IOC/INF-1279
Paris, 16 March 2011
Original: English

INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION
(of UNESCO)

INFORMATION DOCUMENT

AN OVERVIEW OF IOC CURRENT ACTIVITIES IN OCEAN SCIENCES, OBSERVATIONS AND SERVICES

Summary. The Intergovernmental Oceanographic Commission of UNESCO was founded in 1960 to promote international cooperation and to coordinate programmes in research, services and capacity-building, in order to learn more about the nature and resources of the ocean and coastal areas and to apply that knowledge for the improvement of management, sustainable development, the protection of the marine environment, and the decision-making processes of its Member States.

IOC plays a key role as a global broker involving the promotion of science innovation, nurturing programmes, transferring, disseminating and sharing information, data and knowledge, best practices, assessment and scientific services related to Oceanography. This process is done in an inclusive and participatory way, including views of the scientific community, academia, Member States, etc., and including cultural diversity principles. Therefore, the Commission collaborates with international organizations in the field of ocean and coastal area scientific research, observation and related services, and especially with those organizations of the United Nations system which are willing and prepared to contribute to the purpose and functions of the Commission.

INTRODUCTION TO IOC AND IOC SECRETARIAT

UNESCO and the international community recognized the importance of the ocean when they established the IOC (Intergovernmental Oceanographic Commission) in 1960. The United Nations then delegated to IOC, a unique and specialized agency, the mandate to act as the focal point for marine scientific research and to be the link between the Member States on conventions and agreements related to marine and coastal issues (Holland, 2006). As the only UN organization specialized in ocean sciences, IOC has the responsibility to promote basic marine scientific investigations on a global scale (Roll, 1979), and with that has played a major role in the progress and advances in ocean sciences.

IOC develops its competences through the promotion and intergovernmental coordination of programmes, projects and related activities in ocean sciences, services, observations and data management, and with due consideration to integrated ocean and coastal zone management in line with UNESCO's priority for Africa. Scientific research and technological knowledge are vital to our understanding of the integrated ocean system, which depends on advances in science, technology and research and IOC is a driver for such advances and expects to be perceived as a benefactor of such scientific approach.

IOC, as the competent body and focal point for ocean matters in the UN system, is responding in its mandated areas of activity to the Johannesburg Plan of Action and the UN Millennium Development Goals, and acting in conformity with international law, including relevant UN conventions.

The IOC Secretariat coordinates and supports the implementation of the programmes of the Commission. It consists of the Executive Secretary and staff provided by UNESCO as well as personnel provided by other organizations, the United Nations system, and Member States. The Secretariat is organized into offices and sections, based on regional coverage and support to specific programmes. In the implementation of the programme the Secretariat may rely on UNESCO Field Offices. Figure 1 shows the current organization of the Secretariat, including the Subcommissions and decentralized programme and project offices.

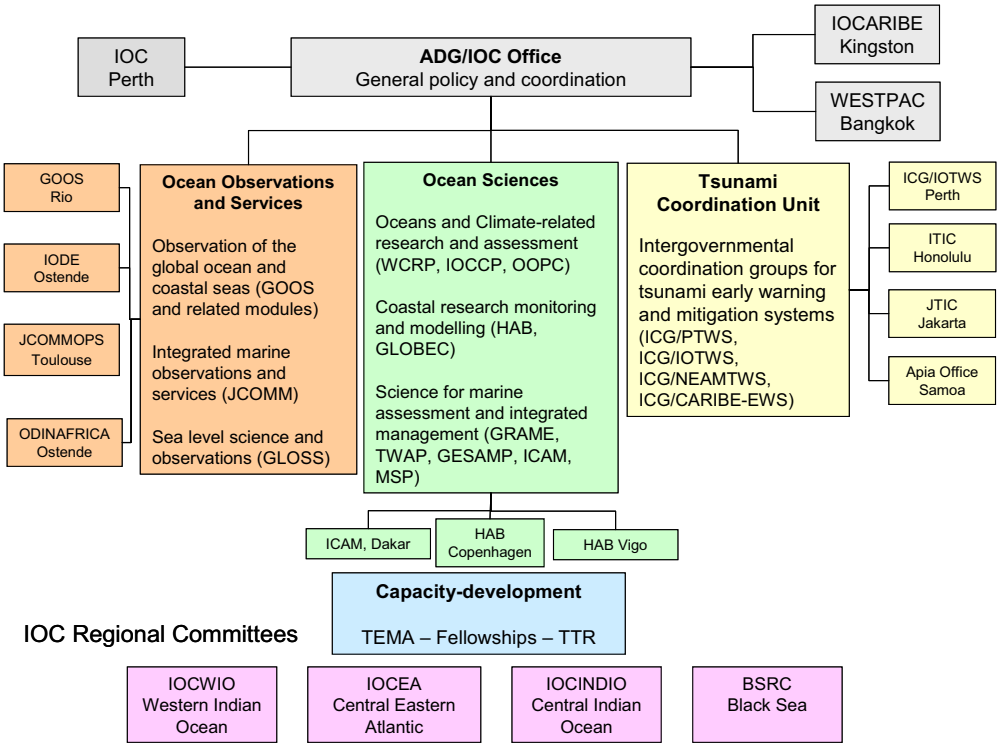


Figure 1: Diagram showing the organization of IOC Secretariat

IOC MISSION AND HIGH LEVEL OBJECTIVES

The IOC Mission is established in Article 2.1 of the IOC Statutes:

> *The purpose of the Commission is to promote international cooperation and to coordinate programmes in research, services and capacity-building, in order to learn more about the nature and resources of the ocean and coastal areas and to apply that knowledge for the improvement of management, sustainable development, the protection of the marine environment, and the decision-making processes of its Member States.*
>
> *The Commission will collaborate with international organizations concerned with the work of the Commission, and especially with those organizations of the United Nations system which are willing and prepared to contribute to the purpose and functions of the Commission and/or to seek advice and cooperation in the field of ocean and coastal area scientific research, related services, and capacity-building.*

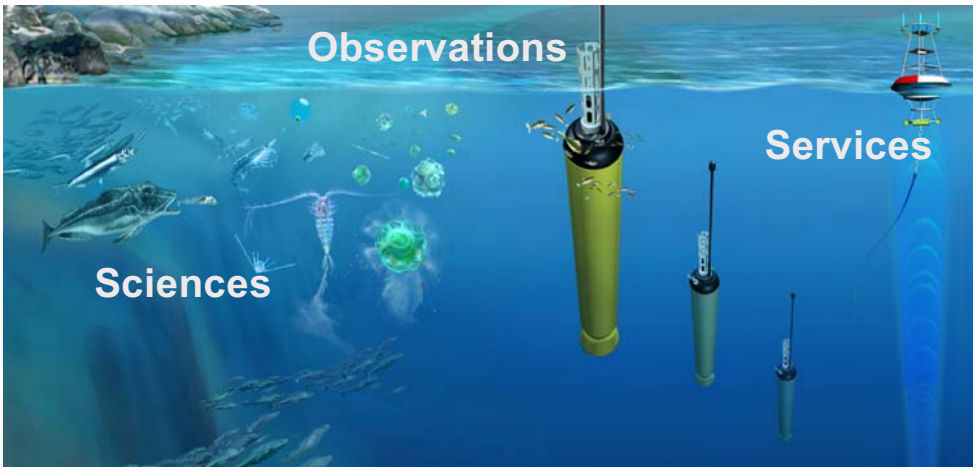


Figure 2: IOC promotes international cooperation in order to fulfill its mission though programmes in ocean sciences, observations and services.

Thus, IOC has a key role to play as a global knowledge broker involving the promotion of science innovation, nurturing programmes, transferring, disseminating and sharing information, data and knowledge, best practices, assessment and scientific services related to oceanography. This process is done in an inclusive and participatory way, including views of the scientific community, academia, Member States, scientific enterprises from the North and the South, scientific workers' perspectives, including cultural diversity principles.

In agreement with IOC Resolution EC-XXXIX.1 (Executive Council of 2006), the medium term strategy (IOC, 2007) for achieving the above vision is implemented and made operative through four High-level objectives (HLO) as follows:

- **HLO 1: Prevent and reduce the impacts of natural marine hazards** through:
    a. Promoting integrated and sustained monitoring and warning systems for coastal and oceanic natural hazards (for example hurricane, tsunami, and storm surges;
    b. Educating communities at risk on natural-hazard impact prevention, preparedness and mitigation measures.

- **HLO 2: Mitigate the impacts and adaptation to climate change/variability** by:
    a. Improving the understanding of the ocean's role in climate variability and climate change;
    b. Contributing to improved prediction of climate;
    c. Increasing the understanding of the impacts of climate change and variability on marine ecosystems and their living resources.

- **HLO 3: Safeguard the health of ocean ecosystems** by:
    a. Actively contributing to the Regular Process for Global Reporting and Assessment of the State of the Marine Environment, including Socio-economic Aspects;
    b. Further developing research and monitoring required for the prevention of marine environment, the maintenance of biodiversity and the sustainable use of marine habitats.
    c. Identifying and developing the capacity-development necessary for maintaining healthy ocean ecosystems focusing on regional needs.

- **HLO 4: Improve management procedures and policies leading to the sustainability of coastal and ocean environment and resources** through:
    a. Enhancing regional cooperation and involvement of Member States;
    b. Facilitating science related to ocean and coastal resource management;
    c. Enhancing development and implementation of decision-support tools that improve integrated ocean and coastal management.

These four HLOs were developed through consultations with stakeholders within and outside of IOC, based on the need to collate and to focus the marine programme to a few areas taking into account the main oceanographic priorities. The four objectives rely on solid science foundations, which are needed to produce credible and independent advice for societal purposes and for a better management and sustainability of marine ecosystems.

FUNCTIONS OF IOC

The IOC plays a lead role in creating the conditions for doing good science and building a network of scientific logistic facilities at global and regional scales. Current activities of the IOC are clustered around the IOC Mission, the high level objectives adopted for the period 2008–2013 and the priority areas of research determined by the Member States. IOC actively contributes to make all science efforts as extensive and global as possible, but also tries to contribute to build scientific capabilities in the developing world, especially in Africa, in line with UNESCO's priorities.

Recognizing the ocean's key role in human life and global change of environment, the IOC takes the responsibility of monitoring and observing the global oceans through broad cooperation. The IOC, in partnership with other international organizations concerning oceans, provides a coordinated approach to monitor oceans and coastal zones; to develop and deliver marine information; to inform and aid marine management and decision makers; and to increase the appreciation of the general public of our changeable oceans.

