

Chapter 32. Capacity-Building in Relation to Human Activities Affecting the Marine Environment

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1. Introduction

The oceans provide various ecosystem services or what are also referred to as the "benefits that people desire from ecosystems" (Millennium Ecosystem Assessment, 2005). It is therefore necessary to know the types or nature of services that humans receive from the oceans and the scale or level of human activities that can be exerted without causing imbalances that could affect sustainability. Achieving sustainability requires strong public understanding of the importance of the ocean. This therefore calls for enhanced outreach and communication efforts through the development of mechanisms and partnerships to build capacity for outreach and awareness programmes. The major types of ecosystem services are described in Chapter 3. For sustainability the following are needed: scientific understanding of the services; assessment of the level of food production which results from various ecological processes, in order to address food security and safety; assessment of aesthetic uses of the ocean environment; and the level and type of capacity for studying and managing human activities and their impacts arising from exploitation of the ecosystem services. The level of capacity-building reflects, among other things, the efforts at identifying knowledge gaps in science, technological advances, human skills development and infrastructure.

To fulfil the overall objective of the Regular Process, all States need to address the overall objectives of the Regular Process as set out in the reports of the Ad Hoc Working Group of the Whole (AHWG) to the United Nations General Assembly (UNGA) (A/64/347, 65/358), and the United Nations Secretary-General's Report (A/65/69/Add.1) (UNGA 2010, UNGA/AHWG 2009 and 2010). This outcome can only be achieved with significant efforts at capacity-building. The Regular Process itself therefore promotes, facilitates, and, within its capabilities, ensures that capacity-building and technology transfer are undertaken through promoting technical cooperation, including South-South cooperation amongst developing countries and taking gender and equitable geographical distribution into account. Over the long-term (i.e., beyond this first Assessment), the Regular Process will support and promote capacity-building through identifying opportunities and facilitate linkages for international cooperation that includes technical cooperation and technology transfer with regard to developing countries (in particular the least developed countries, African coastal States and Small Island Developing States), in order to improve the capacity in these geographical areas

to undertake integrated assessments. Substantial capacity-building efforts are being undertaken by United Nations agencies through technical cooperation programmes. It is also important that gaps are identified and priorities shared so that a coherent programme to support capacity-building in marine monitoring and assessment, including socioeconomic aspects, is achieved. The approach for this first baseline Assessment was to conduct integrated assessments using the "Driver Pressure State Impact Response" (DPSIR) methodology commonly used to represent human-environmental /economic interactions, including scaling up assessments (national, sub-regional, regional and global). The workshops were also used as fora to explain the processes for conducting integrated assessments. The workshops were participatory and helped to promote ownership of the Regular Process outcomes at various scales. Furthermore, the workshops not only added further value in creating and promoting awareness of the Regular Process, but also promoted institutional capacity linkages. Various regional and international reviews of capacity-building have been conducted by various agencies. These also provide sources of information for a critical analysis of this subject, in particular for identification of gaps; therefore this chapter also includes an overview of these regional and international initiatives as per the chapters authored in this section.

This first Assessment has two chapters on capacity-building: one each in Parts V and VI. Part V deals with "Assessment of other human activities affecting the marine environment" and includes this chapter on "Capacity-building in relation to human activities affecting the marine environment." Part VI, entitled: "Assessment of marine biological diversity and habitats", includes Chapter 53 on "Capacity-building needs in relation to the status of species and habitats". The topics addressed in the chapters are based on the DPSIR Methodology as approved by the AHWGW. Furthermore, pursuant to the guidance of the AHWGW, the regional workshops will also contribute to identification of capacity-building strategies to address the approved themes in the two chapters on capacity-building for regional needs.

2. Outcomes based on regional workshops on capacity-building needs

The analysis showed that for most regions the main capacity needs were cross-cutting issues among the regions; these are summarized as follows: (i) Data accessibility and data sharing; (ii) The provisions for mentoring and training opportunities for less experienced scientists and practitioners; (iii) Data collection and marine habitat mapping to inform management of ecosystems, biodiversity and fisheries; (iv) Need to improve professional capacities to assess socioeconomic issues; and (v) Capacity to conduct integrated and ecosystem-services assessments.

The regional workshops were undertaken in the following regions: south-west Pacific region (UNGA 2013a), Wider Caribbean region (UNGA 2013b), eastern and southeastern Asian Seas (UNGA 2012a), South-East Pacific region (UNGA 2011), the joint North

Atlantic, Baltic Sea, Mediterranean and the Black Sea region (UNGA 2012b), the Western Indian Ocean (UNGA 2013c), South Atlantic Ocean (UNGA 2013d) and Northern Indian Ocean (UNGA 2014). The regional outcomes in terms of knowledge gaps and capacity needs were as follows:

2.1 Capacity needs for marine assessments in the south-west Pacific Region

This workshop was held in Brisbane, Australia, 25-27 February 2013 (UNGA 2013a). The focus was on linkages and upscaling from national to regional and global scales to promote synergies for building capacity which will include mentoring, learning and cooperation in communication, data and information transfer, as follows:

