranged in the Region to discuss and share the results of many cruises. An evaluation of the results occurred at the Assembly in 1975. The positive outcome triggered the establishment in 1977 of the Working Group for the Western Pacific, WESTPAC. This was an important step towards the regionalization of the IOC. Already in 1966 a proposal was made for a cooperative study of the Caribbean Sea, and in 1967 the IOC adopted this and established the Coordination Group for the Co-operative Investigations of the Caribbean and Adjacent Regions, CICAR. This was an area-oriented research programme which stimulated interest in many Caribbean States in marine affairs. The Member States wanted to continue co-operative marine research. The IOC thus created the IOC Association for the Caribbean and Adjacent regions, IOCARIBE, in 1975. The importance of the Southern Ocean was recognized through the IOC International Coordinating Group for the Southern Ocean. This played a role in supporting the Biological Investigation of Marine Antarctic System and Stocks, BIOMASS, generated through the Scientific Committee on Antarctic Research (SCAR) and SCOR. All these efforts led to a much enhanced interest for marine research in the countries of the regions concerned, awareness in governments, and facilitated the creation of more formalized intergovernmental mechanisms in form of subsidiary regional bodies of the IOC. The regional projects pooled together considerable human and infrastructure resources of the Member States. Important discoveries and confirmation of ocean processes and conditions were made, including elements of ocean-atmosphere interactions. The results provided for improved basis for a more managed exploitation of marine living resources in many areas, and inputs to the first assessment of progress in marine science prepared by IOC and SCOR in 1969.

Global cooperation and long-term perspectives: The regional programmes brought out the importance of the ocean, its resources and coastal areas for regional developments and thus contributed to the plans for the International Decade of Ocean Exploration (IDOE) 1971–1980. This had been proposed by the USA and endorsed by the UN. It involved the IOC as the intergovernmental coordinating body. The Decade was envisaged as the initial phase of the Long-term and Expanded Programme of Ocean Exploration, LEPOR. The development was called for by the UN General Assembly which requested the IOC to prepare a framework programme. This was done and endorsed by the UN-GA in December 1968. The General Assembly then called upon the IOC to prepare, in cooperation with the Secretary General, a comprehensive outline for LEPOR, and report to the General Assembly in 1969. The IOC was also requested to propose implementation in cooperation with FAO, WMO, IMCO (now IMO). The IOC was commended for its development of cooperation and close working relationships with these organizations, noted through the establishment of the Interagency Committee on Scientific Programmes relating to Oceanography, ICSPRO, an Agreement signed by the respective Heads of Agencies. A first review of the existing activities in the UN system in relation to seas and oceans in light of present and emerging needs of Member States was also requested. Obviously the results of the IOC and the regional studies had given the desired impacts in bringing ocean research and exploration to the attention of governments, policy makers and the highest intergovernmental level represented by the UN General Assembly. This is to be seen as a great success for IOC, UNESCO and the ocean science community, together with the confirmation of the wisdom of the vision of that community.

The LEPOR and the IDOE focused on: (i) problems of ocean-atmosphere interactions, ocean circulation, variability and tsunamis; (ii) living resources and their relations with the marine environment; (iii) marine pollution problems; (iv) geology, geophysics and mineral resources beneath the ocean floor; (v) Integrated Global Ocean Station System, IGOSS; and (vi) investigations in specific regions. These research themes all covered the new elements of “enhanced utilization of the ocean resources for the benefit of mankind”, stressing the application of scientific results. Programmes of the IDOE included: the Joint Air-Sea Interaction Study, a component of the Global Atmospheric Research Programme; the International Southern Ocean Studies; the Coastal Upwelling Ecosystem Analysis; the Deep Water formation in the Norwegian-Greenland Seas; Cooperative Investigations of North Eastern Central Atlantic; Eastern Atlantic Central Margin; studies of the North and Baltic Seas.

Service programmes: During the first three decades the IOC also developed several service-oriented programmes. The need for these efforts was recognized from the start. They should cover the needs of the scientific community for data and information exchange services. This is fulfilled through the International Oceanographic Data and Information Exchange (IODE) system. It should be noted however that the data exchange and storage system had been put in place through the International Geophysical Year 1957–58 in form of two World Data Centres A in WDC and B in Moscow, supported by the USA and the USSR respectively. The IOC in 1961 decided to adopt and continue this system of World Data Centres, supplemented by a number of specialized data centres. These include the Permanent Service for Mean Sea Level, the International Hydrographic Bureau, the FAO Fishery Data Centre, and the data centre of ICES covering the North-east Atlantic.

Other services address the needs of governments and the public for warnings for natural hazards, protection of coastal areas, marine pollution incidents and protection of the marine environment, proper use of living and non-living resources, improved weather forecasting, support to shipping and marine transport. Awareness creation and training in use of warning systems are part of the services.

International oceanographic data exchange: While the IOC formally entered the subject of provision of warnings for hazards originating from the ocean in the middle of its first decade, it entered the area of data management already at its first meeting in 1961. Member States then launched the programme on oceanographic data management and the creation of National Oceanographic Data Centres, and created an intergovernmental working group to assist Member States and to coordinate the work. The resulting International Oceanographic Data and Information Exchange (IODE) is an overarching programme of the IOC interrelated with all other activities of the Commission. The Assembly at its 8th session in 1973 changed the working group to the Working Committee on International Oceanographic Data Exchange, adjusted in 1987 to the Committee on International Oceanographic Data and Information Exchange. The membership includes not only Member States but also representatives of the IOC partners as ICSU, ICES, WMO, FAO. A policy of timely, full and open access to quality ocean data has been followed throughout. This was reconfirmed in the IOC Oceanographic Data Exchange Policy formally adopted in 2003. Training and education in data management and marine information management form central parts of the IODE programme throughout. The IOC worked consistently over the decades to develop and improve the data management system in cooperation with other data exchange partners through the mechanism of joint working groups or committees. Thus the first *Manual on International Oceanographic Data Exchange* was approved by the Assembly in 1964 and published in 1965 (UNESCO, 1965). Several revised editions have been published taking into account new demands and new regulations, coupled to the gradual expansion of observations and data flows. This was related to the Integrated Global Ocean Station System, IGOSS, which aimed at developing and maintaining a network of oceanographic observing stations, initially involving only fixed stations. The growing requirements for ocean data on a global scale for many different users and uses as shipping, research, engineering, fisheries and overall forecasting needs, led IOC to establish a Working Committee for Integrated Global Ocean Station System, IGOSS, which was to govern all related activities. IGOSS was also an essential part of the Long-term and Expanded Programme of Oceanic Exploration and Research, LEPOR, formulated by IOC and approved by UNGA in 1969. The same year the IOC adopted the *General Plan and Implementation Programme for IGOSS phase I* (UNESCO, 1971). The gradual organization of the governance of this system resulted finally in the creation of the Joint IOC-WMO Working Committee for IGOSS in 1977. This can be seen as a precursor to the current IOC-WMO Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM).

Marine pollution research and monitoring: Another early undertaking of the Commission concerns the marine pollution problem. Already at the Copenhagen Conference the need to address the increasing pollution of seas and oceans was noted. Accordingly, in 1965 the IOC initiated the formulation and specification of a dedicated research, human resources and institutional development programme on marine pollution. The Global Investigation of Pollution in the Marine Environment, GIPME, programme was formally adopted by IOC in 1971, as a major component of

the International Decade activities. The Stockholm Conference on the Human Environment in 1972, resulting in the creation of UNEP, provided strong stimulation to the creation of GIPME, as did the initial reviews of marine pollution problems by the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) started in 1969. The cooperation between IOC and UNEP within the framework of GIPME has been very important since the inception of the UNEP Regional Seas Programme in 1974. In the case of marine pollution there remained to be developed methods for chemical and biological observations. The required research was the task of GIPME, while the operational observations and product delivery was part of IGOSS. The Stockholm Conference in its resolution 90, endorsed by the UNGA, recommended that “IOC jointly with WMO and in cooperation with other interested intergovernmental bodies should organize marine pollution monitoring, preferably within the framework of IGOSS”. A pilot programme was formulated by the Joint IOC-WMO Planning group for IGOSS as a first step. This focused on oil, petroleum, resulting in the Marine Pollution (Petroleum) Monitoring Pilot Project established by IOC and WMO in 1973. The Working Committee for GIPME provided the scientific advice on the implementation and further development of the Marine Pollution Monitoring Programme, while the Working Committees for IODE and TEMA provided advice on the data management and training and mutual assistance needs. Thus the operational phase could start 1 January 1975. Several workshops were held over the decade reviewing the results and endorsing the continuation of the pilot project. At the end of the decade, on basis of the positive results and growing interest, the project was converted into an operational monitoring project.

The framework was the Comprehensive Plan for GIPME adopted in 1976, guiding the programme for over two decades. The studies covered chemical and biological processes associated with contaminants and biological effects of pollution leading also into harmful algal bloom research. Activities included much capacity building and training exercises through intercalibrations, biological effects workshops, in cooperation with UNEP, the IAEA Monaco Laboratory, FAO, and IMO, often working on a regional seas scale. Links were close between the marine pollution and global ocean flux studies. Open ocean baseline studies in the Atlantic were carried out in the 1990s, demonstrating the penetration into the deep water of trace metals as cadmium, lead, copper, iron; IOC-GIPME with NOAA carried out an early research cruise to map the oil pollution in the Persian Gulf following the first Gulf War. The global International Mussel Watch identified hot-spots of pollution and mapped distribution of persistent pollutants in the Eastern Pacific and Asian Seas.

Nutrient balances and harmful algal blooms: The harmful algal bloom research increased in importance and developed into the Harmful Algal Bloom programme. The IOC thus responded to the increasing concern over the issue in the 1970s and the 1980s by an IOC Workshop on international cooperation in the study of ‘red tides and algal blooms’ following the International Symposium on Red Tides in Japan 1987. This marked the first broad support and co-sponsorship by several organizations with participants of the scientific community over a wide range of disciplines. Early in 1990 an IOC-FAO/OSLR ad hoc group of experts drafted a programme for international cooperative studies on basis of the Symposium in Japan. The plan was endorsed by IOC and further elaborated by SCOR, resulting in the overall goal of the HAB programme to be “to foster and organize the management and scientific research of Harmful Algal Blooms in order to understand the causes, predict the occurrences and mitigate the effects”. Cooperation between governmental and non-governmental communities formed a basic, much needed element, as did training and capacity development. The programme was governed by the IOC/FAO Intergovernmental Panel on Harmful Algal Blooms, with its first meeting in mid-1992. The HAB problem is in many ways linked to the marine living resources and thus to the Ocean Sciences and Living Resources (OSLR) programme, which as noted also initiated the HAB development within the IOC.

THE END OF THE SECOND MILLENNIUM AND TRANSITION INTO THE THIRD

Milestones of the last decade: Important external milestones influencing the Commission include the release of the Brundtland report 1987 (UN, 1987), launching the sustainable development process in the UN system; the Second World Climate Conference 1990, which IOC co-sponsored; the UN Conference on Environment and Development in Rio 1992 where IOC participated as well

as in the preparatory process, helping drafting Agenda 21; the negotiations for the climate change convention, UNFCCC, in which the IOC participated in the preparatory and drafting process; and the entering into force of UNCLOS in the end of 1994. The significance of this for ocean science cannot be overstated. It was marked by the Second International Conference on Oceanography: Towards Sustainable Use of Oceans and Coastal Zones, Lisbon November 1994, in which the IOC was a major partner. The International Year of the Ocean 1998, with much preparatory work by the IOC as the lead Agency, brought out the importance of the role of the IOC in promoting marine research, the understanding of ocean processes and the inclusion of ocean science concerns and the need for observations in the various international instruments and actions aiming at addressing the challenges to sustainable development including global and climate changes. The programme for the International Year of the Ocean included several dedicated research cruises, national science conferences, reviews of coastal and ocean economics. The preparation of the third assessment of ocean science was initiated in 1998 and completed with the publication in 2002 as *Oceans 2020: Science, Trends and the Challenge of Sustainability* (IOC, SCOR, SCOPE, 2002), jointly by SCOR, SCOPE and IOC. It acknowledges that “recent progress in ocean science has been achieved through international coordination and planning”, and confirmed the trend of ocean research moving towards establishment of sustained observation platforms at sea, paired with use of satellites for observations and data transmission in real and near-real time. This together with fast computers and dynamic modelling provided the foundation for development of long-term forecasting of phenomena as El-Niño, the monsoon and seasonal inter-annual variations.