The **functions** to fulfil IOC Mission and to guide IOC within the HLOs and successfully deliver outcomes and results include:

- **innovation and management:** promotion, nurturing and coordination of scientific projects and programmes;
- **synergy:** stimulating co-operation between researchers and organisations to explore new directions;

- **scientific services:** providing guidelines and scientific criteria for ecosystem and data management, and early warning systems;
- **outreach:** publishing results, educating general public and giving visibility to IOC activities;
- **capacity building:** transferring knowledge and assisting policy makers.

As result, IOC is at the forefront of many important international developments and events and is responsible for the execution of many essential activities related with the promotion and coordination of best marine science and oceanographic research. These include the coordination and monitoring of the programmes during their entire lifetime, likely the most visible function of IOC. But equally important are the assessment based in scientific knowledge, data management, early warning systems, setting standards and guidelines, organising training courses, promotion of symposia, outreach and other critical tasks essential for the successful implementation of UNESCO and the HLOs of the IOC mid-term strategy.

PROGRAMMES AND ACTIVITIES

The IOC Mission, the HLOs, and the priority areas of research are achieved through a series of programmes, projects and actions that collectively constitute the IOC scientific work-plan.

The scientific programmes and projects are essential to implement ideas and techniques and to guarantee that new findings, methods and models are delivered at global scale in timely manner. IOC also develop projects and activities to prepare the IOC to respond to the increasing demand of scientific and technical assessment on emerging issues; most of IOC work is developed in relationship, through co-sponsorships, with other United Nations system agencies and partners (including civil society organizations, academia and the scientific community). Programmes are organized to attain specific goals within a given time line and are actively supervised by a programme manager.

Ocean Sciences

The IOC Ocean Sciences Section (OSS) plays a lead role in creating the conditions for doing good science and building a network of scientific logistic facilities at global and regional scales. Current activities of the OSS are clustered around the IOC Mission, the high level objectives adopted for the period 2008–2013 and the priority areas of research determined by the *ad hoc* Advisory Group for the IOC Ocean Sciences Section: climate change, ocean health and coastal research and assessment and management (IOC, 2007, 2009).

OSS is also the forefront of many important international developments and events (guidelines, publications, symposia, etc.). All these take place in a wide range of scientific areas.

Oceans and climate-related research and assessment, The IOC/OSS catalyzes, promotes and coordinates marine scientific research in climate change through: (i) contribution to increasing the understanding of the ocean's role in climate variability and climate change (WCRP), including observations and models on carbon cycle and ocean acidification (IOOCP); (ii) anticipating and understanding the impacts of climate change and variability on marine ecosystems and their living resources; and (iii) promoting actions to increase the resilience of marine ecosystems, mitigating coastal erosion and protecting communities and economies, and exploring the potential of Earth System Engineering measures to enhance carbon sequestration by the ocean without causing new undesirable impacts in the ecological processes. It is conducted through several programmes and projects:

- World Climate Research Programme (WCRP) (Fig. 3): The WCRP was established by ICSU and WMO in 1980 as an outcome of the first World Climate Conference in 1979. IOC joined as a sponsor in 1993. As the first of the modern-day global environmental

change (GEC) research programmes. The two major objectives of WCRP are to determine the extent to which climate can be predicted, and to determine the extent of human influence on climate (http://www.wcrp-climate.org/). The WCRP encompasses studies of the global atmosphere, oceans, sea- and land-ice, the biosphere and the land surface, which together constitute the Earth's climate system. The four major core projects, diverse working groups, various cross-cutting activities and many co-sponsored activities of the WCRP are designed to improve scientific of human influence on climate, which in turn result in better forecasts and hence benefits to users of climate research and policy of relevant assessments of climate conditions. CLIVAR is the WCRP project that addresses Climate Variability and Predictability, with a particular focus on the role of ocean-atmosphere interactions in climate. Next CLIVAR meeting will be organized by IOC in Paris (May, 2011). The WCRP–IOC Task Group on Sea-Level Variability and Change was established as the result of the workshop on "Understanding Sea Level Rise and Variability" (IOC/UNESCO, 6–9 June 2006). The Group will develop a process to address uncertainties in forecasting sea-level rise, and a framework to systematically work with young scientists and students from regions affected by sea-level rise. IOC is planning a workshop in the third quarter of 2011, with a focus on regional sea-level-rise issues (more information further below).

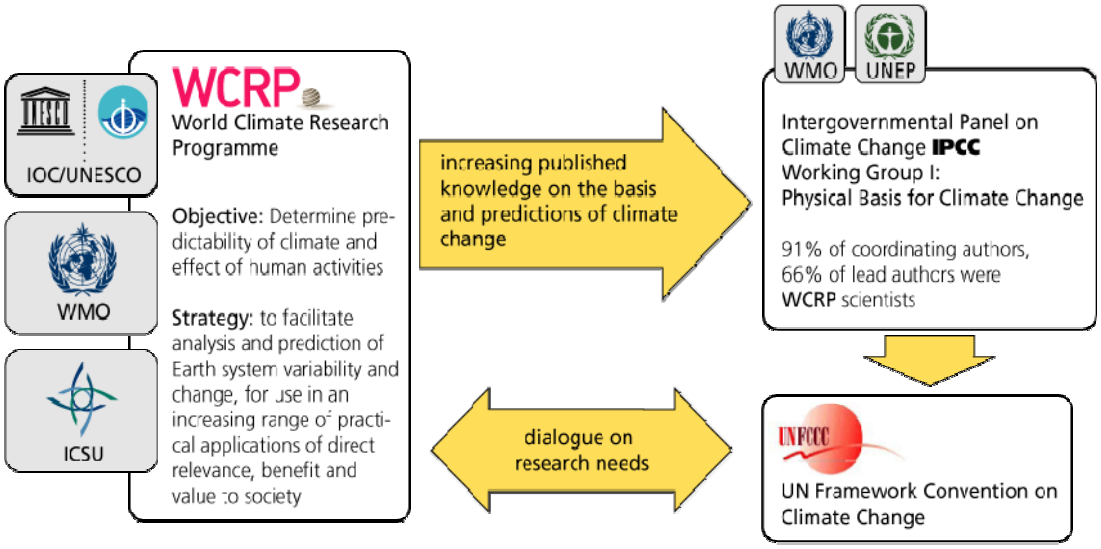


Figure 3: Diagram showing the information flow of the World Climate Research Programme (WCRP)

- International Ocean Carbon Coordination Project (IOCCP): IOCCP is co-sponsored by IOC and SCOR. The IOCCP promotes the development of a global network of ocean carbon observations for research through technical coordination and communications services, international agreements on standards and methods, and advocacy and links to the global observing systems. IOCCP contributes to reducing uncertainty in the global estimates of the efficiency and functioning of the ocean sink for anthropogenic CO_2 through improved research and observation programme coordination and data sharing. IOCCP coordinates GO-SHIP, the Surface Ocean CO_2 Atlas Project (SOCAT) which contains more than 2,100 cruises from 1968–2007, as well as activities in ocean acidification including 'The Ocean in a High-CO_2' symposia (http://www.ocean-acidification.net).
- Ocean Acidification (Fig. 4). In addition to above mentioned series of symposia, IOC is working with IPCC in supporting the working group on Ocean Acidification and also produces with IGBP and SCOR brochures and other material for policy makers and general public.

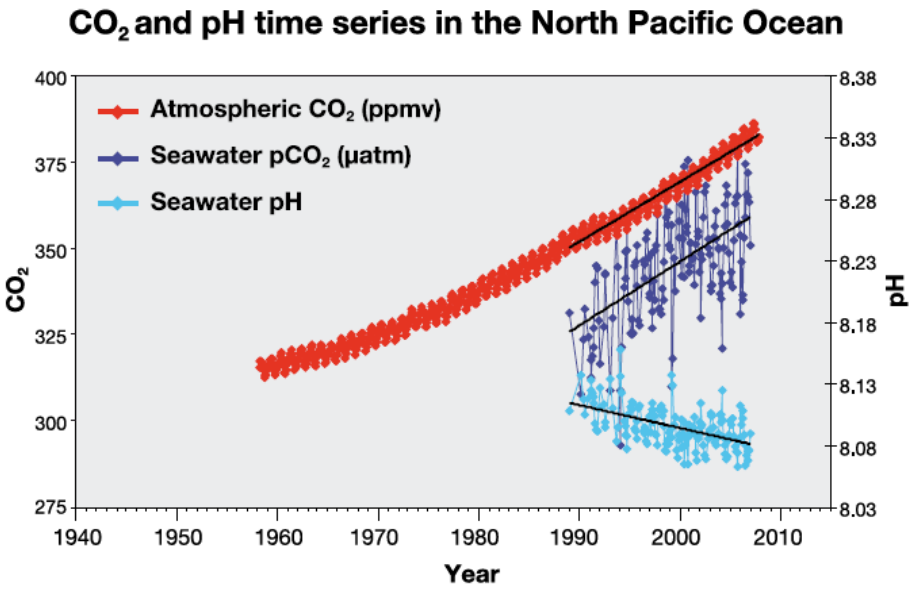


Figure 4: CO_2 time series in the North Pacific Ocean.

- GLOBEC and beyond: IOC has supported GLOBEC together with SCOR and IGBP (http://www.globec.org/). GLOBEC has completed the time life, but some GLOBEC projects still continue and the key question of understanding and forecasting the impacts of climate variability and change on the dynamics of oceanic ecosystems is still valid. The small pelagic fishes and top predator populations requires a substantive international collaborative effort. The main goal is to improve knowledge and to develop a reliable predictive capacity combining observation and modelling for single species and ecosystem dynamics at short-, medium- and long-term scales. And this needs to be carried out in a multiplicity of regions, oceans and species. These objectives require an approach involving the collaboration of existing programmes and oriented projects related with small pelagics (e.g. SPACC) and top predators (e.g. CLIOTOP) which address the mechanisms linking physical forcing (e.g. upwelling systems, climate variability), primary and secondary production, prey abundance and distribution, etc., with modellers involved in climate, physical and biogeochemical oceanography and ecosystem dynamics. Recently (December, 2010) IOC has adopted IndiSeas (Indicators for the Seas) which is a project aimed to evaluate the effects of fisheries and climate change on marine ecosystems by using a panel of ecological indicators.
- Climate change adaptation for Africa and SIDS: Funded by the Global Environment Facility (GEF) the ACCC Project contributes to a better understanding of shoreline change induced by climate variability in the five participating countries (Senegal, Gambia, Cape Verde, Guinea Bissau and Mauritania), with an emphasis on the impact of climate change, and the formulation and implementation of appropriate adaptation and remediation strategies within the wider context of integrated coastal area management (http://ioc3.unesco.org/accc/). In 2009, each country has started implementing innovative adaptation measures in their respective pilot sites (plantation of mangroves, dune fixation, development of ecotourism activities, and delimitation of protected areas). All those are designed to alleviate human pressures on sensitive coastal habitats that are particularly vulnerable to climate change impacts. In addition, the Regional Project unit based at UNESCO Dakar office has implemented a regional training programme to build technical capacity in the area of coastal adaptation. It also includes and action to understand the combined impacts of coastal pollution plus ocean warming in the Mediterranean Sea (field office in Rabat).

