Annex V: Supra-regional Summaries

Shipping

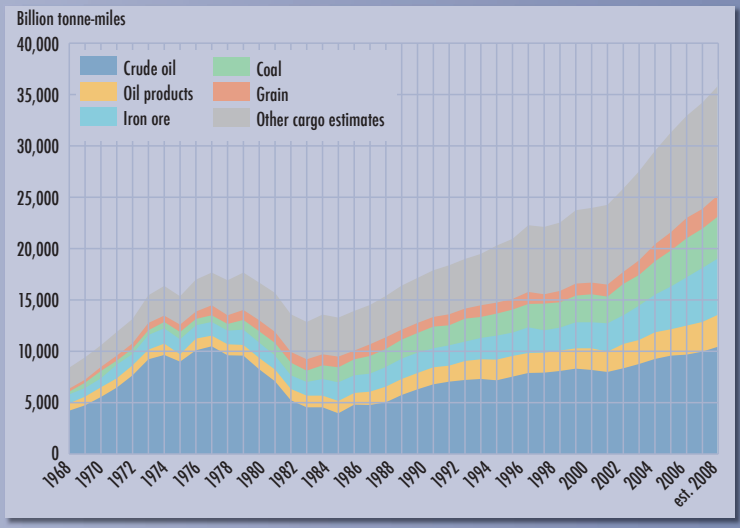
Jacqueline McGlade and Alan Simcock

1. INTRODUCTION

Whilst no firm estimate exists of the proportion of world trade carried by sea, the International Maritime Organization (IMO) puts the proportion at well over 90 per cent[1]. Passenger transport, via short-haul ferries and cruises, is also a substantial and conspicuous part of growing world tourism. World seaborne trade is estimated to have risen from around 15 000 billion tonne/miles in 1988 to some 35 000 billion tonne/miles in 2008, an increase of around 80 per cent in 16 years (see Figure 1). The carriage of oil and petroleum products accounted for a significant part of this increase, rising by over 70 per cent, from 6 500 billion tonne/miles in 1988 to 11 200 billion tonne/miles in 2004. Shipping is clearly an international industry.

A number of environmental challenges arise from this growth in trade. For example, some of the biggest passenger ships consume 200 000 litres of fuel per day, the equivalent of a small city, whilst ocean-going ships account

Figure 1: **World Seaborne Trade: 1968–2008**



Source: Fearnley's Review 2009

1 Speech by Secretary-General, International Maritime Organization, Goa, 5 February 2008

for roughly 10 to 20 % of global oil consumption and 4.5% of global greenhouse gas releases. Emissions are expected to grow by 32% by 2020.

2. INSTITUTIONS INVOLVED IN ASSESSMENTS

To date there has been no comprehensive global assessment of the impacts of shipping on the marine environment. However, there are a number of assessments from different institutional settings which focus on specific aspects such as oil spills, marine acoustics and ballast water.

The assessment of safety and environmental impacts of shipping involves many institutions, including agencies and programmes of the United Nations (UN), such as the UN Convention on the Law of the Sea (UNCLOS), the IMO, the International Labour Organization (ILO), the World Trade Organization, vessel owners, naval fleets, maritime transportation systems, shipyards, brokers, insurers, port authorities, national agencies, research institutes, university departments, industry associations, non-governmental organizations (NGOs) and professional bodies.

The IMO provides an overarching and effective international regulatory framework for international shipping. Its adoption and entry into force, for example, coincided with the biggest single decade-to-decade reduction in oil spills. A recent overview of the relationship between the oceans and shipping has been provided by the IMO Secretary-General[2]. This document describes how the various impacts of shipping have been brought under global controls through the IMO, and shows that the trends for certain environmental impact have been downwards, despite the overall growth in shipping over the past 40 years. The International Convention for the Prevention of Pollution from Ships (MARPOL 1973/78) is the fundamental tool for controlling the adverse impact of shipping through pollution, both catastrophic and chronic.

A number of organizations are involved in producing assessments also on specific issues. For example on:

a. The release of alien invasive species (AIS) from ballast water and hull-fouling. The Global Ballast Water Management Programme (GloBallast) executed by the IMO includes risk assessment of ballast water in 13 pilot sites around the world (http://globallast.imo.org/). The Invasive Species Specialist Group of the International Union for

2 "Shipping's environmental credentials – Where to focus our attention now", Articles by the Secretary-General of the International Maritime Organization, Lloyd's List of 25th and 26th of January 2007.

Conservation of Nature (IUCN) Species Survival Commission also regularly reviews the marine environment;

b. Air emissions. These are covered under various legal frameworks, resolutions and co-operation mechanisms including MARPOL Annex VI, the IMO Assembly Resolution and the UN Framework Convention on Climate Change (UNFCCC);
c. Oil spills from maritime shipping. These are covered by various national and regional bodies which feed in at the supra-regional level under MARPOL 1973/1978;
d. The impacts of climate change. Various assessments have been undertaken by the International Panel on Climate Change (IPCC), the Protection of Arctic Environment Working Group of the Arctic Council (AC) and more recently by the European Commission (EU) in anticipation of the potential incorporation of maritime shipping into the EU- Emissions Trading Scheme.

3. DATA

Over the past two centuries there has been a large amount of activity on data capture, analysis and information provision to support the shipping industry. Two of the better known commercial sources of information are the Lloyd's List and Fearnley. There are a substantial number of specialist services also for the various sub-sectors. Shipping and maritime transport also has become a significant academic subject, with a specialist global university, the World Maritime University, a member of the UN family, devoted to it.

Several data sources on marine AIS exist and are described in the Marine Biodiversity and Invasive species supra-regional summaries of the AoA (see Annex V). For example, under the International Convention for the Control and Management of Ships' Ballast Water and Sediments, regional authorities and other responsible organizations are required to monitor the effects of ballast water management on marine waters under their jurisdiction.

Since 1968, the UN Conference on Trade and Development has produced an annual review of maritime transport. This provides a comprehensive picture of international shipping, with supporting statistics and a special chapter focussing on an area or theme; for example, Small Island Developing States. This series gives an unrivalled view of the economic and some of the social aspects of shipping. More recently, the IMO has established the Global Integrated Shipping Information System (GISIS), which makes information available electronically on issues such as

maritime security, port reception facilities, greenhouse gas emissions, the ship-condition assessment scheme, maritime casualties and incidents and pollution-prevention equipment. As a result, today there is a large body of high quality information and analysis to refer to when assessing the socio-economic benefits and impacts of shipping on the world's oceans.

4. ASSESSMENTS

Given the significant proportion of shipping that is inter-continental, the impacts of shipping on the marine environment need to be assessed at the supra-regional level. This is recognised in UNCLOS which provides for detailed regulation of shipping at a global level to be carried out by the IMO, except where agreement has been reached on local regulation such as for "particularly sensitive sea areas" or the regional ballast-water management strategies under the International Convention for the Control and Management of Ships' Ballast Water and Sediments.

To date, assessments of the relationships between the world's oceans and shipping have been largely focussed on particular regions or on particular themes. Examples include the impact of shipping in the Oslo/Paris Convention for the Protection of the Marine Environment of the North East Atlantic (OSPAR) Quality Status Report on the North East Atlantic, assessments of oil spills by the Bonn Agreement, the international agreement between north-western European States for cooperation in this field in the North Sea, English Channel and the Celtic Seas, and the International Maritime Bureau's assessment of the worldwide risks of piracy. In some regions there have been in-depth studies of the environmental impacts of major oil spills such as the *Exxon-Valdez* in Alaska, the *Braer* in Scotland, the *Sea Empress* in Wales, the *Amoco Cadiz* in France and the *Prestige* in Spain. The International Convention on Oil Pollution Preparedness, Response and Cooperation, and its Protocol on similar issues relating to hazardous substances, has given rise to assessments at a national level on the risks from shipping disasters. Assessments such as these will need to be further streamlined, integrated and, where needed, co-ordinated if they are to contribute to a global assessment of the marine environment.

The economic and social importance of seaborne trade has also led to an increase in assessments of the future to help shape infrastructure and commercial developments. This has largely been done by consultants working for the shipping and port industries. In most regions, there are assessments of likely future growth of bulk trades in both hydrocarbons and

chemicals, and of container traffic. These provide an important basis on which to plan the future development of ports and extensions to maritime traffic regulation schemes to reduce the risks of collisions.

A recent and very important regional assessment has been produced by the AC's Protection of Arctic Marine Environment Working Group on future scenarios for Arctic marine shipping (Brigham 2008). The four scenarios, known as Arctic Race, Arctic Saga, Polar Lows and Polar Preserve, are built around anticipated impacts and uncertainties of climate change on shipping routes and coastal infrastructure and are likely to have significant yet differentiated impacts on the environment. It describes how the Arctic states are challenged by an overall lack of maritime infrastructure to adequately support current and future levels of Arctic marine operations, including ports, communications, environmental monitoring, search and rescue, incident response, aids to navigation and coastal charting. The assessment demonstrates that there will need to be a drastic improvement in the system of rules and regulations governing Arctic navigation to enhance marine safety and ensure marine environmental protection throughout the Arctic basin.

5. PRIORITIZING ISSUES

The impacts of pollution from shipping on the marine environment can be both catastrophic and chronic and even low impact pollution does not mean no impact. The effects of catastrophic pollution, resulting from ships breaking up, being wrecked or colliding, have dropped noticeably. The average annual number of oil spills involving over 700 tonnes of oil has shrunk from over 25 in the 1970s to just 3.7 in this decade according to data collected by the Independent Tanker-Owners Pollution Federation (ITOPF), which provides specialist assistance in combating such spills.

Chronic oil pollution i.e. pollution resulting from discharges in the course of normal ships' operations, is more difficult to assess. Over time, the number and area of MARPOL "special areas" have increased. In these, the international rules and standards set levels of discharge of oil which mean that, in effect, any discharge of oil visible on the surface of the water is prohibited. Together with port-state inspections to enforce the precautionary measures of MARPOL, this has had some effect. Assessments based on aerial surveillance for the waters covered by the Bonn Agreement, which include some of the most heavily trafficked by shipping in the world covering the approaches to all the major northern European ports, show a significant

reduction over time in the number of oil slicks observed[3]. Nevertheless, parallel work in the same waters by the OSPAR Commission has shown that the number of sea-birds being killed by oil in areas near shipping routes is still around 10%, compared to 2% in northern European waters away from major shipping routes (OSPAR 2006).

Atmospheric pollution from ships leads to direct and indirect environmental impacts. Direct impacts are caused by exhaust emissions entering the oceans via the atmosphere. Indirect impacts come from the contribution of ship exhaust emissions to depletion of the ozone layer and the formation of greenhouse gases. Regulation of exhaust emissions was brought under a MARPOL regime in 1997, the extension taking effect in 2005. Previous research had shown that a significant share of ship emissions occurring along coastlines travelled inland over much longer distances than previously realized. A comprehensive review of the new regime, taking into account the experience gained in its implementation, as well as improvements in engine and fuel technology, is currently underway in the IMO. A provisional commentary on the legal regimes to limit the exhaust emissions from ships suggests that the initiatives being undertaken by the IMO regarding nitrogen oxide (NO_x) and sulphur oxide (SO_x), may lead to a separate convention.

The pattern of using evidence from one area leading to a global agreement on controls over shipping, followed by studies of the implementation of this agreement has been widely repeated. For example it has been used to prioritize and respond to:

a. Dumping: the London Convention 1972 established a regime for the control of dumping at sea from ships, which was enhanced by the 1996 Protocol to the Convention. Regular reports are made by all Contracting Parties, and the implementation and effectiveness of the regimes can be assessed from these;
b. Anti-fouling treatments: the International Convention on the Control of Harmful Anti-fouling Systems on Ships 2001 requires the cessation of the use of certain harmful anti-fouling treatments on ships' hulls. The most significant is tributyl tin, which has produced severe endocrine effects on some shellfish, leading to local extinctions;
c. Ballast water: International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004 establishes regional management regimes for ballast water and sediments. This is leading to

3 Bonn Agreement Annual Reports on Aerial Surveillance (www.bonnagreement.org).

regional assessments of the problems (particularly the introduction of AIS) caused by ballast water and sediments in ships' tanks.

6. CONCLUSION

In conclusion, there can be no doubt that shipping constitutes a major supra-regional issue which needs to be considered in a global marine assessment. A significant amount of economic, social and environmental information is available and collected through a range of institutional processes and organizations, covering international, coastal and cruise shipping. Globally, there are long-standing assessments of the economic aspects of international shipping and there are a range of assessments for specific regions or specific themes which are likely to continue in the future and which could form a basis for the regular process. The substantial amount of commercially-based assessments of the economic aspects is also very likely to continue. To date, many of the relevant organizations and institutions are loosely associated through various international conventions and informal and formal working arrangements. What is largely lacking is a consistent picture of the environmental impacts of shipping and a framework in which to integrate all the material into a global assessment.

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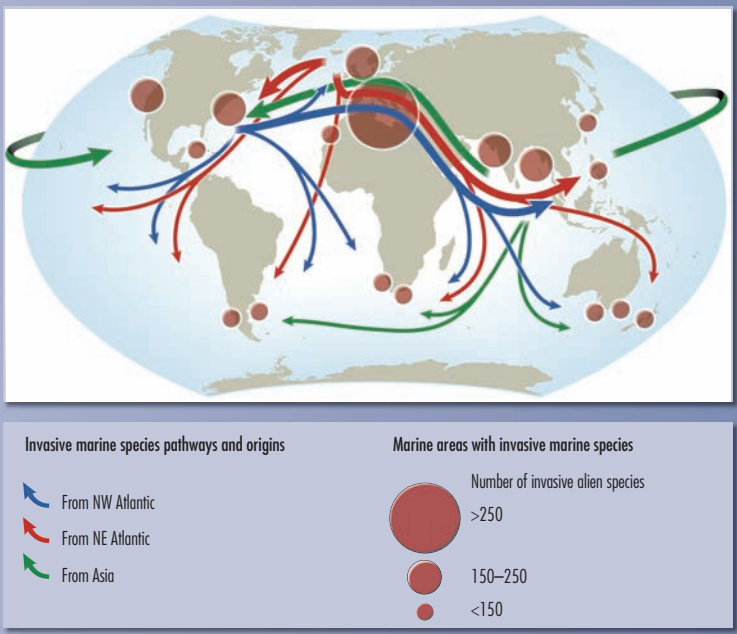
Alien Invasive Species

Jacqueline Alder and Rolph Payet

1. INTRODUCTION

The threat of marine invasive species to the health of the oceans is often not given the appropriate importance despite its long-lasting and often irreversible effects. Cases of marine invasions have continued to grow across the world oceans. Main pathways for the introduction of marine invasive species include ballast water and hull-fouling from increasing maritime traffic, introduction through aquaculture, aquarium fish trade, marine debris, and climate change as certain species migrate across latitudes due to changes in global climate. According to a study by the Nature Conservancy, at least 84 per cent of the world's seas have been impacted by invasive marine species. Figure 1 shows the major pathways and origins of invasive species infestations.

Figure 1: **Major pathways and origins of invasive species infestations in the marine environment**



Source: UNEP/GRID-Arendal 2008

Information on marine invasive species is also provided in the Marine Biodiversity supra-regional summary of the Assessment of Assessments (AoA) (see Annex V).

2. DATA

Several data sources on marine invasive species exist including:

a. The Global Invasive Species Database which is hosted by the Invasive Species Specialist Group (ISSG) of the International Union for Conservation of Nature (IUCN) Species Survival Commission. This database provides information on the taxonomy of invasive plant and animal species as well as a very broad description of where the species is a problem. For some species, information on their impact on ecosystems and human well-being is included. The ISSG has not used the database to undertake an assessment. (http://www.issg.org/database/welcome/);
b. The Global Invasive Species Information Network (GISIN) which was formed to provide a platform for sharing invasive species information at a global level. GISIN does not provide information directly, but connects data providers with users through its list of Alien Invasive Species (AIS), an online information service. A needs assessment survey was conducted to identify the information requirements of a range of the network users accessing taxonomic data exchange services. The information which can be provided by people using the network covers the spatial/temporal, species descriptions/profiles and checklist information aspects of the invasive species. This same information is required by users of the GISIN. While this assessment provides limited information for the AoA, the scope and nature of the data required by users does inform the Global Marine Assessment of potential indicators. (http://www.gisinetwork.org/).

There are other databases which either provide publications on invasive species or have links to other Alien Invasive Species (AIS) sites. These include:

a. The Global Restoration Network which links to other sites and publications including marine plants and animals. (http://www.globalrestorationnetwork.org/database/cipm-database/);
b. The Invasive Species Resource Library which is sponsored by the United States of America Department of Agriculture and links to other databases and publications on invasive species including marine. (http://www.invasivespeciesinfo.gov/resources/intldb.shtml);

c. The Non-Indigenous Species Network which provides a list of invasive species found primarily in the USA and in Australia with an emphasis on marine and aquatic species. (http://www.nisbase.org/nisbase/index.jsp);
d. The North European and Baltic Sea Network on Invasive Alien Species which has links to other studies and databases on invasive species, including marine species, in Europe. (http://www.nobanis.org/DBCatalogue.asp).

Under the International Convention for the Control and Management of Ships' Ballast Water and Sediments, regional authorities and other responsible organizations are required to monitor the effects of ballast water management on marine waters under their jurisdiction. This process could contribute data for assessment of marine invasive species.

3. ASSESSMENTS

Several global assessments have been undertaken to evaluate the impact of invasive species on the marine environment.

3.1 GloBallast

The Global Ballast Water Management Programme (GloBallast) is a Global Environment Facility (GEF) project executed by the International Maritime Organization (IMO). It includes risk assessment of ballast water in 13 pilot sites around the world. The project, currently in its second phase (ending 2012), is aimed at reducing the risk of invasive species and strengthening measures to reduce any risk in the long-term. The current programme expands beyond the initial six pilot sites where assessments have been carried out on a suite of invasive species in an effort to establish a baseline to measure the effectiveness of the programme. Publications and databases have been developed on the six pilot sites, and will be expanded as information on the other seven sites is analyzed. (http://globallast.imo.org/).

3.2 Nature Conservancy Global Review of Marine Invasive Species

This is the only study which can be considered an assessment for the purposes of the AoA. This assessment is based on a global database of 330 marine invasive species identified through a literature review and geo-referenced. The literature was used to populate the database and to derive a threat scoring system. It was also used to identify the most likely pathways for 330 invasive species and other species to enter ecosystems,

primarily through ship ballast and aquaculture. The analysis is presented by eco-region and uses Geographic Information System (GIS). (http://conserveonline.org/workspaces/global.invasive.assessment).

3.3 Global Invasive Species Programme

The Global Invasive Species Programme (GISP) is an international partnership addressing the threat of invasive species globally (http://www.gisp.org/). It provides support to the implementation of Article 8(h) of the Convention on Biological Diversity (CBD). There have been a number of regional reviews containing country overviews and a few in-depth country reviews which are highly variable. However, they generally include lists of species and their profiles in the country, including ecosystem, economic and human well-being impacts, work on managing invasive species and their management capacity as well as their priorities in building capacity and managing threats. Many of the reviews and overviews, which are primarily on terrestrial species, acknowledge that marine invasive species may be present but the capacity to assess the problem is lacking. The GISP is about to launch its In-depth Review of Invasive Alien Species report, for the Convention on Biological Diversity (CBD) COP 9. It was not available for downloading from the GISP website, but one of the COP 9 documents provides a summary of the sections relevant to the AoA. It states: "*Section II contains an overview of the status and trend of invasive alien species, including an overview of the ongoing work to protect biodiversity from alien species invasions. Section III reviews the implementation of the decisions of the Conference of the Parties related to invasive alien species*" (CBD 2008) – In-Depth Review of Ongoing Work on Alien Species that Threaten Ecosystems, Habitats or Species UNEP/CBD/COP/9/11. Montreal: CBD. 17 pp).

3.4 UNEP/Global Resource Information Database

GRID-Arendal, a collaborating centre of UNEP, has documented and produced global maps of major pathways of invasive species in the publication In Dead Water, available for download from: http://maps.grida.no/go/graphic/major-pathways-and-origins-of-invasive-species-infestations-in-the-marine-environment. The report, however, is not an assessment of invasive alien species.

4. PRIORITIZED ISSUES

An International Union for Conservation of Nature (IUCN) publication (Meliane and Hewitt 2005) discusses the gaps and priorities in addressing marine invasive species. Among the urgent priorities to be addressed are strengthening capacity in traditional taxonomy and marine species identification, adopting the ecosystem approach, applying rapid scientific risk assessment methodologies, introducing early warning detection and monitoring systems, understanding invasion patterns and evaluating the interactions with climate and other global change processes. The impacts of climate change on the global oceans will have effects on the establishment of invasive species (Biodiversity supra-regional summary). The Millennium Ecosystem Assessment (MA) concluded that the impact of invasive species on coastal ecosystems is high and increasing and on island ecosystems it is very high and increasing.

5. CAPACITY OF INSTITUTIONS TO UNDERTAKE MARINE INVASIVE SPECIES ASSESSMENT

There are few global assessments of marine invasive species since the capacity to undertake such a study is limited in most countries. However, efforts are underway to build capacity, including capacity to manage the threats resulting from the introduction of invasive species in marine systems through best practices, shipping protocols and maritime regulations.

REFERENCES

UNEP/GRID-Arendal (2008). *Major pathways and origins of invasive species infestations in the marine environment*, UNEP/GRID-Arendal Maps and Graphics Library, http://maps.grida.no/go/graphic/major-pathways-and-origins-of-invasive-species-infestations-in-the-marine-environment> (Accessed 24 March 2009)

Meliane, I. and Hewett, C. (2005). *Gaps and Priorities in Addressing Marine Invasive Species*. IUCN Information Document, IUCN, Gland, Switzerland, 9 pp (http://cmsdata.iucn.org/downloads/ais_gaps_priorities.pdf)

Fisheries and Aquaculture

Jake Rice, Andrew Rosenberg, Jacqueline Alder

This report provides a broad overview of the status of assessments and data regarding the world's fisheries resources and aquaculture.

1. INSTITUTIONS UNDERTAKING ASSESSMENTS

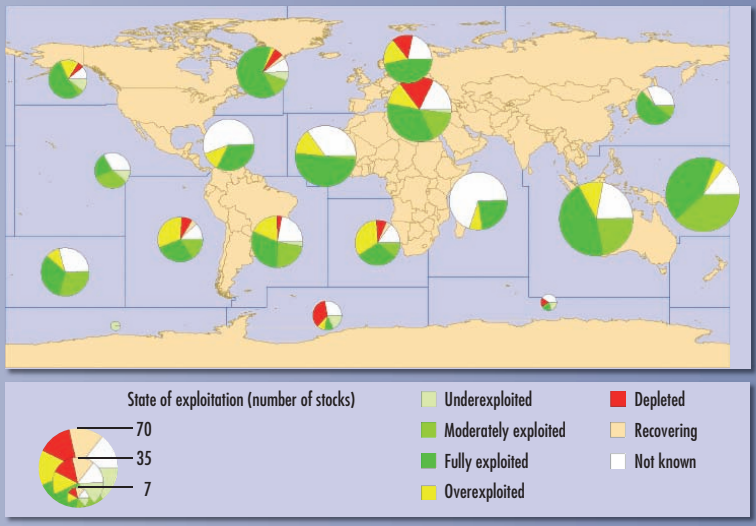
At the global scale, the Food and Agriculture Organization (FAO) State of World Fisheries and Aquaculture (SOFIA) (FAO 2009) report provides a regular global assessment of fishery resources every two years. More detailed assessments which include reference points and stock and fishery status determinations are made by the Regional Fisheries Management Organizations (RFMOs). The availability of financial and human resources determines the frequency of assessments and the number of fish stocks and species assessed. Rarely is a comprehensive, ecosystem wide assessment conducted even by well-resourced RFMOs such as those in the North Atlantic through organizations such as the North West Atlantic Fisheries Organization (NAFO) and the North East Atlantic Fisheries Commission (NEAFC). The International Whaling Commission (IWC) also holds data and performs assessments on whale populations on a regular basis. Scientific organizations such as the International Council for Exploration of the Sea (ICES) conduct a broad array of fishery assessments on behalf of the European Union (EU) and other clients and as part of their regular work programme. Although the assessments from ICES and the regional organizations are not specifically integrated in the FAO SOFIA report, together they provide a strong basis for assessing living marine resources in a Regular Process.

2. DATA

2.1 FAO: Global statistics – catch, trade, consumption, vessels, and fishers

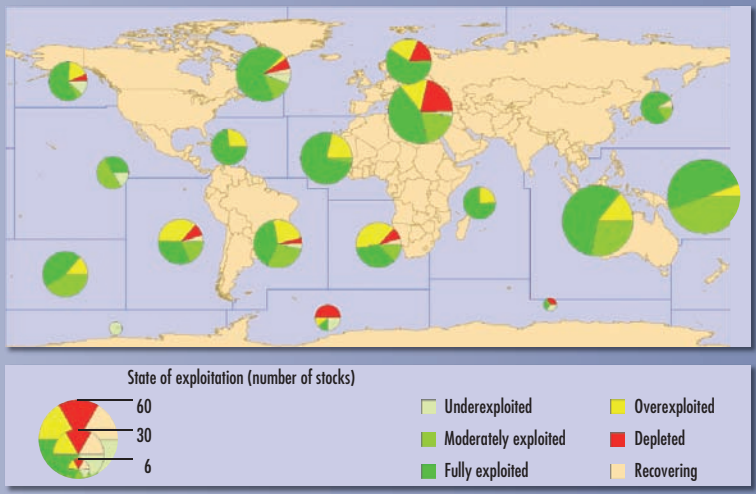
Every two years FAO reports on the global state of fisheries and aquaculture in the SOFIA report. Periodically FAO also produces a more detailed review of the state of world aquaculture, with the last one published in 2006 (FAO 2006) and a more detailed review of the state of world marine fishery resources, the last one in 2005 (FAO 2005), which provides a more detailed assessment of the state of exploited marine fish stocks by major FAO fishing areas (Figures 1a & 1b) and a section on special topics

Figure 1a: **State of exploitation of selected stock or species groups by major marine fishing areas**



Source: FAO 2005

Figure 1b: **State of exploitation of selected stock or species groups for which assessment information is available by major marine fishing areas**



Source: FAO 2005

including tunas, world squid resources, deepwater fisheries and fisheries and long-term climate variability. These regular reviews of the state of the world's marine fisheries and fishery resources are based mainly on official catch statistics derived from FISHSTAT, which is a database of national fisheries and aquaculture information managed by the FAO, and from relevant stock assessment and other complementary information available to FAO. It covers marine, brackish and freshwater environments. SOFIA consistently reports on a core set of variables including landings, production, value, imports, exports, utilization, fishers and fleet statistics as well as the state of fishery resources, supplemented by specific topics which are current or which address a specific issue for that year. The most recent report – SOFIA 2008 – was published in 2009 (FAO 2009) and is available on the FAO website (http://www.fao.org/fishery/sofia/en).

The information used in SOFIA is based primarily on inputs from national fishery reporting systems, augmented by reports from RFMOs. These reports are not consistent in terms of reporting detail and differ considerably in quality and accuracy across countries (FAO 2008a). FAO carries out checks for internal consistency, species identification or anomalous trends and cross-checks with other data such as fleet statistics and international shipping registers where available (FAO 2008a). FAO works with countries to clarify questionable data and to improve reporting. For example, China and Indonesia are working with FAO to improve the quality and reliability of their fishery statistics and to incorporate new information where possible (FAO 2008a). If the information for a particular country or species is not available or no support is given from a country to verify statistics, FAO applies an estimate unilaterally.

The FAO data are far from perfect, and some key statistics such as fishing capacity at the global level are not current. Despite these limitations, FAO considers that general trends are probably reliably reflected by the available data, but that annual statistics and assessments have some degree of uncertainty. It also considers that small changes from year to year are probably not significant (FAO 2008a).

2.2 Fisheries and aquaculture data for stocks within national jurisdictions

States with well-resourced fisheries management agencies generally devote significant resources to the collection and quality assurance of fisheries data on catches, effort, fishing locality and other parameters. Collection of

information on species and sizes of fish not targeted by specific fisheries, whether landed as retained by-catch or discarded has traditionally been poorer, but is improving in many jurisdictions. Recent legislation and policies in the USA, EU and a number of other developed states have attempted to address inaccuracies and gaps in data collection systems including the EU Data Recording Policy and US Magnuson-Stevens Act 2007 reauthorization. This positive trend is augmented by increasing use of observers or automated observing systems on vessels to ensure accuracy of catch data. In the best cases, these observing systems record and report on by-catch and discarded catch as well as commercially targeted species. While such comprehensive catch recording systems are being used increasingly, they remain the exception, not the rule (http://www.fao.org/fishery/topic/14772).

On the other hand, many developing countries lack the resources required for extensive, and sometimes even basic fishery data collection. International development agencies have cooperated in capacity building with FAO and many states (http://www.fao.org/fishery/fishcode-stf/4,5), but progress has been uneven. In some cases it has not been possible to maintain even partial infrastructures (Bhathal 2005, FAO 2008a).

Even where some capacity exists for the collection of commercial fisheries statistics, many countries do not collect, or at best intermittently collect statistics for artisanal and small-scale inshore fisheries, fishers and vessels. For example, recent studies in the US territories in the Western Pacific have shown these local fisheries to be significantly under-reported, with some islands under-reporting by as much as 500 per cent (Zeller and others 2005). Even in the most developed countries, monitoring and data reporting systems are often not as developed for small vessels and coastal and recreational fisheries as for larger vessels, particularly when observer systems are relied on as a core part of data quality assurance (http://www.qc.dfo-mpo.gc.ca/peches/en/surveillance/programme.htm). A similar problem exists in aquaculture where small-scale production often is not recorded in national statistics.