Global and climate change concerns: It had been realized by the scientific community and the IOC Member States that global change as a framework within which local, regional, global cooperative scientific programmes should be viewed, as well as continental shelf dynamics and harmful algal blooms, required greater role for the IOC in climate-related issues. This included paying attention to areas particularly vulnerable to hazards such as sea-level rise, storm surges and tsunamis. The IOC participation in climate-related research and assessments were achieved through the partnership with World Climate Programme through co-sponsorship of WCRP and the joint SCOR-IOC CCCO, together with the development of the Global Climate Observing System (GCOS) and the Global Ocean Observing System (GOOS). However, the IOC was not asked to co-sponsor the Intergovernmental Panel on Climate Change (IPCC), despite some informal consultations by the in-coming Secretary of IOC in 1988. An in-depth report on climate-related ocean issues was prepared following a request from the Executive Council, and discussed by the Assembly in 1995, bringing out the sea-level rise threat to small islands, the ocean uptake of carbon dioxide, initiation of coral reef studies from carbon accumulation aspects, and the role of the ocean in the carbon dioxide budget, which was specifically addressed through the Joint SCOR-IOC Panel on carbon dioxide. Several expert meetings were convened to elucidate the various roles of the ocean in the climate system and for climate variability and change. The Assembly stressed the need for close cooperation with IPCC and the Framework Convention on Climate Change. The Convention Secretariat was accordingly supported through provision of an expert.

Ecosystem dynamics and biodiversity: The Convention on Biological Diversity, the CBD, also entered into force in 1994. An IOC-NOAA supported expert consultation in 1995 noted that several IOC programmes were related to marine biodiversity. The difference between research on terrestrial and marine biodiversity was noted, motivating the need for an IOC association with the research on biological diversity within the framework of the Convention. At the same time the International Global Ocean Ecosystem Dynamics, GLOBEC, Programme was initiated by SCOR, IOC, ICES and PICES. The marine biodiversity problem was also introduced in IOC through the DIVERSITAS association with UNESCO. The IOC dedicated effort within the context of the CBD, drawing on several of ongoing IOC activities, became part of GLOBEC. The moves towards more interdisciplinary research, or at least multidisciplinary was motivated by the needs to address the linkages, confirming that the ocean needed be treated as a whole. The same was highlighted by growing needs to deal with multi-hazards originating from the ocean, in cooperation with the International Decade on natural Disaster Reduction.

The IOC as a facilitator: The role of the IOC in facilitating the application of the scientific results was shown through several publications. An example is the book entitled *Continental shelf limits: The Scientific and Legal Interface* in 2000 (IOC, IHO, 2000). This provides information to all States to help in their planning of research and surveys necessary for sustainable claims as regards outer limits of their continental shelf in conformity with provisions in UNCLOS, part VI, articles 76 and 77 in particular. The need for this work was realized by UN-DOALOS which invited IOC and IHO to produce a scientifically oriented book which could help nations make appropriate use of Article 76 on delimitations of maritime zones. The work can be seen as a contribution of the IOC OSNLR programme. Other elements of facilitation include development, testing and provision of standards for measurements of nutrients, other constituents and pollutants, dissolved oxygen and organics, and gradually other priority substances as carbon dioxide in ocean surface water. These developments are results of cooperation with ICES, the IAEA Monaco Laboratory and industry.

Follow up to UNCED 92: Following UNCED 92 the Sub-Committee on Oceans and Coastal Areas of the Inter Agency Committee on Sustainable Development was created in 1993 to guide and support the implementation of chapter 17 of Agenda 21. IOC provided the secretariat services to the Committee. It fulfilled its role over the decade, but was abolished at the restructuring of the UN governance. The adoption in 1995 of the Global Programme of Action on the Protection of the Marine Environment from Land-Based Activities aimed to address this problem raised in Chapter 17. UNEP was requested to lead that effort. The implementation of the Plan requires cooperation between many international agencies but no well-defined forum for such coordination existed. It was created by the General Assembly in 1999, following the proposal from the Commission for Sustainable Development, in form of the open-ended Informal Consultative Process on the oceans, for which the DOALOS serves as the secretariat. The coordination of all the activities is crucial, and needs commitment from States and the staff serving the intergovernmental organizations. This includes consistency at the national level, following a consistent policy in the various international bodies.

After changes of the governing structure of the United Nations at the start of the first decade of the new Millennium the UN-Oceans was created in the form of an oceans and coastal areas network. This was given the task of coordination of implementation of chapter 17 and the agreements reached at the World Summit on Sustainable Development, Johannesburg 2002, and later also of the ocean-related Rio+20 agreements. Clearly there is a strong need for the Informal Consultative Process and UN-Oceans to maintain a dialogue. These mechanisms also need take up the regular process on global assessment and help ensure its effectiveness and use. Implementation and fulfilment of commitments are necessary together with provision of sufficient resources to the international actions and processes.

In parallel to all this development, the IOC participated in the creation and strengthening of the Global Forum on Oceans, Coasts and Islands as part of the preparatory work for the WSSD 2002. This served as an NGO to facilitate the formulation and adoption of the ocean part of WSSD 2002, continuing this for later conferences and the review of the degree of achievement of the Millennium Development Goals, the Sustainable Development Goals and the drafting of new ones for UNGA 2015. The IOC is a partner in the whole process and the work.

Global coordinated assessments: On basis of the outcome of the WSSD the UN General Assembly decided to establish by 2004 a regular process under the United Nations for global reporting and assessment of the state of the marine environment, including socio-economic aspects, both current and foreseeable, building on existing regional assessments. The goal is to improve ocean governance. The IOC and UNEP were subsequently in 2005 requested to take the lead in moving the process. The Assessment of Assessments was carried out and the result published in 2009 (UNESCO, 2009). This confirmed the feasibility of the Regular Process and proposed how to achieve it. The First Global Integrated assessment of the Ocean, the World Ocean Assessment, was presented to UNGA in 2015.

Sustained ocean observations: In order to do any reliable assessments of conditions there is a need for reliable, systematic observations. This has been manifested through all the actions of the

IOC, very well highlighted in the early establishment of the IODE. At the Assembly in 1989 it was agreed to establish a global ocean observing system on basis of then reasonably reliable technologies covering the initial needs. However, it was the calls for systematic global ocean observations from the second World Climate Conference in 1990 that confirmed the establishment of the Global Ocean Observing System, GOOS. This call was reinforced by UNCED 1992. Presently the implementation arm of GOOS is the Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology, mostly addressing open ocean needs, with an agreed Strategy for JCOMM 2012–2017, and the governance of GOOS on basis of the Framework for Ocean Observing of 2012. The development of the coastal and shelf seas parts of GOOS are presently stimulated through the regional approach with Member States sharing a common sea area working together in GOOS Regional Alliances. The Global Coastal Network helps ensure interaction and clarifying variability and change from global to local scales. The global component is required to capture the linkages of local conditions to regional impacts. These in turn are influenced by tele-connections between different areas and regions.

Growing concern for the climate system: The last two decades of the century was much influenced by concerns for global changes and gradual planetary adjustments to human actions, population and socio-economic developments, utilization of natural resources and ecosystem services, changes in the heat content due to the increase of greenhouse gases, and losses of biodiversity. The market economy does not internalize these losses or the ecosystem services. The problems were understood by the scientific community, as manifested through several scientific programmes at global level, including the World Climate Programme with the World Climate Research Programme initiated 1978/79, and the initiation of the Global Climate Observing System following the second World Climate Conference. The creation of the Intergovernmental Panel on Climate Change in 1988 and the negotiations for the climate change convention confirmed the need for a mechanism to make assessments and synthesize the scientific findings for policy makers and having a framework to agree on joint policy and related actions. IOC became co-sponsor of the climate research programme in 1991, until then having addressed the problem in cooperation with SCOR through the joint committee on climate change and the ocean, the CCCO. The progress was reviewed in the second assessment of SCOR and IOC, published in SCOR-IOC, 1984. The findings confirmed the very important role of the ocean in the climate system.

The WCRP included the Tropical Ocean-Global Atmosphere (TOGA) project 1985–95. This laid the foundation for professional forecasting of El Niño, as well as parts of the global ocean-global climate observing systems, and led to the creation of the International Institute for Climate Prediction. The World Ocean Circulation Experiment (WOCE) started its field phase in 1991 and concluded its analysis phase in 2002. It resulted in an about 2-3 orders of magnitude increase in ocean data, with atlases, advances in modelling and understanding of processes, laying another foundation for global observing systems with identification of critical parameters to observe. The importance of the atmosphere-ocean interactions was elucidated through several research efforts on regional, basin-wide and global scales. The coupling to the hydrological cycle was the focus of the Global Energy and Water Cycle Experiment of the World Climate Programme initiated in the mid-1990s. The follow-up to TOGA focused on the climate variability problem through the Climate Variability and Predictability Study, CLIVAR.

Coastal zones and shelf seas: There was also increasing concerns for growing pollution and deterioration of coastal areas. The pollution research and related land-sea flux studies draw attention to the processes and circulation on the continental shelf seas. The need to study this area further was also realized from the open ocean end for instance in the context of living resources, migratory species and basin-wide oscillations, and their coupling to climate variability. The need was thus demonstrated for a much improved understanding of the dynamics of the continental shelf and coastal seas, the conditions there, the interactions with the land and ocean boundaries and the fluxes across these. The IOC initiated the formulation of a dedicated research programme in cooperation with SCOR. This was formally established through the First COASTS-Coastal Ocean Advanced Science and Technology Study-workshop in May 1994, with co-sponsorship of IOC, SCOR, the Commission of European Communities, the US National Science Foundation and the Office of Naval

Research. The regional subsidiary bodies of the IOC became involved in this programme, which also contributed to the Land-Ocean Interaction in the Coastal Zone programme as well as the Joint Global Ocean Flux Study, in which also GIPME played a significant role. These efforts constituted the ocean-related components of the International Geosphere-Biosphere Programme initiated already in the 1980s. A particular perspective, coincidence and opportunity, is seen in the combination of research on impacts of climate variability and change, integrated coastal area management and adaptation to climate change. This led to IOC initiating regional projects as “Adaptation to climate change-responding to shoreline changes and its human dimensions in West Africa through the Integrated Coastal Area Management Programme, ICAM”. The project was completed in 2012 with a regional symposium and adoption of *Coastal Adaptation Guidelines for Local Decision Makers*, with support from GEF (UNESCO, 2012). Similarly, the South Pacific Information and Data Management project in support of ICAM resulted in coastal indicator framework and regional indicators in 2012. A second phase of the project was supported by the Government of Flanders (Belgium) 2013–2015. The problem of coastal eutrophication and nutrient sources is addressed through the IOC Nutrients and Coastal Impacts Research Programme, with a three-year Joint UNEP-IOC project seeking global foundations for reducing nutrient enrichment and oxygen depletion from land-based pollution.

Living resources and food concerns: The Ocean Science in Relation to Living Resources was a major programme of the IOC from the start, co-sponsored by the FAO, focusing initially on recruitment studies at regional level. Gradually the harmful algal blooms became a serious concern impacting recruitment and aquaculture, being coupled to changes in nutrient inputs and balances in coastal waters as well as to transfer of non-indigenous species, other ocean processes, decadal oscillations and changes: a formidable problem involving many scientific disciplines as well as strong economic interests of tourism, fisheries, food provision and security. This stimulated a broad cooperation involving IOC, FAO, IMO, WHO, ICES and SCOR and led to the establishment of the Harmful Algal Bloom Programme. The ecosystem research was further consolidated through the Marine Ecosystem Dynamics and Living Resources Programme. The Large Marine Ecosystem concept initiated in the early 1970s gradually became a focusing mechanism with strong financial support from GEF and others, and associated involvement of the related scientific communities. It is noticeable that this also includes economic aspects, as does the HAB programme; some early indications of the emerging new economic order, referred to as Blue economy, or ocean economy.