- Earth System Engineering measures (including ocean fertilization): Despite the compromises that were agreed upon during the 2009 Copenhagen COP-15 (Conference of the Parties-15) meeting concerning control and target emissions of greenhouse gases, there are concerns that suggested mitigation actions may not be sufficient or may not be implemented in time to avoid adverse impacts from climate change. In that scenario, some geo-engineering methods are being considered for moderating the consequences of climate change. These methods include technologies for directly removing carbon dioxide from the atmosphere, and also technologies to manage solar radiation that reaches the planet's surface (Royal Society, 2009). The ocean can be directly used and directly affected by such techniques, for instance, ocean fertilization and the storage of CO_2 in deep-sea reservoirs (Fig. 5). Although dispersing aerosols and other actions on the stratosphere could theoretically reduce temperatures globally by controlling incoming solar radiation, they will not reduce atmospheric carbon dioxide concentrations or ocean acidification. Intensive research is needed to evaluate the efficiency, risks, and consequences of these interventions and to assess their viability to mitigate impacts of climate change without creating new undesirable environmental consequences. A workshop organized by IOC, the Science Sector of UNESCO and the Royal Society of London was held in November 2011 in our headquarters in Paris.

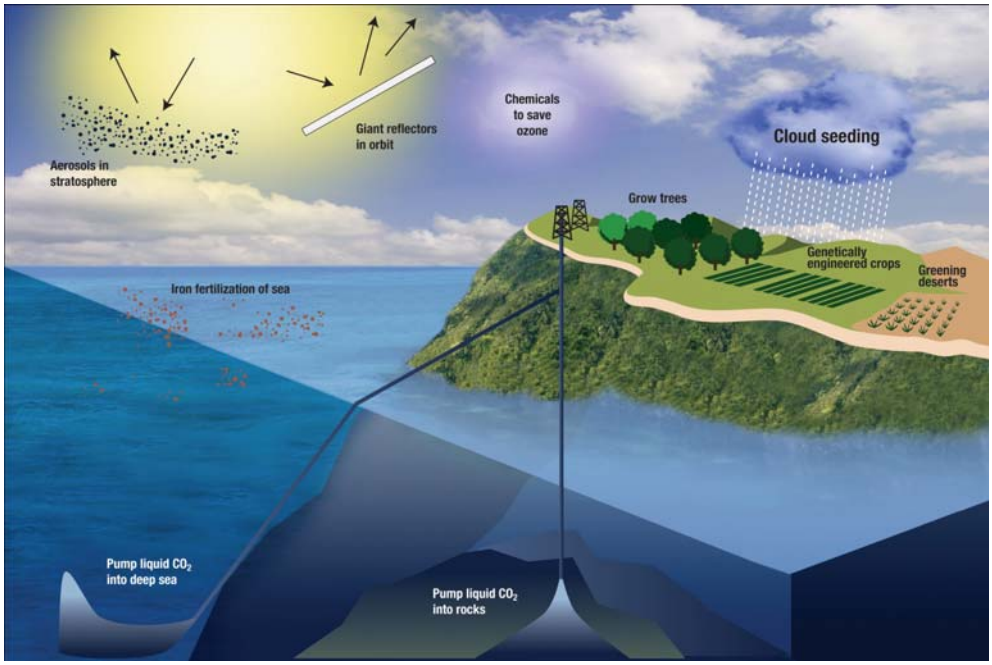


Figure 5: Possible Geoengineering interventions
(courtesy Lawrence Livermore National Laboratory)

- Blue Carbon-Blue Forest: The recent report titled 'Blue Carbon' (Nellemann et al., 2009) (Fig. 6) highlighted the considerable uncertainty surrounding estimates and the level of understanding of carbon storage in the ocean's vegetated habitats (e.g. mangroves, salt marshes, seagrasses). Current scientific information on the dynamics of marine carbon sequestration and cycling is patchy and relatively sparse compared to equivalent knowledge generated for terrestrial counterparts. The GEF 'Blue Forest Targeted Research Project' would review current biophysical and socioeconomic scientific information to identify gaps, opportunities and priorities for future research to support Blue Forest ecosystem service management. The research would be targeted to provide information relevant to ecosystem and resource management and financial policy development and to explore the potential for developing global Blue Forest ecosystem service market and governance mechanisms.

Figure 6: The Rapid Response Assessment report "Blue Carbon - The Role of Healthy Oceans in Binding Carbon" was released on 14 October 2009 at the Diversitas Conference, Cape Town Conference Centre, South Africa. (See list of References: Nellemann et al., 2009).

- IOC in partnership with ICES and PICES and also with the sponsorship of other organizations like WCRP and SCOR will organise the Second International Symposium on the Effects of Climate Change on the World's Oceans'. This Symposium will be co-funded by KORDI and the Yeosu Expo 2012 (Rep. of Korea) will provide the local organization and facilities. The planned dates are 14–18 May 2012 (Yeosu, Korea).

Ocean health, marine ecosystem research, monitoring and modelling. Ecological processes and biodiversity are essential pieces to maintain ecosystem resilience at local and global scale. In fact resilience is an essential characteristic to assure ecosystem recovery after adverse stresses and perturbations, and to minimize the effects of natural or induced variability. A better knowledge of ecosystem functioning is necessary for a sustainable management marine ecosystems and to maintain a healthy ocean environment. In this area, the OSS has been active through:

- The 'Assessment of Assessments' (AoA) of the Regular Process for Global Reporting and Assessment of the State of the Marine Environment, Including Socio-Economic Aspects was established by decision of the United Nations General Assembly and it represented the first step in this international initiative to improve our understanding of the oceans and to develop a global mechanism for delivering science-based information to decision makers and public on a regular basis (http://www.unga-regular-process.org/). The UN General Assembly, requested that UNEP and the IOC will serve as the lead agencies to carry out a three years start-up phase, in cooperation with all relevant UN agencies and Programmes of the UN, to conduct an "Assessment of Assessments (AoA)", tasked with a detailed examination of the various existing marine assessments, an evaluation of factors central to the quality of assessments, such as scientific credibility, policy relevance and legitimacy. The Group was also charged with the identification of best practices; thematic, geographic or data gaps, scientific uncertainties, as well as research and capacity-building needs, particularly in the developing world. The final and most critical task of the group was to formulate a series of options and recommendations regarding the institutional arrangements that would need to be put in place to implement the Regular Process. The published version of the AoA report (Fig. 7) was launched by IOC and UNEP on 31 August 2009 in New York. The UN General Assembly has formalized in 2010 the Regular Process as a routine assessment of the marine environment at global scale.

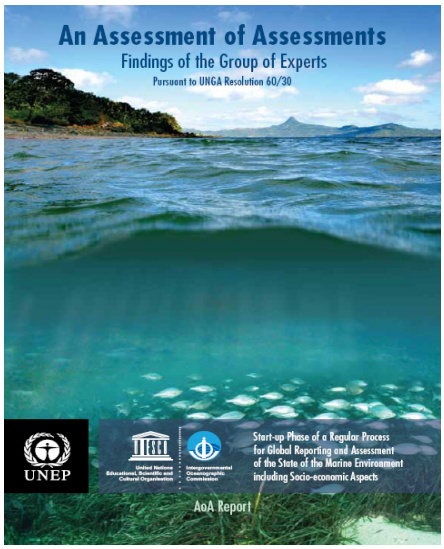


Figure 7: the Assessment of Assessments report is the first ever comprehensive overview of the marine assessment landscape, which also considers socio-economic factors

- The IOC Harmful Algal Bloom Programme (HABP) aims at assisting Member States to understand and mitigate the effects of harmful algal blooms on national economies, aquatic living resources, public health and the aquatic ecosystem. This is achieved through a broad programme (http://www.ioc-unesco.org/hab/) including capacity enhancement, five regional networks, working groups, Science and Communication Centres in Copenhagen (Denmark) and in Vigo (Spain), publication of manuals and guides, and a research programme GEOHAB. The programme is multidisciplinary and relates to many scientific and societal issues in the coastal oceans (http://www.geohab.info/). The Global Ecology and Oceanography of Harmful Algal Blooms (GEOHAB) is a research programme (IOC-SCOR) aimed, through a comparative system approach, to advance our understanding of the mechanisms underlying the population dynamics of harmful algae and to enhance our ability to model and forecast harmful algal events through development of improved observation systems (Fig. 8).

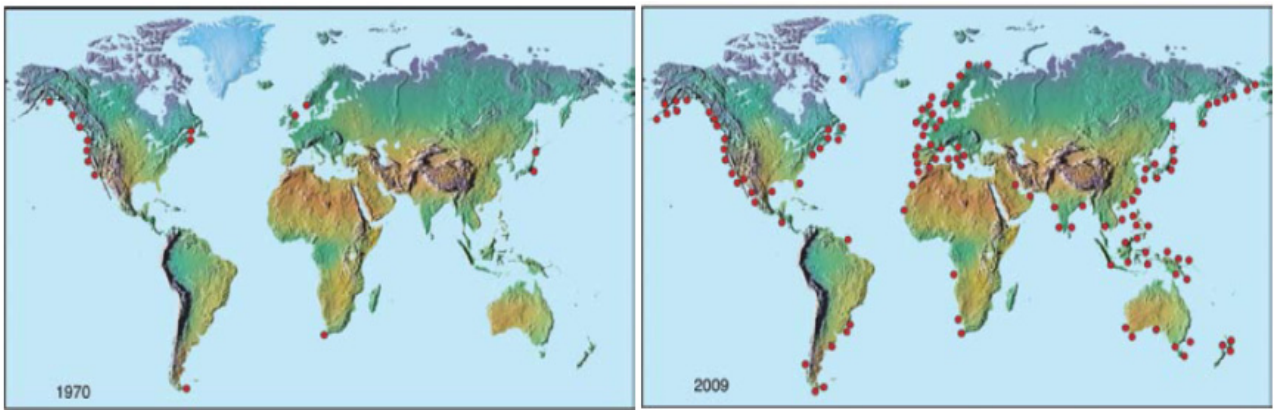


Figure 8: The global expansion in the distribution of PSP toxins – 1970 compared to 2009. Red dots denote locations with documented measurements

- Nutrient standards. Comparability and traceability of nutrient data in the world's oceans are fundamental issues in marine science, and particularly for studies of global change. An IOC-ICES Study Group on Nutrients Standards (SGONS) has undertaken specific tasks to develop reference materials for nutrients in seawater and measurement protocols to improve the comparability and traceability of nutrient data in the world's oceans. The first meeting was organized by IOC and took place in Paris in March 2010.