- The production of global marine assessments should be linked to ongoing efforts to support regional (led by the Secretariat of the Pacific Regional Environment Programme) and national state-of-the-environment reporting and streamlining of reporting arrangements (led by the Pacific Islands Forum Secretariat/Secretariat of the Pacific Regional Environment Programme). By providing capacity development and other support to these initiatives, the region will be better placed to contribute to and benefit from the Regular Process. The production of global marine assessments should be done in a way that provides mentoring and learning opportunities for less experienced scientists and practitioners.
- Active facilitation of involvement of practitioners from Pacific Island countries and territories in producing global marine assessments, including improved communication efforts to ensure awareness of the opportunity to be involved, assistance in registering for the Pool of Experts and resourcing support for and formal recognition of work done will all contribute to capacity-building in those countries.
- A large quantity of data and information exists, but it is often not readily identifiable or accessible. Enhanced regional and national capacities to store, access, share and interrogate data and information would assist the production of global marine assessments and facilitate the meeting of regional and national objectives.
- Resourcing is a substantial constraint on the capacity of the region to contribute to the production of global marine assessments. This can in part be addressed by the nature, scope and process for the development of assessments that more deliberately support national and regional objectives, as well as the objective of producing a global report. For example, the global marine assessment could provide region-specific information and access to the underlying data and information.
- Because of the limited capacity of the region to engage in the drafting of this Assessment, the review stage might be an efficient point for the region to ensure that regional information and perspectives are appropriately reflected therein. A second workshop or network among involved practitioners may provide

mechanisms for doing this. Similarly, providing support to an appropriate Pacific regional organization to facilitate and coordinate ongoing regional engagement may be useful.

2.2 *Capacity needs for marine assessments in the Wider Caribbean Region*

This workshop was held in Miami, United States of America, 13-15 November 2012 (UNGA 2013b). The emphasis was placed on: needs for projects to include capacity-building and have specialized research institutions and research vessels offer opportunities for training, including the use of ships of opportunity; specialized research institutions to offer learning and mentoring opportunities, especially data and information analysis and synthesis; building collaboration and networks across experts, institutions and a variety of stakeholders, and promoting a culture of manpower retention for sustaining research in institutions. Other points included:

- Previous or ongoing regional marine assessments, specifically the Caribbean Coastal Marine Productivity Programme, the Caribbean Planning for Adaptation to Climate Change Project and the Caribbean Large Marine Ecosystem Project, were highlighted as successful cases of capacity-building.
- In some disciplines, such as physical oceanography and remote sensing of the ocean environment, capacity is highly concentrated in a few institutions. In other disciplines, such as social sciences, it is highly dispersed.
- Access to research vessels (e.g., NOAA ships) and ships of opportunity (e.g., those used in relation to the Living Oceans Foundation) offer opportunities and synergies on a wider scale with advanced technology for enhanced marine assessments.
- Data are often abundant, including data collected by ships of opportunity; the limitation is in the capacity to manage the data, including how to organize, store, synthesize and analyse them. Participants discussed the need for nationals to study at institutions where data are already being used and then to bring the expertise home.
- Building collaboration among scientists, resource managers and other stakeholders is central to capacity-building, especially as it includes building a willingness to share and communicate. With this in mind, capacity-building in the region would benefit from establishing and promoting networks of practitioners, experts, institutions and countries and promoting regional programmes.
- A fundamental shortfall exists in capacity to integrate the key insights of existing research into policy and management agendas, and this is a core area where capacity-building would yield benefits.
- There would be great costs in capacity from failure to retain the knowledge that is invested in training employees and management leadership. Such retention requires fiscal incentives to retain individuals in positions. The constant cycle of promotion at all levels results in an export of knowledge out of the field. Often,

the bulk of expert individuals will be lost from policy and management to narrow academic research fields.

2.3 *Capacity-building needs for the eastern and south-eastern Asian Seas*

This workshop was held in Sanya, China, 21-23 February 2012 (UNGA 2012a). The focus was on building skills in integrated assessments, methodologies and quality assurance of data through effective creation of synergies and communication for data and information sharing. Creating awareness of the Regular Process within the scientific community of the region was emphasized. A successful WOA would require the ability to understand the implications of what we know about the status of biodiversity and link this with the state of the environment, as well as with ecosystem-based fisheries assessments in order to produce accurate fisheries status reports. In addition to assessing capture fisheries correctly, there is insufficient capacity for assessing impacts of aquaculture on the surrounding marine ecosystems and more generally for assessing environmental impacts that are anthropogenic, and/or due to climate change and invasion of alien species, as well as for socioeconomic assessments of human well-being. All these are candidates for capacity-building that would improve capacity to conduct integrated assessments. Other points included the following.

1. At the highest level, the workshop participants identified as the first priority the need for improved skills in and knowledge on the conduct of integrated assessments (i.e., including environmental, economic and social aspects). Such experience/skills were lacking throughout the region and training in methodologies for conducting integrated assessments would be of direct benefit to the Regular Process.
2. Additional short-term capacity-building needs (i.e., that could deliver results within the next 18 months) identified by the workshop included the following:
 - (a) Building awareness of the need for interoperability between States and regions regarding several areas, including: an international classification standard for marine economic activities; quality assurance/quality control for data collection and analysis; enhancing comparability and compatibility of data from different sources; and biological information management, including taxonomy;
 - (b) Improved international networking and resource sharing, including a network to facilitate international communication and cooperative platform-building related to marine environmental, social and economic data;
 - (c) Following the kind offer from UNEP, IOC-UNESCO and the Asia-Pacific Network for Global Change Research (APN), the organization of a regional workshop focusing on capacity-building and the technical and scientific aspects of the Regular Process would aim to share information about available assessments, data and knowledge of methodologies to be used

in compiling and developing the first global integrated marine assessment.