2.3 Fisheries data from RFMOs and Regional Fisheries Bodies

FISHSTAT data for reviewing the state of straddling, shared or high seas fish stocks are generally obtained from RFMOs and Regional Fisheries Bodies (RFBs), whose records, in turn, are usually derived from scientific studies and

from national reports which sometimes include discards and estimates of illegal, unreported and unregulated (IUU). The organizations also collect, compile and disseminate statistics in various ways. Well-established RFMOs such as those in the North Atlantic and Antarctic regions are well-resourced to collect, analyse and manage the data provided by RFMO systems and/or Member states, as are the RFMOs for tunas and large pelagics (e.g., http://www.iccat.int). The RFMOs, however, are still generally dependent on the cooperation of Member states to ensure reliable data are provided, although some national reports are sporadic and often incomplete (Kelleher 2005). Additionally, RFMOs are absent, or in development for many parts of the high seas and IUU fishing is not effectively controlled still in many areas. These governance limitations leave additional gaps in the data on highly migratory, straddling and high seas fish stocks.

Where RFMOs do exist, traditional data collection protocols differ greatly in their requirements to report discards, non-target and protected species and other associated data. RFMOs are working closely with FAO to harmonize the collection of fishery statistics and resolve discrepancies as well as encourage the use of a central, linked database for these data (FAO 2007). A concern is distinguishing Exclusive Economic Zone (EEZ) catches from those from the high seas to better reflect management responsibilities. Another concern is obtaining greater consistency in recording fishing effort and catch composition, including more complete species identification.

Since 2006, RFMO reform has been a major initiative in international fisheries policy, with the collection and management of reliable data as one of the featured goals. However, the extent of the success of this initiative is still unknown. NEAFC was the first organization to pilot a performance review, which was published in late 2006 and included examining data quality and timeliness issues. The review panel made several recommendations regarding gaps, quality, spatial resolution and coordination (NEAFC 2006).

3. FISHERIES ASSESSMENTS

3.1 Global fisheries

SOFIA reviews of the status of fish stocks consist of a category classification of the exploitation level of stocks centred on under-exploited, fully-exploited, over-exploited or crashed. They are based on national reports, RFMOs, the scientific literature, industry reports and the judgment of FAO experts (FAO 2008a). As these evaluations necessarily focus on

stocks which are relatively well-monitored, they might not include smaller stocks or those which support local or small-scale fisheries, lower trophic level marine species/groups or important habitats. FAO is working with many countries to improve this situation, but it is a slow process (FAO 2008a).

3.2 Sub-global assessments

States and RFMOs vary greatly in their capacity to assess the status and trends of fish stocks and fisheries within their jurisdictions. As a generalization, assessment capacity varies in similar ways as capacity to collect and manage reliable fisheries data. Capacity for assessment is generally high in the North Atlantic and North Pacific Oceans, but in the low latitudes and southern hemisphere it is variable with good capacity in the tuna commissions and in the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) region which includes Australia, New Zealand and South Africa. Where assessment capacity is high, states or intergovernmental organizations (IGOs) such as ICES have well-developed infrastructure for periodic assessments of exploited fish stocks and has structured into the assessment process quality assurance mechanisms and protection of the independence of the assessment from management and policy. Most jurisdictions with significant investments in fisheries assessments are making increased use of risk assessment approaches in their work.

Elsewhere, assessment capacity is uneven and often inadequate, although it can be very good locally for commercially important stocks, for example in Namibia, Morocco and Peru. As with the collection of fisheries statistics, the capacity for assessment of artisanal and small-scale fisheries is particularly weak. Priority is being given to the development of assessment methods appropriate for states and regions with limited capacity (Caddy and Mahon 1995, FMSP 2005). While progress is being made, it is slow compared to the scale of the problem.

Recently ICES began to assess and advise on some fish stocks in the deep seas of the North Atlantic (http://www.ices.dk/iceswork/wgdetailacfm.asp?wg=WGDEEP). New Zealand and Australia have undertaken a few similar assessments in the deep seas in the South West Pacific Ocean and the adjacent Indian Ocean (http://www.fao.org/docrep/010/a1341e/a1341e00.htm). However, these assessments are few compared to the scale of the fisheries on the high seas.

Fisheries assessments have expanded beyond assessing the status of the targeted stocks. Implementing ecosystem approaches to fishery management requires assessing the impacts of the fishery on the structure and function of the ecosystem in which the fishery is conducted. This creates the need for a wide spectrum of information, including data on fishing methods and equipment, by-catch and discards as well as the habitats and marine communities in the exploited ecosystem. The human dimension of the ecosystem approach also requires reliable data on fishing fleets and socio-economic parameters.

Even the most developed countries are in the early stages only of undertaking such assessments. For example, the ICES Working Group on Ecosystem Effects of Fishing has been exploring appropriate approaches for assessing the ecosystem effects of fishing for almost 20 years, but their recommendations could be implemented by only those countries and RFMOs with extensive fisheries and research data holdings as well as significant assessment capacity (http://www.ices.dk/iceswork/wgdetailace.asp?wg=WGECO).

Some efforts to assess trends and impacts of aquaculture were carried out under the UNEP Global Programme of Action for the Protection of the Marine Environment from Land-Based Activities (GPA), which is an intergovernmental programme that addresses the inter-linkages between freshwater and the coastal environment. A few specific assessments of aquaculture have been conducted by the World Bank, Network of Aquaculture Centres in Asia-Pacific (NACA), The World Wildlife Fund (WWF) and the FAO Consortium. The 2004 Consortium synthesis report on Shrimp Farming and the Environment provides details of the activities and outcomes of work conducted under the World Bank, NACA, WWF and FAO Consortium program on Shrimp Farming and the Environment. Another example in this regard is the Capture-based aquaculture – global review which is a FAO technical paper containing two reviews on environmental/biodiversity and on social/economic impacts of capture-based aquaculture as well as 11 species review papers.

Several initiatives are underway to develop and formally test at various regional and national scales the performance of various approaches, including indicator-based evaluations of the ecosystem impacts of fisheries. Although substantial progress is being made (Cury and Christensen 2005, http://www.ieep.eu/projectminisites/indeco/index.php), there is not a scientific consensus yet on the best approaches. However, some indicators

such as the Marine Trophic Index (Pauly and Watson 2005), resilience indicators (Planque and others, in press) and a variety of size-based indicators (Bianchi and others 2000, Shin and others 2005, Pope and others 2006) may be informative about the impacts of fisheries on marine food webs and fish communities. It might be possible to estimate a number of these indicators from the most basic fisheries data. Prospects for indicators which reliably assess habitat impacts of fisheries are less optimistic, at least in the short-term (Rice 2005).

4. AQUACULTURE ASSESSMENTS

The State of Aquaculture (FAO 2006) is the most recent global assessment of aquaculture, including mariculture. The report provides an overview of production, value, diversity of species cultured in various environments, markets, trade and food security. It provides detailed analyses of resource use, environmental issues and the social benefits of aquaculture for the poor and for small-scale producers. Trends and emerging issues are also discussed. However, the report does not provide any criteria or indicators to measure the positive and negative impacts of aquaculture. Other than the State of Aquaculture report, no broad regional assessments were found. At the national level, many assessments are available of the potential for developing an aquaculture industry and of particular farmed species in specific locations. Current initiatives for developing certification schemes for aquaculture (FAO 2008b) may provide a framework for assessing this industry.

5. GAPS

The most significant gaps in fisheries data are found in small-scale and artisanal fisheries, in areas beyond national jurisdiction and where effective RFMOs are not in place. However, data gaps and/or inaccuracies are widespread globally when considered alongside the magnitude of the world's fisheries. Additional resources are needed to improve FAO's capacity to collect and analyse fishery statistics and to work with countries to improve their reporting.

Fishery assessment methodology is well-developed, but many methods depend on extensive data on catch, fishing effort, biological data, fish population dynamics, stock abundance and other information. These data are available primarily for high-value fisheries in developed countries, but even in these countries there is limited knowledge about many minor

stocks. In general, data availability for small-scale fisheries is more limited and consequently assessments are weaker and less frequent. While there has been substantial scientific work on the development of assessment techniques in data-poor situations, these methods are not as widely applied as they could be. Overall, fisheries data assessment coverage and capacity is very uneven globally. The problem of uneven or unavailable data is even greater for other components of fishery ecosystems, including in areas such as by-catch and discarded fish species and habitats as well as for other groups such as seabirds, mammals and reptiles which may be impacted by fisheries. While there are extensive efforts to acquire this information in some areas, data may be scant or absent in many others.

Social and economic assessments of fisheries and fishing-dependent communities are a major gap also in the global capacity for assessing the marine environment. The studies that do exist tend to be individual exercises in response to a crisis such as the cod collapse in the Canadian Atlantic as opposed to long-term monitoring programmes with well-established databases which inform fisheries policy. This is true also in well-developed fisheries for high-value species.

In the aquaculture sector, assessment methodologies are continuing to evolve, especially for social and economic assessment. There are considerable data gaps in the species, production and geographic areas of farming which is making it difficult to assess the scale and scope of the impacts, especially for introduced species.

6. CAPACITY OF INSTITUTIONS TO UNDERTAKE FISHERIES ASSESSMENTS

Collectively, FAO and RFMOs have the infrastructure and mandate to assess fisheries and aquaculture within a global marine assessment context. However, a considerable increase in resources to improve reporting and the collation and dissemination of data is needed in many countries as well as in regional fisheries organizations.

While the methodology for fisheries assessment is well-developed, the human and financial capacity to carry out these assessments remains very limited. For aquaculture, there is no clear methodology for assessment and until there is some agreement on approaches, the capacity question might be premature.

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Climate Change: Warming, Ocean Circulation, Sea Level Rise, Acidification Assessments

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1. INTRODUCTION

The information included here has been drawn from the synthesis and summary of the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) Working Group I Report "The Physical Science Basis", as well as from recent published works. The spatial focus is global and supra-regional, but does not cover regional and national aspects of climate change. The aim of this document is to summarize the state and current trends of the selected topics of ocean warming, circulation, level rise and acidification. It looks at (i) which institutions have, are and will be conducting global and supra-regional assessments, (ii) the sources and nature of the data and information used, (iii) the main threats and priority issues in the gaps in knowledge mostly based on IPPC assessments, and (v) some descriptions of the institutional capacity for conducting future assessments. This summary also contains some limited socio-economic aspects contained in the Synthesis and Summary for Policy Makers made from the Working Group II Report "Impacts, Adaptation and Vulnerability" and Working Group III Report "Mitigation of Climate Change".

2. INSTITUTIONS UNDERTAKING ASSESSMENTS

The most important assessments are completed by the IPCC, a scientific intergovernmental body set up in 1988 by the World Meteorological Organization (WMO) and by the United Nations Environment Programme (UNEP). The mandate of the IPCC is to "*…provide the decision-makers and others interested in climate change with an objective source of information about climate change*". It is constituted by all member countries of WMO and UNEP and supported by hundreds of scientists working as authors, contributors and reviewers. The most important assessments are completed by the IPCC. To date they have conducted four assessments published in 1990, 1996, 2001 and most recently the Fourth Assessment Report (AR4) in 2007. For this summary, and for the aspects of the ocean covered in warming, sea level, circulation and acidification, the main source is the outcomes of the IPCC's 4th Assessment report of the Working Group I "The Physical Science Basis", report which covers all aspects of physical climate,

including the ocean. Working Group II provides the most comprehensive and up-to-date scientific assessment of the impacts of climate change, the vulnerability of natural and human environments and the potential for response through adaptation. IPCC Assessments are written by selected international teams of authors writing individual chapters which undergo peer review. The Assessments are based on papers published in the extensive peer reviewed literature as IPCC neither does research nor collects data. Working Group III deals with measures to combat anthropogenic climatic warming. (http://www.ipcc.ch/ipccreports/index.htm).

The World Climate Research Programme (WCRP) coordinates climate research including ocean climate, and carries out simulations of past and future climate, with the results providing a central component of IPCC Reports. Most of the research assessed by the IPCC Working Group I is coordinated by the WCRP which itself synthesizes understanding of climate change and is initiating regular assessments of sea-level rise. (http://wcrp.wmo.int/wcrp-index.html)

The Global Climate Observing System (GCOS) was established in 1992 to ensure that the observations and information needed to address climate-related issues are obtained and made available to all potential users. It is co-sponsored by the WMO, Intergovernmental Oceanographic Commission (IOC) of United Nations Educational, Scientific and Cultural Organization (UNESCO), UNEP, and International Council for Science (ICSU). GCOS has three panels. One of these panels, the Ocean Observing Panel for Climate (OOPC), coordinates ocean climate observations and works closely with WCRP to define the requirements and implementation plans. GCOS is intended to be a long-term, user-driven operational system capable of providing the comprehensive observations required for monitoring, detecting and assessing impacts as well as the application of, and research into earth's climate variability and change. The GCOS addresses the total climate system including physical, chemical and biological properties as well as atmospheric, oceanic, terrestrial, hydrologic, and cryospheric components. (http://www.wmo.ch/pages/prog/gcos/)

The Global Ocean Observing System (GOOS) is a system of programmes, each of which is working on different and complementary aspects of establishing an operational ocean observation capability for all nations. GOOS is a permanent international cooperative organization with a focus on global ocean observations, modelling and analysis of marine and ocean variables .under the umbrella of UNESCO-IOC. GOOS is implemented by

Member states via their government agencies, navies and oceanographic research institutions working together in a wide range of thematic panels and regional alliances.

GOOS is designed to monitor, understand and predict weather and climate. It describes and forecasts the state of the ocean, including living resources. It improves management of marine and coastal ecosystems and resources, mitigates damage from natural hazards and pollution, and protects life and property on coasts and at sea. It provides a wealth of products and services. GOOS is a distributed system, with data stored, served and processed by numerous institutions and governments. The outputs from GOOS provide descriptions of the present state of the oceans including living resources, continuous forecasts of future conditions of the sea for as far ahead as possible as well as the basis for scenarios of climate change. (www.ioc-goos.org).

The International Geosphere-Biosphere Programme (IGBP) was started in 1987 by the ICSU at the time the need emerged for an international collaborative research endeavour on the phenomenon of global change. It is an international scientific research programme which studies the interactions between biological, chemical and physical processes and how they impact on, and are impacted by human systems. The programme is built on interdisciplinary, international networking and scientific integration. IGBP adds value to a large number of individual, national and regional research projects through the integration of activities in order to achieve enhanced scientific understanding of the Earth System. IGBP complements the research activities through a greater focus on the biological aspect of climate and has several programmes relative to the oceans. They are the Global Ocean Ecosystem Dynamics (GLOBEC), Land-Ocean Interactions in the Coastal Zone (LOICZ) and Surface Ocean and Lower Atmosphere Studies (SOLAS). Its work also underpins the Assessments of IPCC Working Groups I and II. (http://www.igbp.kva.se/)

The Scientific Committee on Oceanic Research (SCOR) is a non-governmental organization (NGO) for the promotion and coordination of international oceanographic activities. It was established in 1957 and since then has promoted international cooperation in ocean sciences through a variety of activities. Its principal focus has been on promoting international cooperation in planning, conducting oceanographic research and solving methodological and conceptual problems which hinder research. A total of 35 nations participate in SCOR working groups and scientific steering

committees for the large-scale ocean research projects. As an NGO its members are individuals representing national SCOR committees, not national governments. Each national committee can be represented by as many as three individual ocean scientists. Its meetings are held in all parts of the world, usually in conjunction with a major scientific meeting or workshops. The main science activities of SCOR are through narrow topic working groups, large-scale ocean projects and its ocean carbon activities (http://www.scor-int.org/).

The Royal Society (TRS) based in London is the oldest scientific academy which has had as its aim and focus since 1660 to pursue scientific enquiry and discovery. TRS is an independent scientific body of the United Kingdom (UK) and the British Commonwealth (Commonwealth of Nations), centred on promoting and supporting excellence in science, and as such it commissions science policies. Areas of TRS policy work are climate change, energy and the environment. On these topics, the TRS regularly produces major reports or consultations which it both issues and responds to and provides independent advice based on the best scientific evidence available to those determining policy. A good example of the TRS's excellence in science is its ocean acidification report (TRS 2005) which drew the attention of the whole world, including academics, policy makers and the public to this emerging issue. (http://royalsociety.org/document.asp?id=1170)

The International Arctic Science Committee (IASC) is an NGO which is aimed at encouraging and facilitating cooperation in all aspects of Arctic research, in all countries engaged in Arctic research and in all areas of the Arctic region. In general, IASC supported activities are international, circum Arctic and of interest to several IASC Member states. The IASC activities which support science development include assessments and science planning, the International Conference on Arctic Research Planning (ICARP II) and long-term programs, initiated under the umbrella of IASC as well as the Arctic Climate Impact Assessment (ACIA). The ACIA is an international project of the Arctic Council and the IASC which has been set up to evaluate and synthesize knowledge on climate variability, climate change and increased ultraviolet radiation along with their consequences. The ACIA report, in Chapter 9 on Marine Systems, provides a detailed synthesis of the likely impacts of climate change on the Arctic marine systems. (http://www.acia.uaf.edu/).

The International Council for the Exploration of the Sea (ICES) is the organisation which co-ordinates and promotes marine research in the North Atlantic. It includes adjacent seas such as the Baltic Sea and North Sea.

For more background information see the ICES Convention, (Convention For The International Council For The Exploration Of The Sea, 1964). ICES acts as a meeting point for a community of more than 1600 marine scientists from 20 countries around the North Atlantic who gather information about the marine ecosystem. The non-political advice provided through ICES is used by the 20 member countries which fund and support ICES to help them manage the North Atlantic Ocean and adjacent seas. ICES runs a number of working groups on activities such as oceanic hydrography, cod and climate change, statistical methods for analyzing climate change consequences and hypotheses regarding the effects of climate change. These groups are designed to deal with the physical effects and biological impacts of climate change and to provide advice and present reports on a regular basis. (http://www.ices.dk).

The 1992 Oslo and Paris Convention for the Protection of the marine environment of the North-East Atlantic (OSPAR Convention) is the current mechanism guiding international cooperation on the protection of the marine environment of the North-East Atlantic. It combined with and up-dated the 1972 Oslo Convention on dumping waste at sea and the 1974 Paris Convention on land-based sources of marine pollution. The work under the convention is managed by the OSPAR Commission, which is made up of representatives of the governments of 15 Contracting Parties and the European Commission (EC), representing the European Community (EU). The Japanese Arctic Monitoring Program (JAMP) includes questions associated with climate developments and its consequences, mainly on its biological influence. For the most part, the information is compiled in conjunction with ICES. OSPAR publishes a comprehensive report every 10 years on the status of the North-East Atlantic marine environment. The next report will be published in 2010. There are, however, some reports which have a narrow focus, such as one on the environmental effects of the ocean acidification due to elevated carbon dioxide (CO_2) in the atmosphere (OSPAR 2006). (http://www.ospar.org/eng/html/welcome.html)

The Helsinki Convention (HELCOM) applies to the Baltic Sea Area, which, for the purposes of this Convention is the Baltic Sea and the entrance to the Baltic Sea bounded by the parallel of the Skagerrak at 57° 44.43'N. The observations of physical climatic development as well as biological impacts are included in the monitoring programme. Assessments are based on the information provided by ICES. (http://www.helcom.fi/Convention/en_GB/convention/)

The European Environmental Agency (EEA) is part of the EU and reports on the status of the European seas every 5 or 10 years. The latest report, titled "Europe's environment – The fourth assessment" includes a chapter on climate change which mixes land and marine information in a rather superficial way. A more advanced report titled "Impacts of Europe's changing climate – 2008 indicator-based assessment" was released in September 2008. Special assessments of climate issues in the marine environment are not available, but it is expected that routine community action in the field of marine environmental policy on this subject will be in place in the future as part of the Water Framework Directive and the Marine Strategy Framework Directive. (http://www.eea.europa.eu)

3. DATA

Most of the data used in the IPCC assessments includes information from the institutions mentioned above. The assessment from the IPCC's Working Group I-III comes from large amounts of past and new data, more sophisticated data analyses techniques, improvements in the understanding and simulation of physical processes in climate models, and more extensive exploration of uncertainty ranges in model results. The data sources used are varied and numerous, ranging from *in-situ* long term monitoring of multiple environmental variables, indirect back calculations from proxy records such as trees, ice, corals and sediments, and improved remote sensing with satellites and monitoring arrays for both climate and oceanographic monitoring. Much of the value on the data sources are derived from the combinations of datasets and from the multiple modelling techniques used.

Ocean data are collected by many groups for many reasons. The most comprehensive set of physical ocean data were collected by the World Ocean Circulation Experiment, a project of the WCRP. The GCOS's Implementation Plan contains a description of what data is required for understanding the role of oceans in climate and their impact. These include surface data on sea-surface temperature, sea-surface salinity, sea level, sea state, sea ice, current, ocean colour and CO_2 partial pressure as well as sub-surface data on temperature, salinity current, nutrients, carbon, ocean tracers and phytoplankton. One of the most important global climate observing programmes for the oceans is Argo, a system of more than 3000 vertically profiling deep-sea drifters which contribute temperature and salinity data from the upper 2000 metres (m) of all oceans. (http://www-argo.ucsd.edu/index.html).

The GOOS provides a collection of ocean observing and information delivery systems providing near to real time measurements, data and products of the state of the oceans with direct relevance to climate change assessments. For example, most global climate change studies are strongly dependant on the heat content calculation of the oceans. The GOOS is currently focused largely on physical and geochemical data, observing platforms and data products. Coastal GOOS are now intended to contribute to the understanding of the effects of human activity, climate change and natural disasters in coastal systems. Presently, other than primary production (chlorophyll), the GOOS does not cover observation systems for biological or biodiversity of the world's oceans.

Unfortunately, many of the networks needed to collect these data remain incomplete, particularly in the southern hemisphere and in the deep ocean, and essentially none has sustained funding.

Data are assembled at the various World Data Centres, through numerous data networks which for the most part are connected to the WCRP and the GCOS, and through information collected by satellite agencies. There are significant shortfalls in ensuring all data is adequately quality-controlled and freely available because of issues concerning funding and national security.

4. ASSESSMENTS

The IPCC's 4th Assessment reports provide the best scientific basis for the evaluation of status, trends and projections of the five topics summarized below. For each topic all available current and past quantitative information has been used and a series of baselines, indicators and reference points have been proposed for both descriptions and model-based forecasting (Bindoff and others 2007).

4.1 Warming

The assessment of Solomon and others (2007) and Bindoff and others (2007) concluded in agreement with the IPCC Third Assessment Report that the ocean is warming. Over the period 1961 to 2003, global ocean temperature has risen by 0.10°C from the surface to a depth of 700 m, absorbing energy at a rate of 0.21 ± 0.04 W m^{-2} averaged over the earth's surface. Southern Ocean waters and Upper Circumpolar Deep Waters warmed from the 1960s to about 2000. A similar pattern of warming in the Gulf Stream and Kuroshio waters in the North Atlantic and North Pacific has been observed. Long-term cooling is observed in the

North Atlantic sub-polar gyre and in the central North Pacific. Projections made in the EEA report (EEA-JRC-WHO, 2008), suggest that sea surface temperature and the sea level of some European seas could rise more than the global average. Since 1995, the upper North Atlantic sub-polar gyre has been warming and becoming more saline. However, it is unclear whether the present increase is a reversal already of the long-term trend. There is a growing field of evidence supporting the hypothesis that as the seas warm (Levitus and others 2005, Ishii and others 2006), the ocean has more energy to convert to tropical cyclone wind (Elsner and others 2008; Saunders and Lea, 2008).

4.2 Ocean circulation

Ocean warming is affecting key oceanic water masses, however there is no clear evidence for ocean circulation pattern changes. It is very likely that up to the end of the 20th century, the Atlantic meridional overturning circulation has been changing significantly at inter-annual to decadal time scales. Over the past 50 years, no coherent evidence for a trend in the strength of the meridional overturning circulation has been found (Bindoff and others 2007). Indeed, recent modelling work predicts that the ocean's circulation will weaken in response to global warming. However, when this prediction is contrasted with the warming at the end of the last ice age, a different outcome is suggested and indicates there is a stronger oceanic circulation in the warmer climate to come (Toggweiler and Russell, 2008).

4.3 Sea level rise

The works of Church and others (2008), Bindoff and others (2007), and Solomon and others (2007) have concluded that the global mean sea level has risen and the rate of rise has increased from the 19th to the 20th century. There is evidence of an increase in the occurrence of extreme high waters worldwide. Figure 1 depicts the global mean thermosteric mean sea level curves from the reconstruction for January 1870 to December 2001 and the inset shows comparisons of the *in situ* data with direct measurements from satellite altimeters. This data indicates that sea level rise is clearly not constant over time and shows considerable fluctuations. A significant component of the sea-level rise observed in the past 50 years can be explained only partially by ocean warming, the related thermal expansion and loss of land ice because of increased melting. Bindoff and others (2007) have reported that, from 1961 to 2003, the average rate of sea level rise was 1.8 ± 0.5 mm yr^{-1}. For the 20th century,

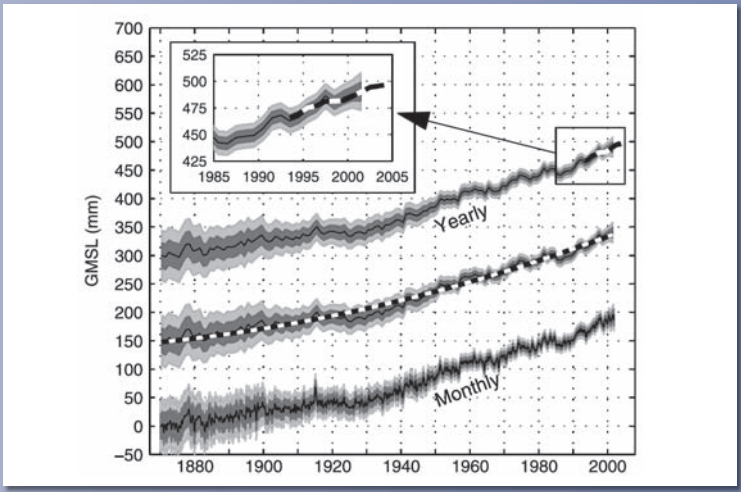
the average rate was 1.7 ± 0.5 mm yr^{-1}, which is consistent with the IPCC 3rd Assessment Report estimates of one to two mm yr^{-1}. There is high confidence that the rate of sea level rise has increased between the mid-19th and the mid-20th centuries. Sea level change is highly irregular spatially, and depending on changes in wind and current systems in some regions, the rates of change are up to several times the global mean rise, while in other regions the level is falling. The fall in the observed sea level is attributable largely to substantial spatial variations and non-uniform changes in temperature and salinity and is associated with local changes in the ocean circulation (Bindoff and others 2007). There is evidence for a worldwide increase in the occurrence of extreme high water associated with storm surges. The extreme variability during this period is linked to the rise in the mean sea level and the variations in regional climate. The papers published since the IPCC (e.g. Rahmstorf and others 2007; Domingues and others 2008; Church and others 2008) have confirmed and strengthened the IPCC conclusions that sea level has been raising near the upper boundary of the IPCC projections since 1990.

4.4 Ocean acidification

Bindoff and others (2007) clearly stated that associated to climate change, the biogeochemistry of the oceans is also changing. The total inorganic carbon content of the oceans has increased by 118 ±19 GtC between the end of the pre-industrial period (ca. 1750) to 1994 and continues to increase. It is more likely than not that the fraction of emitted CO_2 taken up by the oceans has decreased, from 42 ± 7 per cent during 1750–1994 to 37 ± 7 per cent during 1980–2005. This would be consistent with the expected rate at which the oceans can absorb CO_2, but the uncertainty in this estimate does not allow firm conclusions. The increase in total inorganic carbon caused a decrease in the depth at which calcium carbonate ($CaCO_3$) dissolves and caused a decrease in surface ocean acidity (pH) by an average of 0.1 units since 1750. Direct observations of pH at available time series stations during the past 20 years also show trends of decreasing pH at a rate of 0.02 pH units each decade. There is evidence for a decrease in the oxygen concentrations which "…*appeared to be driven primarily by changes in ocean circulation, and less by changes in the rate of O_2 demand from downward settling of organic matter*" (Bindoff and others 2007). The decrease is likely driven by reduced rates of water renewal, the thermocline depths (~100–1,000 m) in most ocean basins from the early 1970s to the late 1990s. The assessments of The Royal

Society (2005) and of Bindoff and others (2007) indicate that surface pH has decreased globally, with the lowest decrease in the tropics and highest decrease at high latitudes. This is consistent with the lower buffer capacity of the high latitudes compared to the low latitudes. The impacts of acidification will be most severe for calcifying biota and aragonite shelled organisms (Hoegh-Guldberg and others 2007). The increase and predicted global changes in the ocean's acidification and its consequences on aragonite saturation are shown in the Figure 2. In particular, it is expected that the biological production of corals, phytoplankton and zooplankton may be inhibited or slowed down and that the dissolution of $CaCO_3$ at the ocean floor will be enhanced (Denman and others 2007).