- NEWS2USE: IOC-UNESCO has over the past five years, through the IOC Global Nutrient Export from WaterSheds project (Global NEWS), developed models of nutrient export for dissolved inorganic, dissolved organic and particulate nitrogen, phosphate and carbon, as well as for dissolved silica. The Global NEWS framework includes the Integrated Model for the Assessment of the Global Environment to generate spatially explicit land use, greenhouse gas emissions, and climate fields. This experience positions UNESCO/IOC to take the lead in developing scenarios for nutrient impacts on coastal ecosystems. Now we have initiated the NEWS2USE. The primary UNESCO/IOC product resulting from NEWS2USE will be an assessment tool for use by scientists as an aid to, and in close collaboration with, managers and policy makers from developed and developing regions to use in the evaluation and implementation of policies to improve coastal water quality. NEWS2USE will act as a link between several IOC programmes with interest in aspects of coastal zone biology, chemistry or management.
- Invasive species and Ballast water (Fig. 9). A major concern associated with ballast water has been the spread of invasive alien species and toxic dinoflagellates, and the rate of introductions has been increasing exponentially since the last two decades. Invasive marine species are now considered one of the greatest threats to the world's oceans and the economical impacts of these invasions can be considerable. IOC together with IMO and ICES support one stable Working Group on Ballast water as vector for invasive species.

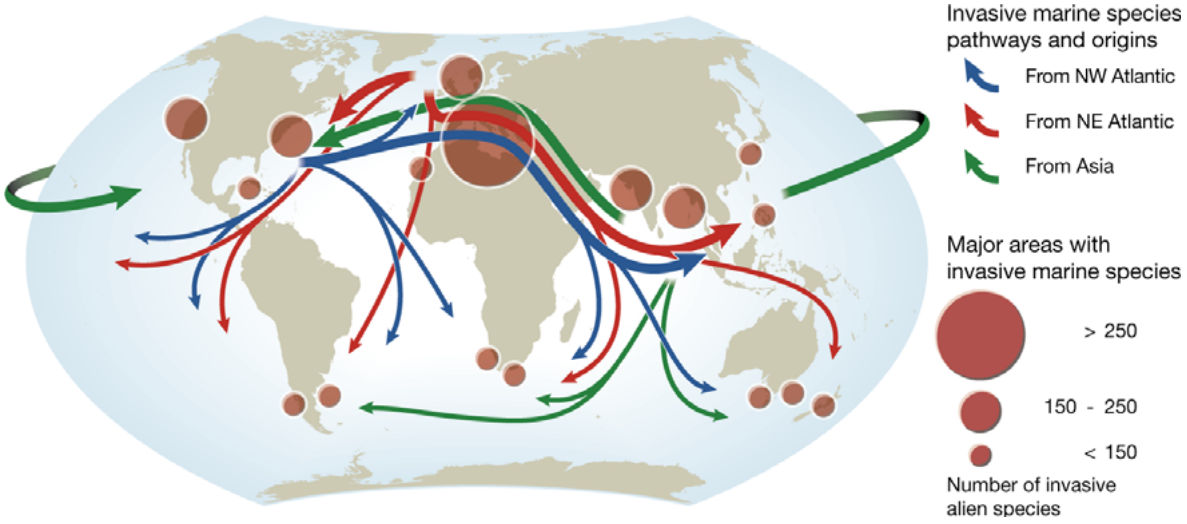


Figure 9: Major pathways and origins of invasive species infestations in the marine environment (source: UNEP/GRID-Arendal 2008)

- IOC tasks in coral reefs has twofold: firstly towards the improvement of management and conservation of coral reefs by providing manuals, equipment, databases, training, problem solving, and helps with finding funds for reef monitoring (all coordinated in a global network); and secondly to integrate, synthesize and develop global research on coral bleaching and related ecological impacts of climate change on coral ecosystems. This is a decentralized activity carried out by IOC office in Bangkok in cooperation with the Global Coral Reef Monitoring Network (http://www.gcrmn.org/).
- Biodiversity in high seas. The open ocean and deep sea beyond national jurisdiction of coastal nations covers almost half of Earth's surface and gives refuge to unique and varied biodiversity. Additionally, options for mitigating the impacts of climate change will certainly involve the use of the high seas and deep seafloor for carbon sequestration, sinks, and storage. These issues require international interdisciplinary discussion. Also

related to these issues are the establishment of global regulation and governance of transboundary and high-seas marine protected areas and the consequent protection of biodiversity, and regulation of high-seas biodiversity (Fig. 10). On the other hand, MPA concept has evolved from isolated, coastal, small-sized MPAs (mostly linked to small islands) to a more complex ecological and conceptual meaning. Now MPAs are integrated in networks, and are planned in open oceanic waters and/or the deep sea, extending protection to large areas beyond national jurisdiction and need of international authorized body to coordinate the protection and governance of these protected areas. IOC is cooperating with CBD and IUCN in several activities related with biodiversity in high seas, including the project Global Ocean Biodiversity Initiative (GOBI, http://www.gobi.org/).

Figure 10: Global distribution of marine and terrestrial protected areas (blue polygons). Note that only a small fraction of the ocean and seas are actually protected. Source: http://www.wdpa.org/

- Microplastics: During the past 40 years, world production of plastic resins has increased some twenty-five-fold, while the proportion of material recovered (5%) has remained constant, so that plastics account for a growing segment of urban waste. Once discarded, plastics are weathered and eroded into very small fragments known as microplastics. These particles, together with plastic pellets, are already found on most beaches around the world (Ogata et al., 2009; Fig. 11), and we still do not know the impacts they will have on the marine environment and on the marine food web. IOC is paying special attention to marine pollution and impacts on habitats and ecosystems in cooperation with GESAMP and both institutions with funding support from the European Commission and the Swedish fund SIDA have organized a Workshop on microplastics in June 2010. A workplan to support a global activity in microplastics is being developed (www.gesamp.org/micro-plastics;jsessionid=A416DAA303A7E716A33591D9F7500790.

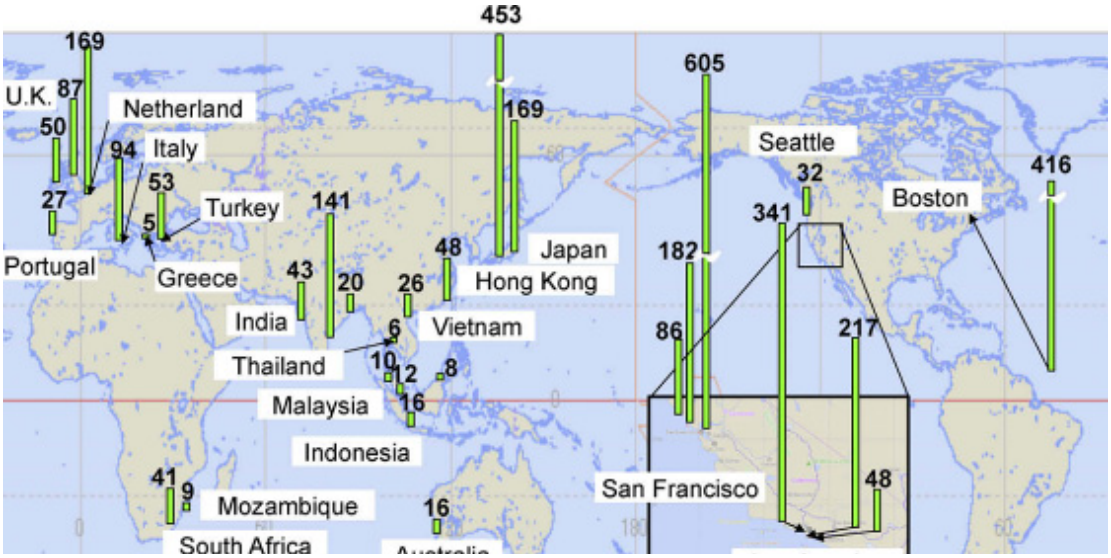
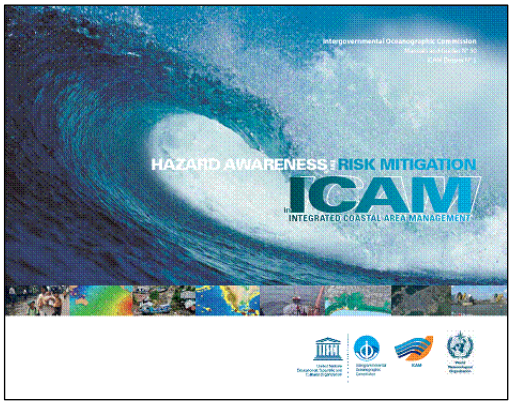


Figure 11: Concentration of PCB P13 (ng/g de granules) plastic granules that reach the beach. (Ogata et al., 2009).

Improve management procedures and policies leading to the sustainability of coastal and ocean environment and resources. Use of our coastal areas and our ocean wealth will continue if done in a sustainable manner, and if an integrated approach is taken when making decisions about how to best use these resources. The IOC/OSS activities under this HLO provide guidance about how coastal and ocean areas are to be used and protected. These activities complement other processes overseen by OSS like the Regular Process and the MPA beyond national jurisdiction.