3. This regional workshop would aim at gathering scientists and relevant national authorities to raise awareness of the Regular Process within the scientific community of the region. The workshop would also aim at facilitating the appointment by States of individual scientists from the region to the pool of experts. The workshop would be co-organized by UNEP, IOC-UNESCO, GRID-Arendal, the North-West Pacific Action Plan (NOWPAP) and the Coordinating Body on the Seas of East Asia (COBSEA), with the support of APN.
4. Long-term capacity-building needs (i.e., that should be started quickly but which would only deliver results in the next three to five years) identified by the workshop included the following:
 - (a) Conduct of marine habitat mapping to inform management of ecosystems, biodiversity and fisheries. This included the development of skills in areas such as collection and analysis of remote sensing data, acoustic seafloor mapping, underwater video analysis and statistical analysis of biophysical environmental data;
 - (b) Long-term and well-planned biodiversity assessments were needed on both commercial and non-commercial marine species, including using genetic information to trace and determine stocks and species;
 - (c) Ecosystem-based fisheries assessment for capture fisheries and forecasting the status of fish and shellfish stocks;
 - (d) Assessing impacts of capture fisheries on the marine ecosystem;
 - (e) Assessing impacts of aquaculture on the surrounding marine ecosystem;
 - (f) Assessing impacts of habitat degradation (e.g., using ecological modelling and forecasting) on projected fish and shellfish stocks and aquaculture;
 - (g) Monitoring anthropogenic contamination of water, sediment and biota, to ensure maintenance of food security;
 - (h) Assessing impacts of climate change on marine biota and ecosystems, including the effects of ocean temperature change, ocean acidification, changes in coastal sediment and water discharge, changes in tidal and other currents, swell and wave patterns and coastal habitat changes due to sea-level rise;
 - (i) Assessing impacts of alien species;
 - (j) Assessing socioeconomic aspects.

2.4 Capacity needs for marine assessments in the south-east Pacific Region

This workshop was held in Santiago, Chile, 13-15 September 2011 (UNGA 2011). The focus was on addressing institutional and individual capacity-building, especially with regard to technical support and joint development and implementation of partnership projects. It called attention to the insufficient capacity to monitor harmful and alien

species using remote sensing capabilities, as well as creating capacity to organize databases using standardized tools and formats. It was also important to build capacity to assess the effects on biodiversity of human activities and to address biophysical and socioeconomic issues for human well-being. Other needs included:

2.4.1 Information

- Information on this vast ocean region of the South Pacific is scattered and has not been summarized and collated, although it exists in the form of reports of scientific expeditions, historical records of fishing activities (fishing fleets) and a large number of scientific publications. The large increase in databases on biodiversity from 5 million entries in 2005 to over 32 million geo-referenced records in 2011 was noted;
- The South-East Pacific Group of Experts considered it essential in the short term to strengthen the capacities of the competent technical bodies with regard to integrated assessment methods. The DPSIR methodology adopted by the UNGA as the conceptual basis for carrying out this first integrated assessment of the marine environment, although known in the region and widely used in the terrestrial environment, has thus far not been regularly used in marine environmental assessments. The fruitful exchange of information between experts from the west coast of the Americas, from Mexico to Chile is noted;
- Incorporate geo-referencing information systems for ecosystem-focused analysis;
- Improve information and monitoring systems;
- Compile base-line data, which is difficult and costly;
- Improve information systems that can be shared.

2.4.2 Capacity-building

- The South-East Pacific Group of Experts acknowledges the shortfall in ability to generate capacity to analyse the ocean environment in areas beyond national jurisdiction;
- More experts able to conduct research on climate change with reference to oceans;
- Capacity to organize databases using standardized formats and tools for access by the public;
- Strengthen methodology for economic assessment;
- Pilot project in Chile to harmonize economic assessment methodologies.

2.4.3 Knowledge gaps

- Technical support for the maintenance of equipment and sensors;
- Development of projects and research capacity on palaeoclimatology at the regional level, including effects on marine coastal areas (corals, sediments, ice cores, etc.);
- Monitoring of harmful algal blooms by remote sensing;

- Assessment of wide-scale processes at the level of the entire South Pacific Basin is of great importance in understanding and predicting the behaviour of living marine resources, particularly those exhibiting migratory behaviour (birds, turtles, mammals and pelagic fish species) in the south-east Pacific region;

2.5 Capacity needs for marine assessments in the North Atlantic, the Baltic Sea, the Mediterranean Sea and the Black Sea

This workshop was held in Brussels, Belgium, 27-29 June 2012 (UNGA 2012b). The meeting determined that transfers of skills within the region were needed and that the region can provide a source of knowledge and skills for other regions through creation of partnerships. It is necessary to address food security, marine biodiversity and habitats and information on anthropogenic impacts on the marine environment. Other points included:

- It was agreed that capacity shortfalls did exist within the area covered by the workshop, and that the region could serve as a source of knowledge for other regions. Transfers of skills within the region were needed both from north to south (particularly within the Mediterranean) and from west to east.
- Knowledge gaps at national and regional scales were identified in the report entitled “Analysis of the existing marine assessment in Europe”, prepared in June 2012, including information on:
 - a. Food security;
 - b. Marine biological diversity and habitats;
 - c. Human activity affecting the marine environment.