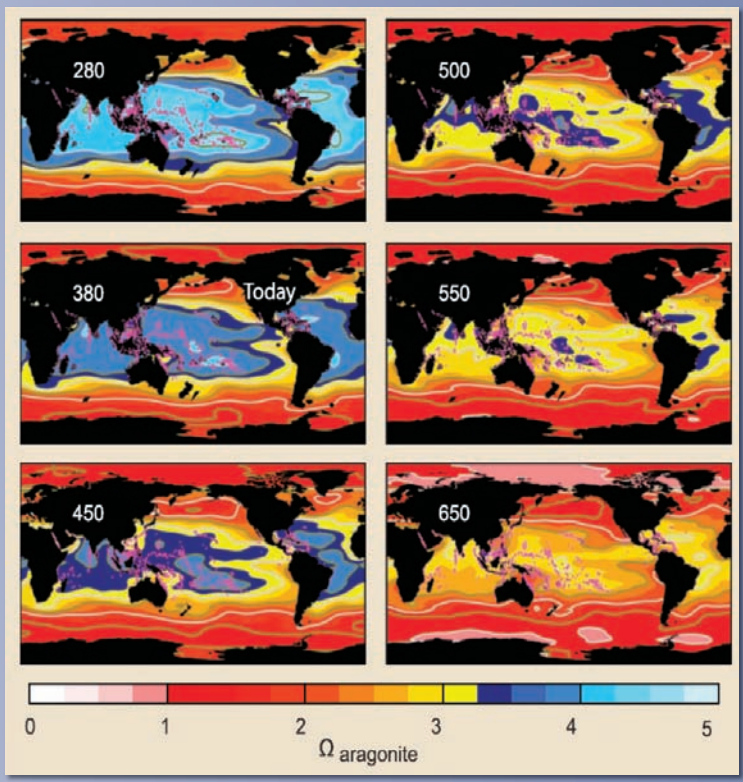
Figure 1: **Global mean sea level from the reconstruction for January 1870 to December 2001**



Global mean sea level from the reconstruction for January 1870 to December 2001. The monthly global average, the yearly average with the quadratic fit to the yearly values and the yearly averages with the satellite altimeter data superimposed are offset by 150 mm. The one (dark shading) and two (light shading) standard deviation error estimates are shown. The inset compares global averaged sea level estimated from the *in situ* data with direct measurements from the TOPEX/Poseidon (T/P) and Jason-1 satellite altimeters.

Source: Church, J.A. and White, N.J. (2006). Reproduced/modified with permission from the American Geophysical Union.

Figure 2: **Changes in aragonite saturation**



Changes in aragonite saturation $\{W_{aragonite} = ([Ca^{2+}].[CO_3^{2-}])/K_{sp\ aragonite}\}$ predicted to occur as atmospheric CO_2 concentrations (ppm) increase (number at top left of each panel) plotted over shallow-water coral reef locations shown as pink dots (for details of calculations, see the SOM). Before the Industrial Revolution (280 ppm), nearly all shallow-water coral reefs had $W_{aragonite}$ > 3.25 (blue regions in the figure), which is the minimum $W_{aragonite}$ that coral reefs are associated with today; the number of existing coral reefs with this minimum aragonite saturation decreases rapidly as $(CO_2)_{atm}$ increases. Noticeably, some regions (such as the Great Barrier Reef) attain low and risky levels of $W_{aragonite}$ much more rapidly than others (e.g., Central Pacific).

Source: Hoegh-Guldberg, O. and others. SCIENCE 318:1737 (2007). Reprinted with permission from AAAS.

4.5 Integration

The synthesis report prepared by IPCC (2007a) with its summary for policymakers provides a comprehensive integration across all information provided on the assessments carried out by the three working groups of the IPCC. It provides an integrated view of climate change and addresses the observed climate change and its effects, the causes of change, the scenarios forecast for climate change and its impact in the near and long term as well as the adaptation and mitigation options and responses, the long-term perspective of scientific and socio-economic aspects relevant to adaptation and mitigation, and the robust findings and key uncertainties.

5. PRIORITIZED ISSUES

A major issue is the inherent limitations in the IPCC Ocean Assessment Chapters of their inadequate historical and ongoing datasets which reflect the still incomplete understanding of the oceans and the continental ice shields. This is particularly true for the limited sampling in the southern hemisphere oceans and the deep ocean, where changes can only be evaluated with moderate confidence.

The syntheses of Solomon and others (2007) identified that it is not possible to satisfactorily quantify the known processes causing the global average sea level rise for the past 50 years.

Ocean acidification as a result of dissolved CO_2 forming carbonic acid is now detectable with various seemingly rapid processes underway which are likely to have severe biological and socio-economic impacts (Orr and others 2009). This process should be a priority issue requiring urgent concerted, collaborative international study and assessment.

Perhaps the highest priority issue is completing the designed on-site and satellite observational networks and obtaining sustained funding for their ongoing implementation, particularly in the southern hemisphere and in the deep ocean.

Ongoing research is required to decrease gaps in system knowledge and assess significant uncertainties which limit the ability to understand and predict climate variability and change as well as its impact on society. One such example is the rate and regional distribution of sea level rise and the relationship between warming and storm intensity and frequency, which is likely to impact tens of millions of people through the 21st century. As a result, the priority here is centred on the extent to which observations can be

sustained so that research programmes utilising the resulting data are able to significantly improve the understanding and narrow projections of future sea-level rise and variability.

A substantial increase in computing resources is required to simulate climate and ocean climate adequately, particularly at the regional and local scale.

There is no well supported and established international network for the cooperation of researchers and current systems and structures are still inadequate (resources, funding, coverage) to address the many climate challenges facing the world, particularly in the inclusion and involvement of the developing world.

The WCRP and IGBP have, within their funding limitations, done good work in coordinating physical global climate research which has been focused on the atmospheric and terrestrial components, with an increasing focus on the oceans. These programs should be continued to be supported appropriately. The strengthening of the Intergovernmental Committee for the GOOS (I-GOOS) can offer the complementary support platform and venue to enhance the international cooperation required to maintain an operational ocean observing systems. Thus, the existing structures should be supported appropriately and be extended to cover areas not adequately covered.

5.1 Socio-economic impacts, adaptations and mitigations

The IPCC's 4th assessment reports have made available the best synthesis in the current knowledge of observed impacts of climate change on the natural and human environment in which regional effects are emerging, although many impacts are difficult to discern because of adaptation and non-climatic drivers. Ocean warming, sea-level rise, the progressive acidification of oceans and human development are contributing jointly to losses of coastal wetlands, mangroves and corals reefs and are increasing flooding damage to coastal communities and industries in many areas. This is particularly relevant for the northern Indian Ocean and North Atlantic Ocean and Wider Caribbean Region for example where there has been a large increase in recent years in the number and proportion of extremely strong cyclones reaching categories four and five. As a consequence, many millions of people are and will be affected in the next years-to-decades. It is expected that adaptation and mitigation for the affected coasts will be more challenging in developing countries than for developed countries because of constraints on their adaptive capacity (IPCC 2007b). The mitigation strategies outlined in the IPCC's 4th assessment reports are largely centred on controlling, reducing,

managing and offsetting the CO_2 emissions from human activities which, in turn affect climate and ocean change. The mitigation strategies for the oceans are not clear or explicitly presented because there is an evident focus or bias to land-based strategies. However, changes in lifestyles and consumption-exploitation patterns such as fisheries which emphasize resource conservation can contribute to developing a low CO_2 economy. Ocean fertilisation is the only geo-engineering option listed in the reports to proactively remove CO_2 directly from the atmosphere (IPCC 2007c). However, recent UN policy developments regarding ocean fertilization state that *"…ocean fertilization activities other than for legitimate scientific research should not be allowed, and that scientific research proposals should be assessed on a case-by-case basis" and that "…ocean fertilization activities were not carried out until there was an adequate scientific basis on which to justify such activities"* (Conference of the Parties to the Convention on Biological Diversity, Contracting Parties to the London Convention and London Protocol and the General Assembly (resolution 63/111, paragraphs. 115 and 116 http://www.unhcr.org/refworld/pdfid/49c226da0.pdf).

6. CAPACITY OF THE INSTITUTIONS, (PARTICULARLY REGIONAL INSTITUTIONS TO UNDERTAKE GLOBAL ASSESSMENTS

The IPCC has been very successful with its assessment, building and consolidation of the work of the WCRP, GCOS and IGBP, which has resulted in the WCRP moving to strengthen its underpinning of the IPCC assessment process by initiating the assessment of individual components of the climate system. One such focus is sea-level rise.

The IPCC assessments are moving towards regional scales, but significant scientific research is required along with more coherent and sustained observational networks before regional assessments can become as rigorous as the global scale assessments that have been completed to date.

The increasing role of the I-GOOS as a way to coordinate the intergovernmental networking activities of the various thematic and regional GOOS programmes offers possibly the best platform for the formulation of policy, principles and strategy for planning and coordinating the likely global and regional ocean observation systems to provide for climate change assessments of impacts, adaptation and mitigation strategies.

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Global Summary: Marine Biodiversity Assessments

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1. INTRODUCTION

The information below covers assessments, status reports, scientific reviews, atlases, databases and online resources which hold significant datasets with global coverage for marine species, important habitat/critical areas and vast ecosystems such as the open ocean as well as deep seas and marine genetic resources. The aim of this document is to summarize (i) the institutions which have, are and will be conducting global and supra-regional data collection and assessment for marine biodiversity; (ii) the sources and nature of the data and information; and (iii) a range of current assessments undertaken within about the past 10 years. During this time frame, some scientific publications have made significant contributions to knowledge on the state of conservation of important ecosystems such as coral reefs (Hughes and others 2003, Graham and others 2008) and species or trophic levels such as large predators (Myers and Worms 2003, Heithaus and others 2008) in relation to human and environmental pressures. Although influential, they will not be reviewed here as their main objective was to contribute to the progress of science and not to management advice *per se*. This summary also addresses priority threats and issues and institutional capacity for conducting future assessments. Threats to marine biodiversity are also covered in the supra-regional summaries on climate change, fisheries, invasive species, land-based pollution and pollution of the open oceans outside national jurisdiction.

2. INSTITUTIONS UNDERTAKING ASSESSMENTS

2.1 Intergovernmental, inter-agency and convention processes

The Secretariat of the Convention on Biological Diversity (SCBD) supports implementation of the Convention's cross-cutting programme on marine and coastal biodiversity under the Jakarta Mandate on Marine and Coastal Biodiversity adopted in 1995 (http://www.cbd.int).

The Food and Agriculture Organization (FAO) is a part of the UN system, which among other things is working on marine fisheries, aquaculture, forestry and other important marine and marine-related resources, including mangroves. FAO conducts assessments regularly on the status of marine

resources, their habitats and the impacts of industries exploiting those resources (http://www.fao.org).

The Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) is an inter-agency body of the UN System comprised of the UN, FAO, the International Maritime Organization (IMO), the Intergovernmental Oceanographic Commission (IOC) of UNESCO, the World Meteorological Organization (WMO), the International Atomic Energy Agency (IAEA), the UN Industrial Development Organization (UNIDO) and the UN Environment Programme (UNEP). It provides scientific assessments and advice on a wide range of marine issues (http://www.gesamp.org).

The International Coral Reef Initiative (ICRI) and the Global Coral Reef Monitoring Network (GCRMN). The ICRI is a partnership among governments, international organizations and non-government organizations (NGOs) to preserve coral reefs and related ecosystems. The ICRI and the GCRMN initiatives and other partners have produced assessments on the status of coral reefs of the world. The GCRMN was established as one of the operating networks of ICRI and aims to improve management and conservation of coral reefs by assessing status and trends in the reefs and how people use and value the resources. Other activities include providing manuals, equipment, databases and training. It also assists with problem solving and mobilizing funds for reef monitoring. GCRMN operates through 17 regional country networks. Each of these regional nodes has a regional coordinator, and countries within a node have a national coordinator (http://www.gcrmn.org). Reefbase is the official database of GCRMN and is maintained by the WorldFish Center (http://www.reefbase.org).

The International Seabed Authority (ISA) was established by the 1982 UN Convention on the Law of the Sea (UNCLOS) as the organization through which UNCLOS states Parties organize and control activities associated with minerals recovery from the seabed in areas beyond national jurisdiction. This includes management of activities to avoid adverse environmental impacts and to protect and conserve natural resources other than minerals and prevent damage to marine flora and fauna (http://www.isa.org.jm).

The International Whaling Commission (IWC) was established by a 1946 Convention. The analysis and advice of its Scientific Committee (SC) provide the basis for the IWC to develop regulations to conserve and regulate whaling. Stock assessments of cetaceans as well as research and field observations can be found at (http://www.iwcoffice.org).

The Division for Ocean Affairs and the Law of the Sea (DOALOS) is a part of the UN Office of Legal Affairs and serves as the secretariat for UNCLOS and oceans-related meetings held at the UN. DOALOS prepares synthesis reports on ocean developments worldwide, covering among other things, marine biodiversity and marine genetic resources (http://www.un.org/depts/los).

UNEP is a programme of the UN established by the UN General Assembly with a mandate to promote and support cooperation in the field of the environment and draw attention to emerging environmental issues as well as provide policy guidance and coordination of environmental programmes in the UN System and promote scientific and other expert contributions to assessment and exchange of environmental knowledge and information (http://www.unep.org).

The UNEP World Conservation Monitoring Centre (WCMC) has a mandate for assessing biodiversity and providing information for improved decision making. The recently established One Ocean Programme focuses on assessments on coastal, marine and deep sea ecosystems, and their use by society (http://www.unep-wcmc.org/oneocean).

The UN University-Institute of Advanced Studies (UNU-IAS) is part of the UN System established in 1996 to conduct research and strengthen post-graduate education, both in-house and through collaborative arrangements with other academic institutions and international organizations. Its research concentrates on sustainable development (http://www.ias.unu.edu).

2.2 Non-governmental and research processes

Birdlife International is a global partnership of NGOs with a special focus on conservation and birds. Each partner represents a unique geographic territory, working on the status of birds, their habitats and the issues and problems affecting bird life. Birdlife acts as the official Red List Authority for birds for the International Union for Conservation of Nature (IUCN) Red List process (http://www.birdlife.org).

The Census of Marine Life (CoML) is a decade-long initiative which in 2010 will deliver an assessment and explanation of the changing diversity, distribution and abundance of marine species and predict the future for ocean life. It is coordinated by an international scientific steering committee and a secretariat based in Washington, DC, and involves a network of more than 2 000 researchers from some 80 countries. Through 11 regional and national committees, the CoML strives to strengthen support for marine

biodiversity research, in partnership with a variety of governments and funding agencies (http://www.coml.org).

Conservation International (CI) is an international NGO with a focus on science-based conservation at a global scale and activities ranging from species to large-scale regions. It has an oceans and seascapes priority area and its most relevant activity is the State of the World's Sea Turtles (SWOT) – a partnership with the IUCN Marine Turtle Specialist Group (MTSG). SWOT is a global network of specialists working to accelerate the conservation of sea turtles and their habitats while collecting and managing data. So far, it has produced three status reports (http://www.conservation.org).

The Foundation for Environmental Conservation (FEC) has coordinated scientific and ecological assessments of various marine ecosystems between 2002 and 2005, usually published in the journal Environmental Conservation, conference proceedings or books. The FEC has assessed threats to resilience and likely changes in nine major marine habitats and ecosystems projected over the next 25 years (e.g. Steneck and others 2002 and Polunin 2008). Most of the data come from scientific and academic institutions with expertise in marine ecosystems (http://www.ncl.ac.uk/icef).

The Global Marine Species Assessment (GMSA) is a collaboration between the IUCN Species Survival Commission (SSC) and Conservation International's Center for Applied Biodiversity Science. This new initiative expects to complete assessments for 20 000 marine species by the year 2010. The data and findings are being used to complete Red List assessments which are designed to assist species conservation and the identification of key biodiversity areas in the marine environment (http://science.odu.edu/gmsa).

The IUCN Red List assessments, which are revised every four to five years, evaluate the conservation status of plant and animal species and habitats, including marine species. Undertaken by specialist group networks of the SSC, the assessments are used by various organizations including the Convention on International Trade in Endangered Species (CITES), the Convention on Migratory Species (CMS), governments and several regional conventions, including regional seas conventions, to consider whether to designate species as endangered or threatened. They are also used by scientists and conservation organizations. The SSC's primary role is to provide information on biodiversity conservation, the inherent value of species, their role in ecosystem health and functioning, the provision

of ecosystem services and their support to human livelihoods. The SSC is a science-based network of some 7 000 volunteer experts from almost every country of the world. Members include researchers, government officials, wildlife veterinarians, zoo and botanical institute employees, marine biologists and protected area managers as well as IUCN World Commission on Protected Areas experts on plants, birds, mammals, fish, amphibians, reptiles and invertebrates (http://www.iucnredlist.org).

The Global By-catch Assessment of Long-lived Species project (GloBAL) is a joint venture between Duke University and the Blue Ocean Institute working on fisheries by-catch of marine mammals, seabirds and sea turtles. It hopes to strengthen communication and knowledge transfer among those working on these issues and to identify areas for collaborative research (http://bycatch.env.duke.edu).

Additional international organizations, such as the Scientific Committee on Oceanic Research (SCOR) of the International Council for Science contribute to marine data collection and assessment through participation in major international research programmes such as the International Geosphere-Biosphere Programme (IGBP) and the Census of Marine Life.

Other NGOs engaged in supra-regional data collection, analysis and assessment include the World Wide Fund for Nature (WWF) which often works in conjunction with other agencies and partners (TRAFFIC, IUCN, NOAA and funding agencies) on such issues as responses to reduce seabird by-catch and fish discards and conservation and management of critical habitats and species (Lack 2007). The Nature Conservancy (TNC) is involved in similar work through projects such as its regional assessments of conservation priorities in Latin American (Chatwin 2007) and in Latin America and the Caribbean (Sullivan and Bustamante 1999) as is the World Resources Institute (WRI) with respect to habitat assessments and the Earthtrends database noted below.

3. DATA

3.1 Species and ecosystem data

a. Intergovernmental, inter-agency and convention processes

This section identifies a number of substantial data collection initiatives, but it is not intended to be exhaustive. The initiatives are listed in alphabetical order.

The FAO, in addition to its regular fisheries, trade and sea food consumption databases (e.g., Fisheries Global Information System (FIGIS)), has developed guidelines and criteria for use by states and Regional Fisheries Management Organizations (RFMOs) to identify vulnerable marine ecosystems (VMEs) such as cold water corals and sponge grounds, and the impacts of fishing on them. The FAO is to develop a global database on VMEs in areas beyond national jurisdiction in cooperation with other relevant organizations (FAO Technical Consultation 2008).

Coral reef monitoring data will be accumulated within each of the GCRMN's 17 regional nodes in a specialized database for distribution within the region and to ReefBase, the official database of GCRMN (http://www.reefbase.org). The data will be combined into biannual reef status summaries and disseminated to international forums, organizations and the media. Another database on coral reefs is found at http://www.reefcheck.org.

The Inter-American Biodiversity Information Network (IABIN) is an internet-based forum for technical and scientific cooperation to promote greater coordination among 34 western hemisphere countries in the collection, sharing and use of information on natural resources and biodiversity relevant to decision-making and education. Each country has designated an official focal point and the system will be based on the use of common information standards. The initiative has been endorsed by the Organization of American States, which hosts the website, and is seen as a decentralized partnership of governments and organizations (http://www.iabin.net/).

The ISA is developing databases of scientific and technical information to improve understanding of the deep ocean environment. This includes environmental databases associated with its minerals of interest so that the Authority can effectively control environmental impacts from mining activities (no commercial activities to date). The first steps have been taken to develop databases on the benthic biology and genetic flow for benthic taxa in the abyssal sediments of the Clarion-Clipperton Zone of the Pacific Ocean and the Central Indian Ocean, together with data on ocean currents, sedimentation, organic carbon and other matters (ISBA/13/A/2 2007).

UNEP WCMC has online databases on marine biodiversity, including spatial datasets on seagrasses, mangroves, coral reefs, cold water coral reefs and salt marshes. To make available existing datasets, it is developing centralized data visualization and analysis tools to link these marine and coastal datasets with socio-economic data and provide primary analysis.

Additional international data collection and survey programmes that yield important data on distribution of biodiversity include the Continuous Plankton Recorder Survey, which is run by the Alistair Hardy Foundation for Ocean Science, and the European Deep sea project, Hotspot Ecosystems Research on the Margins of European Seas (HERMES).

b. Non-governmental and research processes

AlgaeBase houses significant online information on more than 122 554 species of marine algae, particularly seaweeds, and it is continuing to expand. Its main purpose is taxonomy, but it also contains detailed information on habitats, distribution and relevant literature for each recorded species. This database has been spearheaded by the National University of Ireland (NUI), Galway (http://www.algaebase.org).

Aquamaps is a web-based tool housing standardized distribution maps for about 9 000 species of fish, marine mammals and invertebrates. It draws on the Ocean Biogeographic Information System (OBIS) and Global Biodiversity Information Facility (GBIF) data sources. It is supported by the Pew Fellows Programme in Marine Conservation, IncoFish and the European Commission (EC) (Kaschner and others 2008) (www.aquamaps.org).

Birdlife International maintains an updated and fully online relational database, the World Bird Database, containing all available information for most seabird species and families with regard to distribution, status, ecology, important areas and population trends as well as threats and priority issues for specific species and the respective conservation needs and responses (http://www.birdlife.org/datazone/index.html).

The CoML's OBIS provides online access to marine biodiversity data. CephBase, which is also part of the CoML, is an international programme on the diversity, distribution and abundance of marine life. The website database is a repository of scientific data and information, images, videos and contact information for all living species of cephalopods at global and regional levels, and in some cases at the national level (www.iobis.org, www.cephbase.utmb.edu).

FishBase is an online relational database with information on all known fish species, both freshwater and marine. It contains available and updated information about taxonomy, biology, status and general management and conservation. This database has been developed at the WorldFish Center in collaboration with the FAO (Froese and Pauly 2000).

The IUCN Red List process maintains a species information service and is working toward interlinked databases which will make information easily accessible on the status, distribution, threats and conservation actions associated with individual species.

Project GloBAL is in the initial stages of collecting, synthesizing and analyzing worldwide studies associated with fisheries by-catch of marine mammals, seabirds and sea turtles, and associated mitigation measures. Database information on fishing effort and by-catch is being organized by region and by type of fishery (e.g., longline, gillnet). Goals include the development of comprehensive regional profiles to allow for identification of areas/situations where urgent conservation measures are or are not needed and those where it is important to fill gaps in by-catch knowledge.

SeaLifeBase, established in 2008, operates on the same principles as FishBase to provide information on non-fish marine organisms. It holds data on more than 20 000 marine species, including deep sea species (www.sealifebase.org). It is a project between the WorldFish Center and the University of British Columbia Fisheries Centre The Sea Around Us Project which has online databases, including on marine biodiversity and on the impacts of fishing on marine ecosystems and biodiversity (www.seaaroundus.org).

SeagrassNet is an expanding monitoring programme which investigates and documents the status of seagrass resources worldwide and the threats to this important marine ecosystem. The programme started in 2001 in the western Pacific and now includes 70 sites in 23 countries. A global monitoring protocol and a web-based data reporting system have been established. The ultimate objective of SeagrassNet is to preserve the seagrass ecosystem by increasing scientific knowledge and public awareness. SeagrassNet is a partnership among various private foundations, academic and research institutions, international NGOs (WWF, TNC) and government agencies in the United States of America, Vietnam and Brazil (http://www.seagrassnet.org).

The World Register of Marine Species is a part of the Catalogue of Life. It contains taxonomic and related geographic data. Maintained by the Flemish Institute of Marine Science, it is also a part of the CoML network of projects (www.marinespecies.org).

WRI's Earthtrends is another online source of marine biodiversity data, including spatial datasets (http://earthtrends.wri.org).

3.2 Summary: Species and ecosystem data

There is generally good data on species targeted by fisheries, some large and charismatic fauna such as seabirds, whales and other marine mammals, and conspicuous coastal macroflora such as seagrasses, mangroves and kelp forests as well as other taxa such as coral reefs. However, further data collection and analysis is needed for highly diverse groups such as marine invertebrates, algae and zooplankton. Data deficiencies also exist for sharks (noted below), and there are major gaps in fisheries by-catch data which makes accurate estimates of many species such as sea turtles, sharks and small cetaceans difficult. Sea turtle assessments in general are approximate because they are based primarily on the changing number of breeding females which come ashore to nest each year. The data have significant limitations, because nesting sites change and many non-nesting individuals do not get counted in any given year. In view of the globally distributed nature of the species and disparate population trends and threats in different regions, discussions are being held on whether to focus assessments on population trends at regional and national scales. An important component in marine biodiversity assessments is historical time series data to establish appropriate baselines, and there are efforts to discover relevant data through projects such as the CoML's Oceans Past programme outlined below.

On the global scale, open ocean and deep sea areas are still relatively poorly studied. Less than 0.001 per cent of the deep seafloor has been subject to biological investigations, yet it is believed that more species live in the variety of deep sea environments than in all other marine environments combined (UNEP 2006). The CoML programmes are beginning to produce new datasets on high and deep sea geomorphic features such as seamounts, vents, cold seeps and cold-water corals (Corrigan and Kershaw 2008).

3.3 Socio-economic data

On socio-economic conditions, there is regular information in most of the world on the scale and value of multiple human activities which exploit and affect biodiversity within areas of national jurisdiction and major activities such as shipping and fisheries in areas beyond national jurisdiction. This information, however, is often not collected specifically for the purpose of assessing uses and impacts over a determined marine resource or ecosystem, which limits the possibility of integrating the information in marine assessments. For coral reefs, for instance, a socio-economic manual for coral reef management published in 2000 was motivated by the need to integrate biophysical and socio-economic aspects in the assessment of status and

trends of coral reefs. At the global level, Reefbase offers some information in this rapidly developing field. The economic valuation of marine and coastal biodiversity is another new field and to date there are no global or supra-regional assessments. Examples of local valuations for the Caribbean reefs can be found in a recent report by WRI (Burke and others 2008).

4. ASSESSMENTS

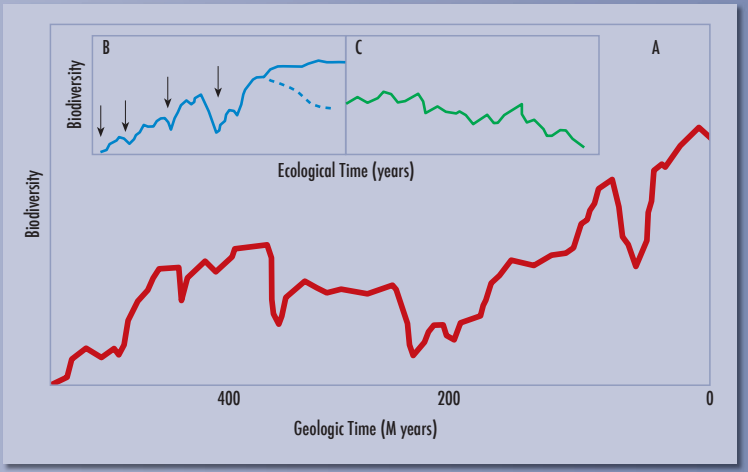
4.1 General

The Convention on Biological Diversity (CBD) Global Biodiversity Outlook 2 (SCBD 2006) assesses the current status and trends of biodiversity and the key drivers of biodiversity loss, including for coastal and marine ecosystems and species, in some cases using the Convention's indicators.

Sala & Knowlton (2006) have produced a synthesis of scientific knowledge on global trends in marine biodiversity. They state that marine biodiversity has naturally exhibited slow increases with clear mass extinctions events (Figure 1A and B). Human threats causing rapid declines include overfishing, global warming, biological introductions and pollution (downward trend shown in Figure 1C). The expected consequences are changes to ecosystem function and to the provision of ecosystem services. These global trends indicate growing biodiversity losses which are likely to accelerate in the future with unpredictable consequences.

A report prepared for the CMS presents what is known about the impacts of climate change on various biota, including marine mammals, corals, macroalgae, invertebrates and marine turtles, and their vulnerability based on a review of scientific studies. It emphasizes that expected effects, both positive and negative, on primary production, recruitment processes and biogeography will be widespread. Climate change impacts on global oceans will also have effects on phenological relationships and community structure, the establishment of invasive species and disruptions of biogeochemical cycles and physiological responses to temperature rise. Recommended measures are designation of adaptive no-take zones and areas fully protected from synergistic human-induced impacts. Protections for marine mammal prey are a suggested priority response for managing human impacts on the resources used by migratory marine mammals. Monitoring and research priorities are also suggested (Migratory Species and Climate Change 2006).

Figure 1: **General trends in marine biodiversity over evolutionary and ecological times**



(A) General increase over geological timescales, punctuated by declines caused by mass extinctions (adapted from Newman 2001). Abbreviation: M, million. (B) Solid line: typical trend of marine biodiversity (e.g., species richness, ecodiversity, evenness, functional diversity) over ecological timescales in the absence of human disturbance. Arrows indicate pulse disturbances that reset succession. Dashed line represents decrease in ecodiversity during late successional stages in communities with competitively dominant (architectural) species. (C) Marine biodiversity trends under chronic human disturbance.

Source: Sala. E. and Knowlton, N. (2006). Reprinted, with permission, from the Annual Review of Environment and Resources, Volume 31, ©2006 by Annual Reviews www.annualreviews.org

4.2 Species

The IUCN Red List provides taxonomic, conservation status and distribution information on evaluated species and on those which cannot be evaluated because of insufficient information. The criteria, categories and methods, developed through many years of discussion and consensus-building among experts are available at www.iucnredlist.org. Great care is taken to ensure that the assessments are based on quantitative data and that a well-structured peer review process is applied. The marine mammal assessments cover cetaceans (dolphins, porpoises, whales), polar bears, pinnipeds (seals and walruses) and sirenians (dugongs and manatees). All seven sea turtle species are also covered, five of which are distributed around the world. Out of the 41 415 species on the IUCN Red List, 1 530 use the

marine environment. Of these, about 30 per cent (416) are at risk and 80 species are threatened with extinction. While some 240 species have been recently added to, or reassessed for, the 2007 Red List, 71 per cent are in jeopardy, with 31 species facing high risks of extinction. Most of these are seabirds, marine mammals, sharks and rays.

The Global Marine Species Assessment (GMSA) will complete approximately 20 000 marine species assessments by 2010, concentrating on fish (15 000 species) and habitat-forming primary producers such as seagrasses, mangroves, corals and select macro-algae as well as certain mollusks and echinoderms. An extensive data-gathering stage is followed by data review and species assessments, typically in a workshop setting which often is held at the regional level. A distribution map is created for every species and species data are compiled in a geographical information system (GIS) database. The coral assessment has been completed (e.g., Carpenter and others 2008; Polidoro and others 2008) as well as many other taxa and certain regional assessments (e.g., Mediterranean fish). As the assessments are released, the data utilized will be made available for separate analyses. All assessments completed to date, and their resulting information, are posted at their web page (http://sci.odu.edu/gmsa/about/completeworkshops.shtml). After completing the workshops, the data are reviewed and released, either for scientific publications or on the Red List online. More detailed information is generally posted at the GMSA website.