The concerns for changes in biological diversity increased and came into focus through the Convention on Biological Diversity (CBD), resulting from the Rio Conference and entering into force in 1994, just as the Framework Convention on Climate Change and the Convention on the Law of the Sea; synergism? These all influenced the IOC significantly, the most important being the Law of the Sea.

Responsibilities of IOC within UNCLOS: In addition to the Lisbon Conference, the initiative of the International Year of the Ocean 1998, the IOC responded by establishing in 1997 the Advisory Body of Experts on the Law of the Sea, IOC/ABE-LOS. This should provide advice to the Commission with respect to its role in relation to UNCLOS. Through this mechanism the law of the sea became an integral part of the work of the IOC. It must be stressed that UNCLOS has a separate part on marine scientific research, Part XIII. Its Article 247 provided a focus in demanding cooperation between States through a competent international organization that promotes, facilitates and coordinates research projects. This is precisely the mission of the IOC and thus the IOC is acknowledged as the competent international organization in UNCLOS. The work of IOC/ABE-LOS resulted in the adoption of a *Procedure for the Application of Article 247* by the Assembly at its 23rd session (UNESCO, 2007). Transfer of marine technology is another central theme of UNCLOS, its Part XIV, including Article 271 on guidelines, criteria and standards, and section 3 on creation of national and regional marine scientific and technological centres. Through its advisory body of experts on LOS, the IOC could meet its role in promoting guidelines, criteria and standards for transfer of marine technology. The ocean observations organized through GOOS constitute important parts of implementation of UNCLOS, meeting needs in particular of its parts: V on EEZ; VI on Continental Shelf; VII on High Seas, mainly its Section 2; X on Enclosed and Semi-enclosed

Seas; XI on The Area; XII on Protection and Preservation of the Marine Environment; and of course parts XIII and XIV; and elements of parts XV and XVI. GOOS involves floats, satellites and ships which operations also depend on implementation, interpretation and application of UNCLOS provisions. The IOC/ABE-LOS addressed related questions resulting in provisions adopted by the Executive Council in 2008. In April 2012 the UNGA in its Resolution on the Ocean and the Law of the Sea encouraged Member States to use the *IOC Criteria and Guidelines on Transfer of Marine Technology* (UNESCO, 2005) developed by IOC through IOC/ABE-LOS, and take note of the advice of this Advisory Body of IOC for the implementation of parts XIII and XIV of UNCLOS. The same resolution also took note of the role of GOOS for increasing the understanding of the ocean-atmosphere interface through observations and geographic information system developments. The Law of the Sea also needs information on the practices of Member States in the areas of research and transfer of marine technology. The IOC/ABE-LOS invited Member States to provide relevant information through responding to a questionnaire. This has been circulated a few times and should be seen as a long-term effort. Responses and analysis provide useful inputs to DOALOS in updating of “Marine Scientific Research: A guide to the Implementation of the relevant provisions of UNCLOS”. This effort also resulted in a constructive cooperation between IOC/ABE-LOS and DOALOS. The on-going project of the IOC on the Global Ocean Science Report is likewise relevant in this context.

THE DAWN OF THE THIRD MILLENNIUM

The IOC at middle-age recognition and new challenges: The year 2000 marked the 40 years’ anniversary of the IOC, noted by taking stock of developments and milestone results in the Annual Report 2000. Success in establishing broad inter-agency cooperation through ICSPRO and, following UNCED 92, the Sub-committee for Oceans and Coastal Areas in support of the implementation of Chapter 17 of Agenda 21 led to co-sponsorship and joint implementation of many programmes pooling resources and know-how from different sectors and disciplines. This culminated in the transition to the new Millennium in completion of a substantive report on ocean science and capacity building for the second session of the UN Informal Consultative Process (ICP) on Ocean Affairs and the Law of the Sea in 2001. The ICP was created in 1999 as a high-level mechanism reporting directly to the General Assembly, thus providing a means to reach the highest level of decision and policy shaping. The ability of the IOC to maintain recognition at that level also implies an increasing realization of the importance of ocean science and observations to help address some of the major challenges of the New Millennium. This includes the importance attached by the IOC community to a Global Assessment of the ocean reflected in the decisions of the 2002 Johannesburg Summit.

Ocean big science and ocean-related hazards: The transformation to multi- and inter-disciplinary, system-oriented ocean research was an on-going process, ocean research being also ‘Big Science’. Observation technology advanced very significantly, providing for improved early warning possibilities, and integrated coastal area management became a norm. Vulnerabilities of many coastal and island areas were obvious and risk-reduction, preparedness and training to use early warnings for hazards originating at sea became very important for saving lives and property. However, it was only after the Indian Ocean tsunami in December 2004, caused by an earthquake off Indonesia, that the political will was generated to support establishment of tsunami warning systems in regions beyond the Pacific Ocean. On basis of its experiences from the Pacific tsunami warning system the IOC was asked to lead intergovernmental cooperation within the United Nations system for the creation of several other similar warning systems. This has led to the creation of four regional tsunami warning systems all with Intergovernmental Coordination Groups, of which three were established in 2005. The Indian Ocean System was the first one to become formally operational in June 2006. Other hazards resulting from the ocean include storm surges and rising sea level, flooding driven by sustained ocean waves and swell from far away storms. The International Decade of Natural Disaster Reduction of the 1990s led to the creation of the International Strategy for Disaster Reduction. The IOC is supporting this through incorporating other hazards into the tsunami warning system, thus establishing the Global Tsunami and other Ocean-related Hazards Early Warning System and has defined the requirements through a resolution in 2005. The IOC coordinates its activities and development with the UN-ISDR and IUGG Tsunami Commission. The

digestion of the scientific information on storm surges, flooding, tsunamis, sea-level rise and coastal erosion has resulted in formulation of guidelines for coping with such hazards, for establishing integrated coastal area management, for coastal adaptation to climate change, and for marine spatial planning by the IOC/ICAM programme over the period 2005–15. Following the Third UN World Conference for Disaster Risk Reduction in Sendai, Japan 2015, the IOC continues the work contributing to fulfilment of the Sendai Framework for Disaster Risk Reduction 2015–2030, which resulted from the Conference.

Impacts on the ocean ecosystems from carbon dioxide and climate change: The climate change problem came increasingly into focus, including the role of the ocean in the greenhouse gas balance, evaporation and cloud formation and in the heat balance, together with the possible impacts on the ocean ecosystems, including from the acidification of the ocean water. This led to a partial integration of several global programmes as GLOBEC, JGOFS, WOCE bringing together observations and theory in ecological studies. The carbon flux and carbon dioxide sequestration were elucidated in the JGOFS synthesizing phase. The carbon dioxide development was addressed by the SCOR-IOC Advisory Panel on Ocean CO₂, supporting the establishment of a global ocean carbon observing system. The IOC Assembly recognized the need to monitor the developments with respect to the carbon dioxide sequestration and established a Watching Brief on Ocean Carbon Sequestration through the Advisory Panel. This resulted in the initiation of the International Ocean Carbon Coordination Pilot Project, coordinated by IOC and co-sponsored by SCOR. It has stimulated a series of symposia on “The Ocean in a High CO₂ World”. The HAB programme has maintained its identity with a coherent framework for its activities through the stable support of DANIDA over two decades, 1991–2007. Cooperation with SCOR has been essential including through the IOC-SCOR programme Global Ecology and Oceanography of Harmful Algal Blooms, GEOHAB, launched in the late 1990s. A continued challenge of the HAB programme is to maintain the involvement of the leading scientific community as well as managers and governments, and provide the intergovernmental coordination to deliver the needed research translated into results for management, and build capacity.

The World Summit on Sustainable Development, WSSD 2002, and the Millennium Development Goals with targets for 2015 and later, manifest the social, human concerns and must be part of the focus for the ocean research with governmental support. This was further underlined by the *Millennium Ecosystem Assessment*¹ published in 2005. Cooperation in these efforts is necessary together with adequate coordination, confirming the importance of the functions of the IOC. The IOC science programme was adjusted in the early part of the Millennium to concentrate on three interactive lines in research: Oceans and Climate; Science for ocean Ecosystems and Marine Environmental Protection; and Marine Science for Integrated Coastal Area Management. For the second decade this was reformulated to meet the four High-level Objectives for the *IOC Medium Term strategy, 2014–2021* (UNESCO, 2014d) to cover four priority areas identified by the governments concerning climate change; ocean health; coastal resources assessment and management; and modelling. In light of the increasing ocean acidification, the related research is growing fast and was part of the IGBP. IOC and SCOR are cooperating in this research and have provided a summary of the knowledge for policy makers on basis of the outcomes of the Third Symposium on the Ocean in a High-CO₂ World, Stockholm 2013, based on studies over the past two decades.

Regional activities increasingly focused on development of regional networks in context of training, data and information exchange and management. The first such network was created in Eastern Africa in the 1980s. In 1997 the Ocean Data and Information Network for Eastern Africa extended the coverage throughout the region and a similar process developed in Western Africa. This led to the creation of the Pan-African Ocean Data and Information Network for Africa. The success of these activities over the last decade has triggered creation of similar networks in several other regions over the first decade of the Millennium. Coordination has always been essential in these developments. The creation in April 2005 of the IOC Project Office for IODE in Ostend,

¹ <http://www.millenniumassessment.org/en/About.html#1>

Belgium, provides for a focus of all IODE-related activities. The training and education component is forming an on-going substantial part of the work. This has resulted in creation of a global network in form of the Ocean Teacher Academy supplementing the ODIN networks. The Tenth Anniversary of the creation of the project office was celebrated in 2015 (UNESCO Platform Vlaanderen, 2015). The IODE Committee has reorganized the governance of the programme with a joint IAMS LIC/IODE group of experts on marine information management, an ocean data standards and best practice project, an IODE Associate Data Unit and IODE Global Data Assembly Centres as new structural elements. The importance of the work is manifested through the establishment of 14 Associate Data Units and 67 National Oceanographic Data Centres. The OBIS, with a joint OBIS-GOOS biology position, the International Coastal Atlas Network and the Partnership Centre for IODE Ocean Data Portal in the Russian Federation, likewise bring out the significance. Training and education is forming an on-going important part of the work.

The evolving development of ocean governance and implementation of UNCLOS requires clear involvement of the IOC as a competent international/intergovernmental body and a joint specialized mechanism. The continued debate with respect to the participation of the Commission in the implementation of the Law of the Sea is manifested in discussions of the further use of the IOC/ABE-LOS at the Executive Council in 2014 and the Assembly in 2015. The IOC now must find the most appropriate route to continue its support to the implementation of UNCLOS and participate in the adjustment of ocean governance driven by economic and social challenges, changing climate and increasing risks both from and for the ocean, as well as the new economic order envisaged through the Blue economy coming increasingly into focus. These challenges can only be faced through extended cooperation between the communities of marine sciences, operational oceanography, sustained ocean observations, including shelf seas and coastal areas, as well as other sectors and stakeholders of society. The IOC can in this process play a very substantial role both as an intergovernmental body and as part of UNESCO. This leads to the specification of the medium to longer term Visionary Strategic Goal.

In 2011 the IOC Assembly adjusted the governing structure of GOOS to be aligned with the Framework for Ocean Observing with an Essential Ocean Variable approach following the results of the OceanObs '09 Conference in September 2009. The resulting GOOS Steering Committee has had four meetings during 2012–2015, then also acting as the Steering Group for the Framework, which was formally published by UNESCO in 2012. The importance of ocean observations for the Law of the Sea implementation is noted through the UNGA Resolution on Oceans and the Law of the Sea in December 2011 which noted the problems of vandalism of ocean data buoys urging States to take necessary action and to cooperate with organizations as IOC, WMO and FAO in this regard. This leads to the proposal of a medium to longer term Visionary Strategic Goal for IOC, see Conclusion and Outlook.