- Integrated Coastal Area Management (ICAM) is an interdisciplinary activity where natural and social scientists, coastal managers and policy makers, in the long-term, focus on how to manage the diverse problems of coastal areas (Fig. 12a). At present, issues related to coastal management are becoming increasingly urgent since the rapid exploitation and development of coastal areas along with augmenting population growth and urbanization have led to environmental degradation of world-wide marine ecosystems (http://ioc3.unesco.org/icam/). IOC is applying ICAM as a management tool in the SPINCAM project (Southeast Pacific data and Information Network in support to ICAM), led to the identification of a set of indicators in each participating country which will be measured and integrated in a national and regional web-based atlas system, developed in collaboration with ODINCARSA and IODE.
- Marine Spatial Planning (MSP) is aimed towards the development of good practices on ecosystem-based, marine spatial management, particularly through the demonstration of marine spatial planning techniques (Fig. 12b). It takes the whole maritime ecosystems, and provides tools to assess how the resources can be exploited sustainably – or not – alongside competing human demands on local resources, be they for recreation and tourism, offshore oil and gas exploitation, marine transportation, gravel mining, marine aquaculture, etc. The MSP process usually results in a comprehensive plan or vision for a marine region. MSP is one element of ocean or sea use management; zoning plans and regulations are one of a set of management measures for implementing MSP. The purpose of this initiative is to help countries operationalize ecosystem-based management by finding space for biodiversity conservation and sustainable economic development in marine environments (http://www.unesco-ioc-marinesp.be/).



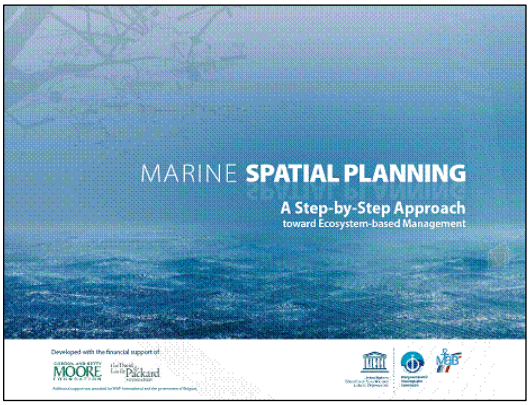


Figure 12: a) Hazard awareness and risk mitigation in Integrated Coastal Area Management: Guidelines for coastal managers; b) Between November 2007 and May 2009, UNESCO has been developing a guide that lays out a "Step-by-Step Approach for Marine Spatial Planning toward Ecosystem-based

- UNEP in partnership with IOC and several other organizations, are executing a GEF Medium Size Project on Transboundary Water Assessment Programme (TWAP; http://twap.iwlearn.org/). The project aims to develop: (i) a partnership among organisations; (ii) the methodology for assessment/results tracking for each of the five categories of transboundary water systems (transboundary groundwater; transboundary lakes/reservoirs; transboundary river basins; Large Marine Ecosystems (LMEs); and open ocean areas); and (iii) the arrangements needed to conduct a baseline transboundary waters assessment that may be conducted with GEF funding following completion of the MSP. The periodic assessment would then be sustained in the future through the partnership of agencies and organizations, and would include data series collected by GEF IW projects that would be useful to those agencies and to UNEP's GEO process.
- A Global GEF Community of Practice for learning and experience sharing among LME Projects and related coastal and marine initiatives is being developed (LME/ICM-CoP). The LME/ICM-CoP will establish a global support network for the GEF LME and ICM projects and practitioners and provide leadership and coherent development assistance to States to increase their capacity to address climate variability and change and incorporate ICM. The network will create a dynamic web of experience sharing and learning partners, linking existing GEF-IW LME and ICM projects, with marine and coastal initiatives supported by GEF and other organizations. The LME/ICM-CoP will build upon the successes of GEF "Learning Center Website", and synergies with the new GEF science projects, and the GEF-IW Conferences (http://www.lme.noaa.gov/). The network will harvest best practices, generate and manage knowledge, and increase South-to-South learning and experience sharing opportunities, and regional and global partnership opportunities through twinning, and personnel exchanges, workshops and training courses.
- Research at unprecedented geographic scales will be required to improve our understanding of climate change and ecosystem functioning, including biodiversity conservation and management options. This is a crucial and necessary step to account for the wide distribution of marine life through a variety of habitats and climatic regions. During the OceanObs'09 meeting there was a general call for the creation of a new framework of sustained ocean observations to be available in the next decades. This framework will integrate new biogeochemical and physical measurements with ecosystem observations, while still preserving and supporting existing structures. Marine research stations have proven historically, to have been very important in the emergence and development of ocean science. A worldwide association of marine

laboratories (WAMS) will provide a unique opportunity for an the development of an integrated observing system, in combination with high level experimental and analytical facilities, capable of making essential ecosystem information and products available for policymakers, resource managers, researchers, and other stakeholders, in order to assess marine ecosystem responses to natural and anthropogenic perturbations. It will coordinate many independently operating sites and marine stations around the globe and bring them together in an umbrella system. With common goals to maximize the versatility, accessibility, and robustness of observations and experimental analyses, existing infrastructures and capacities can provide a foundation upon which increased global cooperation and coordination to develop common protocols and standards would naturally lead to a broader, more global and comprehensive understanding of ocean ecology. The first international planning group for the establishment of a world association of marine research stations (WAMS) was organized by IOC and took place in Paris in April 2010.

Ocean Observations Programme

Observations should underpin all ocean science and marine management decisions; policy decisions are generated based on observed issues, are developed based on measured changes and, after implementation, are evaluated through continuous monitoring of the environment and social-economic impacts. The IOC Ocean Observations Programme is tasked with assuring that complete, timely and useful ocean data will be available when needed by all nations of the world. A global ocean observing system is recognized as an undertaking which exceeds the resources of any individual country and reaches its full value only with the participation of all nations, whether they directly resource instrumentation installation, or, for many developing States, they participate by making use of ocean data for local needs.

The Oceans Observations Programme coordinates the Global Ocean Observing System (GOOS). GOOS is a permanent global system for observations, modelling and analysis of marine and ocean variables to support operational ocean services worldwide. GOOS provides best possible descriptions of the present state of the oceans, including living resources; continuous forecasts of the future conditions of the sea, and the basis for forecasts of climate change. GOOS coordinates a multitude of observing systems (Fig. 13) and programmes which participate in the goal of providing global data for climate monitoring, and global ocean assessment, and providing regional and local data of use to individual nations, coastal communities and alliances of countries who share common goals for their shared ocean spaces.

Figure 13: GOOS is designed and being implemented to embrace the oceans as a single entity, to provide a global view of the ocean system. Many separate observing systems comprise the GOOS. These vary from a few buoys operated by a research lab, to intergovernmental cooperation which organizes globe spanning efforts.

The GOOS is comprised of several UNESCO/IOC/WMO/ICSU/UNEP sanctioned bodies which coordinate together to advance the GOOS objectives of a comprehensive, sustained, operational and international ocean observing system. I-GOOS (Intergovernmental Committee for GOOS) is the intergovernmental body responsible for strategic direction and encouraging its Member States to commit to sustainable support. Three advisory bodies supply the I-GOOS with scientific studies and expertise underpinning the strategic goals of GOOS: PICO (Panel for Integrated Coastal Observations), GSSC (GOOS Scientific Steering Committee) and OOPC (Ocean Observations Panel for Climate) (Fig. 14).

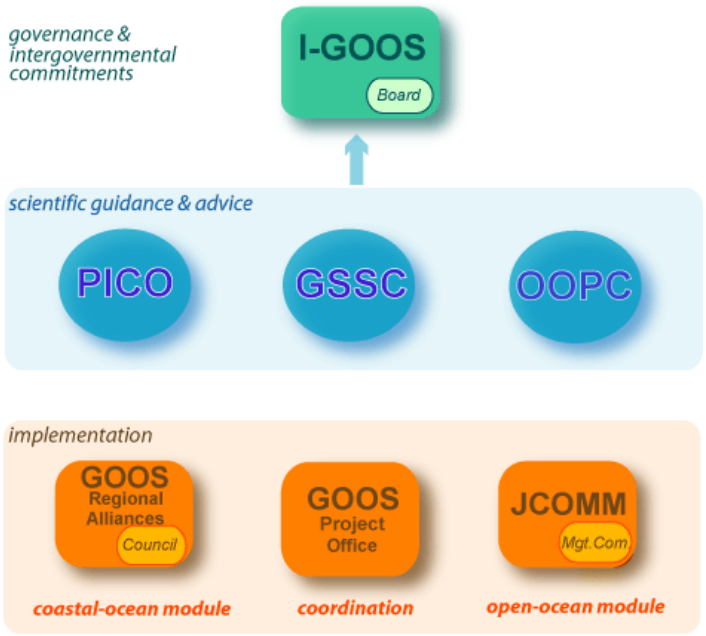


Figure 14: Architecture of GOOS bodies

Deployment of instrumentation and funding of individual observation platforms is a nation by nation decision. However international coordination of implementation decisions to advance the global goals of GOOS are the concerns of the implementation bodies (Fig. 15). These bodies aid the community by coordinating deployment of instrumentation, setting standards for instruments and data, and coordinating data sharing decisions. These operational bodies are: GRAs (GOOS Regional Alliances) for the regional seas and coastal implementation; GPO (GOOS Programme Office) for the executive coordination and the JCOMM (Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology) for the open-ocean and climate module implementation (Fig. 2).

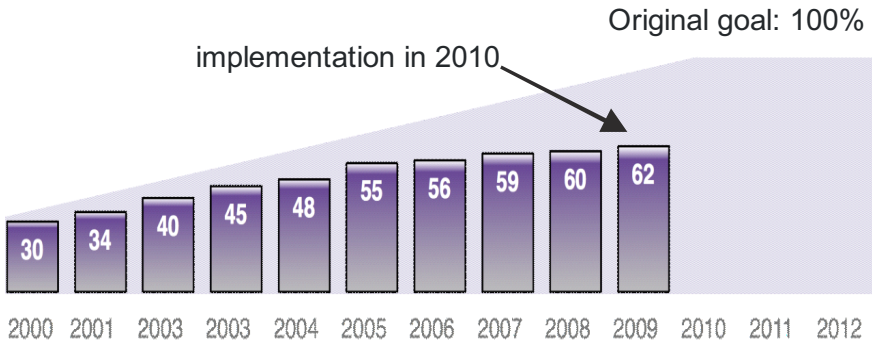


Figure 15: Time series implementation of GOOS with current level of achievement and the expected goal for 2010.

The GOOS Regional Alliances (GRAs, Fig. 16) were created to facilitate sustained ocean monitoring to meet regional and national priorities. They require interagency collaboration and an internationally accepted policy. The activity and cooperation of GRAs is especially important to the development of the coastal module of GOOS. The GRAs are formed by agreement between participating countries, national organizations, and/or international bodies. The GOOS Regional Alliances have constituted a GOOS Regional Council to advise IGOOS regarding their collective needs.