2.6 Capacity needs for marine assessments in the western Indian Ocean

This workshop was held in Maputo, Mozambique, 6-7 December 2012 (UNGA 2013c). The focus was on capacity needs to address biophysical issues, which are important for alteration of biodiversity, and socioeconomic impacts due to anthropogenic impacts which consequently influence human well-being. Further emphasis was placed on building institutional and individual capacity to address biodiversity, fisheries, tourism, aquaculture, information and data, mining, and economic valuation of natural resources and the environment for human well-being.

The experts assembled at this workshop clearly endorsed the Regular Process; however, capacity-building needs were not highlighted in the December 2012 workshop report. In the assessment workshop of August 2012 the following capacity needs and gaps were identified:

- Information on environmental flows for major rivers;

- Information on ocean acidification: degree and extent of ocean acidification resulting from human activities (including coral bleaching) and socioeconomic implications;
- Regional perspective on ocean-source carbonate production;
- Information on pollution determination from aquaculture use and modification of habitats;
- Environmental flow assessments of coastal, riverine and atmospheric inputs from land;
- Lack of capacity for assessing offshore hydrocarbon industries;
- Lack of capacity to assess offshore mining industries;
- Carrying-capacity studies need for tourism and recreation;
- Economic valuation of resources/environment.

2.7 *Capacity needs for the marine assessments of the South Atlantic Ocean*

This workshop was held in Grand-Bassam, Ivory Coast, 28 to 30 October 2013 (UNGA 2013d). The focus was on identifying knowledge gaps with regard to the biophysical, food security and safety, socioeconomic, and biodiversity aspects, based on which the capacity needs were identified.

2.7.1 *Biophysical aspects*

The principal gaps identified by the experts are: (i) Absence of continuous long time-series on sea-level rise and its impact on the coastal and marine environment; (ii) Absence of information on the knock-on effect of El Niño in the sub-region, especially in West Africa; (iii) Poor links between meteorological and oceanographic institutes; (iv) Lack of continuous, long time-series on acidification, especially *in situ* measurements at tropical latitudes; (v) Scarcity of studies on the factors influencing surface-layer and *species variation, notably studies based on in situ measurements of surface layers and plankton.*

2.7.2 *Food security and safety aspects*

In the South Atlantic region, many national institutions and regional organizations conduct assessments of the status of fish and shellfish stocks and fisheries. Although fisheries statistics are available, continuous time series are lacking in many areas. In fact, many assessments are project-related, so when financing stops, the data collection is discontinued. This happens in all countries; the only exceptions are Argentina and Uruguay, where fairly complete time series are available for the most economically important fish stocks. Vessel availability for independent fishery surveys is a constraint for the whole region.

2.7.3 Socioeconomic aspects related to fishing

The principal gaps identified by the experts in the economic evaluation of fishing activities are: (i) Scarcity of evaluations of economic consequences (risk assessment) of disasters and impact of other activities on fisheries and the living standards of fishers; (ii) Scarcity of studies on the impacts of the global economy on fisheries; (iii) Lack of data on post-fishing losses (during processing, marketing, etc.); (iv) Absence of studies on the impact of harmful algal blooms on fisheries in West Africa; (v) Lack of information on the contribution of artisanal fisheries.

The principal gaps identified by the experts on fishing practices and health and safety are: (i) Stock assessments of species caught by both the industrial and artisanal sectors (they are frequently pooled together, although some countries have good reporting systems); (ii) Scarcity of information on illegal, unreported and unregulated (IUU) fisheries, although the Food and Agriculture Organization of the United Nations (FAO) evaluates the implementation of the Code of Conduct for Responsible Fisheries country by country; (iii) Scarcity of assessments of incidental catches of marine mammals, turtles and birds, especially in the African countries; (iv) Scarcity of information on the number of people employed by the sector; (v) Ineffective implementation of health and safety control systems (poor reporting mechanisms).

2.7.4 Socioeconomic aspects related to environment

The principal gaps identified by the experts on environmental pollution affecting human health and their socioeconomic impacts are: (i) Poor reporting mechanisms and/or difficulty in accessing existing documentation (reports) on oil leakages and spills; (ii) Lack of information on the types and amounts of oil dumped into the sea and trends for the next decade; (iii) Poor capacity in the region to assess the disposal of solid waste in the ocean; (iv) Impacts of exploration and exploitation activities and the lack of regulation of offshore oil and gas exploration and exploitation as well as of sand and gravel mining; (v) Scarcity of studies on land reclamation and habitat modification; (vi) Lack of socioeconomic data and technological skills; (vii) Scarcity of studies on the tourism industry and poor capacity to assess tourism and all associated (i.e., economic, environmental and social) aspects.

2.7.5 Biodiversity aspects

The principal gaps identified by the experts regarding coastal areas, continental shelf and deep sea habitats are: (i) Scarcity of information on deep sea and continental shelf habitats; (ii) Lack of information on the current status of the mangrove species (in this regard, surveys and geographic information system (GIS) mapping projects need to be conducted); (iii) Scarcity of seagrass mapping programmes; (iv) Lack of research on vulnerability and adaptation in response to climate change; (v) Scarcity of close monitoring programmes of cetaceans, especially in West Africa; (vi) Absence of monitoring programmes for certain estuarine areas, especially in West Africa; and (vii) Scarcity of knowledge with regard to deep-water corals and plankton.

2.7.6 Capacity needs

A major capacity shortage facing many countries in the South Atlantic region is the ability to conduct assessments of the state of the marine environment at national to regional spatial scales. This need is mainly due to the lack of funding, but also due to the lack of resources and capability to conduct such studies, especially at the local and national levels. It is important to note, however, that capacity needs are unevenly distributed and that South-South cooperation also represents an opportunity to fill existing gaps. The experts therefore suggested that more capacity-building activities be organized under the umbrella of the Regular Process.