FURTHER INTO THE SECOND DECADE AND THE POST-2015 AGENDA

The Second Decade of the Millennium started with the 50 years' anniversary of the IOC. This was marked by a substantial publication *Troubled Waters: Ocean Science and Governance*, published by Cambridge University Press (Holland, G. & D. Pugh. 2010). In a series of chapters, the developments, activities and results of the IOC are presented, covering the global context, oceans and science, observations and data, applications, a presentation of IOC partners, including FAO, IHO, IMO, UNEP and WMO, and a concluding chapter on the future. This last chapter elucidates several important points, including: time scale perspectives, noting that it takes 4 years before major conclusions are reached by IOC; that trends in science usually manifest over 3-5 years; that ocean technology takes up to one decade from idea to operations; that conventions can take several decades to reach conclusions and entering into force.

Many other activities celebrated the 50 years' anniversary of the IOC and are presented in the 2010 Annual Report (UNESCO, 2011). One was the conference in April 2010 in St Petersburg "50 years of Education and Awareness Raising for Shaping the Future of Oceans and Coasts", also resulting in publication of proceedings in book form (UNESCO-RSHU, 2010). The official celebration

year was launched on 8 June 2010 during the session of the Executive Council, same day as the United Nations World Oceans Day.

Several important results of the IOC work emerged during the year, including *Guide to Best Practices in Ocean Acidification Research and Data Reporting* (EC, 2010); *Marine Spatial Planning: a step-by-step approach toward ecosystem-based management*, first published in 2009 (UNESCO, 2009); *Coastal Adaptation in West Africa*, leading to the new project on adaptation for South East Pacific and for SIDS, confirming an important role of IOC in climate change adaptation; the establishment, within the Framework of UNESCO/IOC Regional Network of Training and Research Centres on Oceanography in the Western Pacific, of the IOC Regional Training and Research Centre in Qingdao, China, focusing on ocean dynamics and climate, and the holding of the World Ocean Week in Xiamen, China. Several other milestones were noted, including the completion of the Census of Marine Life project and the integration of the resulting Ocean Biogeographic Information System (OBIS) into the IOC-IODE system.

The year also is noted for the re-initiation of tsunami warning and disaster reduction systems. This was effectuated through several devastating tsunamis occurring during the year, in Chile, Sumatra, and Haiti, thus of concern to all the regions, triggering actions by all the Tsunami Warning System Intergovernmental Coordinating Groups. The IOC Sub-commissions and other regional bodies were very active during the year, raising awareness, including through many training activities and scientific meetings, including the IOC/UNESCO Perth Regional Programme Office, the Southwest Atlantic Ocean through the Rio GOOS Office, marking 13 years of operation of the PIRATA Project observations and data delivery, incorporation of CO₂ sensors on the ATLAS buoys under the scope of the South Atlantic Climate Consortium, and operation of GLOSS stations in Argentina, Brazil and Uruguay.

Climate, ocean observations and adaptation: The climate change activities shifted focus from global scale human interference with the climate to effects on regional ecosystems and needs for adaptation and mitigation at local level. Open ocean GOOS implementation level rested at 62%, stressing the need for GOOS to include biogeochemistry and ecology dimensions, which are gradually becoming feasible. The direct observations of marine carbon organized through the International Ocean Carbon Coordination Project had proved their value. Products include creation of the Surface Ocean CO₂ Atlas, data on ocean acidification, and the development of quantifiable climate change biodiversity and ecosystem indicators addressed in the OBIS System.

Important activities of the IOC climate change strategy are developments of coastal planning tools and related focus on capacity building. Thus the WCRP Implementation Strategy for 2010–2015 aims at meeting the information needs of society, with focus on regional and decadal climate prediction, providing information adapted to local needs and creating capacity, regionally and globally, of the next generation of climate experts. The achievement of the common vision for GOOS for the decade 2010–2020, integrating new physical, biogeochemical and biological observations agreed at the 2nd Symposium on “The Ocean in a High CO₂ World” in 2009 is envisaged in the *Framework for Ocean Observing* endorsed at the 3rd Symposium in 2012, and by the IOC governing bodies (UNESCO, 2012).

The UN Regular Process: Reliable, controlled ocean observations together with indicators of the state of the ecosystems are required for a useful assessment of the ocean conditions and ecosystem health. This is the overall aim of the World Ocean Assessment by the UN Regular Process of reviewing the state of the marine environment including socio-economic aspects, for which IOC plays a leading role since 2005. Following the successful pilot effort of assessment of assessments proving the feasibility, the UNGA in 2009 agreed on objective, scope, principles and cyclical approach for the Regular Process. In 2010 the deadline for the first integrated assessment was set to 2014, and IOC, UNEP, IMO and FAO were invited to provide scientific and technical support, under the coordination of UN-DOALOS.

The First Global Integrated Assessment of the Ocean, the World Ocean Assessment, was presented to the UNGA in 2015. The IOC contributed scientific and technical advice together with data and information through several of its programmes, participated in regional workshops, cosponsoring some, and attended the leading specially appointed WOA Group of Experts meetings. The development of indicators is the objective of the GEF Transboundary Water Assessment Programme for assessing the conditions of 64 LMEs and the Open Ocean areas. It aims at assessing global ocean issues related to climate, ecosystems, fisheries and pollution and looking at local impacts on vulnerable ocean ecosystems and human systems. The IOC association with the TWAP confirms its support and involvement with the LME network. This includes the secretariat support to the GEF-funded project on LMEs.

HAB and Eutrophication: The problems associated with the eutrophication of coastal waters require an interdisciplinary approach as adopted in the HAB and Global Ecology and oceanography of Harmful Algal Blooms, GEOHAB, Programme. The objective of the IOC-HAB activities is to develop effective management of and scientific research on harmful algal blooms to understand their causes, predict their occurrences and mitigate their effects. Jointly HAB and IODE compile data on HAB events and species biogeography, with OBIS. Through these activities Member States are assisted in dealing with detrimental effects of HABs.

The range of actions include: capacity building, regional networks, working groups, organized mainly through the Science and Communication Centres in Copenhagen, at the University of Copenhagen supported by DANIDA, and in Vigo supported by Spain, publications of guides, manuals and newsletters. GEOHAB uses a comparative system approach to increase understanding of mechanisms of population dynamics of harmful alga and enhance modelling and forecasting abilities.

High seas and biodiversity: The open ocean is also impacted by human activities. The IOC instituted a pilot project on biodiversity and distribution of megafaunal assemblages in the abyssal nodule province of the eastern equatorial Pacific, completed in 2010, (UNESCO, 2006). This action can help defining representative Marine Protected Areas in the open ocean. In 2010 the UNGA approved the Intergovernmental Science-Policy Interface on Biodiversity and Ecosystem Services, for which IOC can deliver data from the Ocean Biogeographic Information System, OBIS. The integration of that system from the Census on Marine Life into the IODE confirms the status of the IODE.

Data management: The 50 years of activities of IODE were noted also by continued growth of the regional Ocean Data Information Networks, the Ocean Teacher Training system and Ocean Teacher Academy, which are all guided from the IOC Project Office for IODE in Ostend, Belgium, supported by the Government of Flanders. The Office has understood the need to reach “beyond ourselves” by increasing partnerships with other organizations in its training and outreach activities. To celebrate 2010 several manuals were published, in addition to eight training courses with 155 participants. In 2010 the IOC, as part of its work on setting scientific standards, adopted the *International Thermodynamic Equation for Sea water*, following endorsements by SCOR and IAPSO (IOC, SCOR and IAPSO. 2010).

Management procedures and policies: The increased scientific understanding of the ocean and coastal zone conditions, the data series, the training and human resources development and partnerships with groups beyond the ocean community would lead nowhere without the provision of useful tools to improve management procedures and policies leading to sustainability of coastal and ocean environments and their resources. With that objective in mind the provision of such tools has become the goal of several actions of the IOC. These include enhancing regional cooperation, and facilitating development of: related science; decision support tools for improving integrated ocean and coastal management; standards and their adoption.

With respect to science related to ocean and coastal management IOC cooperates with IUCN, ESF, and CBD in the Global Ocean Biodiversity Initiative (GOBI) defining and assessing scientific

criteria for Marine Protected Areas and identification of Ecologically and Biologically Significant Areas, also, as noted above, for the deep-sea environment. GOBI provides inputs to both CBD and UN-DOALOS actions. In view of increasing attention to geo-engineering techniques, the IOC with the Science Sector of UNESCO convened in 2010 an expert meeting analysing the status of the science and the governance. It was recommended that an international research programme be initiated modelled on WCRP to address the related technological and scientific challenges. Somewhat related to this is the first “Blue Carbon” International Scientific Meeting also in 2010, aimed at elucidating arguments for protection of marine ecosystems. The meeting encouraged the inclusion of coastal vegetated ecosystems in national carbon accounting and mitigation strategies.

The IOC with partners are promoting the establishment of coastal “Blue Forests” as conservation and management tools under the GEF funded project “Blue Forest Carbon Accounting Methodologies for Coastal Management”. The Southeast Pacific Data and Information Network in support of Integrated Coastal Area Management focused on developing common regional indicators to provide information on MPAs, population dynamics, water quality, biodiversity and planning tools in ICAM. In this context the IOC in cooperation with ICES is facilitating the development, testing and provision of reference materials for measurements of various constituents including nutrients, dissolved oxygen and dissolved organic matter. Another successful completion in 2010 concerned the enhancement of safety from ocean-based marine hazards in the Indian Ocean for the benefits of 12 Indian Ocean countries.

The status and state of IOC at 50: The celebrations and the reported activities and results of the IOC after 50 years certainly highlight the development and transition of the IOC into a substantial intergovernmental body. The IOC has demonstrated values for coordination, cooperation, facilitation of many aspects of ocean research, observations and data management, technology transfer and capacity building. It has achieved sufficient status to build partnerships with other organizations and is accepted as an equal.

The diversity of activities is very large and represents strength as well as a potential danger in losing concentration and identity. The account also brings out some shortcomings which need be addressed in a well thought-out way. These concern the sustained funding at an adequate level, possibly in particular for the regional activities and the warning systems; the development of the internal management and coverage of the statutory mission; lack of focus on ocean science debate, concentrating on how best to increase our knowledge of the ocean, and attraction of science programme managers; the need for streamlining and concentration on priorities of Member States in light of limited resources overall, also at national level, for the ocean research communities; making full use of the very significant technological developments to incorporate new ideas and emerging issues in the strategic actions; defining operational oceanography and advancing sustained ocean observations, which represents a large challenge; the need to not only think but really reach beyond ourselves, to reach out to other communities of society at large, users, the public, economy and industries, public and private enterprises, and to UNESCO delegations and sectors; having functioning National Oceanographic Committees for IOC in all Member States. The funding problems were highlighted by the cut experienced in 2011–2012, leading to freezing of professional regular positions and loss of seconded staff, impacting the JCOMM and GOOS activities. The IOC maintained its involvement with the important actions but lost in leadership, impact and possibly reliability.

It is impossible to predict the future and therefore learning from the past can be a useful exercise. The book Holland, G. & D. Pugh, 2010 celebrating the 50 years’ anniversary of IOC provides good examples. Several aspects have been referred to in the present text. Several transformational events are noted in the chapter on the future. These include scientific ones as TOGA, which gave very significant socio-economic results; and WOCE with a major impact on ocean data amounts and on dynamic modelling. The IOC was instrumental in supporting many aspects of these large global programmes. There have been several studies and evaluations of the future of IOC over the decades. It has generally been concluded that “The future of IOC should be based on the premise that the IOC remains and be re-enforced within UNESCO. The IOC should look for an

enhanced role within UNESCO in terms of intersectoral cooperation, based on its technical expertise. Options for a more independent IOC outside of UNESCO were not broadly supported and were recognized as being premature". While in the past the IOC was directly involved in coordinating and facilitating climate change ocean research, presently the role lies more in providing an underpinning infrastructure; this can be seen as a strategic objective for the IOC. The science programme should address diverse regional and national-local needs using a common systematic approach to scientific uncertainty, data analysis and management, generation of fundamental knowledge, ensuring inter-comparisons and compatibility, and data reliability, as added values. Synergism between global and regional programmes need be more exploited. The global ocean observing community should find a mechanism that will secure the global ocean observing system for the future, the IOC having taken the system from proof of concept to establishment. The required mechanism has evolved in the form of the *Framework for Ocean Observing* (UNESCO, 2012).