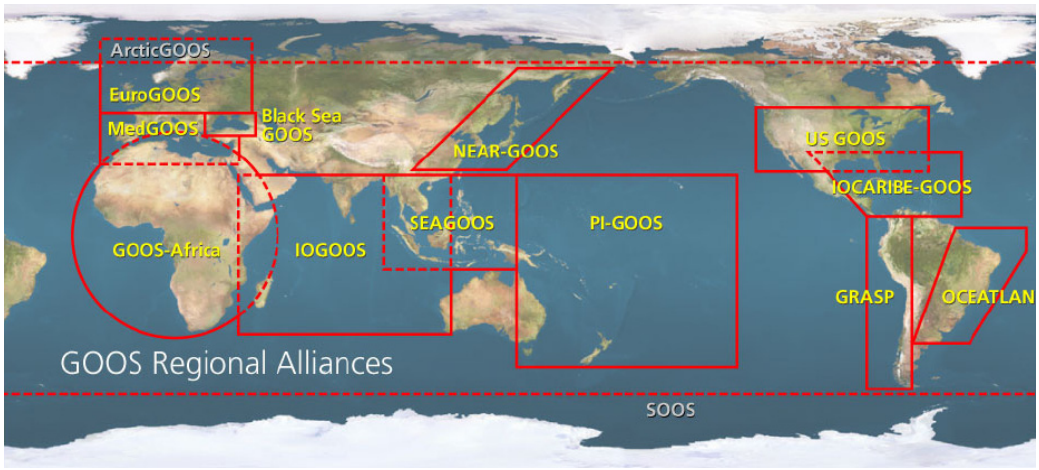


Figure 16: GOOS Regional Alliances (GRAs)

The GCOS-GOOS-WCRP Ocean Observations Panel for Climate (OOPC) serves as a hub for scientific advice on the requirements for sustained ocean observations for climate research, projections, and information. Through reports by GCOS, OOPC maintains a dialogue with the UN Framework Convention on Climate Change (UNFCCC) on requirements for sustained observations. It defined Essential Climate Variables (ECVs) for the ocean and reviews and provides advice on implementation actions needed to sustain *in situ* and satellite observing networks to measure these ECVs. It interacts with the scientific community, with JCOMM (see below), and with communities surrounding ocean observing networks. It maintains a weekly-updated site of key ocean climate indices (www.ioc-goos-oopc.org) to help promote the importance of ocean observations for climate. It helped organize the OceanObs'09 conference (www.oceanobs09.net) along with many other international sponsors, which pointed to new opportunities for sustained ocean observations in other domains.

The WMO-IOC Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM) was established in 1999 to coordinate worldwide marine meteorological and oceanographic services and their supporting observational, data management and capacity building programmes. Its vision is to coordinate, develop and recommend standards and procedures for, a fully integrated marine observing, data management and services system that uses state-of-the-art technologies and capabilities. It is a unique example within UN system, that two organizations integrated their efforts for common issues and interest of Member States —in this context, it is the key for JCOMM implementation to ensure liaison and collaboration with other global programmes and international agencies both within and outside the UN system.

As for the observing systems, JCOMM is the means of implementation for GOOS to develop the observing networks particularly for open oceans, in coordination with the Global Climate Observing System (GCOS), the World Weather Watch (WWW) and other operational programmes. JCOMM is also responsive to the evolving needs of all users of marine data and products, and includes an outreach programme to enhance the national capacity of all maritime countries.

JCOMM seeks commitments for all components of an operational programme in the global oceans. Making efforts to realize this goal, JCOMM prioritizes the marine/oceanographic services

that answer to the users' requirements. An important component of delivering services products is the coordination of the safety-related marine meteorological and associated oceanographic services, including scientific/technical supports for marine and coastal disaster mitigation and warnings. In this context, JCOMM closely works with other IOC programmes and relevant international programmes to provide technical guidance and enhance synergies.

Implementation of integrated end-to-end data management systems in collaboration with the WMO Commission for Basic Systems (CBS), the Committee for International Data and Information Exchange (IODE), the International Council of Scientific Unions (ICSU), and other appropriate data management bodies, to meet the real-time operational needs of the present operational systems and the global observing systems.

The Global Sea Level Observing System (GLOSS), under the auspices of JCOMM, aims at the establishment of high quality global and regional sea level networks for application to climate, oceanographic and coastal sea level research (Fig. 17). The programme became known as GLOSS as it provides data for deriving the 'Global Level of the Sea Surface'. The main component of GLOSS is the 'Global Core Network' (GCN) of 290 sea level stations around the world for long-term climate change and oceanographic sea level monitoring. The present definition of the GCN (the definition is modified every few years) is called GLOSS02. GLOSS is advised by the Global Sea Level Observing System Group of Experts (GLOSS-GE). GLOSS is an example of a global coastal observing network and among existing observing elements in GOOS (Global Ocean Observing System) it has the largest participation of Member States (~ 70).

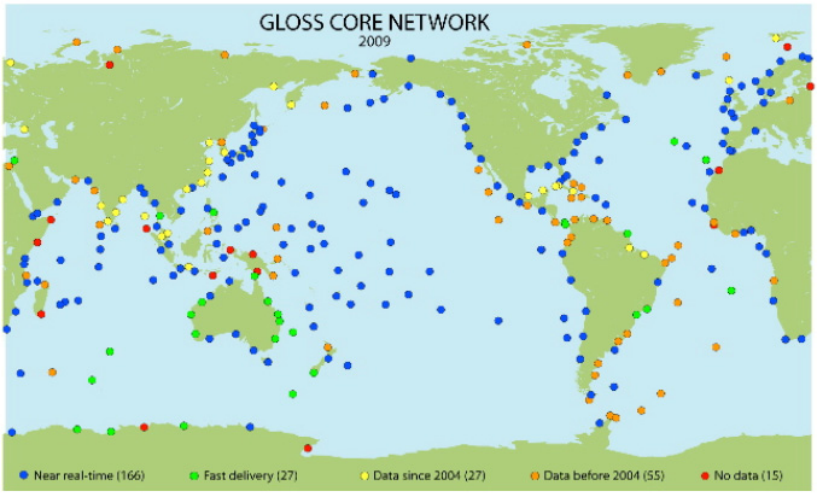


Figure 17: Status of reporting of the sea level gauges in the GLOSS Core Network in 2009.

In appreciation of the multiple uses of tide gauges, GLOSS has also sought to provide water level data that meets the standards and real-time requirements for tsunami warning and storm surge monitoring. Numerous GCN stations have for many years contributed to the Pacific Tsunami Warning System (PTWS) and, following the 2004 Sumatra Earthquake, the IOC and GLOSS have taken an active role in coordinating and implementing the water level network for the Indian Ocean Tsunami Warning System (IOTWS) and the Caribbean Early Warning System (CARIBE EWS).

The Joint Scientific Committee for the World Climate Research Programme and the IOC Assembly endorsed a proposal to establish a WCRP–IOC Working Group on Sea-level Variability and Change. The Initial priority areas include: (i) assessment of the statistical models; (ii) using observations to constrain projections; (iii) the regional distribution of sea-level rise, particularly at the coast, and from all processes; and (iv) the sea level budget. GLOSS contributes to the working group. Following the 2006 Workshop on Understanding Sea Level Rise and Variability organized by the WCRP at UNESCO, GLOSS works with the WCRP to ensure that latest sea-level monitoring and research findings are transmitted to the community on a regular basis. More information on GLOSS at: www.gloss-sealevel.org and http://www.oceanobs09.net/blog/?p=422.

Data management

The IOC's International Oceanographic Data and Information Exchange (IODE) was established in 1961 to enhance marine research, exploitation and development by facilitating the exchange of oceanographic data and information between participating Member States and by meeting the needs of users for data and information products. The IODE system forms a worldwide service oriented network consisting of Designated National Agencies (DNAs), National Oceanographic Data Centres (NODCs), Responsible National Oceanographic Data Centres (RNODCs) and World Data Centres – Oceanography (WDCs). During the past 50 years, IOC Member States have established over 80 oceanographic data centres in as many countries. This network has been able to collect, control the quality of, and archive millions of ocean observations (Fig. 18), and makes these available to Member States. Contributing to this wealth of data several international projects have been created over the past five decades such as GTSPP (Global Temperature and Salinity Profile Programme), GODAR (Global Oceanographic Data Archaeology and Rescue), GOSUD (Underway Sea Surface Salinity Data Archiving Pilot Project). In addition IODE also deals with marine information (library) management promoting the availability of scientific publications and other information. Related projects include ASFA (Aquatic Sciences and Fisheries Abstracts), OceanExpert (Global Directory of Marine (and Freshwater) Professionals), Open Science Directory and OceanDocs (see below).

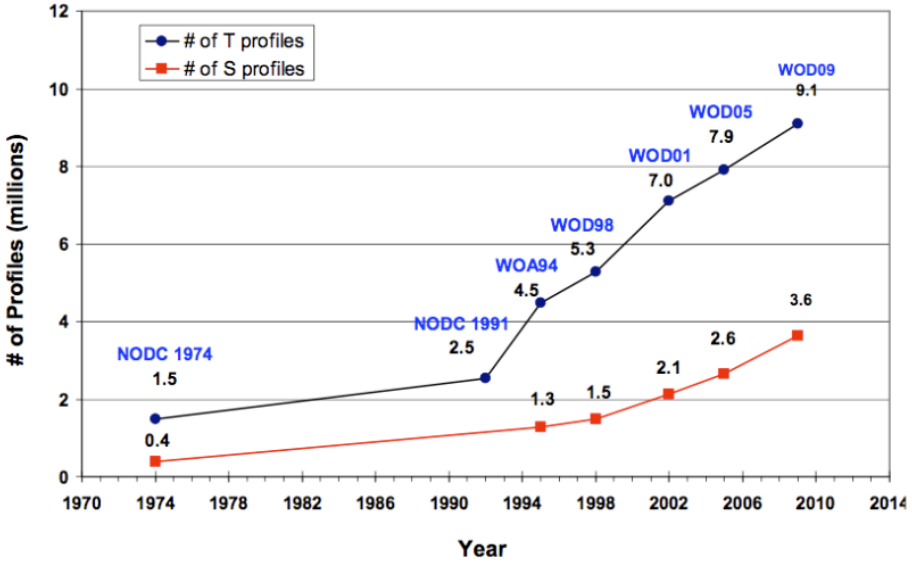


Figure 18: World Ocean Database growth of temperature and salinity profiles.