CoML will estimate the total number of species, in some cases on a global scale and in others in relation to the different realms and zones or field projects targeted in the census. These include nearshore, continental shelves and margins, abyssal plains, polar seas, coral reefs, mid-ocean ridges, seamounts, vents and seeps, regional ecosystems, top predators, zooplankton and microbes. Three other census projects focus on:

a. Oceans Past (History of Marine Animal Populations), which is an interdisciplinary research project using historical and environmental archives to analyze marine population data before and after significant human impacts on the oceans;
b. Oceans Future (Future of Marine Animal Populations), which aims to synthesize census-generated information and develop mathematical ecosystem models to predict future changes in marine animal populations caused by environmental and human influences; and
c. OBIS, the census' web-based provider of GIS on marine species. Historical data from Oceans Past is being integrated into OBIS to

illustrate patterns over large areas and time scales and to cover more forms of life.

Another census working group monitors new technologies for observing marine life and recommends those appropriate for routine use in field projects. Based on a pilot project off British Columbia, Canada, CoML is planning an expanded network of 5 000 sensors spanning 14 ocean regions to monitor marine life and ocean conditions, including water temperature, salinity and light conditions. The sensors will house seafloor acoustic receivers, satellite receivers and computer tags on species (UNGA Doc. A/62/66, 2007, para. 102).

Whales

The IWC's SC provides best estimates of whale populations and associated confidence levels together with the year(s) to which the estimate applies. In addition, in-depth evaluations have been/are being carried out for certain whale stocks on current stock size, recent population trends, carrying capacity and productivity. The SC's detailed annual report also assesses the effects on cetaceans of such impacts as entanglement, pollution, climate change and whale watching. The report also specifies further research needs. Nevertheless, it does not appear that there have been any comprehensive, global assessments for cetaceans. The IWC annual report and stock estimates are available at www.iwcoffice.org but the data are not available. An additional resource maps the worldwide distributions of marine mammals (Kaschner and others 2006).

Small cetaceans

A 2004 IUCN SSC review undertaken for the CMS summarizes available knowledge on the distribution and migration of 71 small cetacean (toothed whale) species, their behavior and threats to them. Its purpose was to develop recommendations for species to be included on CMS Appendix II. Priority threats identified are direct catch, by-catch, pollution at sea and, to a lesser extent, the effects of habitat degradation (Culik 2004).

Dugong

A UNEP global status report for the dugong was unable to determine trends, because their numbers are not known or are poorly documented in current locations. It notes, however, anecdotal evidence of declines in the recent past from what was a conspicuous and widely distributed species. The report identifies several factors which contribute to the decline of dugong

populations, including their slow population turnover (about 5 per cent per year), their high susceptibility to over-exploitation and human-derived impacts (e.g., pollution, boating, habitat degradation), high mobility across jurisdictional boundaries and their specialized dependency on seagrasses (also in decline – see section below on habitats). Furthermore, the report identifies social, cultural and management constraints for effective conservation and suggests optimum conservation strategies to address all three (Marsh and others 2002).

Sea turtles

The State of the World's Sea Turtles (SWOT) is a partnership led by Conservation International (CI) and the IUCN Marine Turtle Specialist Group (MTSG), which brings together a network of more than 400 conservationists who contribute data to the SWOT database, providing a global perspective of sea turtles. This database includes species-specific status reports, online distribution maps, research gaps and priorities. It also provides recommendations for sea turtle conservation. The target audience is mainly coastal communities, policy-makers, fishers and the broader public. SWOT work has identified the main global threats and hazards for sea turtles, which include fishing and harvesting, coastal development, pollution and pathogens as well as global warming. It has also identified clear priorities for key species facing extinction (http://www.seaturtlestatus.org).

Seabirds

To date there have been no global assessments or syntheses on the status and threats of all seabirds. However, in most cases, the species-specific entries in the Birdlife International database provide this information.

A global assessment on the status and future of penguins identified that since 2000, 70 per cent of the 17 species have been listed as threatened or endangered on the basis of the IUCN Red List categories (Woehler and others 2008). Also, 12 species show a clear decrease in their breeding populations, which has been caused by multiple factors, including climate change, competition with fisheries and by-catch, introduced predators, coastal development, pollution and diseases. This assessment also identifies the main priorities for research and conservation.

Chondrichthyans (Sharks and Rays)

A global study of the conservation status of migratory sharks was prepared by the IUCN Sharks Specialist Group (SSG) in 2007 for the CMS

(IUCN/CMS Technical Series No. 15, 2007). This builds on an FAO report indicating that up to 90 per cent of all migratory shark stocks are fully exploited, over-exploited or depleted (Maguire and others 2006). A database created for the CMS secretariat covers migratory sharks, skates and rays. These resources were developed in preparation for CMS consideration of a global instrument on migratory sharks in December 2008. (Migratory sharks under CMS are those which move between nations.) The migratory sharks study is also relevant for implementation of the FAO International Plan of Action for the Conservation and Management of Sharks and the UN Fish Stocks Agreement, implemented through RFMOs and national measures. The study identifies over-exploitation through both target and by-catch fisheries as the greatest threat to shark stocks. Additional threats include habitat degradation and loss, entanglement in marine debris and the depletion of the sharks' prey species. The report also surveys global and regional legal instruments associated with conservation and management of migratory sharks and, to some extent, national measures, and suggests further options for conservation. It notes that data gaps make it impossible to identify conclusively all those sharks qualifying as migratory. It also notes that there are gaps in data on direct take and by-catch in fisheries, as well as on critical breeding and aggregation sites for migratory sharks.

Teleosts (Groupers and Wrasses)

The groupers comprise approximately 160 currently recognized species. In 2007, the IUCN Specialist Group (SG) on groupers and wrasses held a workshop in which 139 grouper species were assessed. Based on the IUCN criteria, the total number of groupers assessed as threatened was increased from 12 to 20 and many other species were identified as near-threatened (www.hku.hk/ecology/GroupersWrasses/iucnsg/Pubs.htm). Despite the fact that most species of groupers and wrasses produce large numbers of eggs each year, population growth rates are slow and evidence is growing that many species can withstand only light levels of fishing pressure. The high value of many species, however, makes them a particularly appealing target. Fishing is not only directed towards adults; juveniles are also taken as ornamentals and for aquaculture. In Southeast Asia, millions of juveniles are targeted annually to supply the aquaculture industry. The SG began the conduct of a global assessment of wrasses in December 2008. The practice of targeting spawning aggregations, both in the western tropical Atlantic and the Indo-Pacific, is considered to be

a particular threat. Many of the larger species aggregate to spawn for short periods and at specific locations each year, and these aggregations evidently represent all annual reproductive activity. These are vulnerable bottlenecks in the life history of many species and need to be protected or managed (www.scrfa.org).

4.3 Important Habitat/Critical Area Assessments

A four-volume study titled A Global Representative System of Marine Protected Areas (MPAs) conducted by IUCN/WCPA was published in 1995 in association with the World Bank and the Great Barrier Reef Marine Park Authority (GBRMPA) (Kelleher and others 1995). This report listed existing marine protected areas in each of the 18 major biogeographic regions of the world, assessed biodiversity and threats and included general recommendations relating to the protection and sustainable use of marine biological diversity. In 2008, UNEP-WCMC/WCPA/IUCN launched a revised world database on protected areas (WDPA) as a foundation database containing GIS for conservation and decision- making (www.wdpa-marine.org).

Seagrasses

The most updated overview on the world's status of seagrasses was done by Green and Short (2003), in the form of an atlas which covers most available information on seagrass species. This was prepared by UNEP-WCMC and provides information on distribution, importance to nature and human society, impacts, threats and management measures for their protection. This assessment produces important spatially-explicit datasets and digital maps on species distribution. Major findings are that there is an estimated 177 000 square kilometers (km^2) of seagrass cover, although in view of the lack of, or poor information in Southeast Asia, West Africa and eastern South America this estimate is considered low. The main sources of impact include turbidity, nutrient loads, direct damage and removal. The effects of climate change remain undetermined, but they are expected to be negative because of changes in sea level, tidal cycling, ultraviolet radiation and salinity. The suggested conservation measures include the expansion of MPAs and stricter control and reduction of land-based pollution and coastal development (Green and Short 2003). A review and update of this work by the UNEP-WCMC is underway.

Mangroves

Spalding and others (1997) completed a first World Atlas of Mangroves in 1997, followed by a major thematic assessment in a report titled The World's Mangroves 1980-2005 (FAO Forestry Paper 2007). Although the latter is not a spatially-explicit atlas, it is based on current information, including national and sub-national datasets along with an updated compilation of estimates of the area covered by mangroves for 124 countries and analyses of historical data to provide country-specific forecasts to 2005. The report identifies major threats as coastal development for aquaculture, agriculture, infrastructure and tourism as well as population pressure, together with solutions based on integrated coastal area management. The effects of climate change on mangroves are not covered by the FAO assessment, but an IUCN report identifies the likely synergistic impacts and consequence of climate change on mangrove ecosystem resilience, where changes in sea level present the major challenge, followed by precipitation, flooding and the high frequency and intensity of cyclones and hurricanes (McLeod and Salm 2006). This report also provides a framework to enhance mangrove resilience to climate change and lists best practices for conservation and management of mangroves. A revised World Atlas of Mangroves is in preparation (due in 2009) by a consortium of partners (FAO, ISME, ITTO, UNESCO-MAB, UNEP-WCMC and UNU-INWEH) and is expected to generate new spatial data for mangroves.

Coral reefs

The 2004 Status of the Coral Reefs of the World report was produced jointly by GCRMN (Wilkinson 2004), following release of the first World Atlas of Coral Reefs in 2001 (Spalding and others 2001). An updated Status of the Coral Reefs of the World (Wilkinson 2008) identifies global, regional and local themes which are placing pressure on and threatening coral reefs and provides a detailed status report in the 17 GCRMN regions. The report also synthesizes recommendations from the 96 participating countries to conserve and manage their coral reef resources. It states that human-derived impacts are the primary direct cause of the global coral reef crisis. The major stresses, in addition to natural impacts include direct human pressures such as sedimentation and nutrient pollution from the land, over-exploitation and destructive fishing practices, engineering modification of shorelines as well as the global threat of climate change causing coral bleaching and rising sea levels and potentially threatening the ability of corals to form skeletons in more acid waters. Other threats include diseases,

plagues, invasive species and management failures. Reefs at Risk Revisited (due in 2009) is a map-based indicator of threats to reefs produced by WRI, UNEP-WCMC and the International Coral Reef Action Network (ICRAN) which will update a 1998 analysis.

Kelp forest

Two scientific reviews have been conducted on kelp forests. The first, Steneck and others (2002), addresses the current conditions in which kelp forests develop globally and where, why and at what rate they become deforested. The second, Steneck and others (2008), reviews how kelp forest ecosystems have changed at very large spatial and temporal scales to allow an appreciation of future states. No socio-economic data have been included. A wide range of threats is identified, including direct threats and impacts produced by destruction and thinning by storms, competitors and herbivores. Kelp deforestation worldwide results from sea-urchin grazing, which is a consequence of human harvesting of top predators (mostly fishes and lobsters). Additionally, kelp forests are expected to be highly susceptible to global climate change, in particular because they are physiologically constrained by low light at high latitudes and by nutrients, warm temperatures and competing macrophytes at low latitudes. Pressures from human population growth, coastal development, oil spills, fisheries-induced impacts, disease and alien invasive species (AIS) will also continue and possibly accelerate over time. Management measures to restore kelp forest ecosystems and minimize fishing on top predators are suggested.

4.4 Open Ocean/Deep Seas

The ISA, in collaboration with an international group of scientists and support from the J.M. Kaplan Fund, is undertaking studies to determine the diversity of sediment-dwelling species in abyssal areas, the levels of species overlap in the areas studied and their diversity in relation to the fauna of continental margins. The scientists recently developed specific recommendations regarding the establishment of marine protected areas to safeguard biodiversity in the Clarion-Clipperton Zone once mining begins (ISBA/13/A/2 2007).

Several reports produced variously by the government of Australia, IUCN, UN/DOALOS, the CBD Secretariat and UNEP review the types of environments/habitats found in the open/deep oceans such as hydrothermal vents, seamounts, abyssal plains, submarine canyons and open ocean hotspots, human activities which are expanding into these areas, the threats posed by current and potential future human activities

and, in some cases, the evolving legal and policy regime and potential best practices to address threats (WWF/IUCN/WCPA 2001; Butler and others 2001; UNEP/CBD/WG-PA/1/INF/1, 2005; UNEP 2006a; UNEP/CBD/SBSTTA/13/INF/13, 2008; UNEP/CBD/SBSTTA/13/4, 2007; UNGA A/62/66, 2007 and A/62/66/Add.2, 2007).

The UNEP-WCMC report of Freinwald and others (UNEP 2004) provides a good description, mapping and characterization of cold-water coral reefs and identifies bottom trawls and heavy fishing gear as the major threats. It lists that potential sources of impact are hydrocarbon and mineral exploration and production as well as cable and pipeline placement and repair, and dumping. A further UNEP report focuses on potential valuation of deep-sea goods and services, knowledge gaps and strategic research needs so that decision-makers better understand the effects of aggregate human impacts on these goods and services, including indirect impacts such as those resulting from climate change, how to take into account the value of these goods and services, and the issues and constraints affecting governance and management of these areas (UNEP 2007).

Another specialized report on seamounts, which was carried out under the auspices of the CoML, summarizes data and information on the global distribution of seamounts and deep-sea corals on seamounts and their occurrence. It qualitatively assesses the vulnerability of corals and, by proxy the diverse assemblages of other species, to the impacts of trawling on seamounts beyond areas of national jurisdiction. It highlights information gaps for development of risk assessments to seamount biota globally (UNEP 2006b). See also Seamounts online at http://seamounts.sdsc.edu.

A major 2007 report for the CBD pulls together information from the best available scientific studies on priority areas for biodiversity conservation in marine areas beyond the limits of national jurisdiction. This reviews and cites numerous studies of seamounts, cold water corals, hydrothermal vents, pelagic habitats and benthic habitats such as sponge reefs and cold seeps. It covers the global distribution and status of these areas, threats to them, functioning of the systems and the ecology of associated species (UNEP/CBD/SBSTTA/13/INF/11, 2007). A related report reviews spatial databases containing information on marine areas beyond the limits of national jurisdiction and the development of an Interactive Map (IMap). The IMap is an interactive geographically-based information system prepared in collaboration with UNEP-WCMC (UNEP/CBD/SBSTTA/13/INF/12, 2008) to aggregate and display data and information for

biodiversity-related assessments. These reports relate to ongoing work under the CBD on criteria for identifying significant marine areas in need of protection, selecting areas to establish representative networks of MPAs and biogeographic and ecological classification systems for delineating ocean regions and ecosystems (Cheung and others 2005; Preliminary Mexico City scientific experts' workshop report January 2007; UNEP/CBD/COP/8/1/INF/16, 2006; UNEP/CBD/COP/8/INF/39, 2006; Spalding and others 2007; UNEP/CBD/SBSTTA/13/INF/14, 2007; UNEP/CBD/SBSTTA/13/INF/19, 2008. See the Global Open Ocean and Deep Seabed (GOODS) Biogeographic Classification (UNESCO 2009) and also covered by the GOODS supra-regional summary in this annex.) UNEP-WCMC is preparing a second iteration of IMap to promote the use of this online mapping tool for identifying ecologically or biologically significant marine areas in open ocean and deep sea environments in collaboration with other international and intergovernmental organizations.

The 5th International Conference on Environmental Future (ICEF) produced a book on the status and future of aquatic ecosystems (Polunin 2008). Prepared by the Foundation for Environmental Conservation (FEC), it synthesizes information on all aquatic ecosystems, both marine and freshwater. It differs from other approaches by including all of Earth's water bodies, including nine major ocean ecosystems. Based on review and synthesis by expert groups, it brings together collective knowledge and represents a scientific consensus on the status and future of each aquatic ecosystem over a time horizon to 2025. It also provides an objective basis for designing environmental strategies and actions at a global level, largely to respond to deliberations of the Intergovernmental Panel on Climate Change (IPCC) focusing on the water-based ecosystems of the world.

4.5 Marine Genetic Resources

As a result of recent international discussions on marine genetic resources in areas beyond national jurisdiction, several reports by UN/DOALOS, the CBD Secretariat, and UNU-IAS identify and summarize what is known of the recovery and use of marine genetic resources in general, with some reference to areas beyond national jurisdiction, their existing and potential value, threats to them and impacts caused by their recovery, and legal and technical options associated with their conservation and sustainable use (UNGA A/60/63/Add.1, 2005; UNEP/CBD/SBSTTA/11/11, 2005; UNU-IAS 2005; UNEP/CBD/SBSTTA/13/4, 2007; UNGA A/62/66, 2007; UNU and UNESCO-MAB 2007).

5. PRIORITIZED ISSUES

For open ocean/deep sea areas, many of the reports and studies in section 3.4 placed the highest priority on the current impacts of fishing activities. The effects of climate change on marine species are another clear priority.

A GESAMP report on pollution in the open ocean cites as priorities atmospheric inputs of nitrogen and carbon dioxide and their possible roles in acidification and ecosystem function, including the long-term effects of ocean acidification on marine organisms, with an emphasis on calcifying species. The report also calls for attention to developments in the field of carbon storage in the open ocean and the proposed use of iron and nitrogen to fertilize the oceans, thereby stimulating algal growth and drawing down CO_2 from the atmosphere. Two other areas noted in the report are the need for further monitoring of, or research into noise levels, their sources, and their impacts, notably on cetaceans and other marine organisms which communicate by sound, and systematic sampling of marine debris at strategic mid-ocean locations (GESAMP 2008).

6. CAPACITY OF INSTITUTIONS FOR GLOBAL BIODIVERSITY ASSESSMENTS

The majority of global marine biodiversity assessments (excluding those on fisheries) concentrate on sensitive habitats in nearshore areas such as coral reefs, seagrasses and mangroves, and on endangered and threatened marine species. These assessments pull together information from national and regional assessments, which are limited by the varying capacity of national institutions to collect data and undertake assessments within national jurisdiction. Multi-sector impact assessments, if they exist at all, are generally limited to established protected areas. A few assessments consider socio-economic aspects, notably the loss and degradation of sensitive habitat in coastal areas. There are no global syntheses which relate small-scale sensitive habitats and/or endangered/threatened species to larger, regional scale ecosystems. At the national level, collaboration with NGOs and intergovernmental organizations (IGOs) in some countries has expanded assessment activities related to priority sites for biodiversity conservation.

For marine species, the capacity to assess the great whales is well-established through the IWC. The IUCN Red List process is recognized as authoritative for other marine mammals, seabirds, sharks and rays. As noted in 3.2, the sea turtle assessments have significant limitations. Beyond these, the vast majority of marine species have not been assessed,

although there are several current initiatives to improve knowledge of marine species and their conservation status and to address major gaps in global assessments for highly diverse groups such as marine invertebrates, algae and zooplankton (e.g., GMSA, CoML, Project GloBAL).

For the open ocean/deep seas, there are no comprehensive global biodiversity assessments. Most assessments focus on a single species or habitat community and are not integrated across ecosystem components. Multi-sectoral impact assessments are limited to a few threatened/endangered species and have significant data deficiencies. Even in the fisheries sector, full knowledge of the impacts on non-target fish and other species, including seabirds, marine mammals and sea turtles, is severely limited by data deficiencies on by-catch from both legal and illegal, unreported and unregulated (IUU) fishing. There are major knowledge gaps regarding important habitat and benthic communities and impacts on them because very few locations have been studied in depth. For example, it is estimated that there are more than 100 000 seamounts in the world's oceans, but fewer than 200 of them (less than 0.001 per cent) have been studied in detail.

CBD initiatives to pull together current knowledge on open ocean/deep sea biodiversity noted above represent an important resource for assessment purposes. These include the synthesis and review of best available scientific studies on priority areas for biodiversity conservation in marine areas beyond the limits of national jurisdiction (UNEP/CBD/SBSTTA/13/INF/11, 2007) and its related website at www.biodiv.org/programmes/areas/marine/research.html as well as the CBD/UNEP- WCMC collaboration on IMAP (UNEP/CBD/SBSTTA/13/INF/12, 2008).

There are numerous publications in the scientific literature and other reviews and reports which contain information relevant for global biodiversity assessments, not all of which could be addressed in this document. The institutions in a position to complete global reports and syntheses are usually intergovernmental bodies, including UNEP, FAO, UN/DOALOS and convention secretariats such as the CBD and CMS, either working independently or in collaboration with international conservation organizations. These conservation organizations are also in a position to complete global reports. There are a number of scientific bodies from government agencies, international research initiatives and others engaged in research in global biodiversity assessments, but the capacity to undertake comprehensive, multi-sectoral assessments in the open ocean/deep seas is

limited by available knowledge, research platforms and funding. Despite this, there is substantial collective capacity to advance such assessments through UN organs such as UNEP, FAO together with RFMOs, the scientific networks of GESAMP and the IUCN Red List process, convention-based processes such as the IWC and CBD and international research programmes such as the CoML and Project GloBAL. What is missing is an initiative and a mechanism to design, conduct and coordinate an assessment drawing on available knowledge and expertise to identify practical ways to expand knowledge and shape further assessments drawing on lessons learned.

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Pollution from Land-based Activities

Michael E. Huber

1. INTRODUCTION

The Global Programme of Action for the Protection of the Marine Environment from Land-Based Activities (GPA) (UNEP 1995) was adopted by governments in 1995 in recognition that most anthropogenic inputs of contaminants, and many physical impacts on coastal and marine habitats, result from human activities on land. The GPA targets eight categories of contaminants, sewage, persistent organic pollutants (POPs), radioactive substances, heavy metals, oils (hydrocarbons), nutrients, sediment mobilization and litter. The GPA also addresses the category of physical alteration and destruction of habitats (PADH), which is not covered in this summary but is addressed in the supra-regional summaries on Coastal development – urban development, tourism and coastal zone management and Marine biodiversity assessments (available in Annex V).

Most contaminants targeted by the GPA do not undergo long-range atmospheric transport, and have effects on local or, at most, regional scales. They are global issues in the sense that they are globally widespread, but assessment and management tend to be primarily at regional and sub-regional levels. This summary does not attempt to describe the various regional assessments relating to the GPA contaminant categories, and addresses only global assessment activities.

2. INSTITUTIONS UNDERTAKING ASSESSMENTS

The UN Environment Programme GPA Coordination Office (UNEP/GPA) acts as the secretariat for the GPA and coordinates and facilitates its activities, including a GPA Clearing House of information relevant to the GPA contaminant categories, with specific nodes for many categories. UNEP/GPA has also commissioned some assessment and related activities.

The Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) is an independent scientific advisory body which is sponsored by eight UN agencies[1]. GESAMP's mission is "*to provide authoritative, independent, interdisciplinary scientific advice to organizations and Governments to support the protection and sustainable use of the marine*

1 IMO, FAO, UNESCO-IOC, WMO, IAEA, UN, UNEP, and UNIDO

environment". GESAMP has a mandate to conduct regular assessments of the state of the global marine environment and to support improved assessments by providing advice and guidance. GESAMP works mainly through specialist working groups established to conduct specific studies.

GEMS/Water is part of the Global Environmental Monitoring System (GEMS) housed in UNEP. GEMS/Water maintains a global database on freshwater quality called GEMStat and supports capacity building in the acquisition and management of freshwater quality information.

The UN Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) was established by the UN General Assembly (UNGA) in 1955 to assess levels and effects of exposure to radiation. Twenty-one countries designated by the UNGA provide scientists to UNSCEAR, which has a small Secretariat linked to UNEP. UNSCEAR meets annually.

The Sanitation Connection (http://www.sanicon.net/gpa/index.php3) is a partnership of the World Health Organization (WHO) with a number of organizations which have expertise and interests in water supply and sanitation. The Sanitation Connection is strongly linked to monitoring and assessment activities related to the Millennium Development Goal (MDG) of halving the proportion of the global population without access to improved sanitation by 2015, including the World Health Organization and the UN International Children's Fund (WHO/UNICEF) Joint Monitoring Programme (JMP) for Water Supply and Sanitation.

The UN World Water Assessment Programme (WWAP) is the flagship programme of UN Water, which is the UN mechanism for following up on the MDGs relating to water. UN Water is a partnership of a range of UN agencies, institutions and non-governmental organizations (NGOs) with water-related interests and activities.

The United States of America National Research Council (NRC), which is the working arm of the US National Academies of Sciences and Engineering and the US Institute of Medicine, draws on members of those bodies to carry out studies with the aim of supporting government decision making and public policy. NRC establishes specialist committees to conduct its studies.

The Land-Ocean Interactions in the Coastal Zone (LOICZ) project is a joint research project of the International Geosphere-Biosphere Programme (IGBP) and the International Human Dimensions Programme (IHDP). The project

involves a global network of scientists investigating the biology, chemistry and physics of the coastal zone and relating this information to human dimensions.

The Global Partnership on Nutrient Management (GPNM) was formed at an informal brainstorming meeting in June 2007 which was organized by UNEP/GPA and the Netherlands Ministry of the Environment (VROM). As well as these partners, GPNM includes additional intergovernmental and national agencies, the Global Environment Facility (GEF) and the International Fertilizer Industry Association (IFA), which is the trade association for the fertilizer industry. The lead partner for assessments is the International Nitrogen Initiative (INI).

INI is an international programme established to maximize the benefits of nitrogen and minimize associated problems. It is sponsored by the Scientific Committee on Problems in the Environment (SCOPE), IGBP and VROM, with a core office at the University of Virginia in the US and regional centres in Africa, Asia, Europe, Latin America and North America. INI is actively involved in a number of assessment and policy activities in partnership with other initiatives, including the Global Nitrogen Enrichment (GANE) research programme, SCOPE, and the Woods Hole Research Center (WHRC).

The WHRC is a non-profit research, policy and education organization dedicated to understanding the causes and consequences of environmental change and promoting policies which protect the integrity of the global environment.

The UNEP Global Initiative on Marine Litter provides a framework for the assessment and improved management of marine litter. The initiative is a partnership of individual regional seas organizations, governments, UN bodies, donors, the private sector and NGOs.

3. DATA

There is no single repository of data relating to all the GPA contaminant categories.

The GEMStat database includes data on approximately 100 water quality parameters in major watersheds around the world. Many of these parameters correspond to, or relate to the GPA contaminant categories, although global coverage is variable across parameters. The GEMS/Water data reflect inputs to the marine environment from major rivers, but not direct inputs from coastal activities or inputs through groundwater discharge. The

GEMStat database is available online, but currently can be queried only by individual monitoring station. GEMS/Water gives a high priority to developing more powerful data summary and analysis capabilities for the GEMStat database but this is dependant on the availability of resources (S. Barker, pers. comm.; R. Robarts, pers. comm.).

3.1 Sewage

The WHO/UNICEF JMP for Water Supply and Sanitation was established to monitor progress toward achieving the MDG target to halve the proportion of people without access to basic sanitation by 2015 (WHO/UNICEF 2000, 2004, 2006). Although the fundamental indicator of access to improved sanitation addresses progress toward the MDG, and thus human health impacts of exposure to sewage-borne pathogens and other contaminants through terrestrial food production and freshwater supply, it does not address the environmental impacts of sewage discharges to marine waters, or human health impacts through the secondary pathway of contamination of seafood with sewage-borne pathogens.

UNEP/GPA (2002, 2003, 2004) summarized and analysed JMP data for 15 regional seas areas from the perspective of the need for, and feasibility of, setting regional emissions targets. This series of reports includes an inventory of available data at regional and national levels, including indicators of inputs, contaminant loads, investment in sanitation and sewage treatment and management frameworks.

The GEMStat database contains data on a number of sewage-related parameters, including nitrogen, phosphorus, biological oxygen demand and pathogens which are relevant to domestic sewage. The database also includes data on other sources such as agricultural and industrial emissions and urban run-off.

WHO maintains a database on the Global Burden of Disease (GBD) from a range of diseases, but does not include data which allow assessment of the possible contribution of sewage contamination of the marine environment causing outcomes such as diarrhoeal diseases from consuming contaminated seafood and upper respiratory infections from bathing in contaminated waters.

3.2 POPs

UNEP Chemicals (1999) compiled an inventory of international and national sources of data and information about POPs. UNEP Chemicals is

also facilitating the development of a global POPs monitoring programme to support the evaluation of the effectiveness of the Stockholm Convention.

The GEMStat database includes data on a number of POPs in some major rivers. GEMS/Food maintains a Chemical Contaminants in Food database which includes POPs in seafood (http://sight.who.int/). The database can be searched by chemical, food item, country and year.

3.3 Radioactive substances

The International Atomic Energy Agency Marine Environmental Laboratory (IAEA-MEL) maintains a Marine Information System (MARIS, http://maris.iaea.org), which is an online Geographic Information Systems (GIS) database that includes data on concentrations of radionuclides in the marine environment as well as oceanographic data such as temperature, salinity and bathymetry. MARIS replaces the IAEA-MEL Global Marine Activity Database (GLOMARD). IAEA-MEL has also developed and maintains inventories of radioactive waste disposals at sea (IAEA 1999) as well as accidents and losses at sea involving radioactive material (IAEA 2001).

The UNSCEAR Secretariat collates data relating to radiation which is provided by Member states, international organizations and NGOs. UNSCEAR prepares annual scientific reviews of the data.

3.4 Heavy metals

No global databases for multiple metals in the marine environment were identified, and available assessments of inputs, concentrations and impacts of metals in the marine environment are largely based on the primary scientific literature. The GEMS/Water GEMStat and GEMS/Food Chemical Contaminants in Food databases include data on metals in some major rivers and seafood items, respectively.