The IOC should focus its attention on areas that add maximum values, as intergovernmental coordination and standard setting and possibly offering of certifications. The IOC can coordinate both globally and regionally, and can connect to marine agencies. These assets should be used in developing the services programme with as light governance and as great efficiency as possible. Pilot demonstration projects and a phased approach to develop confidence and trust are required from the regional bodies of IOC.

Strategic areas and possibilities for growth of the IOC include marine environmental assessment, ocean science for adaptation, coordination of regional ocean science and related activities, and mitigation of impacts of natural hazards using the warning systems, providing support of the risk reduction efforts and the Sendai Framework of 2015, with full realization of the competition it faces in this connection.

The future of the IOC is shaped by the Member States working together towards achieving a shared aim. This conclusion is demonstrated by the progress, developments and recognitions over the past several decades. However, the IOC needs to gain more recognition, respect and impact at the national level, seeking to establish much more contact with the scientific communities, and in particular the emerging ones. The IOC needs to seek contacts proactively, explain what it may be able to do and ask what it can do to help them. While IOC is a necessary part of ocean endeavours, it needs be content with delivering value in its areas of competence and "not seeking to lead ocean science more generally." Introduction of "innovative coordination mechanisms, light on governance, heavy on regional relevance and impact and improved governance arrangements" are highly recommended and called for.

THE AWAKENING IN 2011 AND THE BIENNIUM 2012–2013

End of October 2011, a few months after the conclusion of the 50 years' celebrations, the economic "tsunami" struck when USA decided with immediate effect to withhold its regular and extra-budgetary contributions to UNESCO and IOC. This led to a 31% cut in funding for 2011 and the biennium 2012–2013, to a limited extent compensated through emergency funding from UNESCO and some additional extra-budgetary contributions. Nevertheless, the Secretariat managed, in partnership with others, to keep up most of the important programmes for the biennium as reflected in the *IOC Biennial report 2012–2013* (UNESCO, 2014c), the first of the biennial reporting cycle. The activities continued following the lines specified in the UNESCO Strategy for 2008–2013, with four High-level Objectives, summarized below.

Prevention and reduction of impacts of natural disasters: Despite funding restrictions the four Intergovernmental Coordination Groups for the Tsunami Warning Systems met as planned, and implemented required training with communication and tsunami exercises. These activities showed an increase in participation of Tsunami Warning Focal Points and have raised awareness among decision makers and emergency management institutions. From 31 March 2013 the regional tsunami services for the Indian Ocean are the responsibility of Australia, India and Indonesia, still with the IOC-Perth Office as IOC focal point. Three national tsunami warning centres have been set up by

Member States in the Indian Ocean Region, and three in the Northeast Atlantic and the Mediterranean Region, and tsunami information centres have been established in all four regions. Significantly additional seismic and sea level stations are now available globally to help reducing the time for issuing tsunami alerts. The number of stations of GLOSS reporting real-time data to the IOC Sea Level Station Monitoring Facility and the four regional tsunami warning systems increased from 30 in 2006 to 724 by end of 2013. Over the six years since the tsunami warning system rebirth in 2005/2006 the IOC has organized over 60 workshops on hazard assessment, standard operating procedures, coastal inundation and tsunami modelling, and provided several manuals and guides in required languages.

Mitigation of impacts and adaptation to climate change and variability: The structures and scope of GOOS were reformed by the Assembly at its 26th session in 2011, creating the GOOS Steering Committee, which met in 2012 just prior to the 45th Executive Council and in 2013 to review progress of GOOS. The challenge remains to achieve the agreed global targets. The JCOMM Observing Programme Support Center, maintained by voluntary contributions over the period 2008–2013, serves as a platform for technical coordination and support to operators of GOOS *in situ* networks. This includes time-series stations and ship hydrography. The tracking system shows an implementation level for the whole GOOS at 62%, and a below 50% real-time data return of the tropical Pacific moored array due to reduction of mooring refresh cruises. This has gradually been rectified in subsequent years. At the same time the Argo profiling float network delivered its millionth profile in 2012, with 120,000 new profiles annually of temperature and salinity. The GSC work plan included broadening the variables of GOOS with establishment of three panels to determine societal requirements for sustained observations of physical, geochemical and biology/ecosystem variables. This development will build on the previous panels for climate, ocean carbon and integrated coastal observations, and will cooperate with the GEO Biodiversity Observing Network and OBIS. The Steering Committee communicated with key conventions as CBD and on-going global assessments as the WOA and the TWAP as to their needs for ocean data and information. The GOOS Project Office participated in the three regional consultations over 2012–2013 on sustained ocean observations. The JCOMM at its 4th session in Yeosu, Republic of Korea, May 2012, agreed on its strategy (IOC-WMO, 2012) and work plan for 2012–2017 (IOC-WMO, 2015). A Joint Task Force of the International Telecommunication Union (ITU), WMO and IOC, through GOOS and JCOMM, was established to explore the use of submarine communications cables for measuring bottom pressure and seismic activity for tsunami warning, and deep ocean monitoring for climate change.

Time series of observations are necessary for confirming change, and comparisons of time series require agreed methods. This was the subject of the International Ocean Carbon Coordination Project workshop in 2012 offering common standards and methods for comparisons of specific time series. The IOC is compiling existing biogeochemical time series and put together 33 sites from the workshop with others from the North Atlantic. In total 125 such time series have been compiled from around the world; again an important standard setting work of the IOC. The time series could support the development of a monitoring network for standardized observations of ocean acidification. The surface ocean CO₂ database of IOCCP reached over 6 million data in 2012. The partners IOC, NOAA, and IOCCP are working to establish an International Ocean Acidification Observing System. The 3rd symposium on the Ocean in a High CO₂ World stressed the need to combine CO₂ observations with other stressors as temperature, nutrient availability and hypoxia. The *Ocean Acidification: summary for policymakers; third Symposium on the Ocean in a High-CO₂ World* was published in 2013 (IOC, SCOR, IGBP, 2013).

Health of ocean ecosystems: Marine pollution is an increasing concern, including the marine debris problem. This has been highlighted through the degrading of large amounts of plastic material brought together through the ocean circulation with the debris forming subsurface clouds in the major ocean gyres. Smaller but very distinct such clouds are also found in shelf sea circulation patterns for instance in the North Sea-Skagerrack gyre. The GESAMP study on *Sources, Fate and Effects of Microplastics in the Marine Environment: A Global Assessment* (GESAMP, 2015) led by IOC is elucidating the current state of knowledge (. Eutrophication and nutrient pollution are likewise serious problems. The IOC Assembly in 2011 agreed on the new Nutrients and Coastal Impacts Research

Programme aiming at integrated coastal research and coastal eutrophication, linking nutrient sources to coastal ecosystem effects and management. The three-year Joint UNEP-IOC GEF funded Project “Global foundations for reducing nutrient enrichment and oxygen depletion from land based pollution”, started in March 2012, is a key element of the implementation strategy. It is expected to result in a policy tool box and execution of a pilot project for nutrient reduction in Manila Bay, as a pilot implementation effort. This is part of the IOC efforts for integrated coastal management, also manifested in the West African project concluded in 2012, and the South Pacific Information and Data Management in support of ICAM, the first phase of which was concluded in 2012.

Proper coastal zone development and management is becoming increasingly dependent on Marine Spatial Planning due to the multiple uses of coastal waters. Following the publication UNESCO, 2009 and use of the first guide by IOC a second guide is being prepared expanding advice on practice of implementing monitoring and evaluation of the MSP initiatives. The ICAM plans endorsed by the Assembly in 2011 included preparation of a guide on *Adaptation Options for Local Decision-makers* (UNESCO, 2012b), involving natural and social scientists, coastal engineers and coastal managers. Support was provided by WMO, Republic of Korea and Government of Flanders and the guide was published in 2013. These contributions can be seen as continued facilitating work of IOC. That also includes development of a set of indicators led by IOC for implementation of ICAM (ICZM) Protocols in various regions. An example is the support of the PEGASO project, Portal on People for Ecosystem Based Governance in Assessing Sustainable Development of Ocean and Coast. The need for local information and communication with respect to incidents brings in the potential of citizen science using the modern communication tools.

The Harmful Algal Bloom threat continues to be of considerable concern for coastal areas and shelf seas. The outcome of the IOC-SCOR GEOHAB Programme 1998–2013 was reviewed by the IOC Intergovernmental Panel on Harmful Algal Blooms at its 11th session of the, following a synthesis conference in April 2013. The Panel recommended to the Assembly a research agenda for the next decade named GlobalHAB. Training activities have been a large part of the programme, much recognized, with 10 courses held over the biennium 2012–2013, at the IOC Science and Communication Centre on Harmful Algae at the University of Copenhagen, and at national centres. The IOC Newsletter *Harmful Algae News* has been a standing production supported by the Institute of Marine Investigation, Spain and the University of Copenhagen.

The MOU for the IOC Project Office for IODE between IOC/UNESCO and the Government of Flanders was renewed on 30 March 2012, expiring now on 31 December 2016. The IODE is being restructured to cater for increasing demand of services. A MOU was concluded between IOC and Roshydromet, Russian Federation, on a Partnership Centre for the IODE Ocean Data Portal, with the Centre inaugurated in September 2013. The OBIS was adopted within the IODE Programme by the Assembly in 2009, with necessary funding largely secured from extrabudgetary contributions. Following the withdrawal of support from USA, the OBIS Secretariat moved to the IOC Project Office for IODE in Ostend (Belgium). The Assembly in 2011 established the IODE Steering Group for OBIS and the IODE Group of Experts for OBIS. The OBIS continues to grow and had established a network of hundreds of data providers by 2013. Since the start of 2011, 210 new datasets were added to OBIS; in total OBIS in 2013 integrated 1,130 datasets, serving 35 million observations of 120,000 marine species. With support by Flanders the “Harmful Algal Information System” was upgraded to better serve the data providers and end-users. This IOC/IODE data product, operated jointly with ICES and PICES, provides a global system for compilation of HAB-event related data and metadata, with links to OBIS and the World Register of Marine Species.

Management procedures and policies leading to the sustainability of coastal and ocean environment and resources: The Biennium 2012–2013 saw much activities in development of the World Ocean Assessment, including several regional meetings and sessions of the UNGA ad hoc working groups in both 2012 and 2013, in all of which IOC participated. The IOC as leading the Open Ocean and Large Marine Ecosystem component of the Transboundary Water Assessment Programme, which was formulated in 2012, adopted end of 2012, initiated its part through a

workshop in March 2013, creating partnerships with several scientific institutions in order to move the project. It is expected to provide core ecological, socio-economic and governance indicators using globally available data sets. Following the Conference Rio+20 the IOC also participated in the formulation of the Sustainable Development Goals.

REGIONAL ACTIVITIES

Despite the limited funding significant regional activities were implemented through the IOC Sub-Commissions. The youngest IOC Sub-Commission for Africa and the Adjacent Island States convened in Nairobi 2012 and in Cape Town 2013, when its Strategic Plan for 2014–2021 was adopted and subsequently endorsed by the Assembly in 2013. The implementation of the Ocean Data and Information Network for Africa continued, with development of Coastal and Marine Atlases, African Register of Marine Species, and several workshops including ODINAFRICA Regional Coordination. A comprehensive assessment of capabilities for marine sciences in Africa was carried out. The Republic of Korea supported the Sub-Commission sessions and capacity assessment, Kenya is giving support to the Secretariat, but the projects funded by the Government of Flanders and the Republic of Korea ended in 2013. Extra-budgetary support is provided by Belgium, China and Spain to support new initiatives adopted by the Sub-Commission.

The Sub-Commission for the Caribbean and Adjacent Regions held its 12th session in April 2013, with 37 participants from 12 Member States and other UN Agencies and regional partners. A Working Group of experts was established to help move forward the establishment of a coordinated, integrated and sustainable regional ocean and coastal observing system in the IOCARIBE region. A Coastal Inundation Forecasting Project aims at providing a strategy for achieving improved operational forecasts and warnings for coastal inundation. The IOCARIBE Project to “Demonstrate Approaches for Nutrient and Sediment Reduction at Selected Pilot Study Areas in the Wider Caribbean” is supported as part of a larger GEF project. The Regional HAB component publications on Ciguatera with a workshop on *Ciguatera as a potential risk to public health in the Caribbean* represent results of great socio-economic value.