In order to increase the dissemination of oceanographic data and information IODE has promoted and implemented the development of two major systems: the IODE OceanDataPortal and the IODE OceanDocs. The IODE OceanDataPortal (ODP) (http://www.oceandataportal.org) aims to provide seamless access to collections and inventories of marine data held by IODE NODCs and other data providers. The IODE ODP is being developed in close cooperation with existing and developing initiatives such as the IODE/JCOMM E2EDM Pilot Project, SeaDataNet, WIS, Australian Oceans Portal, US DMAC, Russian ESIMO and others. The ODP will also support the data access requirements of other IOC programmes areas, including GOOS, JCOMM, HAB and the Tsunami warning system. The ODP development will also work closely with other international initiatives including WIS and GEOSS to ensure interoperability with other domains. The IODE OceanDocs is an e-repository (electronic repository) of scientific publications related to marine science and oceanography. OceanDocs enables researchers to deposit the full text of their works: articles, conference papers, technical reports, working papers, thesis and more. Through OceanDocs a wealth of research documents has now become available that prior to OceanDocs remained hidden on library shelves. In addition to OceanDocs, the IOC Project Office for IODE (Ostend, Belgium) is hosting (starting October 2010) the Aquatic Commons e-repository, built by the International Association of Aquatic and Marine Librarian and Information Centres (IAMSLIC).

Aquatic Commons is a thematic digital repository covering the natural marine, estuarine/brackish and fresh water environments.

Underpinning the above-mentioned distributed data systems are standards. The value of standards is clearly demonstrable. In oceanography, there have been many discussions for processing data and information. Many useful ideas have been developed and put into practice, but there have been few successful attempts to develop and implement international standards in managing data. JCOMM and IODE are collaborating in the "Ocean Data Standards Pilot Project" (http://www.oceandatastandards.org) to achieve broad agreement and commitment to adopt a number of standards related to ocean data management and exchange.

Data from research in ocean sciences, whether generated from research or operational observations, are not always deposited in national or international databases in a format that makes them retrievable and reusable, or even to test the reproducibility of reported research. Often, there are insufficient incentives for data submission, only punishments for not submitting data, resulting in low submission rates and even when submitted, a bare minimum of metadata. This issue is not unique to the ocean sciences, but several ocean science organizations have begun an effort to stimulate the submission and availability of ocean data. The Scientific Committee on Oceanic Research, International Oceanographic Data and Information Exchange (IODE) of the Intergovernmental Oceanographic Commission, and the Marine Biological Laboratory/Woods Hole Oceanographic Institution Library are working together to develop and execute pilot projects (i) to deal with data, held by data centres, that are packaged and served in formats that can be cited and (ii) data related to traditional journal articles are assigned persistent identifiers referred to in the articles and stored in data repositories, such as DSpace repositories provided by libraries and IODE's OceanDocs system.

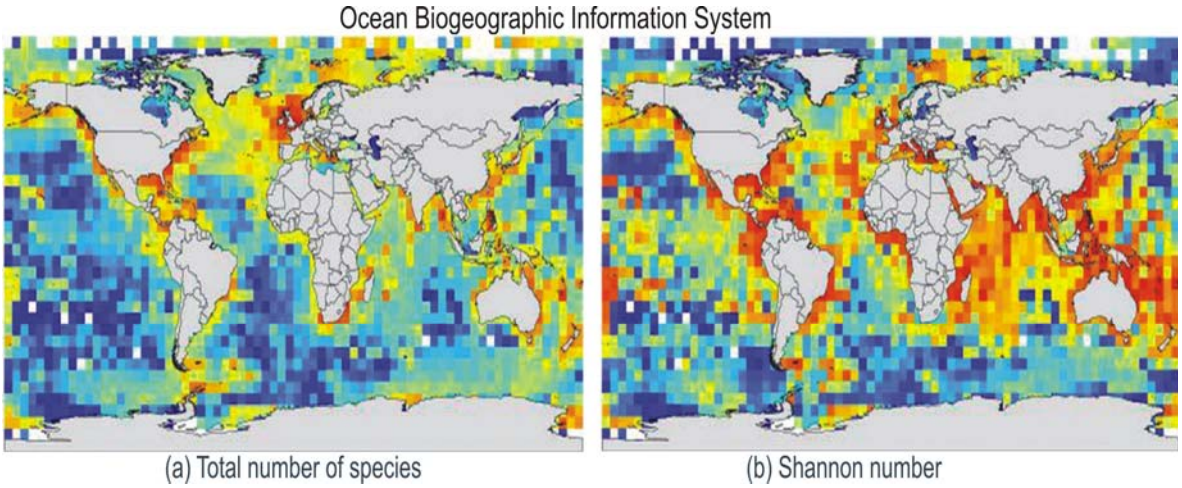


Figure 19: OBIS Records corrected for differences in surface area between squares on different latitude; (a) the total number of species, corrected for differences in surface area between squares on different latitude; (b) Shannon Index.
Source: E. Vanden Berghe/OBIS.

As from 2011 OBIS will become part of IODE. OBIS was established by the Census of Marine Life program (htpp://www.coml.org). Between 2000 and 2010 it developed as an evolving strategic alliance of people and organizations sharing a vision to make marine biogeographic data, from all over the world, freely available over the World Wide Web. Any organization, consortium, project or individual may contribute to OBIS. OBIS provides, on an 'open access' basis through the World Wide Web: (i) taxonomically and geographically resolved data on marine life and the ocean environment; (ii) interoperability with similar databases; and (iii) software tools for data exploration and analysis (Fig. 19). By 2010 the OBIS database contained over 22 million records.

IODE has a long history of capacity building and was in fact one of the first IOC programmes that started training courses in the 1980s. In 1989 IODE developed a new capacity building strategy called “Ocean Data and Information Networks” (ODINs) based upon the following four guiding principles: (i) Linking training, equipment, operational support: provide not only equipment but also training as well as some financial support to operate the equipment and develop products; (ii) Regional context: focus on national requirements but also identify similar needs across a region and develop regional products and services that serve all participating countries in a region; (iii) Product and service oriented: do not develop data centres as isolated facilities but ensure these centres provide services and products that are needed by users; and (iv) Multi-stakeholder approach: ensure that the project is driven by stakeholders as representatives of users and involve these stakeholders as much as possible in the governance of the project. During the past two decades the ODIN strategy has been applied in Africa (ODINAFRICA), Latin America and the Caribbean (ODINCARSA), the Indian Ocean region (ODINCINDIO), the Western Pacific region (ODINWESTPAC), the Black Sea region (ODINBlackSea) and small islands in the Pacific (ODIN-PIMRIS).

Supporting the training component of the ODINs the IODE developed a comprehensive training tool called *OceanTeacher*. The objective of *OceanTeacher* is to provide training tools for Oceanographic Data and Information management. These tools are used during IODE Training Courses but can also be used for self-training and continuous professional development. The *Ocean Teacher* web site (http://www.oceanteacher.org) is comprised of two components: the OceanTeacher Digital Library and the OceanTeacher Classroom. *OceanTeacher* is used as a tool during “live” classroom courses but can also be used for distance learning. Since 2009 IODE offers an annual cycle of 6-8 courses as part of the OceanTeacher Academy programme. *OceanTeacher* courses address data and information centre staff, university students as well as young scientists.

In order to respond to new challenges faced by the IODE Programme, an “IOC Project Office for IODE” has been established in Ostend, Belgium, with substantial support from the Government of Flanders (Belgium) and the City of Ostend. With the opening of the IOC Project Office for IODE on 25 April 2005, the IODE programme entered a new era of capacity building and ocean data/information services. The Office hosts the Secretariat of the IODE programme, implements many of the IODE training courses and organizes IODE workshops and expert meetings.

Tsunami Early Warning System

Most tsunamis are caused by earthquakes. Because it is impossible to predict when an earthquake will occur, it is also impossible to determine exactly when a tsunami will be generated. However, by looking at past tsunamis, we know where they are most likely to be generated (Fig. 20). Tsunamis created by earthquakes have their source in seismically active areas.

In 1965, following devastating tsunamis generated from earthquakes in Chile (1960) and Alaska (1964), the newly-created IOC was requested to establish an International Tsunami Warning System in the Pacific, with the Pacific Tsunami Warning Center (PTWC) and the International Tsunami Information Center (ITIC) in Honolulu, Hawaii (USA).

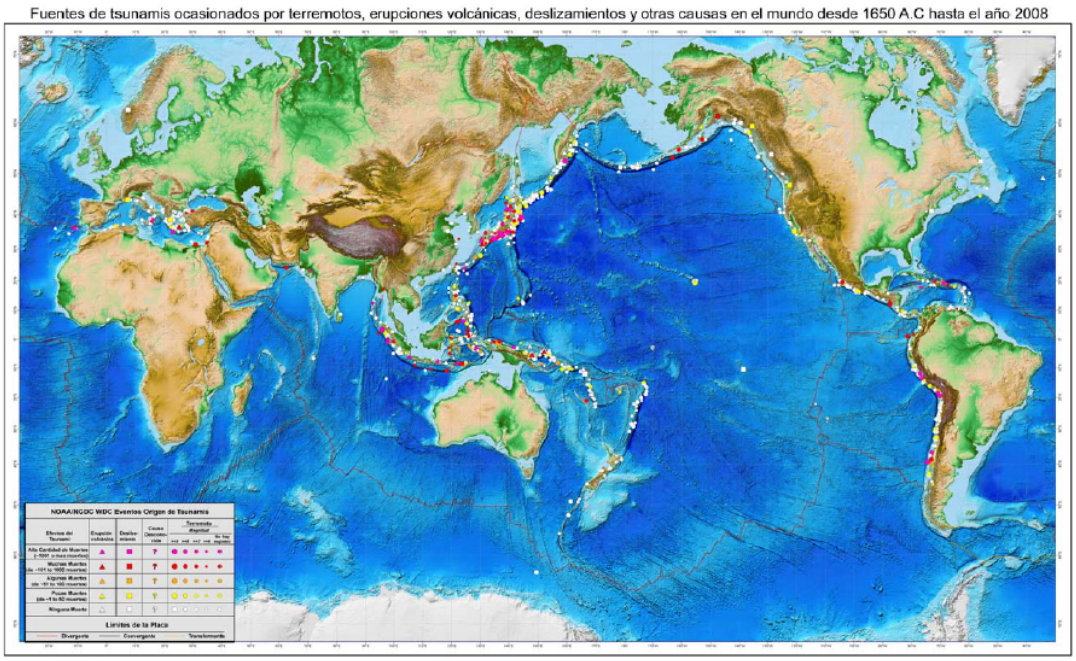


Figure 20: Tsunami sources

While some attempts were made to develop in the Indian Ocean and the Caribbean region similar systems, the dangers of tsunamis were ignored because they have been so rare in these areas.