Another important gap concerns the geographical discontinuity of information in the South Atlantic region, and in particular the scarcity of studies on biophysical and socioeconomic dynamics in the region. This was deemed to be an important gap that hinders the development of an integrated regional assessment. Optimizing the coordination of marine environmental data-collection activities within countries and within the region should contribute to the production of an integrated regional assessment.

2.8 Capacity needs for marine assessments in the northern Indian Ocean

This workshop was held in Chennai, India, 27-29 January 2014 (UNGA 2014). The meeting focused on identifying short-term and long-term capacity-building needs that were determined through gap analyses. The capacity-building should concentrate on developing methodologies for integrated assessments and standardization of data and information generation for national, sub-regional, regional and global assessments. It is also a priority to create regional partnerships for undertaking joint research and to mobilize funds for capacity-building. Capacity-building to address biodiversity, critical habitats, microbial assessments, shipping, and environmental monitoring using satellite technology is also highlighted as a priority. Other points included:

- (1) The immediate action plan recommendation includes identification of the needs for capacity-building (including the acquisition of necessary technology) for marine monitoring and assessment (including integrated assessments). The capacity-building activities need to concentrate on the following issues:
 - (a) methodologies to obtain the information from various sources on a regular basis;
 - (b) standardization of the information content for assessments at various levels;
 - (c) developing common methodologies to carry out the assessment and to train data collectors: this is very important for uniform data collection. The procedure, data collection, formatting and preparation of reports should be standardized for all the member countries.

- (d) developing methodologies for scaling up national, sub-regional, regional and global assessments; and
 - (e) developing reporting forms to assist the integration process, with the aim of securing coherence, consistency and comparability as far as possible.
- (2) Development of a short-term capacity-building plan to mobilize the information and knowledge that is known to exist but has not yet been systematically organized in a way that would allow its use for the Regular Process. However, for this purpose, it may be necessary to identify the gap areas, and make efforts in capacity-building for those areas. India can help other States in capacity-building at various levels.
 - (3) To identify and fill gaps like microbial assessment, seagrass mapping, etc. Satellite-based techniques can be used to identify mangroves, seagrasses, etc., and create an ecosystem report card.
 - (4) Undertake assessments on the open ocean and activities related to shipping.
 - (5) To enhance cooperation between member States of the region, a template / matrix will be developed for circulation to neighbouring countries to complete; the questionnaire will include information for identifying gaps and capacity needs.
 - (6) It is stressed that improving communication among the countries of the region is the most important first step.
 - (7) Shortfalls in continuous monitoring of the environment using satellite technology.
 - (8) Insufficient involvement of regional organizations, undertaking joint research programmes, and securing funds for capacity-building activities.

3. Outcomes based on chapters focussing on knowledge gaps to inform capacity-building needs

3.1 Assessment of major ecosystem services from the marine environment (other than provisioning services)

This section deals with three types of ecosystem services: regulating, cultural and supporting services (Chapters 3-9). The identified gaps and capacity-building needs to address them are as follows:

3.1.1 Ecosystem services other than provisioning services

- Data availability and resolution at different scales and geographical ranges: the developing world especially has massive gaps.
- Capacity to undertake heuristic/participatory processes at regional and global levels: this should involve training and empowering local

stakeholders to enable them to understand the impact of ecosystem services on their well-being.

- Human capacity and infrastructure (research laboratories and institutes, observatories and oceanographic fleets) should be developed on a continual basis.

3.1.2 *Oceans and the hydrological cycle*

- Skills to quantify potential impacts on society and natural environment due to flooding and sea-level rise: the latter are acknowledged as being among the most serious issues confronting humankind.
- Capacity is inadequate to determine local sea-level changes which are also influenced by several natural factors, such as regional variability in the ocean and atmospheric circulation, subsidence, isostatic adjustment, and coastal erosion. It is necessary to study the latter too.
- Regional capacity is not sufficient to study changes in the rates of freshwater exchange between the ocean, atmosphere and continents because of their significant impacts. There is also inadequate ability to determine spatial variations in the distribution of evaporation and precipitation that create gradients in salinity and heat that in turn help drive ocean circulation.
- Capacity is insufficient to utilize traditional knowledge as an additional resource to address adaptation in given impact settings; this knowledge should be carefully evaluated within adaptation planning.
- Capacity is insufficient for standardizing methodologies to address regional differences which are due to differing data sources, temporal periods of analysis, and analysis methodologies.
- Capacity is insufficient for disaster preparedness to address high-intensity cyclones, because the scientific consensus shows that global warming will lead to fewer but more intense tropical cyclones globally. This will certainly affect coastal areas that have not been exposed previously to the dangers caused by tropical cyclones.

3.1.3 *Sea-air interface*

- Regional capacity is not adequate to determine levels of rising carbon dioxide (CO₂) in the atmosphere and increased absorption of CO₂ by the oceans, which has created an unprecedented ocean acidification (OA) phenomenon that is altering pH levels and threatening a number of marine ecosystems. It is necessary to map OA hotspots, which have now become a global problem.
- Capacity is insufficient to study the impact of shellfish farming due to acidification and to establish indicators for OA to facilitate determination of OA hot spots.