The 9th Session of WESTPAC, Republic of Korea, May 2012, included 70 delegates. Key activities in three thematic areas include 22 regional workshops, 10 training/summer schools and 2 joint cruises, within the themes ocean processes in the Indo-Pacific Region, marine biodiversity and food security, and ocean ecosystem health. The Sub-Commission was actively involved in the regional component of WOA with capacity building for conducting integrated marine assessments. The Indo-Pacific Ocean Forum on “Charting the Future of Sustained Ocean Observations and Services”, November 2013 with the support of the Republic of Korea, involved many experts, GOOS representatives and GOOS regional alliances (UNESCO, 2014b). The advice of the Forum was taken into account in the report on the Future of the IOC at the 28th Assembly, 2015. Capacity building continues to be a central activity, with building of the IOC Regional Network of Training and Research Centres on Marine Sciences, having its first Centre in the First Institute of Oceanography supported by SOA in Qingdao, PRP China. The Sub-Commission celebrated its 25 year’ anniversary, leading up to its 9th WESTPAC International Scientific Symposium in April 2014, in Vietnam.

GLOBAL ACTIVITIES

The IOC Medium-Term Strategy, 2014–2021 was adopted by the Assembly at its 27th session in 2013. The new Strategy is organized around four High level Objectives, similar to the previous period. The IOC participated actively in the Rio+20 Conference 2012, presenting a Statement and the UN-interagency report *A Blueprint for Ocean and Coastal Sustainability* (IOC, UNDP, FAO, IMO, 2011), and organizing three major side events, on ocean and science; the International Oceans Day jointly with the Global Ocean Forum; an official UNESCO side event on the ocean covering science, education and World Heritage perspectives on ocean issues. The outcome document *The Future We Want* (UN, 2012) refers to IOC through several issues addressed by the work of IOC, including capacity development and application of *IOC Criteria and Guidelines for Transfer of Marine*

Technology (UNESCO, 2005); the UN Regular Process; conservation and sustainable use of marine biodiversity in areas beyond national jurisdiction; sea-level rise and coastal erosion; ocean fertilization; ocean acidification; and area-based conservation including marine protected areas. The development of the new Sustainable Development Goals was initiated. The IOC participated in this work and provided substantial inputs. The IOC also participated in the 14th Session of the Informal Consultative Process, contributing substantially to the report of the Secretary-General on Oceans and the Law of the Sea. The related Resolution of the 66th Session of the UNGA, April 2012 was referred to above in section on Responsibilities of the IOC within UNCLOS.

The contribution of the IOC to the report of the Secretary-General on Oceans and the Law of the Sea highlighted the continued work of the IOC/ABE-LOS; the first meeting of the new GOOS Steering Committee; the consultations of all IOC Member States to identify ways to improve the activities in sustained ocean observations and services, the results of which were reported to the IOC Assembly in 2015, and reflects on the call by Rio+20 for international cooperation in the observation of ocean acidification and vulnerable ecosystems. The Conference stressed the need for cooperation in marine scientific research to implement the provisions of UNCLOS, including through transfer of marine technology, using the guidelines prepared by IOC. Information was provided to DOALOS on the issue of the 14th Session of the ICP entitled “Impacts of ocean acidification on the marine environment”. The IOC furthermore reported on the development of an Ocean Acidification Observing Network, the results of the 3rd International Symposium on the Ocean in a High-CO₂ World, and its cooperation with the IOCP, the International Ocean Carbon Coordination Project.

THE MIDDLE OF THE DECADE: TOWARDS THE 2030 AGENDA

Most noticeably the middle of the second decade saw the adoption of 17 new Sustainable Development Goals. One, no 14 concerns the ocean, but there are several others which relate to the ocean, the marine environment and resources, and depend upon, and impact, the ocean in many ways. These are all relevant to the IOC. They include:

- SDG 1, to end poverty in all its forms, with ownership and control of resources, vulnerability to climate related extremes and need for protection, together with SDG 2, to end hunger, achieve food security, for which fisheries and aquaculture are important elements, as are the deep ocean genetic resources;
- SDG 7, ensure access to affordable, reliable, sustainable energy, for which the ocean and coastal areas form important sources, locally and regionally;
- SDG 8, sustainable tourism, with the ocean and coasts being very important tourism attractions with dominating contributions to national incomes in many poor countries;
- SDG 11 on cities and human settlements, for which coastal megacities constitute, very significant “players”, and where IOC has been an active player;
- SDG 13 on climate changes where the role and influence of the ocean and coasts must necessarily be properly taken into account, which the IOC has a large responsibility to ensure;
- SDG 14 where all ocean issues and challenges are included: conserve and sustainably use the oceans, seas and marine resources for sustainable development. The time scales are 5-10 years: by 2025, prevent and significantly reduce marine pollution of all kinds; by 2020 sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts; minimize and address impacts of ocean acidification, including through enhanced scientific cooperation at all levels; by 2020 regulate harvesting and end overfishing, and implement science-based management plans; by 2020 conserve at least 10% of coastal and marine areas, based on best available scientific information; by 2020

eliminate fisheries subsidies; by 2030 increase economic benefits to SIDS and LDCs from sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism.

- Under SDG 14 Target 14 a: increase scientific knowledge, develop research capacity and transfer marine technology, taking into account the *IOC Criteria and Guidelines on the Transfer of Marine Technology*, to improve ocean health;
 - Target 14 b, provide access for small-scale artisanal fisheries;
 - and Target 14 c, enhance the conservation and sustainable use of oceans and their resources by implanting international law as reflected in UNCLOS, which provides the legal framework for conservation and sustainable use of oceans and their resources, as recalled also in “The Future We Want”.
- SDG 15 on Protection and restoring terrestrial ecosystems, including inland freshwaters and wetlands, drought and floods;
 - SDG 17 includes capacity building and enhancement of the Global Partnership for Sustainable Development, and data, monitoring and accountability; by 2020 enhance capacity building support to developing countries to increase significantly the availability of high-quality, timely and reliable data; and by 2030 support statistical capacity building in developing countries.
 - SDG 6, ensure availability and sustainable management of water and sanitation for all; by 2030 implant integrated water resources management at all levels, including through trans-boundary cooperation; by 2020 protect, restore water-related ecosystems, including wetlands, rivers, aquifers and lakes; by 2030 expand international cooperation and capacity building support in water and sanitation-related activities, including desalination;
 - SDG 7, ensure access to affordable, sustainable and modern energy for all, and by 2030 clean energy.

The passing of the middle of the second decade marked several anniversaries for IOC, including 50 years since the start of the First International Indian Ocean Expedition, marked by a symposium and the launching of the 2nd IIOE; the 50 years’ anniversary of the establishment of the Pacific Tsunami Warning System and the first International Coordinating Group (Kong et al. 2015), which was marked by a symposium in Hawaii “Making the Pacific Ready for the Tsunami Threat”; the 10 year anniversary of three other regional Tsunami and other ocean-related hazards Warning Systems and 10th session of the Indian Ocean Tsunami and Mitigation System, 2015, in Jakarta, with its recommendations transmitted to the 3rd UN World Conference on Disaster Risk Reduction, Sendai, Japan 2015, resulting in the adoption of the Sendai Framework; the 25th Anniversary of WESTPAC with its 9th International Symposium in Vietnam 2014, generating an agreement to cooperate with ASEAN, focusing on health of coasts and oceans as a programme within ASEAN-UNESCO Joint Programme of Action 2014–2018; celebration of the 10th Anniversary of the IOC-IODE Project Office in Ostend, Belgium, with six functions including Ocean Teacher Academy, International Coastal Atlas Network and OBIS; the 12th Session of the IOC Intergovernmental Panel on Harmful Algal Blooms, highlighting the unique role of IOC in addressing a socio-economic significant problem on basis of science, observations, international as well as intergovernmental cooperation and coordination, with the possibility of adding HAB warning and forecasting to the IOC warning system services. Furthermore, in 2015 the Sub-Commission for the Caribbean and Adjacent Regions held its 13th Session and the Sub-Commission for Africa and Adjacent Island States held its 3rd Session. This all demonstrates the persistence, survival, consistency and usefulness of the IOC.

In 2015 a new *IOC Capacity Development Strategy, 2015–2021*, was adopted by the Assembly (UNESCO, 2016), building on the experiences from the start of the TEMA programme, later referred to as the Capacity Development programme, to include the IOC Principles and Strategy for Capacity-

building adopted in 2005, and the review of the Capacity Development activities by the Assembly in 2011 at its 26th Session. The new strategy refers extensively to the IOC role in conjunction with UNCLOS, and the necessity to address in particular the growing needs of Africa, and Small Island Developing States, as well as some other regions, to help ensure that all Member States can effectively participate in and benefit from all of the IOC work for maintaining healthy ocean ecosystems, including transfer of marine science and technology. This all becomes highlighted through the SDGs of the 2030 Agenda, as shown above. Noticeable reference is made in the Strategy to the emergence of the concept of blue economy, or ocean-based economics, generating in many developing countries incentives for focusing economic development plans on the exploitation and management of marine resources. Reference is likewise made in the Strategy to the IOC Global Ocean Science Report, which aims at providing an overview of national (i) investments, (ii) resources, and (iii) scientific productivity in ocean science, and its potential to stimulate developments of human and institutional capacities of Member States of the IOC. The need for IOC to align its activities in capacity development with national priorities is highlighted, including more use of partnerships rather than the pure assistance. IOC should take the lead in integrating existing capacity development programmes from UN and NGOs to optimize capacity development on a global scale. This harmonizes well with SDG 17 and the spirit of SDG 6.

The year 2015 also saw a major breakthrough for the potential development of a legally binding instrument/agreement under UNCLOS with respect to handling the conservation and sustainable use of marine biological diversity in areas beyond national jurisdiction (BBNJ), which had been discussed since 2006. Many activities of the IOC, parts of its mandate, could be recognized under a new agreement, including: (i) the Ocean Biogeographic Information System (OBIS) (UNESCO, 2015); (ii) as part of the Capacity Development, the Ocean Teacher Global Academy network of 10 Regional Training Centres, coordinated by the IODE, which could form a model for global training in marine biodiversity resources management, conforming very well with the Capacity Development Strategy; (iii) sustained ocean observations under the umbrella of GOOS; (iv) guidance on marine spatial planning. All this argues strongly for an IOC participation in the Preparatory Committee for an agreement, and associated enhanced cooperation with UN-DOALOS. Currently a majority of Member States are in favour of a third agreement under UNCLOS to consider biodiversity as a common heritage, with equitable access and benefit sharing.

The package under consideration covers marine genetic resources, sea-based management tools as marine protected areas, environmental impact assessments, capacity building and transfer of marine technology. In this context the recognition in UNCLOS of the IOC role in Marine Scientific Research and in Transfer of Marine Technology is important, defining both the IOC responsibility and opportunity. The role of OBIS in identification of Ecologically or Biologically Significant Areas within and beyond EEZs, a process led by the CBD Secretariat, should be stressed and used; likewise, the role of the Ocean Teacher Global Academy in context of Article 276 of UNCLOS in relation to establishment of regional centres for marine scientific research and transfer of marine technology, which is being called for by the Third International Conference on SIDS, Samoa 2014.

The SDGs adopted in 2015 reiterate the Rio+20 Outcome document *The Future We Want*, and thus the recognition therein of “the importance of building capacity of developing countries to benefit from the conservation and sustainable use of oceans and seas and their resources”. The role of the IOC in this context is confirmed, including through the *IOC Criteria and Guidelines on the transfer of marine technology*. This is underlined in the UNGA Resolution in 2014 on the Oceans and the Law of the Sea, reiterating the need for cooperation including through capacity building and transfer of marine technology, “to ensure that States...in particular LDCs and SIDS, and coastal African States, are able both to implement the Convention (UNCLOS), and benefit from the sustainable development of oceans and seas”.