The UNEP Chemicals Mercury Programme has collated trade statistics and information supplied by governments and other stakeholders relating to trade in mercury and has prepared a summary report (UNEP Chemicals 2006). The data behind the summary are available online. The Mercury Programme has also developed a global inventory of mercury emissions to the atmosphere. The Global Mercury Watch (http://www.unites.uqam.ca/gmf/intranet/gmp/index_gmp.htm), which is an initiative of the UN Industrial Development Organization (UNIDO), the United Nations Development Programme (UNDP) and the GEF, is developing a database of

mercury emissions from artisanal small-scale gold mining including emissions on a country-by-country basis.

3.5 Oils (Hydrocarbons)

Environmental Research Consulting (ERC) is a commercial consulting firm which maintains an oil spill database containing data on spills from land-based coastal facilities such as refineries. The data are obtained from the International Maritime Organization (IMO), the International Tanker Owners Pollution Federation (ITOPF) and various national and regional agencies. According to the US National Research Council (NRC 2003), the ERC data are not systematically collected and do not include spills of less than 10 000 gallons (34 tonnes), and therefore should be regarded as underestimates of oil inputs to the marine environment from spills.

The GEMStat database includes data on hydrocarbon levels in major rivers.

3.6 Nutrients

The GEMStat database includes data on nitrogen and phosphorus levels in major rivers, with the most complete coverage being for inorganic nitrogen oxides. The Netherlands National Institute for Public Health and the Environment (RIVM) and the UN Framework Convention on Climate Change (UNFCCC) compile data on atmospheric emissions of nitrogen oxide (NOx). FAO and the IFA compile data on fertilizer production and consumption. IFA has also established a task force on reactive nitrogen.

A prototype GPA Clearing House node for nutrients, established by FAO in 2000, provides overviews of information and a bibliography on nitrogen and phosphorus in marine waters in different regions. This Clearing House node, however, does not appear to be actively maintained and the provision of information on nutrients now appears to be through GPNM.

LOICZ has compiled nutrient data and modeled budgets for many coastal areas of the world and the budgets, along with some data are available online. (http://nest.su.se/mnode/).

The Global Nutrient Export from Watersheds (Global NEWS) project is an international working group sponsored by UNESCO-IOC, UNEP, the US National Science Foundation and the US National Oceanic and Atmospheric Administration (NOAA), with support from GEF. Global NEWS is also affiliated with LOICZ. Global NEWS focuses on preparing spatially explicit models of nutrient and sediment export from watersheds

to coastal waters, in the framework of Large Marine Ecosystems (LMEs). It also focuses on linking the river loads to quantitative assessments of coastal ecosystem health. The Global NEWS models are based on a variety of global datasets, the majority of which are provided by the Netherlands Environmental Assessment Agency (MNP) and the Water Systems Analysis Group (WSAG) at the University of New Hampshire. Global NEWS plans to make the data available online.

3.7 Sediment mobilization

FAO maintains an online global database of annual sediment yields from rivers as well as rainfall, runoff and catchment size. The database can be queried by river, country and/or continent. (http://www.fao.org/AG/AGL/aglw/sediment/default.asp).

Global NEWS modeling includes estimates of global sediment fluxes from rivers to coastal marine systems, as described above for nutrient export from watersheds to coastal waters.

3.8 Litter

No global databases on marine litter inputs from land-based activities (LBAs) were identified. National and regional data on marine litter are in large part generated from spot surveys of beaches, and to a much lesser extent, spot surveys of marine areas. Monitoring of marine litter is often carried out at the local level by NGOs and community groups, with varying methodologies and monitoring frequencies. Available data generally do not explicitly distinguish land-based and sea-based sources, although they often do categorize litter items such as plastic bags and rubber footwear in a way that can be associated with land-based sources.

The lack of adequate data on marine litter was recognized by the UNGA in its resolution 60/30, which notes "*the lack of information and data on marine debris and encourages relevant national and international organizations to undertake further studies on the extent and nature of the problem*". In response, UNEP and UNESCO-IOC have recently produced guidelines for the survey and monitoring of marine litter (Cheshire and others 2009).

4. ASSESSMENTS

As is the case for other environmental assessments, global assessments of marine pollution from LBAs may address some or all of the activity sectors which mobilize contaminants (drivers/pressures environmental fluxes),

levels of contaminants and the status of habitats (state) and the impacts of pollution on ecosystems and human well-being (impacts). For contaminants with sea-based as well as land-based sources, however, impact assessment is not generally restricted to consideration of only LBAs, because once contaminants are introduced into the environment their impacts for the most part are not dependant on their source.

4.1 Assessments addressing multiple contaminant categories

GESAMP (2001a) addressed the impacts of LBAs on the marine environment in the specific context of the GPA. Initiated by UNEP as an input to the first intergovernmental review of the GPA, the GESAMP assessment addresses drivers and pressures, and also presents, and in some cases forecasts, the state of the marine environment and ecological, socio-economic and human health impacts. It also describes available strategies and measures to reduce, prevent or reverse degradation. The GESAMP (2001a) assessment was conducted by an expert working group. It is based in part on a synthesis of a series of 15 regional reports produced by regional seas organizations, either as part of their regular work programmes or under the auspices of the GPA, but, to a large extent, also on primary literature, other available assessments and expert opinion. An accompanying summary assessment report aimed at policy-makers and the interested public, A Sea of Troubles (GESAMP 2001b), was not limited in scope to LBAs but was based in large part on the more technical LBA report (GESAMP 2001a). A Sea of Troubles has been widely cited in both peer-reviewed and grey literature, as well as in international policy documents. This influence appears to result in large part from the concise, straightforward language of the assessment, which in turn can be partly attributed to final editing of the report by a professional environmental journalist. GESAMP also produced two previous assessments of the state of the global marine environment (GESAMP 1982, 1990). These assessments were not conducted specifically in the context of the GPA categories but do address all categories. Although GESAMP's three major global assessments (GESAMP 1982, 1990, 2001a) progressively built on the preceding assessments, in terms of process, essentially they were produced as individual one-off assessments.

GESAMP's various thematic studies also address all of the GPA contaminant categories in varying levels of detail. The studies consider individual categories or sub-categories (for example, nutrients and groups of metals, as

well as specific aspects of multiple categories (for example, carcinogens in seafood and atmospheric inputs). These studies have been produced over a period of more than 30 years and some, at least, are likely to require updating. Currently, GESAMP has active Working Groups updating the previous reports on mercury (GESAMP 1986) and on atmospheric inputs (GESAMP 1990). All GESAMP studies are freely available for download (http://www.gesamp.org).

UNEP/GPA (2006) provides an overview of status and trends for each of the GPA categories, largely as a summary of regional assessments prepared by persons from the respective regions. Research and compilation for the global assessment was performed by a consultant commissioned by UNEP/GPA and peer review was provided by two external reviewers and a LOICZ/UNEP workshop on the state of the marine environment in regional seas. UNEP/GPA (2006) was a one-off assessment.

The Global International Waters Assessment (GIWA) Final Report (UNEP 2006) is a synthesis, prepared by the GIWA Secretariat, of 77 reports prepared for individual GIWA regions, which correspond approximately to LMEs and other regional seas areas. GIWA did not address the open ocean. The assessment is framed in terms of GIWA concerns rather than the GPA categories, although reconciliation of the two frameworks is mostly straightforward. GIWA separated nutrient, microbiological and toxicant (chemical) pollution, for which sewage is an important source, while the GPA considers sewage as a contaminant and not a source. Conversely, the GPA contaminant categories of POPs, heavy metals and hydrocarbons are more specific than GIWA's synthesis-level category of chemical pollution.

The GIWA global synthesis addresses the main drivers and pressures, and presents, and in some cases forecasts, the state of the marine environment and ecological, socio-economic and human health impacts. It also addresses, arguably with inconsistent coverage, some management and mitigation measures. The GIWA regional assessments were based on a formalized methodology which attempted to provide inter-comparability among the regions with a very wide range of underlying data ranging from expert opinion to significant long-term datasets, depending on the region and the issue. The GIWA network established for the project consisted of regional nodes and the GIWA Secretariat. The network functioned in a primarily vertical mode, with communication mainly between the nodes and the global secretariat and little substantive horizontal interaction among nodes. The GIWA network has no ongoing institutional or organizational

basis, although contact information for focal institutions and regional experts are held by UNEP and might serve as a starting point for establishing functional, institutionally sustainable networks. GIWA was undertaken as a one-off GEF project, although its extension as an ongoing programme was considered when the project ended. A successor project, the Transboundary Waters Assessment Programme (TWAP), is being developed by GEF.

The Millennium Ecosystem Assessment (MA) did not address pollution in the open ocean on the basis that human impacts on open ocean ecosystems are overwhelmingly from over-exploitation of fisheries. For coastal areas, the MA provided a detailed assessment of the status and trends in the physical extent of major coastal habitat types based on the primary scientific literature and previous assessments of specific habitats. The MA also assessed human impacts on global nutrient cycles as well as approaches to nutrient management. Other forms of pollution were not explicitly and systematically covered in terms that can be directly related to the separate GPA categories, but the MA did note the impacts of sewage, metals, POPs and hydrocarbons on some coastal ecosystems. Impacts were assessed in the MA conceptual framework of ecosystem services and human well-being. Trends in major activity sectors driving environmental change were assessed, including through the use of scenarios, although the analysis was not conducted within the specific conceptual framework of the GPA. The MA was a one-off assessment at the global level which was supported by some regional and sub-regional assessments and case studies.

The WWAP has produced three World Water Development Reports (UNESCO-WWAP 2003, 2006, 2009). These reports primarily address freshwater systems although they include some consideration of coastal ecosystems. The focus on freshwater quality is relevant to sewage and nutrients, and to a lesser extent, sediments.

De Mora (2004) provides a brief review of marine pollution monitoring and assessment activities in the UNEP Regional Seas areas.

A GEF medium-sized project, Development of the Methodology and Arrangements for the GEF TWAP was approved in January 2009. The objective of the two-year project is to form a partnership among organizations to develop assessment methodology for the five categories of transboundary water systems, which include LMEs and open ocean areas, as well as arrangements for a possible assessment which applies the methodology. The assessment would then be repeated periodically

through the partnership of agencies and organizations, and would include data series collected by GEF International Waters projects. TWAP is being implemented by a partnership of UN bodies, scientific organizations and NGOs.

4.2 Sewage

The GPA Clearing House node for sewage is the Sanitation Connection. The GPA explicitly refers to sewage as domestic wastewater. Assessment of sewage as a contaminant is complicated by several factors including that domestic sewage is a variable mixture of contaminants and cannot itself be monitored in the environment as a quantifiable parameter and that the contaminants in sewage have different impacts which often are monitored and assessed separately (e.g., nutrients, organic load, pathogens). It is further complicated by monitoring and assessment activities often considering industrial and/or agricultural effluents and domestic wastewater to be sewage and the fact that sewage may include effluents with varying levels of treatment. The common dichotomy of treated versus untreated sewage, which sometimes carries the implication that treated sewage is of little concern, does not reflect the fact that different levels of treatment may be required to address the impacts of different contaminants (e.g., disinfection to protect human health versus nutrient removal to reduce eutrophication risk). In addition, the effectiveness of a nominal level of treatment can vary widely depending on the characteristics of the wastewater influent, treatment plant loadings and maintenance and other factors, for which data are not widely available. For these reasons, the GPA category of 'sewage' is not widely used in monitoring and assessment programmes, which instead tend to be based on individual constituent contaminants.

Shuval (2003) produced a preliminary, order-of-magnitude assessment of the GBD from sewage-borne pathogens in bathing waters and marine shellfish as a refinement of an initial analysis in GESAMP (2001a). Shuval's assessment was based on extrapolation of available data on levels of environmental and seafood contamination, human exposure, dose-response relationships and morbidity/mortality.

4.3 POPs

The GPA Clearing House node for POPs is UNEP Chemicals. UNEP Chemicals (2003a) provides a global synthesis of 12 regional assessments of persistent toxic substances (PTSs), which were based largely on literature review and national responses to a questionnaire. The global report

was prepared as part of the GEF-funded project titled Regionally Based Assessment of Persistent Toxic Substances (RBAPTS) Project, and was directly linked to the Stockholm Convention. The assessment included consideration of sources, environmental pathways, fates, levels and effects and policy/management responses.

Ritter and others (1995) reviewed the chemistry, toxicology, environmental fate and transport, and sources of POPs as an input to the negotiation of the Stockholm Convention.

4.4 Radioactive substances

The GPA does not have a Clearing House node for radioactive substances.

IAEA-MEL coordinated two major global assessments of radioactivity in the marine environment. The first, IAEA (1995), reports the results of a five-year study of natural and anthropogenic sources of 137Cs and 210Po concentrations in seawater and biota, and relative contributions to dose assessment. The later IAEA (2005) reports the finding of a four-year study of inputs and concentrations of radionuclides in surface water and the water column, which are reported globally by ocean basin and by latitudinal band. Both assessments were prepared by expert working groups.

UNSCEAR has produced 15 reports on sources and effects of ionizing radiation globally. Information on sources is very comprehensive, while reporting on effects is generally focused on human health and other terrestrial impacts.

4.5 Heavy metals

The GPA does not have a Clearing House node for heavy metals. Technically, there is no chemical definition of which elements are 'heavy metals', nor are they defined in the GPA. The term 'heavy metals' is variously applied in different jurisdictions and for different purposes, generally on the basis of atomic mass, toxicity, the presence of potential sources and/or analytical constraints.

No general environmental assessments of metals as a group in the marine environment were identified. Because the sources, pathways, scales of distribution, fates and effects of different metals in the marine environment vary widely, most assessments are of individual metals or sub-groups of metals. Many metals strongly associate to particulate matter in the marine environment and therefore have low bio-availability and scales of transport.

These metals are best assessed at local to, at most, regional scales. At a global level assessment logically consists of summarizing national and regional assessments. A few metals, however, in particular mercury, lead and cadmium, have high toxicity and undergo long-range transport. These metals do require assessment at a supra-regional as well as regional level.

GESAMP has reviewed the scientific aspects of cadmium, lead and tin (GESAMP 1985) as well as arsenic, mercury and selenium (GESAMP 1986) in the marine environment. A GESAMP Working Group is preparing an updated review of mercury in the marine environment. Mercury is particularly problematic because it is present in the environment in a variety of forms, with very different transport pathways, fates and toxicity. Furthermore, there are major technical issues in the analytical chemistry of measuring the concentration and speciation of mercury at environmentally relevant detection limits and in different environmental compartments including air, water, sediments and biota). Because of its long-range transport and high toxicity, particularly in organic form, mercury is being considered for listing as a POP under the Stockholm Convention.

The Global Mercury Assessment (UNEP Chemicals 2003b) is the most comprehensive review of mercury in the environment, including the marine environment. The report was prepared at the request of the UNEP Governing Council in cooperation with the UN Inter-Organization Programme for the Sound Management of Chemicals (IOMC). UNEP Chemicals coordinated the production of the report, which was drafted by consultants. There was no independent peer review of the report, but it was reviewed by an open-ended working group whose members were nominated by governments, intergovernmental organizations (IGOs), and NGOs. The report was based on information submitted by governments, IGOs and NGOs, as well as on the open scientific literature and on other information available in reports and on websites. Topics covered in the mercury assessment include sources, transport pathways and fate, transformations in the environment, chemistry and toxicology, impacts on human health and the environment, prevention and control technologies and practices, management options, and information gaps. The report is not an independent assessment as such, but rather is a global overview of other evaluations and assessments. The open-ended Mercury Working Group continues to operate under the auspices of the UNEP Chemicals Mercury Programme. GESAMP's current Mercury Working Group has close ties with UNEP Chemicals Mercury Programme's Working Group,

including some shared membership. The GESAMP group was established to address perceived gaps in coverage with respect to mercury in the marine environment.

UNEP Chemicals is undertaking reviews of scientific information about lead and cadmium through a process similar to that for preparing the Global Mercury Assessment. An open-ended Lead and Cadmium Working Group of members nominated by governments, IGOs and NGOs has been established to provide guidance and comment on review reports. Interim scientific review reports for both lead and cadmium have been produced and are available on the UNEP Chemicals website. The contents of each report include chemistry, human health, environmental impacts, sources and inputs, production and trade, long-range transport, prevention and control measures, policy and programmatic initiatives, and information gaps. The interim reviews do not state whether they were produced by UNEP Chemicals or consultants.

4.6 Oils (Hydrocarbons)

The GPA Clearing House node for oils/hydrocarbons is the Global Marine Oil Pollution Information Gateway (http://oils.gpa.unep.org), which is a joint initiative of IMO, the GPA and the Swedish Environmental Protection Agency.

The NRC has produced three assessments of inputs, fates and biological effects of oil in the marine environment (NRC 1975, 1985, 2003). The 1985 and 2003 reports identify continuing advances in methodologies and data availability for estimating oil inputs from different sources, including LBAs, although improvements in data availability have mostly been in developed countries in the northern hemisphere. NRC (2003) estimated land-based oil inputs from coastal refineries and other facilities using data from the US Coast Guard and international data in the ERC database. Correction factors were applied to the ERC data, which were considered to be under-estimates. Hydrocarbon inputs from watersheds were estimated on a detailed sub-regional basis for the US and Canada using government data, and then extrapolated to obtain regional estimates for Europe, Africa, Central America, South America, Asia and Oceania based on motor vehicle usage rates. The estimates cannot be directly related to ocean regions except in North America. Each of the NRC reports uses a different methodology. NRC (2003) observed that a lack of documentation of methodologies in NRC, GESAMP and other assessments of oil in the marine environment makes it almost futile

to compare input estimates from different reports. NRC (2003) does provide detailed documentation of data sources and methodologies used in the assessment as well as estimates for polycyclic aromatic hydrocarbons (PAHs) in addition to total petroleum hydrocarbons.

GESAMP (1977, 1993, 2007) assessed inputs, fates and impacts of oil in the sea. The first two assessments included estimation of inputs from land-based sources and a general assessment of impacts, but the scope of the most recent assessment (GESAMP 2007) was limited to inputs from sea-based sources.

4.7 Nutrients

Crossland and others (2005) synthesized the results of LOICZ studies of human influence on nutrient fluxes to coastal marine waters in a drivers-pressures-state-impacts-responses framework within the boundaries of LOICZ's role as a scientific research programme. The report includes overviews of drivers and pressures, nutrient budgets and fluxes and their changes over time, as well as impacts, on both a global and regional basis.

The Steering Committee of INI prepared a preliminary assessment of anthropogenic changes in the global nitrogen cycle and the results were published in the scientific literature (Galloway and others 2004a, 2004b).

The first Global NEWS modeling results were published in 2005 in Global Biogeochemical Cycles (vol. 19, no. 4). The results for nutrient sources and inputs are summarized by Seitzinger and Lee (2009) in the forthcoming UNEP LME Report (Sherman and Hempel, 2009).

UNEP-WHRC (2007) provides a non-technical global overview of the problem of excess reactive nitrogen in the environment, using graphics and information from previously published sources.

4.8 Sediment mobilization

The GPA refers specifically to sediment mobilization, that is, increases in sediment fluxes resulting from LBAs, but reductions in sediment flux can have adverse effects also on sediment-dependent coastal ecosystems (GESAMP 2001a). A prototype GPA Clearing House node for sediment mobilization, which was established by FAO in 2000, provides overviews of information and a bibliography relating to sediments in coastal waters in different regions and identifies some links to relevant information and data sources. The Clearing House node for sediments does not appear to be actively maintained.

Crossland and others (2005) synthesize the results of LOICZ studies of human influence on sediment fluxes, as described above for nutrients. Syvitski and others (2005) also present the results of LOICZ studies of human impacts on sediment fluxes to the coastal marine environment.

Beusen and others (2005) report the first results of Global NEWS modeling of sediment inputs to coastal marine areas.

4.9 Litter

The GPA Clearing House node for marine litter is a joint initiative of IMO, the GPA and the Swedish Environmental Protection Agency. No ongoing global assessment programmes for marine litter were identified. An analytical overview of marine litter produced by UNEP (2005) provides a brief summary of the distribution, amounts, sources and effects of marine litter, but focuses primarily on measures for mitigation and management. A Greenpeace report (Allsopp and others 2006) reviews available information on the sources, effects and management of marine debris in the ocean, including information from specific regions. Neither of these assessments specifically focuses on debris from LBAs, and estimates of the proportion of marine litter from land-based versus sea-based sources vary widely.

UNEP, in cooperation with the Ocean Conservancy, has produced an assessment of marine litter in 12 UNEP Regional Seas areas under the framework of the UNEP Global Initiative on Marine Litter (UNEP 2009). The overview is based on regional assessments in each of the 12 areas and provides a summary and analysis of those assessments. The analysis includes the status of marine litter including quantities in the environment, sources and impacts, and mitigation activities, legislative and institutional aspects and analysis of regional action plans with respect to marine litter. The assessment also provides recommendations on monitoring and research needs, management strategies and measures, and institutional and policy requirements.

The report will include a summary and analysis of regional efforts to reduce inputs and impacts of marine litter as well as a summary of the above-mentioned UNEP/UNESCO-IOC guidelines for monitoring and assessment of marine litter and the UNEP and the Institute for European Environmental Policy (UNEP/IEEP) guidelines for economic instruments

UNEP and the Institute for European Environmental Policy (IEEP) are jointly developing guidelines and case studies on the use of economic instruments

to address the problem of marine litter, including litter from both land and sea-based sources.

5. PRIORITIZED ISSUES

GESAMP (2001a) concluded that the priority GPA categories are PADH, sewage, nutrients and altered sediment flows. GESAMP also identified the depletion of fish stocks as a priority, although not in the context of LBAs. UNEP/GPA (2006) identifies sewage, nutrient enrichment, PADH and litter as priority issues. The GIWA global synthesis report (UNEP 2006) does not identify priorities at a global level, but it does present a detailed matrix of the severity of problems in terms of GIWA-defined issue and impact categories. For coastal areas, the MA identified PADH as the most serious threat to coastal ecosystems and sediments and nutrients as major threats. It also identified sewage, metals, POPs and hydrocarbons as significant threats to some systems.

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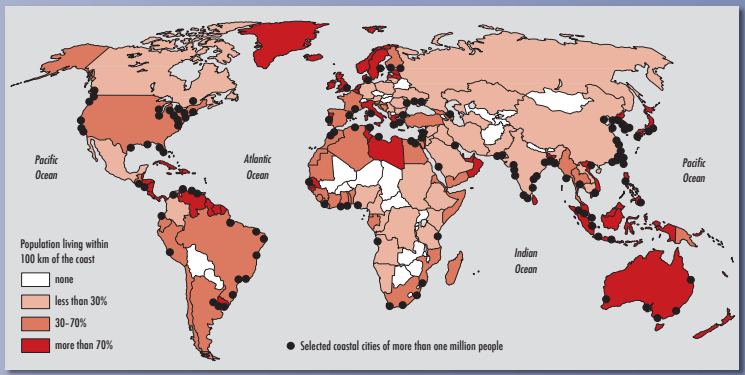
Coastal Development: Urban Development, Tourism and Coastal Zone Management

Jill Jäger

1. INTRODUCTION

Within the coastal zone land, sea and atmosphere interact. The coastal zone is heavily influenced by human activities. According to United Nations Environment Programme's Global Environmental Outlook Yearbook 2004/2005, approximately three billion people representing almost half of the current global population live within 200 kilometres (km) of the coastline. A significant growth in coastal populations is expected in the coming years. The natural systems in the coastal zone provide more than half of the global ecosystem goods, including fish, oil, and minerals as well as services such as natural protection from storms and tidal waves and opportunities for recreation. In addition, 14 of the world's 17 largest cities are located along coasts with most of them (11) in Asia's fastest growing economies. The coastal zone with its biodiversity, productive habitats and major biogeochemical processes supports the life, welfare and health of a growing part of the global population. The ability to provide this support is strongly dependent on the maintenance of the coastal environment and its ecological functions. A range of user groups compete for the ecosystem goods and services of coastal land and of the sea. Despite the

Figure 1: **Populations in coastal areas**



Source: UYB 2005

diversification of the global tourism market and the growing importance of special interest forms of tourism, coastal and beach tourism remains the dominant segment in terms of number of tourists. Coastal and island destinations experience increasing pressure on their natural and cultural resources because of the ever increasing demand. Pressures are also created by tourism activities being concentrated in specific seasons and having infrastructure and operations in the narrow coastal zone.

Coastal zone assessments tend to consider multiple attributes such as water quality, habitat characteristics and impacts and are generally integrated assessments which often take socio-economic factors into account.

2. INSTITUTIONS UNDERTAKING ASSESSMENTS

A range of institutions carry out assessments, including the international global change research programmes, intergovernmental bodies and environmental non-governmental organizations (NGOs).

The Land-Ocean Interactions in the Coastal Zone (LOICZ) project is a part of the International Geosphere Biosphere Programme (IGBP) and the International Human Dimensions Programme on Global Environmental Change (IHDP). LOICZ aims to provide an integrated framework to address the primary issues of sustainable human use of coastal systems, with the vulnerability of coasts and risks for human uses playing a key role. Research on the biogeochemical, physical, and human dimensions of coastal change is being carried out by LOICZ within five scientific themes:

a. Vulnerability of coastal systems and hazards to society;
b. Implications of global change for coastal ecosystems and sustainable development;
c. Human influences on river basin and coastal zone interactions;
d. Biogeochemical cycles in coastal and shelf waters; and
e. Working towards coastal system sustainability by managing land-ocean interaction.

The UN World Tourism Organization (UNWTO) has been promoting tourism development as part of integrated coastal zone management practices through international and regional collaboration, technical cooperation, research and capacity building activities. (http://www.world-tourism.org).

The Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) is an advisory body consisting of specialized experts nominated by the sponsoring agencies IMO, FAO, UNESCO-IOC, WMO,

UNIDO, IAEA, UN, UNEP. Its principal task is to provide scientific advice to each of the sponsoring agencies on the prevention, reduction and control of the degradation of the marine environment. (http://www.gesamp.net).

The UNEP Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA) Physical Alterations and Destruction of Habitats Programme aims to:

a. Build governments' capacities to address the urgent threats to coastal zones through, among others, strengthening legislation and regulatory capacity and facilitating multi-stakeholder/partnerships;
b. Safeguard ecosystem function, maintain the integrity and biological diversity of habitats, which are of major socio-economic and ecological interest, through integrated management of coastal areas; and
c. Promote effective action in specific locations to reduce and prevent the degradation of the coastal and marine environment caused by pollution and physical alteration and destruction of habitats, and where practicable, restore marine and coastal habitats that have been adversely affected by anthropogenic activities.

The programme focuses on sediment mobilization effects from four economic sectors which pose significant threats to coastal habitats, tourism, aquaculture, mining through sand and aggregate extraction and ports and harbours. The Physical Alterations and Destruction of Habitats (PADH) programme of the GPA aims to support the efforts of stakeholders in protecting coastal and marine habitats from alteration and destruction through development activities.

The International Oceanographic Commission (UNESCO-IOC) was created in 1960 to promote international cooperation and coordinate programmes in research, sustainable development, protection of the marine environment, capacity-building for improved management and for decision-making. It assists developing countries in strengthening their institutions to obtain self-driven sustainability in marine sciences. It also provides assistance for interagency coordination through the UN-Oceans mechanism and works with the United Nations Environment Programme (UNEP) in establishing a process for global reporting and assessment of the state of the marine environment. http://www.ioc-unesco.org/index.php?option=com_frontpage&Itemid=1

The Regional Seas Programme (RSP), launched in 1974 aims to address the accelerating degradation of the world's oceans and coastal areas through the sustainable management and use of the marine and coastal environment,

by engaging neighbouring countries in comprehensive and specific actions to protect their shared marine environment. It has achieved this objective by stimulating the creation of RSP prescriptions for sound environmental management to be coordinated and implemented by countries sharing a common body of water. http://www.unep.org/regionalseas/

Coastal development and all of the related issues with respect to the oceans have also been covered by a number of international assessment processes. These include the Intergovernmental Panel on Climate Change (IPCC), the Millennium Ecosystem Assessment (MA), the Global Environmental Outlook (GEO) and the Global International Waters Assessment (GIWA). Environmental organizations, including the International Union for Conservation of Nature (IUCN) and the World Resources Institute (WRI) also produce assessments associated with coastal zone issues.

3. DATA

Data from the coastal zones are available from a wide range of sources. The data used in UNEP's GEO are available from the GEO data portal. Its online database holds more than 450 variables, as national, subregional, regional and global statistics or as geospatial data sets in maps, covering themes such as freshwater, population, forests, emissions, climate, disasters, health and GDP (http://geodata.grid.unep.ch/).

In the LOICZ programme, the development of budget models for carbon, nitrogen, and phosphorous across a spread of global sites is a major initiative. The models are available on the Biogeochemical Budget website as well as in database form from the global typology website (www.loicz.org).

The World Data Centre for Human Interactions in the Environment is one of 51 data centres of the World Data Centre System (WDCS). It is hosted by the Centre for International Earth Science Information Network (CIESIN). The WDCS provides access to geophysical and environmental data to all scientists free of charge or for the cost of reproduction. In accordance with the system mission, the WDCS for Human Interactions in the Environment promotes the development, dissemination and preservation of high-quality global data sets on population, sustainability, poverty, health, hazards, conservation, governance and climate.