On 24 December, 2004 a massive (magnitude 9.1) earthquake off the coast of Banda Aceh, in Western Sumatra (Indonesia), generated a tsunami that caused over 230,000 deaths and billions of dollars of damage in 11 countries. Although Banda Aceh, itself, bore the brunt of the catastrophe, coasts and their populations in Sri Lanka, India and nine other Indian Ocean countries as far as 5,000 km away, were also severely hit by the tsunami. It was the first basin-wide tsunami on record in the Indian Ocean. As there was no early warning system in the region, local people and tourists were neither warned, nor prepared to face the disaster. Following this catastrophe the IOC was mandated to establish a global warning system. It became imperative that a tsunami should never again create such avoidable loss of life.

In 2005, UNESCO/IOC was mandated to coordinate intergovernmental efforts to set up an Indian Ocean Tsunami Warning System (IOTWS), building on over 40 years of experience gained with the Pacific Warning System. Five years later, after a tremendous effort involving 28 Member States, the system is planned to be operational by 2011. The Pacific Tsunami Warning Centre (PTWC) in Hawaii, USA and the Japanese Meteorological Agency (JMA) in Tokyo, Japan has, since April 2005, been providing an interim tsunami advisory service to the Indian Ocean. Similar tsunami warning systems are reaching completion for the Mediterranean and the North East Atlantic (NEAMTWS) and the Caribbean (CARIBE-EWS), thus covering all the earthquake (and therefore tsunami) prone ocean basins in the world. PTWC provides an interim tsunami warning service to the Caribbean Sea. We are now almost able to provide global coverage for tsunami and other sea-level related hazards.

The end-to-end approach to regional tsunami early warning and mitigation system (Fig. 21) is evolving to include the development of Member States' capacities for coastal hazard assessment and a more comprehensive approach to address sea-level related hazards (tsunamis, sea-level rise and coastal erosion, storm surges), with a special attention to SIDS and Africa.

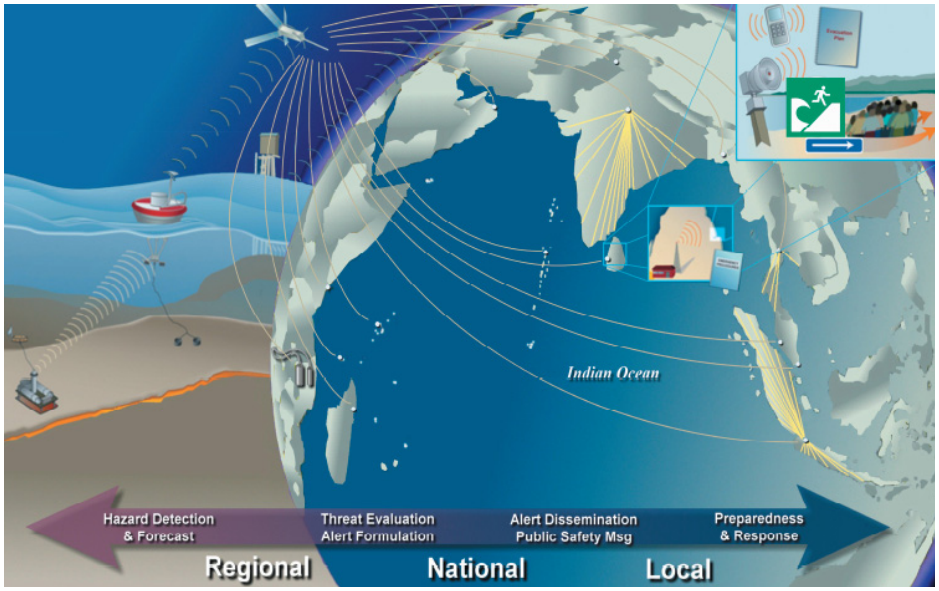


Figure 21: Conceptual diagram for an end-to-end warning system

Increasing vulnerability to natural hazards in the coastal zone poses a major threat to sustainable development, and affects lives and livelihoods. Within the framework of the Hyogo Plan of Action, our strategy to reinforce Member States capacities to deal with coastal related hazards includes hazard assessment, monitoring and warning dissemination and community preparedness. Following the rapid progress in installing the Indian Ocean Tsunami Early Warning and Mitigation System [IOTWS], the IOC will streamline its work on tsunamis and other sea-level hazards including in the North-eastern Atlantic and Mediterranean (NEAMTWS); Caribbean Sea (CARIBE-EWS) and Pacific Ocean (PTWS).

THE WAY FORWARD

Since its foundation, IOC has evolved in both scientific understanding and practices. For instance, oceanographic research has expanded from individual initiatives to international networks, which not only changed our approach to address global ecological questions but also opened new opportunities for inter-disciplinarily research, for creating distributed facilities, and for transferring knowledge and technologies (Valdés et al., 2010). IOC has contributed to advances in ocean science by catalyzing, coordinating, and communicating marine scientific research through participation in research and coordination of scientific programmes on targeted themes as well as scientific networking though the sponsorship of global research programmes. IOC has a history of cooperation with leading UN interagency groups and also with other relevant international organizations. The Commission has also provided the framework for extensive scientific services and data archiving. Other important contributions are related to the development of standards and guidelines for data exchange, marine technology and research.

To support IOC mission and to achieve the objectives of the programmes (and so the HLOs), IOC plans to persevere in their functions and activities. The main IOC activities and objectives for the biennia 2010–2011 and 2012–2013, and the functions and mission of IOC will be safeguarded and delivered.

The IOC continues to maintain an up-to-date scientific basis for its programmes. Strategic priorities in ocean sciences are not static, but must be reviewed periodically. In fact, we are aiming at a moving target, as the oceans are dynamic and we are facing a changing environment in ocean research and coastal management. Currently, this rate of environmental change is unprecedented, and is aggravated by the fact that very few areas of the ocean remain pristine, unaffected by multiple anthropogenic interferences such as greenhouse gas emissions, eutrophication, fishing, habitat destruction, hypoxia, pollution, and species introductions (Halpern et al., 2008).

In order to globally monitor and possibly predict the evolution and impact of climate change the IOC will also need to further develop its Global Ocean Observing System as well as its IODE network of data centres and distributed data network to underpin scientific conclusions with solid observations and data.

To align the lifetime of programmes within the UNESCO mid term strategy, each programme and all facets of work need to be effectively monitored, the results rigorously evaluated, and the work-plan of each programme modified as necessary.

Clearly the drivers for ocean scientific research are connected to the sustainable use of the oceans and to the understanding, mitigation and adaptation to climate change (ICSU, 2010, Valdés et al., 2010). In that sense, the main ocean-related scientific problems of our time are interdisciplinary and call for cooperation between different branches of science. These problems need to be addressed on a global scale through extensive international cooperation, which is clearly the case with climate change and ecosystem functioning. Additionally, there is an increasing call for more social engagement, with science responding more effectively to societal needs. Thus, international cooperation at an institutional level is the key to ensure cohesion in marine science and development. For that, IOC will continue to maintain and extend institutional relationships relevant to UN Agencies, International Councils, global programmes, NGOs, and participate in alliances and international agreements related for instance to ocean governance.

BIBLIOGRAPHY

Halpern, B., S. Walbridge, K.A. Selkoe, C.V. Kappel, F. Micheli, C. D'Agrosa, J.F. Bruno, K.S. Casey, C. Ebert, H.E. Fox, R. Fujita, D. Heinemann, H.S. Lenihan, E.M.P. Madin, M.T. Perry, E.R. Selig, M. Spalding, R. Steneck, and R.Watson. 2008. A Global Map of Human Impact on Marine Ecosystems. *Science* 319(5865): 948-952.

Holland, G. 2006. Observing and understanding Planet Ocean, a history of the Intergovernmental Oceanographic Commission (IOC). In: *Sixty Years of Science at UNESCO 1945–2005*. UNESCO 2006, 332-353.

ICSU. 2010. *Grand Challenges in Global Sustainability Research: A Systems Approach to Research Priorities for the Decade*. International Council for Science, Paris. 20 pp.

IOC. 2007. *IOC draft medium-term strategy, 2008–2013*. Intergovernmental Oceanographic Commission, Paris. IOC-XXIV/2 Annex 5, 18 pp.

IOC. 2007. *Perspective of the Ocean Sciences Section programme in light of the draft IOC medium term strategy*. Intergovernmental Oceanographic Commission, Paris. IOC-XXIV/2 Annex 6, 9 pp.

IOC. 2009. *The Ocean Sciences Section functions, activities and work plan within the IOC Medium Term Strategy 2008–2013*. Intergovernmental Oceanographic Commission, Paris. IOC/INF-1259, 15 pp.

Nellemann, C., E, Corcoran, C. Duarte, L. Valdés, C. deYoung, L. Fonseca, and G. Grimsditch. 2009. *Blue Carbon*. A Rapid Response Assessment. United Nations Environment Programme, GRID-Arendal. ISBN: 978-82-7701-060-1, 78pp.

Ogata Y, H. Takada, K. Mizukawa, H. Hirai, S. Iwasa, S. Endo, Y. Mato, M. Saha, K. Okuda, A. Nakashima, M. Murakami, N. Zurcher, R. Booyatumanondo, M.P. Zakaria, L.Q. Dung, M. Gordon, C. Miguez, S. Suzuki, C. Moore, H.K. Karapanagioti, S. Weerts, T. McClurg, E. Burres, W. Smith, M. Van Velkenburg, J.S. Lang, R.C. Lang, D. Laursen, B. Danner, N. Stewardson, and R.C. Thompson. 2009. International Pellet Watch: Global monitoring of

persistent organic pollutants (POPs) in coastal waters. 1. Initial phase data on PCBs, DDTs, and HCHs. *Marine Pollution Bulletin* 58:1437–1446.

Roll, H.U. 1979. *A Focus for Ocean Research. Intergovernmental Oceanographic Commission, History, Functions, Achievements*. Intergovernmental Oceanographic Commission, Paris. IOC Technical Series, 20, 63 pp.

Royal Society. 2009. *Geoengineering the climate Science, governance and uncertainty*. Policy document 10/09. ISBN 978-0-85403-773-5, 81 pp.

Valdés, L., L. Fonseca, and K. Tedesco. 2010. Looking into the future of Ocean Sciences: an IOC perspective. *Oceanography*, 23(3): 160-175.

Intergovernmental Oceanographic Commission (IOC)
United Nations Educational, Scientific and Cultural Organization
1, rue Miollis
75 732 Paris Cedex 15, France
Tel.: +33 1 45 68 10 10
Fax: +33 1 45 68 58 12
http://loc-unesco.org