The first half of the decade also saw the adoption of the revised governance for the ocean observations in form of *A Framework for Ocean Observing* (UNESCO, 2012). This originates from a strong call of the OceanObs`09 Conference, September 2009, for international integration and coordination of interdisciplinary ocean observations. A Task Team was commissioned after Ocean

Obs'09, to write the *Framework for Ocean Observing* for integrated and sustained ocean observing systems. The Team decided to have the Framework and its coordination processes organized around delivery of “essential ocean variables (EOVs)”, instead of through specific systems, platforms, programmes or regions. The Task Team suggested a governance model, based on the Framework for Ocean Observing, consisting of a GOOS Steering Committee (GOOS-SC) for advice and high level coordination and the Ocean Observing System Panels (Physics & Climate, Biogeochemistry, Biology & Ecosystems), responsible for specification of requirements of EOVs. The GOOS-SC and Panels are comprised of scientific experts, community leaders, representatives of the international sponsors and regional representation of IOC Member States to optimize collaboration and integration across the many observing system elements and communities. The Panels incorporate the work of the Ocean Observations Panel for Climate and the International Ocean Carbon Coordination Project and other existing observing networks where appropriate. The framework assigns responsibility to the IOC to ensure that the governance model functions satisfactorily for all parties.

Drafts of the Framework for Ocean Observing, other reviews of the GOOS governing structure, and the work of the Board of the Intergovernmental Committee for GOOS (I-GOOS) led to the proposal for the streamlined and strengthened GOOS adopted by the IOC Assembly in July 2011. This in turn led to the termination by the end of 2011 of IOC bodies responsible for GOOS and the replacing of all these by the GOOS Steering Committee (GSC) by 1 January 2012. The Task Team in delivering its report proposed the creation of a Framework Steering Committee and endorsed the position of the IOC that the GSC serves as the Framework Steering Committee. This will of course put the responsibility on the IOC to ensure that the governance model functions satisfactorily for all parties. The Framework and the new governance structure for GOOS were endorsed by the IOC Governing Bodies.

This whole development needs be properly harmonized with the Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology and its mandate and objectives. These include enhancement of the provision of marine meteorological and oceanographic forecasting and analysis services; developments, enhancement and delivery of climate services related to the marine atmosphere and coastal and deep oceans; coordination of the enhancement and long-term maintenance of an integrated global marine meteorological and oceanographic observing and data management system; coordination of the evolution of the services. Thus continued engagement with JCOMM and maintenance of JCOMM Observation Coordination Group was recommended by the Task Team.

By the middle of the second Decade the Global Ecology and Oceanography of Harmful Algal Blooms research programme (GEOHAB) of SCOR and IOC, created in 1998, also celebrated 15 years of productive research and observations with preparation of a scientific report with a scientific summary for policy makers (UNESCO, SCOR, 2015). This presents in a concise form the current knowledge of HABs, noting that many HABs are increasing in severity, frequency and biogeographical range, due to many factors as climate change and human impacts, including eutrophication, habitat modification and introduction of exogenous species. The report elucidates the HAB impacts on human health, fisheries, coral reefs, aquaculture and other ecosystems. The report demonstrates that a comprehensive global HAB observing and forecasting information system would cost about one-tenth of the direct economic losses due to marine and freshwater HABs, on basis of a typical value of information estimate of 1% of the HAB-related economic losses. In addition to these losses come the losses of social security, human health and ecosystem services.

Other noticeable work by the IOC in the second decade concerns marine spatial planning, with *A Guide to Evaluating Marine Spatial Plans* (UNESCO-IOC, 2014); and work on adaptation options for local decision-makers, guidance for decision making to cope with coastal changes in West Africa (UNESCO-IOC, 2012), with several partners including GEF and UNDP, published in 2012. These examples from the ICAM programme can both serve as demonstration projects of results of the IOC of priority interests for Member States in many regions. It is unlikely that any other intergovernmental organization would have generated these works.

CONCLUSIONS AND OUTLOOK

The major conclusion is that the IOC has more than proven its value and has put in place mechanisms, bodies, and facilitated developments which no other intergovernmental organization would have or could have done. The third assessment of ocean science presented in the book of 2002 entitled *Oceans 2020: Science, Trends and the Challenge of Sustainability*, (IOC, SCOR, SCOPE, 2002) acknowledges that “recent progress in ocean science has been achieved through international coordination and planning”. International cooperation in ocean research and observations is a great success, and IOC is playing an important role in this process.

The increase in number of Member States from the original 40, most of which were fairly advanced in ocean research, to 148 in 2016, most of which need significant capacity-development support, suggests a strong increase in interest in and understanding of the value of ocean research, observations and utilization of related capacities and results for socio-economic applications. This also means a strong shift in emphasis to development of capabilities over these areas, which is seen in the IOC recent efforts. In parallel to this development the number of institutions, organizations and groups dealing with aspects of ocean research, observations and resources has increased very much compared to the 1960 situation. Messages about the ocean situation are coming from many different sources and interests, sometimes with conflicting interpretations, driving misunderstandings and unjustified perceptions. This increases the need for and importance of qualified science-based messages from an organization as IOC reaching beyond ourselves and reaching the public and becoming even more essential than before. There is a need to influence the public perception of the work, the products and the organization.

A challenge for the IOC and several of its programmes is to maintain the participation of the leading scientists and attract the young, coming ones, as well as science managers. The IOC must continue to prove its value for these groups and attract them. The current challenges to society need science and technology developments together with related human resources to be properly addressed, with governments’ active involvement and intergovernmental cooperation, in particular in relation to the ocean. This is part of the IOC mission and the IOC should support the implementation of UNCLOS, in cooperation with UN-DOALOS as brought out in UNGA Resolutions. The IOC should in line with this facilitate achievement of the Sustainable Development Goals through close dialogue with Member States. This may best be achieved through the regional subsidiary bodies, using synergism between global-regional-national interests and programmes.

Some specific observations: Training and education activities have received considerable support from donors, including UNDP, UNEP and more recently GEF, with regional subsidiary bodies identifying needs of Member States and supporting implementation. Specific programmes have also received sustained support over one to two decades from several Member States. This underlines the importance and success of the IOC role in facilitating and leading cooperation and coordination, building partnerships addressing specific needs of regions and Member States. This is the main mission of the IOC, now at least as important as before in context of globalization and for achieving the goals specified in the UN Global Frameworks: Agenda 2030 and SDG 2015–2030; Sendai 2015–2030; SIDS SAMOA Pathway of 2014; UN-FCCC and COP21 results.

The partnerships developed by the IOC can meet the need for inter-disciplinarity and integration. However, there is a need for appropriate balance so that IOC maintains its identity and integrity. The applications of the results of IOC work are furthermore to a large extent presented by other bodies than the IOC. This implies that IOC does not get the credit and visibility it should have. This “middlemen” problem may be addressed by having a pure IOC brand message always associated with the presentation. The fact that there is an upstream process and that IOC in many cases functions as an assembly line needs be clearly explained to the various customers, including Member States.

The initial regional cooperative studies fulfilled the expectations, stimulated governmental interest in and support to ocean research and observations, and brought out applications in relation

to utilization of ocean resources and management. The resulting continued regional cooperation, established on basis of the expressed wishes of the regional Member States, requires central support, including at least seed money. Links and synergism between global, regional and even national programmes, as well as between the regional programmes, are very stimulating and should be pursued. An important region which needs attention is the Southern Ocean, and this may possibly be achieved through revitalization of the related Intergovernmental Coordinating Group. The careful step-wise evaluation of the problem, its importance and interest to Member States and relevance to IOC before entering into a new obligation applied from the start seems to be generally pursued.

Various trends can be seen in developments of regional subsidiary bodies as well as in the programme developments and persistence, with some important standing programmes. These include capacity development, data and information exchange and management, hazard warning systems, sustained ocean observations and services, and ocean science. However, the diversity of IOC activities is large, with relatively very limited regular funding, and a small Secretariat. There is reason for concentration on priorities of major interest to Member States. This may help obtaining sustained funding at an adequate level. Development and provision of tools for improving management, securing sustained ocean observations and services are some of the possibilities for IOC to deliver values, together with related capacity development, science and technology transfer. The interest for such an approach is shown for instance in the development of the warning systems, the strengthening of the global Sea-Level Monitoring Facility, the OBIS, and establishment of regional centres.

An impression from several reports on IOC activities over the year, from around 2008 onwards, is that there is an indication of IOC becoming a project-oriented mechanism generating project proposals for funding support from GEF, UNDP, UNEP, national donors and foundations. This development seems required in light of the financial conditions, but it puts a large load on the Secretariat to ensure implementation and reporting, if the projects are not implemented by Member States. It therefore seems important that the projects are close to and fully meets the needs of the programmes agreed by the IOC Governing bodies and are of direct interest to Member States and their governments. If this is not the case the actions do not meet the need to be of priority interest for the owners of the IOC, the Member States/governments, who will lose interest in the IOC. Then the IOC runs the risk of becoming a donor driven division within UNESCO, no longer an intergovernmental organization. It should be noted that initially the IOC concentrated on promoting cooperation and coordination leaving operational activities to partners, in particular the ICSPRO Agencies. However, then the situation with respect to funding and competition was very different from now.

On basis of the overview presented here the following medium to long-term goal for the IOC is proposed to form a unifying focusing theme or direction.

The IOC Visionary strategic goal for the decades beyond 2020 aims at *helping securing a healthy ocean, the Ocean we need for the future, on basis of science, observations, technology and related services in support of sustainable development, to be achieved by supporting, within the IOC mandate, good governance and management of the ocean and regional seas, their resources and human uses of them and the marine environment, by contributing to the implementation of the United Nations Convention on the Law of the Sea and Agenda 21 of UNCED 1992, with subsequent international agreements and conventions*. It should be noted that UNCLOS underpins Sustainable Development, including through ocean Blue economy, thus supporting the Sustainable Development Goals adopted in 2015.

The fulfilment of this Visionary strategic goal for the future includes addressing the current and emerging major issues of the ocean, regional seas and coasts through the purpose and functions of the IOC as stipulated in its Statutes Articles 2 and 3, respectively (UNESCO, 2000), including for the period 2016–2021 the High-Level Objectives specified in its *Medium-Term Strategy, 2014-2021* (UNESCO, 2014). Major issues which need be addressed include ocean acidification, implications for human health and food production of harmful algal blooms, ocean biogeochemistry and primary

production changes, pollution of marine debris and plastic residue, climate change projections with sea-level increase and coastal zone erosion and inundations, hazard warnings as one basis for disaster risk reductions and social security, deoxygenation and changes of nutrient balances, species composition and loss of biodiversity.

MOTIVATION FOR THE VISIONARY STRATEGIC GOAL AND CLOSE ASSOCIATION WITH UNCLOS

The IOC is recognized in the Law of the Sea as the competent intergovernmental organization in the fields of Marine Scientific Research (part XIII) and Transfer of Marine Technology (part XIV). The Rio+20 Outcome document *The Future We Want* recognizes “the importance of building capacity of developing countries to benefit from the conservation and sustainable use of oceans and seas and their resources”. Therein it is also put emphasis on “the need for transfer of technology taking into account IOC’s *Criteria and Guidelines on the transfer of marine technology*”, which are contributing to the implementation of Article 271 of UNCLOS. The IOC is providing advice to Member States with respect to meeting the provisions of Part VI Continental Shelf, in particular Articles 76 and 77. Through the scientific, observation, data management, data repositories and capacity building activities the IOC is contributing to the fulfilment of Part XII on Protection and Preservation of the Marine Environment as well as to several elements of Part XI, (the seabed and ocean floor and subsoil thereof, beyond the limits of national jurisdiction referred to as the ‘Area’).

The past experiences also indicate the importance of long-term perspectives over a decadal time-scale. The large scale global research programmes typically have had a decadal timescale, and time series of observations need look even beyond that. Changes of human behaviour normally need inter-generational time scales. The development of UNCLOS required about two decades, 1974 to 1994, or almost three if counted from the speech of the Maltese Ambassador to the UN, Arvid Pardo to the General Assembly in 1967². Finally, it took a bit over a decade to create the IOC. The developments thereafter show the instrumental importance of the IOC in raising the interest and knowledge about the ocean, in a persistent and sustained way even with limited resources.

The experiences of the International Decade for Ocean Exploration 1970–1980 and the International Year of the Ocean 1998 show that they generated very significant interest for the ocean, the marine environment and raised the understanding among the peoples for the importance of the ocean as part of our life-supporting system. The Decade stimulated national, regional and global efforts, as did the IYO ‘98.