Further datasets on the coastal zone such as information on the distribution of mangroves are available from the UNEP World Conservation Monitoring Centre (UNEP-WCMC) (http://www.unep-wcmc.org/oneocean/datasets.aspx)

4. ASSESSMENTS

In 2005, the LOICZ project published a synthesis of knowledge on coastal and riverine material fluxes, biogeochemical processes and indications of change as well as the human influence (Crossland and others, 2005). The coastal budgets prepared for LOICZ have been synthesized by Smith and others (2003, 2005) and Talue-McManus and others (2003). A regional assessment methodology was developed and used by LOICZ which was based on the Drivers-Pressures-State-Impacts-Responses (DPSIR) framework to assess the human dimensions of land-based fluxes to the coastal zone. Policy options are explicitly addressed in the discussion of responses. Results are disseminated through reports and a newsletter published on the LOICZ website (http://www.loicz.org). One example of a regional assessment is provided by the LOICZ Russian Arctic Basin assessment (http://www.loicz.org/imperia/md/content/loicz/print/rsreports/rusabas.pdf) which uses existing environmental indicators to evaluate, confirm and update the qualitative expert assessment of environmental state of biochemical and biological factors in the coastal zone. A second example is the assessment and synthesis of river catchment and coastal sea interactions and human dimensions in Africa (Arthurton and others, 2008).

The UN World Tourism Organization (UNWTO) has undertaken a number of assessments. An assessment on Demonstrating and Capturing Best Practices and Technologies for the Reduction of Land-sourced Impacts Resulting from Coastal Tourism, is a Global Environment Facility (GEF) project started in 2006 which covers Senegal, Nigeria, Ghana, Kenya, Mozambique, the Seychelles, Tanzania, Cameroon and Gambia. The objective of the project is to address the negative impacts of tourism on the coastal and marine environment in Sub-Saharan Africa, through promoting the development of sustainable tourism policies and strategies and the implementation of pilot demonstration projects. In 2004, the UNWTO published a report on the current status of tourism in Small Island Developing States (SIDS), while providing evidence of the key importance it has for the sustainable development of many islands and for the achievement of the Millennium Development Goals (UNWTO, 2004). Two reports have compiled good practices for sustainable development of tourism (UNWTO, 2000, 2002) presenting the background and success factors for sustainability and lessons derived from these experiences. An early assessment (UNWTO 1997) outlines Europe's Blue Flag coastal environment campaign. It explains how Blue Flag assists the tourism sector

and at the same time helps to improve the coastal environment and presents criteria and lessons which can be learned from the European experience.

The assessments of GESAMP have covered the topics of aquaculture and integrated coastal management (GESAMP 1996a and b; 1997; 2001a; 2008). The 2001 report was based on a review of the literature and experience associated with the planning and management of aquaculture development and its integration into coastal management. It explored in detail how more planned and integrated approaches can be applied to aquaculture development.

GESAMP (2001b) considers the persistent problems of alteration and destruction of habitats and ecosystems, the effects of sewage on human health, the widespread incidence of and proliferation of eutrophication, the decline of fish stocks and other renewable resources, and changes in sediment flows due to hydrological changes. It discusses regional perspectives and a framework for strategies and measures to address these issues.

UNESCO-IOC has developed an indicator-based methodology for assessing coastal management initiatives (through the use of ecological, socio-economic and governance indicators). This has been presented in a handbook for measuring the progress and outcomes of integrated coastal and ocean management[1].

The RSP has conducted a series of assessments of land-based pollutant sources and activities affecting the marine, coastal and freshwater environment[2]. The GIWA regional assessment reports also considered coastal waters[3] while the IPCC considered the coastal areas, noting that coasts are experiencing the adverse consequences of hazards linked to climate change and sea-level rise[4].

IUCN has carried out assessments of ecosystems in coastal areas, particularly mangroves and coral reefs. The Millennium Ecosystem Assessment (MA) also considered the ecosystem services in coastal areas[5]. The World Resources Institute (WRI 2008) assessed eutrophic and hypoxic

1 IOC Manual and Guides No 46, ICAM Dossier No. 2, http://unesdoc.unesco.org/images/0014/001473/147313e.pdf
2 http://www.unep.org/regionalseas/publications/reports/RSRS/default.asp
3 http://www.unep.org/dewa/giwa/
4 http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-chapter6.pdf
5 http://www.millenniumassessment.org/documents/document.358.aspx.pdf
http://www.millenniumassessment.org/documents/document.288.aspx.pdf

coastal systems worldwide and highlighted the dramatic growth of areas receiving nitrogen and phosphorus residue from agriculture, increasing industrialization, fossil fuel combustion and population growth.

Kay and Alder (1999) provided a comprehensive guide for coastal planners and those aiming to achieve effective coastal management world-wide. The guide draws on examples of successful coastal planning and management from around the world to provide clear and practical guidelines on decision-making about the world's coastlines.

5. PRIORITIZED ISSUES

The coastal zones are strongly and increasingly affected by human activities, which is reflected in the priority areas for assessment. Those priority areas include pollution resulting from human activities, particularly from agriculture, industrialization, urbanization and tourism as well as the impacts of aquaculture, ecosystem changes in coastal areas the vulnerability of coastal areas, especially to hazards resulting from climatic change and sea-level rise.

6. CAPACITY BUILDING

The institutions which carry out assessments on the coastal zones demonstrate considerable capacity for carrying out these assessments, including the much needed expertise in socio-economics. In some cases, they are also engaged in capacity building activities. For example, LOICZ contributes to an international programme for capacity building and postgraduate training in water and coastal management. The international global change research programmes also carry out capacity building activities within the global change SysTem for Analysis Research and Training (START) (see www.start.org). Together with START, the IHDP ran a capacity building workshop on coastal zones in 2000 (see http://www.ihdp.unu.edu/article/285?menu=53). The UNWTO also provides opportunities for education and training (http://www.unwto-themis.org/ingles/home.html).

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Pollution of the Open Oceans, including Atmospheric Inputs and Ship-based Pollution

Report by a GESAMP Task Team

1. INTRODUCTION: ASSESSMENTS OF THE OPEN OCEANS

There have been no comprehensive assessments specifically focusing on environmental conditions in the open oceans. As a result it is not possible to identify national or international institutions which have special expertise in the design, conduct or co-ordination of marine environmental assessments of the open oceans. There are on the other hand, numerous scientific bodies such as state agencies, research institutes, university departments and others actively involved in particular aspects of ocean science, including contaminants from anthropogenic sources, especially though the atmosphere. In addition, a number of global marine assessments by the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) and others have included open ocean issues.

For the reasons outlined above, the GESAMP Task Team for the Assessment of Assessments (AoA) extended its search for assessment-related information to a range of publications in the open scientific literature containing data on substances of known relevance to the environment and/or human health. This search revealed a number of publications which could be described as assessments of substances, or groups of substances, that enter the oceans either through the atmosphere or from shipping, fishing or other human activities. In addition, there are periodic reviews of literature dealing with particular types of ocean pollution such as oil and marine debris. Both types of publication bring together current knowledge of environmental contaminants and are therefore valuable for assessment purposes. Peer-reviewed research papers provide data, estimates and predictions, based on original, and sometimes scarce data which are fundamental to an understanding of contamination of the deep ocean. Most publications deal with inputs but few studies of the open ocean deal with effects specifically. The Task Team has summarised the more important publications in the above categories and has included appropriate thematic bibliographies in its report. The Task Team made no special attempt to identify the institutional affiliations of the authors responsible for the publications.

2. DATA AVAILABILITY

This thematic review of literature on pollution of the open oceans has given a good indication of the range, reliability and value of existing information on different substances and sources as well as its geographic coverage. Most of the information is associated with measured or estimated inputs in space and time, or both. This is often the best available basis for estimating ambient concentrations and for assessing likely effects. Geographical coverage is extremely patchy and some ocean basins are far more studied than others (see Table 1). Nevertheless, for most substances, the information base is sufficient to assess likely impacts on the oceans, although not necessarily on the environment as a whole.

The mandate for the study did not include ocean fisheries which has been covered by a separate AoA initiative and as a result the Task Team did not target literature dealing with the effects of contaminants on ocean species and communities, a form of literature the team found to be scarce. However, the substance contaminant summaries included in the Team's report do describe the major known effects of the substances concerned.

3. TYPES OF ASSESSMENT AND THEIR COVERAGE

All but one of the assessments identified and reviewed by the GESAMP Task Team are thematic scientific assessments. An exception is the Quality Status Report for the Wider Atlantic (OSPAR Commission 2000). Few other assessments cover socio-economic issues or provide advice on regulatory, legislative or political aspects of marine environmental protection. Previous global marine assessments such as those by GESAMP and the Global International Waters Assessment (GIWA) were also considered but their coverage of the open oceans is limited.

As shown in Table 1, the review of information sources on contamination of the six major ocean basins resulted in more than 300 citations, of which approximately 20 per cent were from thematic assessments, 10 per cent from reviews and 70 per cent from research papers. It should be noted that a single publication may cover several ocean basins.

The study identified gaps in information on the main ocean contaminants, including temporal and spatial coverage. It also considered the significance of the gaps in the context of ocean assessments. There is an urgent need for sustained monitoring of surface water carbon dioxide (CO_2) parameters. In the case of noise and its effects on species and populations, there is a need

for further research to establish the extent of the problem and on the impacts on the behaviour of cetaceans and other species that communicate by sound. Significant geographical gaps exist for atmospheric metals and nitrogen in the North Indian Ocean and to lesser extents in the South Pacific and South Indian Oceans. Trends in atmospheric inputs of selected Persistent Organic Pollutants (POP's) should be determined at strategic oceanic sites. Many of the radioactive materials disposed in the deep ocean, (a practice now prohibited under the London Convention) have very long half-lives, are present in large quantities and remain as radiological concerns. As such, these materials should be considered potential sources of harm to marine ecosystems and be kept under review in accordance with International Commission on Radiological Protection (ICRP) approaches to estimating affects on biota other than humans. For most of the other substances reviewed, the information gaps are considered to be of relatively minor significance.

4. PRIORITY ISSUES

A matter of particular relevance to the health of the open oceans is atmospheric inputs of nitrogen and carbon dioxide and their possible roles in acidification and ecosystem function. A Regular Process should also take into account developments in the field of carbon capture and storage (CCS) in the open ocean as well as the experimental use of iron and nitrogen to fertilize the oceans, thereby stimulating algal growth to draw down CO_2 from the atmosphere.

5. CAPACITY TO UNDERTAKE ASSESSMENTS OF THE GLOBAL OCEANS

In the absence of previous comprehensive assessments of the open oceans there is no real basis for evaluating the capacity of national, regional or global institutions for managing and coordinating ocean assessments, or for conducting scientific programmes specifically designed for assessment purposes. From a logistical standpoint, it is likely that any new data collection programmes covering the global ocean, or even individual ocean basins would place considerable demands on human and financial resources, particularly in relation to marginal seas. Clearly, the justification for such a programme would need to be firmly established before the necessary investments are made.

The GESAMP Task Team has concluded that for the majority of substances entering the oceans from anthropogenic sources there is sufficient information

in the scientific literature (Table 2) to assess their likely impacts on ocean ecosystems as well as the significance of these impacts on the environment and human health. As a result, it should be possible to assess their relative importance as contaminants and their potential for adverse impacts (i.e. to cause pollution). It should be possible to also determine the need to

Table 1: **Numbers of Reports/Studies reviewed***

	Ocean Sector						
Topic	**NA**	**SA**	**NP**	**SP**	**NI**	**SI**	**Global**
Ocean acidification	0	0	0	0	0	0	19
CO_2 and SO_2 from Ships	0	0	0	0	0	0	29
Atm. N	13	7	7	2	2	2	6
Atm. Fe, P, Co	22	11	10	3	3	2	8
Atm. Zn	10	4	2	2	2	1	0
Debris	3	3	7	3	2	3	11
Heavy metals	28	13	10	3	1	2	8
VOCs	7	2	6	3	7	5	8
Ship-based inputs							
- Operational discharges	2	0	0	0	0	0	2
- Oilspills	2	1	1	1	1	1	4
- Chemical spills	0	0	0	0	0	0	1
- Heavy	1	0	0	0	0	0	2
- PAH	2	1	1	1	1	1	4
- NOx	0	0	1	1	0	0	8
- VOCs	1	0	0	0	0	0	3
Shipwrecks	1	1	1	3	1	1	1
Offshore E & P	3	0	0	0	0	0	5
Noise	0	0	0	0	0	0	0
Natural seeps	2	0	0	0	0	0	5

NA- North Atlantic Ocean; SA- South Atlantic Ocean; NP- North Pacific Ocean; SP- South Pacific Ocean; NI- North Indian Ocean; SI- South Indian Ocean

* Where several substances are addressed in the same report, a template may be recorded more than once in this table.

reduce inputs and to decide the levels of priority required for such mitigating measures. Additional data requirements could be met by focused international initiatives. The assessments could be undertaken periodically by a multi-disciplinary, multi-regional group of experts reviewing existing information from national and international sources and from wider scientific literature.

Assessments	Reviews	Res. Papers	Templates completed
12	0	7	4
15	1	13	3
0	7	23	10
0	9	41	18
0	0	16	9
0	4	25	13
0	4	46	50
2	0	26	28
3	0	0	3
4	0	1	4
1	0	0	1
3	1	1	4
4	0	1	4
1	0	9	3
2	0	1	3
3	0	1	1
3	1	1	5
3	7	3	4
3	1	1	5

Table 2: **Open ocean assessment landscape overview**

Topic	Geographic coverage[a] Extent	Geographic coverage[a] Adequacy	Data reliability[b]	Data relevance[c]
CO_2 (inputs)	XX	XX	XXX	XXX
SO_2	X	X	X	X
Heavy metals				
- Hg	X	XX	XX	XX
- Pb, As, Cd, Ni, Cu	X	X	XX	X
VOCs	X	X	XX	X
Debris	X	XXX	XX	XXX
Nutrients				
- N	XX	XX	XXX	XXX
- Fe, Co, P	XX	XX	XXX	X
- Zn	X	X	XXX	X
Noise	X	X	XXX	X
Oil				
- spills from ships	XXX	XXX	XX	XXX
- op. discharges	XX	XX	XX	XX
- exploration and production	XX	XX	XX	XX
- shipwrecks	XXX	XXX	XXX	XX
- natural seeps	XXX	XXX	XXX	XX
- PAHs (exhaust)	X	X	X	X
Chemical, spills	X	X	X	X
Chemical, expl. and prod.	XX	XX	XX	XX
Sewage	X	XXX	XX	XXX
Ballast water	X	XXX	XX	XX
Dumping of waste, including radioactive materials	XX	XXX	XX	XXX
POPs and PBTs	X	X	XX	XX
CFCs	XX	XX	XXX	XXX

Rating scheme: Good: XXX; Moderate: XX; Poor: X

a Geographic coverage: Relates a) to the relative distributions of existing information across the six ocean basins (Chapter 1) and b) to the adequacy of this coverage for purposes of regular assessments (levels, impacts, significance) of the substances concerned in the open ocean.

b Data reliability: An estimate of the relative accuracy and precision of data published in peer-reviewed scientific literature.

c Data relevance: An evaluation of the utility and value of the data for purposes of assessing ocean health.

d Sampling regularity: A determination of the adequacy of sampling regimes (frequency, timing, sample replicates etc.) used to date for purposes of decadal assessments of status & trends.

Sampling regularity[d]	Adequacy of methodology[e]	Knowledge of effects[f]	Overall position[g]
XX	XX	XX	XX
X	X	XX	XX
X	XXX	XXX	XX
X	XX	XXX	XX
X	XX	XXX	XX
X	X	XXX	XXX
XX	XXX	XX	XX
XX	XX	XX	XX
X	XX	XXX	XXX
X	XX	XX	X
XX	XX	XXX	XXX
X	XX	XXX	XX
XX	XX	XXX	XX
X	XX	XXX	XXX
X	XX	XXX	XXX
X	X	XXX	XX
X	X	XXX	XX
XX	XX	XXX	XX
X	XXX	XXX	XXX
X	XX	XX	XXX
-	-	XXX	XXX
X	XXX	XXX	XX
XXX	XXX	XXX	XXX

e Adequacy of methodology: An indication of the suitability of currently available methodologies (sampling, analysis, data processing, evaluation and interpretation etc.) for generating data needed for assessment purposes i.e. the requirement for research and development.

f Knowledge of effects: The general level of scientific understanding with regard to the effects of a substance on marine life, marine ecosystems and human health.

g Overall position: An indication of the current state-of-the-art with regard to investigating the substances and related processes in the open ocean and consequently the potential for use of these capabilities and data products for ocean assessment purposes.

Large Marine Ecosystems Global Assessments

Kenneth Sherman

1. INTRODUCTION: THE LARGE MARINE ECOSYSTEM APPROACH

The world's 64 Large Marine Ecosystems (LMEs) produce 80 per cent of the average annual marine fisheries biomass (see Figure 1). Since 1995, LMEs have been designated by a growing number of coastal countries in Africa, Asia, Latin America and Eastern Europe as place based assessment and management areas for introducing an ecosystems approach to recover, develop and sustain marine resources and their environments (www.lme.noaa.gov/). LMEs are world centers of coastal pollution and nutrient over-enrichment as well as biodiversity and habitat loss in environments such as seagrasses, corals and mangroves. They are also being subjected to the impacts of global warming. It is estimated that LMEs contribute US $12.6 trillion annually to the world's economy in goods and services. At present, they are the focus of a global movement to introduce ecosystem-based management. Ecosystem-based assessments of marine resources and their environments are underway in 16 country-driven LME projects supported by the Global Environment Facility (GEF) in 110 countries in Africa, Asia, Latin America and Eastern Europe. The LME effort is also supported by five UN agencies (IOC-UNESCO, UNEP, UNIDO, UNDP, and the FAO) and two international non-governmental organizations (NGOs), the World Conservation Union (WCU) and World Wildlife Fund (WWF). The assessments for sustainable development are based on the application of five LME modules developed by the LME Programme of the USA National Oceanic and Atmospheric Administration (NOAA): (i) Productivity, (ii) Fish and Fisheries, (iii) Pollution and Ecosystem Health, (iv) Socio-economics, and (v) Governance (Figure 2).

Included in the suite of indicators for productivity assessments are measurements of photosynthetic activity, zooplankton biodiversity and biomass and oceanographic variability, all of which lead to an understanding of the carrying capacity of an ecosystem for living marine resources. Fish and fisheries assessments based on the results of trawl surveys for demersal species and acoustic surveys for pelagic species provide a picture of dominant species within fish communities. The effects of excessive fishing effort and naturally occurring environmental shifts in climate regimes can cause shifts in species composition and abundance. Pollution and ecosystem health assessments are based on a series of temporal and

spatial measurements of water clarity, dissolved oxygen, coastal wetlands loss, eutrophic conditions, biotoxins, sediment contamination and multiple marine ecological disturbances. The Socio-economics Module examines how a sustainable marine resource base can meet the nutritional, social, economic and developmental needs of humans living in LME border countries. Assessments for the Socio-economics Module are based on the explicit integration of social and economic indicators and analyses with all other scientific assessments to ensure that prospective management measures are cost-effective with regard to the use of ecosystem goods (e.g. fisheries, minerals, petroleum) and services (e.g. thermocline structure, primary productivity, nutrient cycling). The Governance Module engages multiple scales of national, regional and local jurisdictional frameworks needed to select and support ecosystem-based management practices leading to the sustainable use of living resources.

The GEF Operational Strategy recommends that nations sharing an LME begin to address coastal and marine issues by jointly undertaking strategic processes for analysing science-based information on transboundary concerns. Each of the GEF-supported LME projects maintains a data management and archiving system. The data are obtained through time series monitoring of suites of indicators depicted in Figure 1 at the end of this summary. The current assessments and resulting data for each of the five LME modules are synthesized and integrated into an annual Integrated Ecosystem Assessment (IEA) and made available to the LME project governance body, Project Coordination Unit and/or the Commission responsible for implementing the agreed upon Strategic Action Programme (SAP).

The SAP is based on the LME Transboundary Diagnostic Analysis (TDA), in which the countries bordering the LME prepare a document based on consensus that ranks coastal resource issues. The ranking is based on the assessments and identifies and prioritizes transboundary problems, analyses socio-economic impacts, outlines root causes and proposes agreed actions. In the SAP, the countries propose to remedy the identified transboundary problems and outline national and LME-wide commitments to policy, legal and institutional reform. The SAP is the principal guiding instrument for participating countries to follow over the two five-year phases of the project and is approved at the multi-sectoral ministerial level by representatives from each participating country. It is designed to support management decisions on the basis of the information provided by LME assessments of ecological conditions and indicators for each of the five modules.

2. RESULTS AVAILABLE

The results of the implementation of the assessments for the five targeted modules are available for each of the 64 LMEs around the world. Also available are the indicators of productivity, fish and fisheries, pollution and ecosystem health, socio-economics and governance. Initial summaries of the ecological condition of the world's LMEs are provided in the UNEP-LME global report titled A Perspective on Changing Conditions in Large Marine Ecosystems of the World's Regional Seas, which was published in November 2008. The report is available on the web at http://www.lme.noaa.gov/. Each LME is described in terms of the five modules. For the three science driven modules, each LME brief contains productivity estimates derived from nine years of Sea-viewing Wide Field-of-view Sensor (SeaWiFs) data, global warming trends for the past 50 years and ocean front maps. For the Fish and Fisheries Module, estimates are produced for fisheries biomass yield trends (1950–2004) for 12 categories of species. For each LME, information is provided in a marine trophic index graph, a fishing in balance index graph and a stock catch figure showing the status of the fishery as either developing, fully exploited, over-exploited or collapsed. The mean annual trophic level of fisheries catches is an indicator of biodiversity, specifically of the richness and abundance of large, higher trophic-level fish species. The fishing in balance index is an indicator of the effect of fishing on the condition of the ecosystem, showing the balance between catches and the trophic level.

For the Pollution and Ecosystem Health Module, nitrogen over-enrichment is reported as a major coastal problem. Excessive nitrogen loadings and oxygen depletion events are causing significant mortalities among marine resource species and have been identified as problems in several LMEs receiving GEF assistance including the Yellow Sea, the South China Sea, the Bay of Bengal, the Gulf of Mexico, and the Patagonian Shelf. Preliminary estimates of nitrogen export from freshwater basins to coastal waters have been assembled. Initial model projections of nitrogen increases indicate that based on a business-as-usual scenario, nitrogen input will double by 2050. Given the expected future increases in population and fertilizer use, without significant nitrogen mitigation efforts LMEs will be subjected to a future of increasing harmful algal bloom events, reduced fisheries and hypoxia that will further degrade marine biomass and biological diversity.

For the Socio-economics Module, the report includes mean annual monetary estimates of fisheries biomass yield trends (1950–2004) for 12 species

categories. Significant changes in LME goods and services, caused in part by global warming, are having a significant impact, both positive and negative, on socio-economic benefits. Based on these results, developing countries are considering ways of estimating economic valuation of LME goods and services, in a movement toward self-financing of LME monitoring, assessment and management activities. Significant progress has been made in the governance of LMEs. A total of 16 countries in West Africa have established an ecosystem-based interim Commission for the assessment and management of the Guinea Current LME. Three countries in South West Africa have established the Benguela Current Commission.

Further information is available on the 16 GEF-funded LME Projects in the project data management system, with each displaying the data and results of their respective analyses. Results are also listed periodically on project websites and in project newsletters. The unprecedented level of GEF and donor financial support provides developing countries with the opportunity to operationalize the five module LME approach to marine resource assessment and management by acquiring and operating advanced sampling systems to obtain time-series data on productivity, coastal oceanography, nutrients, climatology, fish and fisheries as well as pollution and ecosystem health which is also pertinent to the Global Ocean Observing System (GOOS) and the Global Earth Observation System of Systems (GEOSS).

3. TYPES OF ASSESSMENTS AND THEIR GLOBAL COVERAGE

The LME approach introduces ecosystem-based management through the application and operation of the five modules. The adaptive management process is both additive (with regard to the indicators within a module, see Figure 2), and integrative across the five modules. The process provides Integrative Ecosystem Assessments (IEAs) and generates indicators of condition for the entire LME. All five modular assessments are designed for an annual cycle of analysis and for adaptive decision making deliberations in accordance with the TDA and SAP processes, both of which provide a framework for the science-based assessment and management surveys on productivity, fish and fisheries and pollution and ecosystem health being conducted by 16 GEF-supported LME projects. Sound science assists policy making within the specific geographic location of each LME. Engaged in LME projects are the countries adjacent to the Guinea Current, the Canary Current, the Red Sea, the Agulhas and Somali Currents, the Benguela

Current, the Yellow Sea, the Baltic Sea and the South China Sea LMEs. Other pending LME projects are those for the Mediterranean Sea, the Gulf of Mexico, the Caribbean Sea, the Humboldt Current, the Bay of Bengal, the Baltic Sea, the Sulu Celebes and the West Bering Sea LMEs.

Two other initiatives contributing to LME assessments are the Protection of the Arctic Marine Environment (PAME), which is a working group of the Arctic Council, and the Asia-Pacific Economic Cooperation (APEC). The PAME initiative encompasses the 17 LMEs of the Arctic while the APEC region includes 23 LMEs. The five module approach will be operationalized in both regions to provide quantitative data for comparisons of LME condition in support of the four World Summit on Sustainable Development objectives. The objectives are aimed at achieving substantial reductions in land-based sources of pollution, introducing an ecosystem approach to marine resource assessment and management by 2010, designating a network of marine protected areas by 2012, and maintaining and restoring fish stocks to maximum sustainable yield levels by 2015.

4. DATA

Ecosystem data on the five LME modules are provided by the 16 ongoing LME projects in Africa, Asia, Latin America and Eastern Europe. The UNEP-LME Global Report titled A Perspective on Changing Conditions in Large Marine Ecosystems of the World's Regional Seas, provides datasets for each of the world's 64 LMEs. The data includes sea surface temperature time series and primary productivity estimates derived from satellite data originating from SeaWiFS (satellite-derived chlorophyll estimates from SeaWiFs) which allow the classification of LMEs into three categories. The three categories are Class I, high productivity (>300 g $Cm^{-2}\,yr^{-1}$), Class II, moderate productivity (150-300 g $Cm^{-2}\,yr^{-1}$) and Class III, low (<150 g $Cm^{-2}\,yr^{-1}$) productivity. Trends in fisheries biomass yields and catch value are provided by the Sea Around Us Project undertaken by the Fisheries Centre at the University of British Columbia (http://www.seaaroundus.org). A method for economic valuation of LME goods and services has been developed by using framework matrices for ecological states and consequences of change by Hoagland and Jin of the Woods Hole Oceanographic Institution, on the web at www.lme.noaa.gov/. A training workshop on the economic valuation of coastal and marine ecosystems was organized by Hoagland and Jin in April 2008 (www.lme.noaa.gov/). A framework has been developed by the Department of Environmental and

Natural Resource Economics at the University of Rhode Island for monitoring and assessment of the human dimension of LMEs and for incorporating socio-economic considerations into an adaptive management approach for LMEs (http://www.crc.uri.edu/). The LME Metadata Portal (www.lme.noaa.gov/) will maintain a summary of metadata available from each of the GEF-supported LME programmes.

5. PRIORITY ISSUES

Recent trends identified through the five modular assessments are the need for improved forecasts of fishery stock fluctuations as well as for a precautionary cap and sustain action. The cap and sustain action is especially important in relation to recent reports of accelerated warming, as measured in 61 of the 64 LMEs. From a global perspective, 38.2 million metric tonnes or 58 per cent of the mean annual (2001–2006) global biomass yields of fishery stocks are being produced in 29 LMEs adjacent to developing countries. This vital global resource is at risk from serious over-exploitation. Given the importance of sustaining 58 per cent of the world's marine fisheries biomass yield, it would be prudent for the GEF-supported LME assessment and management projects to immediately cap the total biomass yield at the annual five year mean (2000–2004) as a precautionary measure and move toward adoption of more sustainable fisheries management practices.

Another priority is the need to curb excessive nitrogen loading. For the Pollution and Ecosystem health module, matters of high priority are persistent organic pollutants, nutrient over-enrichment affecting human health, the growing extent and frequency of harmful algal blooms, hypoxia, sulfur-induced mortalities in upwelling systems and ocean acidification. The number and frequency of major marine ecological disturbances (MMEDs) in an LME can be used as indicators of a decline in ecosystem health and loss of essential ecosystem services. The increase in the frequency, severity and geographic spread of MMEDs over the past several decades carries with it significant human health and economic costs.

6. SUPRA-REGIONAL ISSUES

The Intergovernmental Panel on Climate Change (IPCC) has stated with a high level of confidence that changes in marine biological systems are associated with rising water temperatures affecting shifts in pelagic algae and other plankton as well as in fish abundance in high latitudes. The constraints

this creates in the adaptive capacity of LMEs bordering developing countries are likely to be more challenging than those faced by developed countries. From a marine resources management perspective, the eight regions of the globe examined by the IPCC, North America, Latin America, Europe, Africa, Asia, the Australia and New Zealand region and the two Polar regions, are important fisheries areas but at a scale too large to determine temperature trends associated with the assessment and management of the world's marine fisheries biomass yields. The UNEP LME Report addresses the lack of information on trends in global warming at the LME scale where most of the world's marine fisheries biomass yields are produced. It provides details on the physical extent and rates of change in sea surface temperature (SST) in association with biomass yields and SeaWiFS derived primary productivity of the world's LMEs. Sixty one out of 63 LMEs included in the study showed linear increases in SSTs during the past 25 years, 18 at a rate two to four times greater than reported by the IPCC.

In the North Atlantic, patterns of positive influence of warming were observed in the increased biomass levels of zooplankton and biomass yields of zooplanktivorous fish species such as blue whiting, herring and capelin within the Iceland Shelf, Faroe Plateau and Norwegian Sea LMEs. In contrast, significant declines were reported for both zooplankton biomass levels and fisheries yields in the North Sea, Celtic Biscay Shelf and Iberian Coastal LMEs. In the North Pacific, increases in zooplankton biomass and fisheries yields were reported for the pollock stock in the Gulf of Alaska and East Bering Sea LMEs. The Report also focuses on the emerging importance of rapid increases in nutrient over-enrichment, eutrophication and hypoxia leading to the increasing frequency and extent of dead zones within the boundaries of the world's LMEs. Nitrogen over-enrichment is a major coastal problem originating from the disruption of the nitrogen cycle in the 1970s, when the world community converted wetlands to agriculture, utilized more chemical inputs and expanded irrigation to feed the world.