3.1.4 *Plankton productivity and nutrients*

- There are important shortfalls in regional capacity in terms of both infrastructure and human skills to enable measurement of primary production *in situ* and through remote sensing. The infrastructure includes multiplatform infrastructure, e.g., laboratories, oceanographic ships, moorings, drifters, gliders, aircraft, and satellites that can enable continuous measurements for both short-term and long-term monitoring.
- Various regions lack long-term measurements of primary production and therefore lack long-term data to construct predictive models to estimate trends.
- Phytoplankton can play a significant role in climate regulation to undertake continuous regional measurements of phytoplankton production through carbon sequestration, which is an order magnitude higher than that provided by grasslands and forest vegetation, and also form a basis for prediction of fisheries production to address food security. For both reasons it is important to undertake continuous regional measurements of phytoplankton production, and these measurements will require improved capacity for plankton monitoring.
- There is insufficient ability to identify which species of phytoplankton are most suitable for development of bio-fuels and pharmaceuticals.
- There is insufficient ability to identify which species of phytoplankton engage in nutrient recycling or nutrient stripping from seawater, culture them and use them for management of water quality in aquaculture.

3.1.5 *Ocean-sourced carbonate production*

- There is a shortfall in capacity to deal with the impacts of global warming and sea-level rise.
- There are gaps in our knowledge of the impacts of future rises in sea level on individual atolls; determining shoreline changes has rarely been undertaken, and long-term studies are especially lacking.
- Drastic effects from loss of sand dunes to beach mining and interruption of sediment pathways, especially as caused by coastal protection works.
- There is shortfall in capacity to deal with the impacts of acidification, which inhibit organisms from secreting carbonate shells or skeletons. Furthermore, reduction in sand-carbonate production leads to a decrease in supply to sand beaches. Relatively few studies exist of rates of carbonate production and transport of marine sand and gravel to contribute to coastal ecosystems.

3.1.6 Aesthetic, cultural, religious and spiritual ecosystem services derived from the marine environment

- It is necessary to identify the priority concerns in terms of the nature of the aesthetic, cultural, religious and spiritual ecosystem services derived from the marine environment in relation to the various geographical areas, developed and developing countries, and find out how humans have adapted for their own well-being.

3.2 Assessment of the cross-cutting issues: Food security and food safety

Food security and food safety are important activities which play a crucial role in human well-being in the provisioning services category of the ecosystem services panoply. The major activities covered are capture fisheries and aquaculture, as well as scientific and socioeconomic aspects. From the gap analyses, the capacity-building needs to address are as follows:

3.2.1 Oceans and seas as sources of food

- Covering 71 per cent of the earth's surface, the oceans offer a variety of habitats for various fisheries species which are used for various competing needs: these are both consumptive and non-consumptive but of varying socioeconomic value. To maximize benefits, to address these competing needs would require multidisciplinary research teams. Fisheries must address food security as well as recreational, cultural and spiritual aspects.
- To enhance the traditional subsistence type of fishing commonly practised in the developing world will require addressing fishing in terms of commerce and profit and thereby creating employment and supporting livelihoods. Advanced capacity-building for appropriate skills will be required to be able to use advanced technologies to create wealth from capture fisheries and mariculture in a sustainable way.

3.2.2 Capture fisheries

- Efforts have been made to create awareness to reduce post-harvest losses, especially in small-scale fisheries, as a means of increasing production. However, little is known to what extent this is implemented and to what extent it has increased production, although this would greatly improve the socioeconomic benefits to small-scale fishers. Enhanced capacity-building for appropriate research and innovative technology and its transfer would address these issues.
- Efforts have been made to reduce by-catch and increase awareness of this problem, including efforts to make by-catch excluder devices. Globally it is still poorly known whether this has been successfully achieved in terms of the relative ratio of the target catch landed and the by-catch caught and either landed or discarded. To address these issues would require building capacity to monitor and ensure compliance and promote observer programmes effectively.

- To improve the ecosystem approach to fisheries management to address not only ecological issues and governance but also socioeconomic issues for human well-being will require increased efforts to promote ecosystem-based management.
- To avoid fisheries depletion requires controlling fishing effort for stocks. For most important fisheries, historical fishing trends are unknown and their recovery rates are also poorly known, but their fisheries continue to expand into new areas. These issues can only be addressed with increased efforts to build enough capacity with appropriate technological and scientific skills to provide adequate information and data to facilitate regional and global management.
- There is insufficient capacity to address fish diseases from capture fisheries and illnesses caused by ingestion of toxic fish. Globally the phytosanitary issues are not well known, especially in developing countries.

3.2.3 *Aquaculture*

- To obtain a clear understanding of the trends and contribution of mariculture globally in terms of aquatic farming will require building capacity to address the relative ratio of freshwater aquaculture production and mariculture. Mariculture includes marine plant cultivation, which mostly consists of seaweeds.
- There is insufficient knowledge of mariculture diseases and how to combat them because they are poorly known, especially in the developing world. Filling this knowledge gap would require greater capacity in fish health in mariculture contexts.
- There is insufficient capacity to categorize mariculture for addressing food security, ornamental and decorative uses and clearly document their socioeconomic benefits.
- There is insufficient capacity to map cultivated species, where they are farmed regionally and globally, and share information and data to facilitate world production.
- To promote sustainability of mariculture will require building capacity to improve mariculture technologies that are environmentally friendly.
- There is insufficient capacity for improving industrial production of fish feed using low-value or trash fish, including by-catch that would otherwise be discarded. However, this should not compete with fish for direct human consumption or deliberate fishing that would be undesirable for biodiversity conservation.