In view of these observations it is suggested that some thought be given to the possibility of generating a second international decade for science-based ocean sustainable development and governance, by 2020, celebrating 50 years after the first ocean decade. Some strategic objectives of the IOC can be related to such an effort, as the role of the IOC in underpinning an infrastructure for sustained research on diverse regional and national needs, using a systematic, common approach to ensure inter-comparisons of results and identification of trends; the IOC role in supporting science for adaptation, mitigation and risk-reduction using the warning systems; the need for IOC to develop innovative coordination mechanisms for instance on basis of modern communication systems; and the IOC role in marine environmental assessments.

² http://www.un.org/depts/los/convention_agreements/texts/pardo_ga1967.pdf

References

- EC. 2010. Guide to Best Practices in Ocean Acidification Research and Data Reporting. Riebesell, Ulf (Author). Riebesell U., Fabry V. J., Hansson L. & Gattuso J.-P. (Eds.). Luxembourg: Publications Office of the European Union 258 p., illus. ISBN 978-92-79-11118-1
- GESAMP. 2015. Sources, fate and effects of microplastics in the marine environment: a global assessment. (Kershaw, P. J., ed.). (IMO/FAO/UNESCO-IOC/UNIDO/WMO/IAEA/UN/UNEP/UNDP Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection). Rep. Stud. GESAMP No. 90, 96 p.
- GITC bv. 2003. The History of GEBCO, 1903–2003: the 100-year story of the General Bathymetric Chart of the Oceans. Jacqueline Carpine-Lancre et al. (authora). 140 pp. ISBN-10: 9080620548
- Holland, G. & D. Pugh. 2010. Troubled Waters: Ocean Science and Governance. Cambridge, UK, Cambridge University Press. 316 pp. ISBN: 978-0-521-76581-7
- IOC, IHO and BODC. 2003. Centenary Edition of the GEBCO Digital Atlas, published on CD-ROM on behalf of the Intergovernmental Oceanographic Commission and the International Hydrographic Organization as part of the General Bathymetric Chart of the Oceans, British Oceanographic Data Centre, Liverpool, U.K. (updated in 2005)
- IOC, IHO. 2000. Continental shelf limits: the scientific and legal interface. Cook, Peter J.; Carleton, Chris M. (Authors); New York, Oxford University Press (Publisher). 363 p., illus., maps. ISBN: 0-19-511782-4
- IOC, SCOR and IAPSO. 2010: The international thermodynamic equation of seawater – 2010: Calculation and use of thermodynamic properties (TEOS-10 manual). Intergovernmental Oceanographic Commission, 196 pp. (IOC Manuals and Guides Series, 56; IOC/2010/MG/56)
- IOC, SCOR, IGBP. 2013. Ocean acidification: summary for policymakers; third Symposium on the Ocean in a High-CO₂ World. 26 p., illus. English, French, Korean, Spanish. (IOC Brochure; IOC/BRO/2013/5)
- IOC, SCOR, SCOPE. 2002. Oceans 2020: Science, Trends and the Challenge of Sustainability. Field, John G.; Hempel, Gotthilf; Summerhayes, Colin P. (Authors); Washington, Island Press (Publisher). 365 p., illus., maps. ISBN: 1-55963-470-7
- IOC, UNDP, FAO, IMO. 2011. A Blueprint for ocean and coast sustainability: a summary for decision-makers. 19 p., illus. English, French, Korean, Spanish. (SC.2011/WS/23)
- IOC-WMO. 2012. Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology, fourth session, Yeosu, Republic of Korea, 28-31 May 2012. Intergovernmental Oceanographic Commission, UNESCO, Paris, 149 pp. English, Arabic, Chinese, French, Russian, Spanish (WMO-IOC/JCOMM-4/3 Rev.)
- IOC-WMO. 2015. A Strategy for JCOMM 2012-2017, World Meteorological Organization, 43 pp. (MAN-11/BM.5.1; SC-2015/WS/10)
- Kong Laura S.I., Paula K. Dunbar, and Nicolas Arcos (eds). 2015. Pacific Tsunami Warning System: A half Century of Protecting the Pacific, 1965-2015; Honolulu: International Tsunami Information Center (NOAA). 194 pp. illus. (ISBN: 978-0-9962579-0-9)
- SCOR-IOC. 1984. Ocean Science for the Year 2000: A Report on an Inquiry by the Scientific Committee on Oceanic Research and the Advisory Committee on Marine Resources Research. Intergovernmental Oceanographic Commission, UNESCO, Paris, 96 pp.
- UN. 1987. Report of the World Commission on Environment and Development: Our Common Future. 300 pp. <http://www.un-documents.net/our-common-future.pdf>
- UN. 2012. The Future we want. UN Resolution adopted by the General Assembly on 27 July 2012 (66/288). English, Arabic, Chinese, French, Russian, Spanish.
- UNESCO, SCOR. 2015. Harmful Algal Blooms: a scientific summary for policy makers. Kudela, R.M. (author). IOC and SCOR, 20 p., illus. (IOC/INF-1320 Rev.)

- UNESCO. 1965. Manual on International Oceanographic Data Exchange. Intergovernmental Oceanographic Commission, UNESCO, Paris, 28 pp. IOC Technical Series, 1.
- UNESCO. 1965-1972. International Indian Ocean Expedition, Collected reprints (I-VIII, index). 7052 pp, illus., graphs, maps, tables. Multilingual.
- UNESCO. 1971. IGOSS (Integrated global ocean station system): general plan and implementation programme for phase I. Intergovernmental Oceanographic Commission, UNESCO, Paris, 27 pp. English, French, Russian, Spanish. IOC Technical Series, 8.
- UNESCO. 1984. IOC Bruun Memorial Lectures 1982: Ocean science for the year 2000. IOC Technical Series, 28. Intergovernmental Oceanographic Commission, UNESCO, Paris, 95 pp. ISBN 92-3-102307
- UNESCO. 1985. Marine science and ocean services for development: UNESCO/IOC Comprehensive Plan for a Major Assistance Programme to Enhance the Marine Science Capabilities of Developing Countries. Intergovernmental Oceanographic Commission, UNESCO, Paris, 55 pp. English, French, Spanish. (IOC/INF-612)
- UNESCO. 2000: Statutes of the Intergovernmental Oceanographic Commission of UNESCO. Intergovernmental Oceanographic Commission, UNESCO, Paris, 47 pp. English/French/Russian/Spanish. (IOC/INF-1148)
- UNESCO. 2005. IOC Criteria and Guidelines on the Transfer of Marine Technology. Intergovernmental Oceanographic Commission, UNESCO, Paris, 66 pp. (IOC/INF-1203)
- UNESCO. 2006, 2010. Biodiversity and distribution of the megafauna: vol.1 The Polymetallic nodule ecosystem of the Eastern Equatorial Pacific Ocean, vol.2 Annotated photographic atlas of the echinoderms of the Clarion-Clipperton fracture zone, vol. 3 Options for the management and conservation of the nodule ecosystem in Clarion Clipperton Fracture Zone; Biodiversity and distribution of faunal assemblages. Intergovernmental Oceanographic Commission, UNESCO, Paris, 3 v., illus., maps. (IOC Technical Series, 69; SC.2006/WS/11)
- UNESCO. 2007. Procedure for the application of article 247 of the United Nations Convention on the Law of the Sea by the Intergovernmental Oceanographic Commission of UNESCO. Intergovernmental Oceanographic Commission, UNESCO, Paris, 110 pp. English/French. (IOC/INF-1222)
- UNESCO. 2009, 2013. Marine spatial planning: a step-by-step approach toward ecosystem-based management. Ehler, Charles; Douvère, Fanny (authors). Intergovernmental Oceanographic Commission, UNESCO, Paris, 99 p., illus., maps. English, Spanish, Vietnamese. (IOC Manuals and Guides, 53; ICAM Dossier, 6).
- UNESCO. 2009. An Assessment of Assessments: findings of the Group of Experts pursuant to UNGA Resolution 60/30: summary for decision makers; towards a regular process for global reporting and assessment of the state of the marine environment including socio-economic aspects (Summary for Policy-makers). Intergovernmental Oceanographic Commission, UNESCO, Paris, 20 pp. English, French, Russian, Spanish. Full report at <http://www.unga-regular-process.org/content/view/18/20/index.html>
- UNESCO. 2011. Intergovernmental Oceanographic Commission of UNESCO: Annual Report, 2010. Intergovernmental Oceanographic Commission, UNESCO, Paris, 78 p., illus., maps. (IOC Annual Reports Series, 17; IOC/2011/AR/17)
- UNESCO. 2012. A Framework for Ocean Observing. Lindstrom, Eric; Gunn, John; Fischer, Albert; McCurdy, Andrea; Glover, L.K. (authors). Intergovernmental Oceanographic Commission, UNESCO, Paris, 28 pp. (IOC/INF-1284 Rev.) A summary document is also available in English, French, Spanish and Russian as document IOC-XXVI/2 Annex 9 (2011)
- UNESCO. 2012b. A Guide on Adaptation Options for Local Decision-makers – Guidance for decision making to cope with coastal changes in West Africa. Niang, Isabelle; Nai, George; Folorunsho, Regina; Diop, Mamadou; Sow, Mamadou; Trawally, Dodou; Faye, Serigne; Bihibindi, André; Diop, Ndiaga; Karibuhoye, Charlotte. Editors: Minielle Tall, Annie Bonnin Roncerel (authors). Intergovernmental Oceanographic Commission, UNESCO, Paris, 54 pp., illus., Incl. bibl., English, French, Portuguese. IOC Manual and Guides, 62 (ICAM dossier, no. 7).

- UNESCO. 2014. A Guide to Evaluating Marine Spatial Plans. Ehler, Charles (author), Intergovernmental Oceanographic Commission, UNESCO, Paris, 97 pp., illus. (IOC Manuals and Guides, 70; ICAM Dossier, 8; IOC/2014/MG/70)
- UNESCO. 2014b. Indo-Pacific Ocean Forum on “Charting the Future of Sustained Ocean Observations and Services”, Bangkok, Thailand, 25-28 Nov. 2013. Intergovernmental Oceanographic Commission, UNESCO, Paris, 23 pp, 2013. (IOC Workshop Report No. 261; IOC/2013/WR/261)
- UNESCO. 2014c. Intergovernmental Oceanographic Commission: biennial report, 2012-2013. Intergovernmental Oceanographic Commission, UNESCO, Paris, 56 p., illus. (IOC Annual Reports Series, 18; SC.2014/WS/8)
- UNESCO. 2014d. IOC Medium Term strategy, 2014–2021. Intergovernmental Oceanographic Commission, UNESCO, Paris, 71 pp. English/French/Russian/ Spanish. (IOC/INF-1314)
- UNESCO. 2015. UN Coordination: a potential role for IOC under a new UNCLOS implementing agreement on biodiversity in areas beyond national jurisdiction. Intergovernmental Oceanographic Commission, UNESCO, Paris, 6 pp. (IOC/INF-1330)
- UNESCO. 2016. IOC Capacity Development Strategy, 2015–2021. Intergovernmental Oceanographic Commission, UNESCO, Paris, 66 pp. English/French and Spanish/Russian. (IOC/INF-1335)
- UNESCO-Platform Vlaanderen. 2015. Unlocking the Ocean – Ten years of the UNESCO/IOC Project Office for IODE in Ostend. 28 pp.
- UNESCO-RSHU. 2010. 50 Years of Education and Awareness Raising for Shaping the Future of the Oceans and Coasts: proceedings of international conference (Sharing lessons learned and proposing long-term projections, input to the Millennium Development Goals and UN Decade on Education for Sustainable Development, 27-30 April, 2010, St. Petersburg, Russian Federation). 585 p., illus. + 1 DVD. English/Russian.

Intergovernmental Oceanographic Commission (IOC)
United Nations Educational, Scientific and Cultural Organization
7 Place de Fontenoy
75 732 Paris Cedex 07, France
Tel.: +33 1 45 68 10 10
Fax: +33 1 45 68 58 12
<http://ioc.unesco.org>