7. CAPACITY OF INSTITUTIONS TO UNDERTAKE LME ASSESSMENTS

Of the 64 LMEs, 26 are adjacent to economically developed countries in North America, Europe, Japan, Australia and New Zealand, and 38 are adjacent to developing countries. Nearly half of the world's developing countries are engaged in GEF-supported LME projects, which are currently receiving US$1.8 billion in funding. Operation of the five modules is well

advanced in the three countries adjacent to the Benguela Current in South West Africa and in the 16 countries of the Guinea Current LME. In both areas, efforts are underway to reduce coastal pollution, restore damaged habitats, recover depleted fish stocks, provide training and educational opportunities in science and technology and support capacity building activities for present and future generations of LME practitioners. Currently, LME practitioners in the world number about 2500. The complexity of the ecosystem-based approach to fisheries management and other marine activities requires a new generation of professionals addressing the sustainability issue on a much broader scale than before. Management goals are defined and defended under the pressure of conflicting ecological interests and societal and political constraints.

Capacity gaps identified include the need for specialists such as ichthyologists, oceanographers and plankton experts as well as fish stock assessment biologists, sociologists, economists and experts in international law. There is an increasing demand for reliable datasets of adequate length and resolution in space and time to feed data-driven models on the medium and long-term consequences of various management strategies. Experienced marine scientists are required to put the facts and findings together to create such management scenarios. There is a need for stronger interaction amongst the various science sectors and between scientists and stakeholders, the public and national and international governance mechanisms. Partnership and communication are required at all levels and on all geographical scales.

Within the operational framework of the LME approach, funds are allocated by LME programme managers to provide opportunities for education and training. The GEF strategy for the fourth replenishment (2007–2010) in the International Waters (IW) focal area proposes the allocation of additional support to projects engaged in assessment and management efforts to restore depleted fish stocks, reduce and control nutrient over-enrichment and adapt to the effects of ice melt in Arctic ecosystems and high latitude glacial ecosystems. Additional financial support is being allocated to IW from other focal areas of the GEF such as biodiversity, climate change and persistent organic pollutants, which will be engaged in cross-cutting activities with IW. There is growing support for LMEs as place-based global management units for ecosystem recovery and sustainability through closer linkages between applied science and improved management of marine goods and services based on ecosystem productivity, fish and fisheries as well as pollution and ecosystem health for ecosystem recovery and sustainability.

Figure 1: **Map of the 64 Large Marine Ecosystems of the world and their linked watersheds**

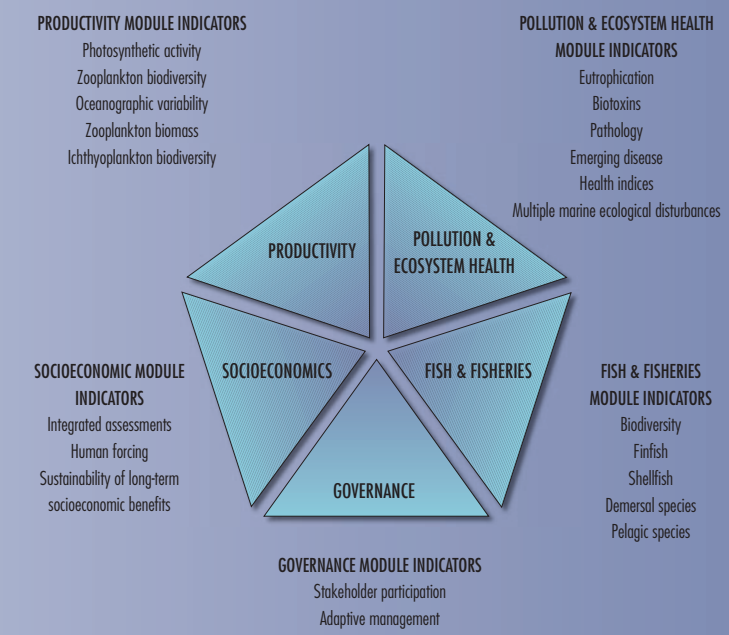
1 East Bering Sea
2 Gulf of Alaska
3 California Current
4 Gulf of California
5 Gulf of Mexico
6 Southeast US Continental Shelf
7 Northeast US Continental Shelf
8 Scotian Shelf
9 Newfoundland-Labrador Shelf
10 Insular Pacific-Hawaiian
11 Pacific Central-American Coastal
12 Caribbean Sea
13 Humboldt Current
14 Patagonian Shelf
15 South Brazil Shelf
16 East Brazil Shelf
17 North Brazil Shelf
18 West Greenland Shelf
19 East Greenland Shelf
20 Barents Sea
21 Norwegian Shelf
22 North Sea
23 Baltic Sea
24 Celtic-Biscay Shelf
25 Iberian Coastal
26 Mediterranean Sea
27 Canary Current
28 Guinea Current
29 Benguela Current
30 Agulhas Current
31 Somali Coastal Current
32 Arabian Sea
33 Red Sea
34 Bay of Bengal
35 Gulf of Thailand
36 South China Sea
37 Sulu-Celebes Sea
38 Indonesian See
39 North Australian Shelf
40 Northeast Australian Shelf-Great Barrier Reef
41 East-Central Australian Shelf
42 Southeast Australian Shelf
43 Southwest Australian Shelf
44 West-Central Australian Shelf
45 Northwest Australian Shelf
46 New Zealand Shelf
47 East China Sea
48 Yellow Sea
49 Kuroshio Current
50 Sea of Japan
51 Oyashio Current
52 Okhotsk Sea
53 West Bering Sea
54 Chukchi Sea
55 Beaufort Sea
56 East Siberian Sea
57 Laptev Sea
58 Kara Sea
59 Iceland Shelf
60 Faroe Plateau
61 Antarctic
62 Black Sea
63 Hudson Bay
64 Arctic Ocean

Source: www.lme.noaa.gov/

7.1 Productivity Module Indicators

Primary productivity can be related to the carrying capacity of an ecosystem for supporting fish resources. It has been reported that the maximum global level of primary productivity for supporting the average annual world catch from fisheries has been reached and that further large-scale increases in biomass yields from marine ecosystems are likely to be at trophic levels below that of the fish available in the marine food web. Measurements of ecosystem productivity can be useful indicators of the growing problem of coastal eutrophication. The ecosystem parameters measured and used as indicators of changing conditions in the Productivity Module are zooplankton biodiversity, species composition and biomass as well as water-column structure, photosynthetically active radiation, transparency, chlorophyll-*a*, nitrite, nitrate and primary production. Advanced plankton recorders can be fitted

Figure 2: **LME modules as suites of ecosystem indicators**



Source: www.lme.noaa.gov/

with sensors for temperature, salinity, chlorophyll, nitrate, nitrite, petroleum, hydrocarbons, light, bioluminescence and primary productivity to provide the means for *in situ* monitoring and for calibrating satellite-derived oceanographic data. Properly calibrated satellite data can provide information on ecosystem conditions including their surface temperature, nutrient characteristics, primary productivity and phytoplankton species composition.

7.2 Fish and Fisheries Module Indicators

Changes in biodiversity and species dominance within the fish communities of LMEs have resulted from excessive exploitation, naturally occurring environmental shifts caused by climate change and coastal pollution. Changes in biodiversity and species dominance in a fish community can move up the food web to apex predators and cascade down the food web to plankton components of the ecosystem. The Fish and Fisheries Module includes both fisheries independent bottom-trawl surveys and pelagic-species acoustic surveys to obtain time-series information on changes in their biodiversity and abundance levels. Standardized sampling

procedures, when employed from small calibrated trawlers, can provide important information on changes in fish species. Fish catch provides biological samples for stock identification, stomach content analyses, age-growth relationships, fecundity and coastal pollution monitoring for possibly associated pathological conditions as well as data for preparing stock assessments and for clarifying and quantifying multispecies trophic relationships. Survey vessels can also be used as platforms for obtaining water, sediment and benthic samples for monitoring harmful algal blooms, diseases, anoxia and changes in benthic communities.

7.3 Pollution and Ecosystem Health Module Indicators

In several LMEs, pollution and eutrophication have been important driving forces of change in biomass yields. Assessment of the changing status of pollution and health in an entire LME requires multiple-state comparisons of ecosystem resilience and stability. To be healthy and sustainable, an ecosystem must maintain its metabolic activity level and its internal structure and organization as well as resist external stress over time and space scales relevant to the ecosystem. The Pollution and Ecosystem Health Module measures pollution effects on the ecosystem through patho-biological examination of fish and fish tissue and estuarine and nearshore monitoring of contaminants and their effects in the water column, substrate and selected groups of organisms. Where possible, bioaccumulation and trophic transfer of contaminants are assessed and critical life history stages and selected food web organisms are examined for indicators of exposure to, and effects from contaminants, effects of impaired reproductive capacity, organ disease and contaminant-impaired growth. Assessments are made of contaminant impacts at both species and population levels. Implementation of protocols to assess the frequency and effect of harmful algal blooms, emergent diseases and multiple marine ecological disturbances are included in the Pollution and Ecosystem Health Module. In the United States of America, the Environmental Protection Agency has developed a suite of five coastal condition indices, water quality, sediment quality, benthic communities, coastal habitat and fish tissue contaminants.

7.4 Socio-economics Module Indicators

LMEs contribute US$12.6 trillion annually to the global economy. The Socio-economics Module emphasizes the practical application of scientific findings to managing LMEs. The module also highlights the explicit integration of social and economic indicators and analyses with all other

scientific assessments to ensure that prospective management measures are cost-effective. Economists and policy analysts work closely with ecologists and other scientists to identify and evaluate management options which are scientifically credible and economically practical with regard to the use of ecosystem goods and services. In order to respond adaptively to enhanced scientific information, socio-economic considerations must be closely integrated with science. This component of the LME approach to marine resources management has been described recently as the human dimension of LMEs. A framework has been developed by the Department of Environmental and Natural Resource Economics at the University of Rhode Island for monitoring and assessing the human dimension of LMEs and for incorporating socio-economic considerations into an adaptive management approach. One of the more critical considerations is a method for economic valuations of LME goods and services, which has been developed by using framework matrices for ecological conditions and economic consequences of change.

7.5 Governance Module Indicators

A Governance Module based on current demonstration projects in several ecosystems is being developed to ensure that ecosystems will be managed more holistically than in the past. In LME assessment and management projects supported by the GEF for the Guinea Current and Benguela Current LMEs, agreements have been reached among the environmental, fisheries, energy and tourism ministers of the LME countries to enter into joint transboundary, international resource assessment and management commissions. Elsewhere, the resources of the Great Barrier Reef and Antarctic LMEs are also being managed from an ecosystem perspective, the latter under the Commission for the Conservation of Antarctic Marine Living Resources. Governance profiles of LMEs are being explored to determine their utility in promoting the long-term sustainability of ecosystem resources. Within an LME, existing governance frameworks and multiple jurisdictions can be scaled to ensure conformity with existing legislated mandates and authorities (see NOAA technical memorandum at: www.lme.noaa.gov/.

Further information is available from the LME Programme Office (Kenneth. Sherman@noaa.gov; mc.aquarone@noaa.gov; Phone: +1 (401) 782-3211; website: www.lme.noaa.gov/).

Global Environment Outlook

Neeyati Patel

1. INTRODUCTION

The Global Environment Outlook (GEO) process of the United Nations Environment Programme (UNEP) has over the past 14 years, produced a series of global integrated environmental assessment reports aimed at providing comprehensive, scientifically credible and policy-relevant information on the interactions between the environment and society.

2. INSTITUTIONS UNDERTAKING ASSESSMENTS

UNEP, in line with its core mandate of "keeping the global environment under review", has coordinated extensive consultative and participatory assessment processes which have led to the production of four volumes of the comprehensive GEO reports. They are GEO-1 in 1997, GEO-2000 in 1999, GEO-3 in 2002 (prior to the World Summit on Sustainable Development (WSSD)) and GEO-4 in 2007 (a 20 year retrospective since the report by the World Commission on Environment and Development, *Our Common Future,* was published).

The assessment process for the next GEO will begin in late 2009. The 25th session of UNEP's Governing Council (in February 2009) requested for the preparation of a set of integrated and thematic assessments and a comprehensive, integrated global assessment – GEO-5.

UNEP has also developed related assessment products[1] which include:

a. Regional and sub-regional assessments, such as the Africa Environment Outlook (2002 and 2006), the Caribbean Environment Outlook (1999 and 2005), the Carpathians Environment Outlook (2007) and the Greater Mekong Environment Outlook (2007);
b. Thematic reports such as the Global Outlook for Ice and Snow (2007) and the Global Deserts Outlook (2006);
c. National and city-level environment outlooks for developing regions; and
d. A range of educational materials for youth, such as Pachamama: Our Earth – Our Future, the Pachamama Teacher's Guide, GEO active and GEO Juvenil.

1 Available at: http://www.unep.org/GEO/GEO%5FProducts/Assessment%5FReports/

The GEO-4 report is a living example of international cooperation at its best (Achim Steiner, the Executive Director of UNEP). GEO is more than a report. It is also a participatory consultative assessment process involving governments, partner organizations and a wide network of scientists. Key priority issues and key questions to be addressed in an assessment process are identified by these stakeholders during global and regional consultations.

3. SCOPE AND MAIN FEATURES OF GEO-4

'Environment *for* Development' is the underlying theme of GEO-4 and the report pays special attention to the role and impact of the environment on human well-being. The GEO-4 report provides an overview of social and economic trends in global and regional environments over the past two decades as well as the human dimensions of these changes, including analyses of vulnerability. It highlights the inter-linkages and challenges of environmental change as well as the opportunities the environment provides for human well-being. It concludes with possible scenarios and provides policy options to address present and emerging environmental issues.

GEO-4 is a unique integrated environmental assessment which covers socio-economic and environmental aspects associated with the atmosphere, land, water (fresh and marine) and biodiversity from a global and region-specific perspective. It shows that the marine and coastal environments are strongly linked to development and that the state of the hydrological regime, its water quality and ecosystems are major factors which contribute to human well-being. These links are shown in Table 1 below and also demonstrate the implications of the state of water in meeting the UN Millennium Development Goals (MDGs).

As highlighted above, a unique feature and strength of the GEO process is its consultative, participatory and inclusive approach. For instance, the GEO-4 assessment process involved:

a. A 'bottom-up' capacity building component and a global network of GEO Collaborating Centres (CCs). More than 50 CCs played an active role in preparing the assessment report;
b. The involvement of more than 380 regional and global experts in research and drafting of the assessment report. In addition, UNEP drew upon the expertise available in its Regional Seas Programmes (RSP), its Global Programme of Action for the Protection of the Marine Environment from Land-Based Activities (GPA) and from its wide network of partners within and outside the United Nations system;

Table 1: **Linkages between state changes in aquatic ecosystems and environmental and human impacts**

STATE CHANGES	Mediating environmental/ ecosystem impacts	HUMAN WELL-BEING IMPACTS Human health
Human water-use related issues – disturbance to the hydrological regime at basin and coastal scale		
⇩ Groundwater levels	⇧ Drying of shallow wells[1] ⇧ Salinity and pollution	
	⇩ Discharge to surface water	⇩ Available surface water[1]
	⇧ Land subsidence	
	⇧ Saline water intrusion	⇩ Available drinking water[1]
	Reverse groundwater flow ⇧ Downward movement	⇧ Pollution from land surface and canals[1]
Human water-use related issues – water quality changes at the basin and coastal scale		
⇧ Microbial contamination		⇧ Water-borne diseases[1]
		⇧ Fish, shellfish contamination[1]
⇧ Nutrients	⇧ Eutrophication	⇧ Nitrate contamination of drinking water[1]
	⇧ Harmful algal blooms	⇧ Fish and shellfish contamination[1] ⇧ Neurological and gastrointestinal illnesses[1]
⇧ Oxygen-demanding materials	⇩ Dissolved oxygen in waterbodies	
⇧ Suspended sediment	⇩ Ecosystem integrity	
Persistent organic pollutants (POPs)		⇧ Fish and livestock contamination[1] ⇧ Chronic disease[2]
Heavy metal pollution		⇧ Seafood contamination[1] ⇧ Chronic disease[1]
⇧ Solid waste	⇧ Ecosystem and wildlife damage	⇧ Threat to human health (infections and injuries)[1]

MDG Goal 1, Target 1: Halve, between 1990 and 2015, the proportion of people whose income is less than US$1 a day.
Target 2: Halve, between 1990 and 2015, the proportion of people who suffer from hunger.
MDG Goal 6, Target 8: Halt by 2015 and begin to reverse the incidence of malaria and other major diseases.
MDG Goal 7, Target 9: Integrate the principles of sustainable development into country policies and programmes, and reverse the loss of environmental resources.
MDG Goal 7, Target 10: Halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation.

c. Government nominations of experts to cover a wide range of thematic, technical and/or policy issues;
d. Government and expert peer-reviewers. Peer-review was a major component of the production process. In excess of 1 000 individual experts were invited to review the drafts of GEO-4 and more than 13 000 sets of comments were received;
e. A High Level Consultative Group of 15 individuals from policy development, science, business and civil society backgrounds, who were brought together to provide strategic guidance on formulating the key messages for the GEO-4 Summary for Decision-Makers (SDM) report. The SDM also

Food security	Physical security and safety	Socio-economic
⇩ Available irrigation water[1] ⇩ Water quality[1]	⇧ Competition for groundwater[1]	⇧ Access costs[1] ⇧ Premature well abandonment[1] ⇧ Inequity[1]
⇩ Freshwater for irrigation[1]		
		⇧ Buildings and infrastructure damage[1]
⇩ Available irrigation water[1] ⇧ Salinization[1] ⇩ Water quality[1]		⇧ Water treatment costs[1]
⇩ Water quality[1]		⇧ Treatment costs for public supply[1]
		⇩ Working days[2] ⇩ Recreation and tourism[1]
⇧ Production of macrophytes for animal fodder[1]		⇧ Cost of water treatment[1]
⇩ Livestock health[1] ⇩ Food available for humans[1]		⇩ Recreation and tourism[1] ⇩ Livelihood income[1]
⇩ High oxygen-demanding species[1]		⇩ Recreation and tourism[3]
⇩ Fish and livestock health[1]		⇧ Cost of water treatment[1]
		⇩ Commercial fish value[1]
⇧ Flood contamination of agricultural lands[1]		⇧ Cost of water treatment[1]
		⇩ Recreation and tourism[2] ⇩ Fisheries[2]

Arrows show trends of state and impact changes

⇧ increase ⇩ decrease ⇔ no statistically proven change

[1] well established [2] established but incomplete [3] speculative

Source: UNEP 2007

underwent two rounds of expert and government peer review before it was subjected to in-depth consideration and subsequent endorsement by the Second Global Intergovernmental and Multi-stakeholder Consultation in September 2007 at UNEP headquarters in Nairobi.

4. DATA

The GEO assessment reports include data from a multitude of sources. Although much of it is not primary data, further development of the GEO data component is linked closely to establishing and

strengthening cooperation with new and existing authoritative data providers around the world, and in focusing on relevant new data and indicators.

The GEO capacity building process promotes the active participation of experts in developing countries in the conduct of integrated environmental assessments and aims at improving access to data. It is supported by:

a. The GEO Data Portal[2] (http://geodata.grid.unep.ch/) which is being updated to include the latest data, trends and indicators on the state of the environment;
b. The development of specific regional GEO Data Portals in developing regions and the use of such tools in GEO and related (sub-) regional integrated environmental assessments; and
c. Networking and establishing partnerships among global and regional data providers and users in UNEP, the UN and beyond.

5. ASSESSMENTS

GEO-4 is an integrated global assessment of a number of specific environmental themes, one of which is fresh and marine waters. The report makes specific reference to the oceans and their role as the primary regulator of global climate and notes that at continental, regional and ocean basin scales, the water cycle is being affected by long-term changes in climate thus threatening human well-being. These changes are affecting Arctic temperatures and sea and land ice, including mountain glaciers. They also affect ocean salinity and acidification, sea levels, precipitation patterns, extreme weather events and possibly the circulatory regime of oceans. Table 2 shows links between some climate change related marine issues and their impacts on human well-being.

The GEO-4 report provides policy options, which it states "*require a sustained combination of technology, legal, and institutional frameworks, and, where feasible, market-based approaches*". In addition to capacity building, it says that the challenge is to develop new approaches while assisting with the practical, timely and cost-effective implementation of existing international and other agreements, policies and targets that can provide a basis for cooperation on many levels.

2 The GEO Data Portal is an on-line database which holds over 400 variables as national, sub-regional, regional and global statistics or as geospatial datasets. They cover a broad range of themes from population, GDP and human health to climate, freshwater and forests.

Table 2: **Linkages between state changes in the oceans and environmental and human impacts**

STATE CHANGES	Mediating environmental/ ecosystem impacts	HUMAN WELL-BEING IMPACTS			
		Human health	Food security	Physical security and safety	Socio-economic
Climate change related issues – disturbances to the hydrological regime mainly at the global scale					
⇧ Sea surface temperature	⇔ Trophic structure and food web	⇩ Food safety[1]	⇔ Fishery species distribution[2] ⇩ Aquaculture production[2]		⇩ Profits (loss of product sales)[2]
	⇧ Coral bleaching		⇔ Artisanal fishers[2]	⇩ Coast protection[3]	⇩ Tourism attraction[2]
	⇧ Sea-level rise		⇔ Aquaculture facilities[2]	⇧ Coastal/ inland flooding[1]	⇧ Damage to property, infrastructure and agriculture[1]
	⇧ Tropical storm and hurricane frequency and intensity	⇧ Disruption of utility services[1]	⇧ Crop damage[1] ⇧ Aquaculture damage[1]	⇧ Drowning and flood damage[1] ⇩ Coast protection[1]	⇩ Energy production[1] ⇩ Law and order[1] ⇧ Damage to property and infrastructure[1]
⇧ Land- and sea ice wasting	⇔ Ocean circulation change ⇧ Mountain glacier wasting ⇧ Sea-level		⇔ Traditional food sources[1] ⇩ Available irrigation water[2]	⇧ Coastal erosion and inundation[2]	⇧ Improved shipping access[1] ⇩ Downstream livelihoods[1]
⇧ Ocean acidification	⇩ Biocalcifying organisms including reef coral		⇩ Coastal fisheries[3]	⇩ Coastal protection[3]	⇩ Reef tourism[3] ⇩ Fisheries as livelihoods[3]

Arrows show trends of state and impact changes

⇧ increase ⇩ decrease ⇔ no statistically proven change

[1] well established [2] established but incomplete [3] speculative

Source: UNEP 2007

6. PRIORITIZED ISSUES

GEO-4 placed emphasis on:

a. The effects of environmental change on human development options, recognizing that the poor were the most vulnerable;
b. The need for integrating environmental activities in the broader development framework;
c. Strengthening environmental knowledge, education, and awareness; and
d. Creating enabling environments for innovations and emerging solutions.

GEO-5 will provide policy-relevant, scientifically credible analyses on the interlinkages within UNEP's priorities of:

a. Climate change;
b. Disasters and conflicts;
c. Ecosystems management;
d. Environmental governance;
e. Harmful substances and hazardous waste; and
f. Resource efficiency and sustainable consumption and production.

7. CAPACITY OF INSTITUTIONS TO UNDERTAKE GLOBAL ASSESSMENTS

Undertaking global integrated environmental assessments is part of UNEP's core mandate. As a result, and at the request of its Governing Council, UNEP continues to refine and develop the GEO process to ensure that the results of its assessments are based on sound science and are policy-relevant.

The GEO capacity building programme includes activities which strengthen the capacities of countries, regions and collaborating centres. They involve:

a. Training in the conduct of integrated environmental assessments (IEAs) at the global, regional, sub-regional, national and city levels. An IEA Training Manual has been developed to support this;
b. Development of a web-based platform – MENTOR (Marketplace for Environmental Training and On-line Resources: http://www.unep.org/mentor) which provides:
    - ❑ Access to high quality-assured environmental resources including guidelines, methodologies and tools;
    - ❑ Structured IEA training courses, including e-Learning modules;
    - ❑ A network of trainers; and
    - ❑ Communities of Practice to facilitate effective exchange of information, experiences and best practices as well as a means for collaboration amongst experts and opportunities for the development of new knowledge on IEA.

The GEO assessment process (which includes a diverse global and regional network of stakeholders and a capacity building platform) and its products (assessment of the state and trends of the marine environment, policy options and outlooks) could be used as building blocks for a Regular Process.

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Millennium Ecosystem Assessment

Marcus Lee and Salif Diop

1. INTRODUCTION

The Millennium Ecosystem Assessment (MA) (http://www.MAweb.org) was carried out from 2001 to 2005. The objective of the MA was to assess the consequences of ecosystem change for human well-being and to establish the scientific basis for actions needed to enhance the conservation and sustainable use of ecosystems and their contributions to human well-being.

2. INSTITUTIONS UNDERTAKING THE ASSESSMENT

The MA responded to requests from governments for information received through four international environmental conventions:

a. The Convention on Biological Diversity (CBD);
b. The United Nations Convention to Combat Desertification (UNCCD);
c. The Ramsar Convention on Wetlands; and
d. The Convention on Migratory Species (CMS).

The MA was also designed to meet the needs of other stakeholders, including the business community, the health sector, non-governmental organizations (NGO) and indigenous peoples.

The United Nations Environment Programme (UNEP) coordinated the MA, which was implemented as a partnership of institutions and donors which included the Food and Agriculture Organization (FAO), the United Nations Educational, Scientific and Cultural Organization (UNESCO), the United Nations Development Programme (UNDP), the World Health Organization (WHO), the Global Environment Facility (GEF), the Consultative Group on International Agricultural Research (CGIAR), the World Bank, the International Council for Science (ICSU), the International Union for Conservation of Nature (IUCN), the UN Foundation and the David and Lucile Packard Foundation.

More than 1 300 authors from 95 countries were involved in the MA and were organized into four working groups:

a. Condition and Trends;
b. Scenarios;
c. Responses: and
d. Sub-global assessments.

The first three working groups carried out the global assessment component of the MA while the fourth involved all the sub-global assessments, of which there were almost 40. Each sub-global assessment was coordinated by an institution in the location where the assessment was undertaken. Further information on the sub-global assessments is available at http://www.MAweb.org.

A number of co-executing agencies hosted the MA's distributed secretariat. The Director's office and Technical Support Unit (TSU) for sub-global assessments were hosted by the WorldFish Centre (formerly the International Centre for Living Aquatic Resources Management—ICLARM). TSUs for the other three working groups were hosted by the UNEP-World Conservation Monitoring Centre (WCMC) for the working group on Condition and Trends; Scientific Committee on Problems of the Environment (SCOPE) for the working group on Scenarios; and the Institute for Economic Growth (IEG) in India for the working group on Responses. The outreach and publications functions were undertaken by the World Resources Institute (WRI) in collaboration with Meridian Institute.

3. DATA

The MA synthesized information from scientific literature, existing datasets and scientific models, and built on knowledge from the private sector, practitioners, local communities and indigenous peoples. In general, the MA did not collect new data or develop new datasets. However, among the sub-global assessments, particularly those at local scales, the lack of data and literature led some sub-global assessments to undertake new research and data collection. In all cases, the assessment findings have been useful in identifying information gaps and priorities for future research.

The MA's data and indicators team selected a small number of core datasets which all MA chapter authors were requested to use to ensure comparability of chapter results. Authors of individual chapters were encouraged to analyse the strengths and weaknesses of these datasets for the particular application in the chapter. They were also encouraged to analyse other datasets as long as the findings were reported with the MA core datasets. The latter included land use and land cover, population density, protected areas, sub-national agricultural statistics, climate and roads.

A data catalogue containing metadata for each data entry in the standard metadata format adopted by the MA was also developed. The data

catalogue has been pre-populated with key datasets used in recent global studies such as the Pilot Analysis of Global Ecosystems, the Global Biodiversity Outlook, the Global Environmental Outlook, the World Development Report, the Human Development Report and World Resources Report.

An archive containing the MA core datasets and data catalogue is available through UNEP-WCMC and the Centre for International Earth Science Information Network. Long-term arrangements are being made for web accessibility to these datasets and the catalogue.

The MA identified a number of major data and knowledge gaps, such as the relatively limited information about the status and economic value of most ecosystem services as well as basic global data on the extent and trend in different types of ecosystems and land use. Some of these gaps result from weaknesses in monitoring systems associated with ecosystem services and their linkages with human well-being. The assessment revealed a significant need for further research into areas such as improving the understanding of nonlinear changes in ecosystems and the economic value of alternative management options. Reference also should be made to the supra-regional summary on Marine Biodiversity available in Annex V of this report.

4. ASSESSMENTS

The MA technical volume on Current State and Trends (Ecosystems and Human Well-being, Volume 1) contains a chapter (18) on marine fisheries systems and a chapter (19) on coastal systems. Chapter 18 assessed the condition and trends of marine fisheries systems globally by five main biomes:

a. The drivers of change such as climate change, subsidies, technology and globalization;
b. Choices, tradeoffs and synergies within the system and with other systems;
c. User rights and protection status of marine ecosystems;
d. Sustainability and vulnerability; and
e. Management interventions.

Chapter 19 assessed coastal systems and subtypes, linkages with other systems and human communities, areas of rapid change and their drivers and tradeoffs, synergies and management interventions.

UNEP-WCMC also produced a synthesis report on Marine and Coastal Ecosystems based on the MA findings. This report focused on the current

status of marine and coastal ecosystems and their services, the drivers of change in marine and coastal ecosystems, the impacts of degradation on human well-being and the available range of policy response options. The report highlights the contention that people are dependent on the ocean and coasts and their resources for survival and well-being. Marine and coastal ecosystems provide a wide range of services to human society, including food, natural shoreline protection against storms and floods, maintenance of water quality, support of tourism and other cultural and spiritual benefits as well as maintenance of basic global life support systems.

Sub-global assessments of marine areas were conducted in the ecosystems of the Arafura and Timor Seas, the Caribbean Sea, Jakarta Bay and Bunaken as well as coastal British Columbia.