3.2.4 *Fish stock propagation*

- There is insufficient capacity in aquaculture technologies which will promote efficient and effective stock propagation; this includes culture techniques under controlled conditions, provision of artificial habitat, feeding, fertilization, predator control and subsequent release of the aquatic organisms into the sea.
- Improved sustainability of fish stock propagation requires applying a comprehensive integrated ecosystem-based fisheries-management approach and therefore it is necessary to build capacity in terms of individuals, infrastructure and institutions that can deliver effective stock propagation.

3.2.5 *Seaweeds and other benthic food*

- Seaweed farming and aquaculture are seriously affected by disease and there is insufficient capacity to research seaweed diseases and build techniques for combating the diseases.
- To harness their wide variety of nutrients, medicinal and food values would require undertaking and building capacity for biochemical research on seaweed extracts from various species.

3.2.6 *Social and economic aspects of fisheries and other marine food*

- Certain issues, particularly at the micro level, demand additional research and therefore need capacity-building to address them. The state of small-scale fisheries throughout the world, and gender issues in fisheries, are particularly prominent and are poorly studied. A further issue that has been seriously under-researched is the relationship between capture fisheries and aquaculture.

3.3 *Assessment of other human activities and the marine environment*

The activities addressed in this section are basically centred on *in situ* use of the ocean, e.g., in shipping, ports, tourism, waste disposal and extractive uses, e.g., mining, desalination, etc. The gaps and the needed capacity-building are as follows:

3.3.1 *Shipping*

Knowledge gaps

- The IMO has emphasized the need for better information on the health and well-being of ships' crews. The death rate is unacceptably high, and little is known about causes of death, injuries and illnesses, with the result that it is difficult to formulate policies to address the problems.
- The potential development of Arctic shipping routes between the Atlantic and the Pacific highlights the inadequacy of charts of these waters: some date back to surveys in the mid-19th century. Similar shortcomings exist in Antarctic waters.
- As new anti-fouling systems for ships are developed, the resolution of the parties to the IMO Convention on the Control of Harmful Anti-fouling Systems on Ships

calling for the harmonization of test methods and performance standards for anti-fouling systems containing biocides presents a necessity to investigate and evaluate such methods and standards.

Capacity-building

- Potential shortages exist in adequately trained ships' officers and crew, and both Africa and South America are proportionally under-represented in the global pool of such officers and crew. Capacity-building to develop training institutions of high quality and to use such institutions to meet the demand is therefore desirable.
- Increased navigation in the Arctic Ocean and (in spite of the emergency response plans of the International Association of Antarctic Tour Operators) the presence of large passenger cruise ships in the Southern Ocean mean that there are gaps in adequate emergency response systems in both areas.
- In coastal areas where large numbers of very small vessels (especially with wooden hulls) operate, to ensure that the operators of such vessels have the knowledge and equipment to make them safe would require capacity-building. This could include capacity-building to ensure that maritime administrations can apply regional safety codes where they exist, or develop them where they have not yet been prepared.
- Improved port-state control is very important for ensuring the safety of shipping and the protection of the marine environment from accidents and unacceptable practices involving ships. There are gaps in the technical skills and equipment in some States for implementing effective port-state control.

3.3.2 Ports

- Because the operation of a port can significantly affect both the successful operation of ships and the economic performance of the countries it serves, some ports need capacity-building in the operational skills needed for successful port operation.
- The delivery to shore of garbage from ships is an important element of combating marine debris. Building capacity in this field for ports which do not have adequate and easily used port waste-reception facilities would improve their ability to combat marine debris.
- Many ports that need dredging to maintain or improve navigation adjoin bays, rivers or estuaries with a history of industrial discharges. Decisions on whether such material can safely be re-deposited in the sea, guided by international standards, requires the capacity to examine the dredged material relative to such standards.

3.3.3 Submarine cables and pipelines

- If coastal States wish to safely locate submarine cables and pipelines that cross areas of potential geological change and disruption, or (at least) to negotiate

successfully with commercial undertakings planning to install cables in such locations, they need access to the skills in marine geology needed.

- In taking decisions on submarine cables and pipelines, States need to have the capacities to address possible competing uses of the seabed on which the cables and pipeline are laid.

3.3.4 Coastal, riverine and atmospheric inputs from land

Shortfalls were found the skills and capacities for several important disciplines, including:

- Skills and infrastructure to monitor wastes and waste water (municipal, cruise ships and degree of treatment, industrial discharges, agricultural runoff, atmospheric emissions).
- Skills and infrastructure to treat waste and wastewater.
- Gaps in capacity to assess the environmental, social and economic aspects related to coastal, riverine and atmospheric inputs from land.
- Capacity to identify hazardous substances, which also includes ability to establish: thresholds of toxicity, persistence and bio-accumulation, a substance database with experimental data, monitoring and assessment programmes.
- Ability to monitor and assess atmospheric circulation and detect airborne inputs.

3.3.5 Offshore hydrocarbon industries

- A major capacity gap is the ability to manage environmental impact assessments and monitor compliance, mainly within (but not confined to) developing countries.

3.3.6 Other marine energy-oriented industries

The other sources of marine energy production industries are: offshore wind, waves, tides, ocean currents, marine biomass and energy from ocean thermal differences between different water layers. The capacity gaps to assess the environmental, social and economic aspects of offshore renewable energy deployment/generation are:

- Lack of information and data for full evaluation of Environmental Impact Assessments (EIAs). Data gaps are very common due to remoteness, or the level of technology not being available for long-term data and information gathering (especially for developing countries).
- Capacity in terms of enabling infrastructure to exploit these sources of energy.
- Skills or knowledge capacity lacking in most developing countries.
- High organizational capacity to foster relationships and linkages among ocean users, stakeholders and resource managers required to enable proper planning for use of these sources with minimal conflict and environmental impact.

More awareness campaigns would enhance appreciation of the fact that these renewable sources of energy, given their immense potential, can reduce use of the fossil-fuel carbon-based energy sources and reduce CO₂ emissions.

3.3.7 *Offshore mining industries*

- As in oil and gas, the major gap for this activity is the ability to undertake EIAs and monitor compliance, especially because of their remoteness; this is mainly so in developing countries.
- The offshore mining technology and management are still nascent and in mostly shallow water (<50m depth). Where such mining affects various stakeholder activities, social and economic conflicts can arise. Enhanced capacity for meaningful engagement with stakeholders will contribute to avoiding and resolving such conflicts.

3.3.8 *Solid waste disposal*

Information gaps

- Serious information gaps exist on the nature and volume of dumping. These gaps exist with regard to waters under the jurisdiction or control of both parties and non-parties to the London Convention and Protocol. The understanding of the potential effect of the dumping of solid waste on the marine environment is directly affected by these gaps.
- In areas where the possibility exists that explosives or containers of harmful substances, such as chemical weapons, have been dumped in the past, especially in areas where fishing vessels operate or where it is planned to locate submarine cables or pipelines, information on the location of such dumping must be available to the authorities, fishers, and others involved in activities in those areas.

Capacity-building

- Where States are still authorizing the dumping of solid waste, they need access to the skills and equipment needed to analyze the chemical constituents of potential hazardous waste to see whether it may be acceptable to be dumped in the sea.

3.3.9 *Marine debris*

- One of the major barriers to addressing marine debris is the absence of adequate scientific research, assessment, and monitoring. Scientific research is needed to better understand the sources, fates, and impacts of marine debris.
- Research is inadequate to qualify and evaluate the effects of plastic polymer masses that cause irritation in the stomach tissue and abdominal discomfort, and stimulate the organism to feel full and cease eating.
- Scientific evidence is insufficient to test for direct links between the chemical characteristics of marine debris and adverse effects on marine life.
- In spite of the growing number of studies documenting the distribution and abundance of marine debris, the ecological impacts, including effects on habitats, are not well documented.

- Research is insufficient to qualify and evaluate the presence of floating debris which can similarly undermine the quality of pelagic habitats; as is information on the impacts of marine debris in benthic habitats which are comparatively well studied.
- Scientific evidence and assessment efforts have not been adequate to evaluate the impacts of microplastics in the water column of the ocean.
- To date, the introduction of an alien species via marine debris has yet to be documented and there are important shortfalls in the scientific evidence of the role of marine debris in introducing alien species, especially in developing countries.
- Research, assessment, and monitoring are not sufficient to evaluate impacts of marine debris on coastal and marine species, habitats, economic health, human health and safety, and social values. Research and monitoring are insufficient to understand and in many parts of the sea, to qualify, the status and trends of marine debris. Development of new technologies and methods for detecting and removing accumulations of marine debris will also require additional research.
- The capacity to raise awareness about the problems posed by marine debris needs to be strengthened, especially in developing countries.

3.3.9 Land/sea physical alteration

- Capacity for data acquisition, especially in developing countries which suffer data-poor conditions.
- Capacity to undertake integrated assessments by multidisciplinary teams in the framework of ecosystem-based management in order to assess and understand the impacts on coastal and shoreline changes caused by a multiplicity of factors which include both anthropogenic and natural causes; capacity for modelling coastal processes, and to collect quality data based on defined standard techniques for use in developing such models.
- Due to the transboundary nature of large coastal water flows and sediment dispersal, undertaking to meet identified research needs can only be done with an improved regional capacity of individuals from various disciplines and a network of institutions.

3.3.10 Tourism and recreation

- Information is inadequate in many parts of the world on the extent of coastal tourism and its contribution to the local economy.
- Authorities concerned with the management of coastal areas where tourism is or could be occurring as an important activity need access to the skills necessary for integrated coastal management.

3.3.11 Desalinization

- Many areas suffering from shortages of freshwater could be helped by the creation of installations for desalinization and the skills needed to maintain and manage them. This is likely to become increasingly important with changes in rainfall as a result of climate change.

3.3.12 Use of marine genetic resources

- Marine biodiversity is best known in areas within national jurisdiction, and it is least known in the vast offshore oceanic areas beyond national jurisdiction.
- Biotechnology of marine biodiversity for commercial products is similarly at its infancy at the global level, and it is almost non-existent in developing countries.
- If marine genetic resources are to be explored and where appropriate developed, there are currently insufficient analytical technologies, especially for developing countries.
- There is current insufficient knowledge and skills to ensure application of environmentally friendly harvesting techniques in poorly known habitats and vulnerable marine ecosystems, such as cold water coral and sponge systems or hydrothermal vents; any exploitation in such areas requires a precautionary approach.
- There is inadequate capacity to study and collect marine genetic resources: this will require suitable vessels, both for deep sea and shallower waters, and appropriate research laboratories; the absence of this spectrum of needed resources is usually an important constraint in developing countries.

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