5. PRIORITIZED ISSUES

The key conceptual approach of the MA on the importance of ecosystem services and the benefits people obtain from ecosystems was illustrated by how many people continue to be dependent on the ocean and coasts for survival and well-being (see Table 1 below). However, this dependence resulted in 15 of the 24 ecosystem services assessed in the MA being confirmed as degraded globally, including capture fisheries. The services derived from marine and coastal systems are being degraded and used unsustainably, which is leading to them deteriorating faster than other ecosystems. Despite this marine and coastal systems are among the most productive globally, providing a range of economic and social benefits.

The main drivers of change and degradation in marine and coastal ecosystems are largely anthropogenic, including population growth, habitat loss, over-fishing and destructive fishing methods, illegal fishing, invasive species, climate change, perverse subsidies, eutrophication and pollution technology change as well as increasing and shifting demand for food.

The highly threatened nature of marine and coastal ecosystems and the demand for their services highlight the need for a local, regional and global response. A range of options exists to respond to the challenges which the degradation of ecosystems is posing, including measures such as the implementation of regional and global agreements or stakeholder participation and capacity development. Addressing uncertainties and elaborating on the provision of trade-offs provide useful mechanisms for operational responses.

Table 1: **Examples of ecosystem services provided by different marine and coastal habitats**

(X indicates the habitat provides a significant amount of the service)

ECOSYSTEM SERVICES	Coastal									Marine		
	Estuaries and marshes	Mangroves	Lagoon and salt ponds	Intertidal	Kelp	Rock and shell reefs	Seagrass	Coral reefs	Inner shelf	Outer shelves edges slopes	Seamounts & mid-ocean ridges	Deep sea and central gyres
Biodiversity	X	X	X	X	X	X	X	X	X	X	X	X
Provisioning services												
Food	X	X	X	X	X	X	X	X		X	X	X
Fibre, timber, fuel	X	X	X						X	X		X
Medicines, other resources	X	X	X		X			X	X			
Regulating services												
Biological regulation	X	X	X	X		X		X				
Freshwater storage and retention	X		X									
Hydrological balance	X		X									
Atmospheric and climate regulation	X	X	X	X		X	X	X	X	X		X
Human disease control	X	X	X	X		X	X	X				
Waste processing	X	X	X				X	X				
Flood/storm protection	X	X	X	X	X	X	X	X				
Erosion control	X	X	X				X	X				
Cultural services												
Cultural and amenity	X	X	X	X	X	X	X	X	X			
Recreational	X	X	X	X	X			X				
Aesthetics	X		X	X				X				
Education and research	X	X	X	X	X	X	X	X	X	X	X	X
Supporting services												
Biochemical	X	X			X			X				
Nutrient cycling and fertility	X	X	X	X	X	X		X	X	X	X	X

Source: UNEP (2006)

It should also be borne in mind that trade-offs in meeting the Millennium Development Goals and other international commitments are inevitable. However, implementing the established ecosystem-based approaches through such measures as integrated coastal management adopted by the CBD, the Ramsar Convention on Wetlands and FAO, as well as existing local and regional legislation, policy and guidelines on the future condition of marine and coastal ecosystem services could be substantially

improved by balancing economic development, ecosystem preservation and human well-being objectives.

6. CAPACITY OF INSTITUTIONS TO UNDERTAKE GLOBAL ASSESSMENTS

The network of partners and organizations involved in the MA, including the sub-global assessments, possess significant general capacity to undertake assessments according to the MA framework of ecosystem services and impacts on human well-being. This exists in locations throughout the world where the sub-global assessments were undertaken and among the MA co-executing agencies. However, specific expertise on marine issues is not as extensively present across the MA network. The MA also had a capacity building component, including fellowships for young scientists.

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Global Open Oceans and Deep Seabed Biogeographic Classification

Elva Escobar

1. INTRODUCTION

The Global Open Oceans and Deep Seabed (GOODS) biogeographic classification[1] represents the first attempt at comprehensively classifying the open ocean and deep seafloor into distinct biogeographic regions[2]. This biogeographic classification takes a primarily physiognomic approach, which uses environmental characteristics of the benthic and pelagic environments to select homogeneous regions of similar habitat and associated biological community characteristics. In other words, it classifies specific ocean regions by their defined environmental features such as habitat structure and ecological functions and processes. To the extent data are available; it also classifies the species composition of specific ocean regions.

This pelagic and benthic biogeographic classification has been produced by a multidisciplinary scientific expert group, initially convened at a workshop in Mexico City in January 2007. Biogeographic classification is an approach aimed at partitioning a large area into distinct geographical regions containing groups of plants and animals and physical features which are sufficiently distinct or differentiated from their surroundings at the chosen scale (UNEP-WCMC 2007). It is an important tool which will help to develop an understanding of the distribution of species and habitats for scientific research as well as for conservation and management, and is therefore important to policy deliberations. More specifically, this approach will assist in determining the appropriate scales within the natural system for ecosystem-based management and in identifying areas representative of major ecosystems. The principal open ocean pelagic and deep sea benthic zones presented in this report are considered to

1 UNESCO. 2009. Global Open Oceans and Deep Seabed (GOODS) – Biogeographic Classification. Paris, UNESCO-IOC. (IOC Technical Series, 84.)

2 Sponsored by the Australian Government through the Australian Department of the Environment, Water, Heritage and the Arts; the Canadian Government through Canadian Science Advisory Secretariat Fisheries and Oceans Canada; The JM Kaplan Fund; Universidad Nacional Autónoma de México (UNAM); Mexico's Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO); The Intergovernmental Oceanographic Commission, UNESCO's Division on Ecological and Earth Sciences; The International Union for Conservation of Nature (IUCN); and the German Federal Agency for Nature Conservation, Ministry of the Environment, Nature Conservation and Nuclear Safety.

be a reasonable basis for advancing efforts towards the conservation, assessment, management and sustainable use of biodiversity in marine areas beyond the limits of national jurisdiction in line with a precautionary approach to advancing the efforts.

The biogeographic classification provides a foundation for discussions based on the currently available information and analysis which can assist policy development and implementation in the context of the Convention on Biological Diversity (CBD) and other sources. Available information and analysis must be updated as new information and understanding of the deep sea become available.

2. SCOPE OF THE WORK

This biogeographic classification covers open oceans and deep seabeds with an emphasis on areas beyond national jurisdiction. Open ocean and deep seabed are non-legal terms, commonly understood by scientists to refer to the water column and seabed beyond the continental shelf and are used in that context in this report. Open ocean and deep seabed habitats may occur in areas within national jurisdiction in states with a narrow continental shelf, or where the continental shelf is intersected by underwater canyons. The terms reflect natural rather than man-made jurisdictional boundaries relevant to ecological processes and influences relating to physical, biological and geological factors. It was chosen to complement the Marine Ecoregions of the World (MEOW) global marine biogeographic regionalization (Spalding and others 2007), which currently is limited to coastal waters and continental shelf systems.

In the pelagic environment, large-scale oceanographic features which strongly influence species assemblages are inherently dynamic resulting in their boundaries changing over time and causing some of these features to commonly extend from the open ocean onto continental shelves and into national jurisdictions. Consequently, the pelagic provinces include these areas when it is biologically appropriate. The fact that the resulting biogeographic maps (see Figures 1a-d) cover some areas within national jurisdiction is not intended to impinge on the national sovereignty and jurisdiction coastal nations have over these waters and continental shelves, but rather to enhance understanding and inform management.

3. METHODOLOGY AND PRINCIPLES

As a first step, the expert group considered existing global and regional biogeographic classifications of marine areas (Spalding and others 2007; and Annex 1 below) with the understanding that its work should draw on the considerable experience in biogeographic classification which exists nationally, regionally and globally. It was agreed that the development of a biogeographic classification for deep sea and open ocean areas would need to start with a definition of a set of basic principles. These principles would include dealing with the pelagic and benthic environments separately because of their different characteristics, although the ecological coupling between the two environments was acknowledged. The group also emphasized that a preferred system of classification should be consistent with available knowledge on taxonomy, physiognomy, palaeontology, oceanographic processes, geology and geomorphology, and that a biogeographic classification would combine all these approaches and factors.

4. PELAGIC BIOGEOGRAPHIC CLASSIFICATION

After reviewing a variety of proposed biogeographic models, including models developed for marine pelagic systems within national jurisdictions, the expert group concluded that the main large-scale physical features a pelagic biogeographic classification system should capture include:

a. Core areas or gyres;
b. Equatorial upwelling;
c. Upwelling zones at basin edges including those associated with coastal currents; and
d. Important transitional areas, including convergence and divergence areas.

Based on these criteria and a review of existing classifications, a map which included 30 provinces of pelagic biogeographic classes was produced (see Figure 1a). These provinces have unique environmental characteristics in variables such as temperature, depth and primary productivity. The classification was later validated using a data-driven cluster analysis.

5. BENTHIC BIOGEOGRAPHIC CLASSIFICATION

At the Mexico workshop, the expert group produced a preliminary map of the distribution of organisms in the deep sea showing the locations of what were termed the centres of distribution of deep sea provinces at bathyal and

abyssal depths. It was recognized also that for much of the deep sea there is very little information which can be used to delineate scientifically robust biogeographic units at the level of either province or region. The existing information was subsequently compiled using Geographic Information Systems (GIS) technology.

The delineated benthic biogeographic units relied on previous work by a variety of researchers, with the proposed boundaries altered on the basis of more recent data, both published and unpublished. The proposed deep sea benthic classification encompasses three large depth zones:

a. The lower bathyal (800–3 500 m);
b. The abyssal (3 500–6 500 m); and
c. The hadal (depths greater than 6 500 m, which includes primarily trenches).

The bathyal and the abyssal classifications were further broken down into 14 biogeographic provinces each and the hadal into 10 biogeographic provinces (see Figures 1b-d). In addition 10 hydrothermal vent provinces were delineated based on biological data and other records from field sampling and observations.

Seamounts were considered among the geomorphological features in the lower bathyal depth in offshore areas dominated by abyssal plains. These are being studied by means of Remotely Operated Vehicles or submersible dives and through trawl studies region-wide. Based on satellite altimetry, a map with the predicted summit depths of seamounts has been included for depth ranges 10–800 metres (m), 800–2 000 m, and 2 000–3 500 m. It should be noted that most of the seamounts at depths less than 800 m are partially within national Exclusive Economic Zones (EEZs), as are a large number of those seamounts with summits at depths between 800 and 2 000 m. As additional biological data become available, one or more of the bathyal and abyssal provinces may be further divided.

6. POSSIBLE APPLICATIONS OF BIOGEOGRAPHIC THEORY TO THE CONSERVATION AND SUSTAINABLE AND EQUITABLE USE OF DEEP SEA AND OPEN OCEAN AREAS

Sound biogeographic information has many possible applications. Two examples of practical applications of biogeographic classification refer to marine protected areas and spatial planning.

So far it has been difficult to undertake strategic action towards the development of comprehensive, effectively managed and ecologically representative systems of protected areas (CBD 2004) in deep and open ocean areas because of incomplete knowledge about how and where species and their habitats are distributed geographically. These areas should incorporate the full range of biodiversity in protected sites, including all habitat types. Preliminary steps towards a representative network can build on scientific criteria and guidance for selecting areas to establish a representative network of marine protected areas, including in open ocean waters and deep sea habitats, making it possible to select sites which incorporate these features in each of the biogeographic units identified in this report.

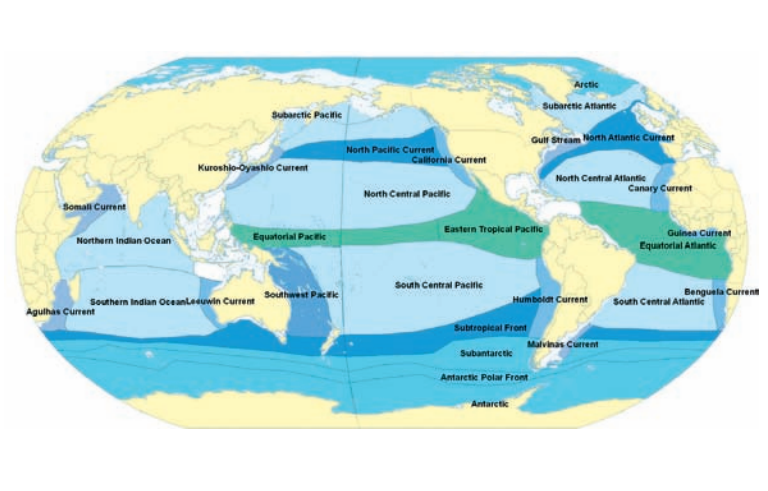
In the context of marine spatial planning, biogeographic scientific information is combined with information on uses, impacts and opportunities for synergy among stakeholders to identify specific areas for protection or for specific uses over different time scales. This approach has been successfully used in the marine coastal areas of many countries around the world (Ehler and Douvere 2007). The inclusive and participatory governance processes that are involved in spatial planning need information about the scales at which the ecosystems being considered function. These biogeographic classifications capture the information needed in clear and usable ways. An example is given by the regional units identified in the context of the Regular Process for the Global Reporting and Assessment of the State of the Marine Environment including socio-economic aspects, because the identified regions represent a combination of ecological, legal, policy and political criteria which serve well the purpose of assessing the state of the marine environment from a combined ecological and human use perspective.

7. FUTURE EFFORTS TO LINK BIOGEOGRAPHIC CLASSIFICATION WITH POLICY MAKING

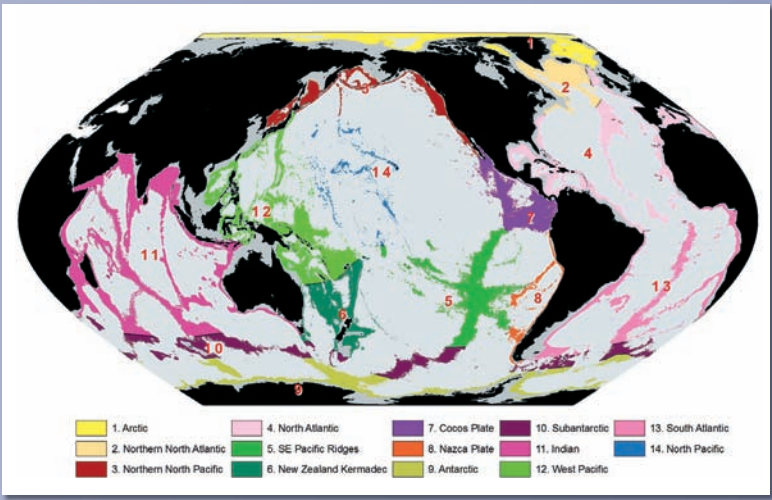
There is an increasingly clear recognition of the importance of biogeographic classification to priority-setting in the policy context as well as an increasing demand from policy-makers for biogeographic information on open ocean and deep sea areas beyond national jurisdiction. As a result, there is a need to bridge the gap between such policy demands and scientific research aimed at generating biogeographic knowledge. One factor impeding the filling of this gap is funding. Biogeographic investigations, especially in the open and deep ocean realms, are expensive and time-consuming, and the

Figure: 1

The pelagic provinces

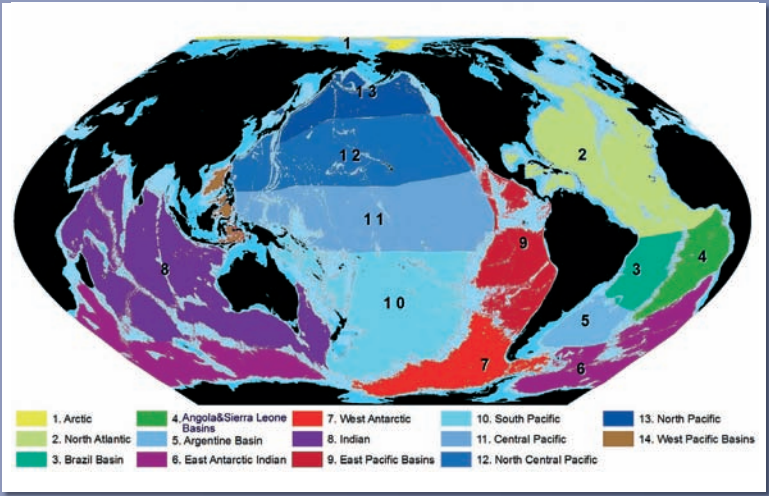


Lower bathyal provinces (Depth range 800 to 3500 m)

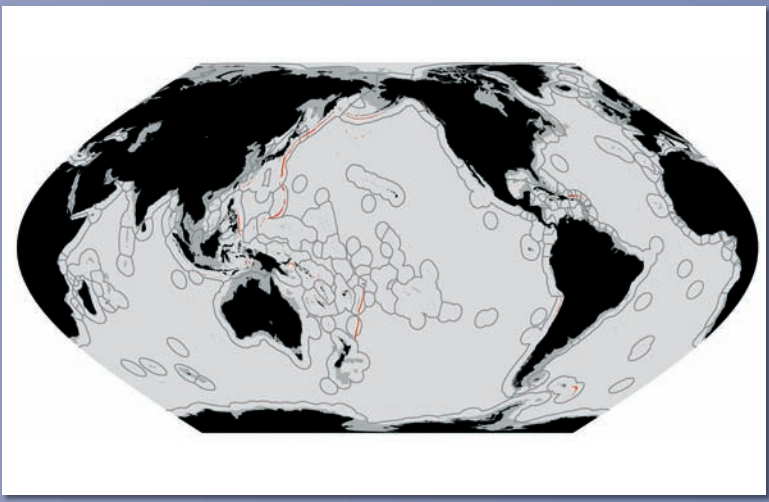


Source: UNESCO 2009. Global Open Oceans and Deep Seabed (GOODS) – Biogeographic Classification. Paris, UNESCO-IOC Technical Series, 84).

Abyssal provinces (Depth range 3500 to 6500 m)



Hadal provinces of the world ocean (>6500 m)



analysis of the data collected presents complex challenges. Such programmes will benefit from the political support needed to build international scientific cooperation at a global scale, as well as support for adequate funding.

Scientifically, this biogeographic classification can provide a basis for hypotheses and further scientific studies on the origin and evolution of deep sea fauna assemblages as well as the linkages between species communities and open ocean and deep seabed environments. From a policy perspective, such a classification is a necessary component when considering area-based management options such as marine protected areas, particularly when assessing the representativeness and ecological significance of a potential network of marine reserves.

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Jorge, M.A., Lombana, A., Lourie, S.A., Martin, K.D. McManus, E., Molnar, J., Recchia, C. A., and Robertson, J. (2007). Marine Ecoregions of the World: a Bioregionalization of Coastal and Shelf Areas. BioScience 57(7): 573-583

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Annex 1: **Regional marine biogeographic classifications**

(Adapted from Spalding and others 2007)

Publication	Region
Powles H, Vendette V, Siron R, and O'Boyle B. 2004. Proceedings of the Canadian Marine Ecoregions Workshop. Ottawa: Fisheries and Oceans Canada.	The Arctic, North West Atlantic, North East Pacific
Dinter W. 2001. Biogeography of the OSPAR Maritime Area. A synopsis of biogeographical distribution patterns described for the North-East Atlantic. Bonn, Germany: Federal Agency for Nature Conservation.	The Arctic, North East Atlantic
Banks D, Williams M, Pearce J, Springer A, Hagenstein R, and Olson D, eds. 2000. Ecoregion-Based Conservation in the Bering Sea. Identifying important areas for biodiversity conservation Washington DC: World Wildlife Fund and The Nature Conservancy of Alaska.	The Arctic

Publication	Region
Van den Hoek C. 1975. Phytogeographic provinces along the coasts of the northern Atlantic Ocean. Phycologia 14: 317-330.	North East Atlantic
ICES. 2004. Information and advice about appropriate eco-regions for the implementation of an ecosystem approach in European waters. Pages 115-131 in ICES, ed. Report of the ICES Advisory Committee on Fishery Management and Advisory Committee on Ecosystems, 2004, vol. Volume 1, No. 2, Book 1. Copenhagen: International Council for the Exploration of the Sea (ICES).	North East Atlantic, Mediterranean
Bianchi CN, Morri C. 2000. Marine Biodiversity of the Mediterranean Sea: Situation, Problems and Prospects for Future Research. Marine Pollution Bulletin 40: 367-376.	Mediterranean
WWF MedPO. 2001. Defining the Mediterranean SubER: an overview.: WWF Mediterranean Programme Office, Conservation Unit.	Mediterranean
Wilkinson T, Bezaury-Creel J, Hourigan T, Wiken E, Madden C, Padilla M, Agardy T, Herrmann H, Janishevski L, and Morgan L. 2006. Spaces: Marine Ecoregions of North America. Montreal, Canada: Report developed by the North American Marine Ecoregions project team, Commission for Environmental Cooperation.	North West Atlantic, North West Pacific, North East Pacific, Tropical Atlantic
Hayden BP, Ray GC, and Dolan R. 1984. Classification of coastal and marine environments. Environmental Conservation 11: 199-207.	North West Atlantic
DeBlieu J, Beck M, Dorfman D, and Ertel P. 2005. Conservation in the Carolinian Ecoregion: An Ecoregional Assessment. Arlington, VA, USA: The Nature Conservancy.	North West Atlantic
Schumacher JD, and Stabeno PJ. 1998. The continental shelf of the Bering Sea. Pages 789-822 in Robinson A, Brink K, eds. The Sea. The Global Coastal Ocean – regional studies and syntheses. New York: John Wiley and Sons, Inc.	North West Pacific
Floberg J, Goering, M., Wilhere, G., MacDonald, C., Chappell, C., Rumsey, C., Ferdana, Z., Holt, A., Skidmore, P., Horsman, T., Alverson, E., Tanner, C., Bryer, M., Lachetti, P., Harcombe, A., McDonald, B., Cook, T., Summers, M. and Rolph, D.. 2004. Willamette Valley-Puget Trough-Georgia Basin Ecoregional Assessment, Volume One: Report. The Nature Conservancy with support from the Nature Conservancy of Canada, Washington Department of Fish and Wildlife, Washington Department of Natural Resources (Natural Heritage and Nearshore Habitat programs), Oregon State Natural Heritage Information Center and the British Columbia Conservation Data Centre.	North East Pacific
TNC. 2004. Southern California Marine Ecoregional Assessment. San Francisco: The Nature Conservancy.	North East Pacific
TNC 2006. Northern California Marine Ecoregional Assessment. San Francisco: The Nature Conservancy.	North East Pacific
Hayden BP, Ray GC, and Dolan R. 1984. Classification of coastal and marine environments. Environmental Conservation 11: 199-207.	North East Pacific
Sullivan Sealey K, and Bustamante G. 1999. Setting Geographic Priorities for Marine Conservation in Latin America and the Caribbean. Arlington, Virginia, USA: The Nature Conservancy.	North East Pacific, Tropical Atlantic, Tropical Eastern Pacific

Publication	Region
Huggins AE, S. Keel, P. Kramer, F. Núñez, S. Schill, R. Jeo, A. Chatwin, K. Thurlow, M. McPearson, M. Libby, R. Tingey, M. Palmer and R. Seybert.. 2007. Biodiversity Conservation Assessment of the Insular Caribbean Using the Caribbean Decision Support System, Technical Report. The Nature Conservancy. Also online at: http://conserveonline.org/workspaces/Caribbean.conservation/CDSS_summary_report_final.pdf.	Tropical Atlantic
Smith ML, Carpenter KE, and Waller RW. 2002. An introduction to the oceanography, geology, biogeography, and fisheries of the tropical and subtropical western central Atlantic. Pages 1-23 in Carpenter KE, ed. The Living Resources of the Western Central Atlantic. Volume 1. Introduction, molluscs, crustaceans, hagfishes, sharks, batoid fishes and chimaeras. Rome: Food and Agriculture Organization of the United Nations.	Tropical Atlantic
Geselbracht L, Torres R, Cumming G, Dorfman D, and Beck. M. 2005. Marine/Estuarine Site Assessment for Florida: A Framework for Site Prioritization. Final Report for Florida's Wildlife Legacy Initiative, a program of the Florida Fish and Wildlife Conservation Commission. Gainesville, Florida: The Nature Conservancy.	Tropical Atlantic
Almada VC, Oliveira RF, Goncalves EJ, Almeida AJ, Santos RS, and Wirtz P. 2001. Patterns of Diversity of the North-Eastern Atlantic Blenniid Fish Fauna (Pisces: Blenniidae). Global Ecology and Biogeography 10: 411-422.	Tropical Atlantic
WWF. 1999. WWF Africa Ecoregion Assessment Workshop participants' notes: WWF-US.	Tropical Atlantic, Western Indo-Pacific
WWF 2004. The Eastern African Marine Ecoregion Vision: A large scale conservation approach to the management of biodiversity. Dar es Salaam, Tanzania.: World Wide Fund for Nature.	Tropical Atlantic, Western Indo-Pacific
Allen GR. 2002. Indo-Pacific coral-reef fishes as indicators of conservation hotspots. Proceedings of the Ninth International Coral Reef Symposium, Bali 2: 921-926.	Western Indo-Pacific, Central and Eastern Indo-Pacific
Bakus G, Arthur R, Ekaratne S, and Jinendradasa S. 2000. India and Sri Lanka. Pages 295-324 in McClanahan T, Sheppard CRC, Obura D, eds. Coral Reefs of the Indian Ocean. Their ecology and conservation. Oxford, UK.	Western Indo-Pacific
Sheppard CRC. 1999. Corals of Chagos, and the biogeographical role of Chagos in the Indian Ocean. Pages 53-66 in Sheppard CRC, Seaward MRD, eds. Ecology of the Chagos Archipelago. London: Published for the Linnean Society of London, by Westbury Publishing.	Western Indo-Pacific
Ch'ng KL. 1993. South East Asian Marine Region. Report from an IUCN/CNPPA working group of representatives from South East Asian nations. Pages 18. Malaysia: Ministry of Science, Technology and the Environment, Malaysia.	Central and Eastern Indo-Pacific
Pauly D, and Christensen V. 1993. Stratified models of Large Marine Ecosystems: a general approach and an application to the South China Sea. Pages 148-174 in Sherman K, Alexander LM, Gold BD, eds. Large Marine Ecosystems: Stress, Mitigation, and Sustainability. Washington, DC: AAAS Press.	Central and Eastern Indo-Pacific
Lourie SA. 2006. Report on challenges in biogeographic classification of Sumatra/Java and the Eastern Indian Ocean. Pages 6.	Central and Eastern Indo-Pacific

Publication	Region
Green A. and Mous P. 2006. Delineating the Coral Triangle, its ecoregions and functional seascapes. Report based on an expert workshop held at the TNC Coral Triangle Center, Bali Indonesia (April – May 2003), and on expert consultations held in June and August 2005. Version 3.1 (February 2006). Pages 50: The Nature Conservancy, Coral Triangle Center (Bali, Indonesia) and the Global Marine Initiative, Indo-Pacific Resource Centre (Brisbane, Australia).	Central and Eastern Indo-Pacific
Commonwealth of Australia (2005) National Marine Bioregionalisation of Australia. Department of Environment and Heritage, Canberra, Australia	Temperate Australasia, Central and Eastern Indo-Pacific
Thackway R. and Cresswell ID. 1998. Interim Marine and Coastal Regionalisation for Australia: an ecosystem-based classification for marine and coastal environments. Version 3.3. Canberra: Environment Australia, Commonwealth Department of the Environment.	Temperate Australasia, Central and Eastern Indo-Pacific
Lyne V, Last P, Scott R, Dunn J, Peters D. and Ward T. 1998. Large Marine Domains of Australia's EEZ. CSIRO Marine Research and Department of Environment and Land Management, Tasmania. Report commissioned by Environment Australia.	Temperate Australasia, Central and Eastern Indo-Pacific
Boschi E. 2000. Species of Decapod Crustaceans and their distribution in the American marine zoogeographic provinces. Revista de Investigación y Desarrollo Pesquero 13: 7-136.	Central and Eastern Indo-Pacific
Emanuel BP, Bustamante RH, Branch GM, Eekhout S, and Odendaal FJ. 1992. A zoogeographic and functional approach to the selection of marine reserves on the west coast of South Africa. South African Journal of Marine Science 12: 341-354.	Temperate Southern Africa
Engledow HR, and Bolton JJ. 2003. Factors affecting seaweed biogeographical and ecological trends along the Namibian coast. Pages 285-291 in Chapman ARO, Anderson RJ, Vreeland VJ, and Davison IR, eds. Proceedings of the 17th International Seaweed Symposium. Oxford, UK.	Temperate Southern Africa
Turpie JK, Beckley LE, and Katua SM. 2000. Biogeography and the selection of priority areas for conservation of South African coastal fishes. Biological Conservation 92: 59-72.	Temperate Southern Africa
Bolton JJ, Leliaert F, Clerck OD, Anderson RJ, Stegenga H, Engledow HE, and Coppejans E. 2004. Where is the western limit of the tropical Indian Ocean seaweed flora? An analysis of intertidal seaweed biogeography on the east coast of South Africa. Marine Biology 144: 51-59	Temperate Southern Africa
Knox GA. 1960. Littoral ecology and biogeography of the southern oceans. Proceedings of the Royal Society of London, B 152: 577-624.	Temperate Australasia, Southern Ocean
Snelder, T.; Leathwick, J.; Image, K.; Weatherhead, M.; and Wild, M. 2004. The New Zealand Marine Environment Classification. NIWA Client Report CHC2004–071. 86 p.	Temperate Australasia
Walls K. 1994. The New Zealand Experience in Developing a Marine Biogeographic Regionalisation: Great Barrier Reef Marine Park Authority.	Temperate Australasia

Publication	Region
Linse K, Griffiths HJ, Barnes DKA, and Clarke A. 2006. Biodiversity and biogeography of Antarctic and Sub-Antarctic Mollusca. Deep Sea Research II 53: 985-1008. LME. 2006. Large Marine Ecosystems: information portal. (1 December 2006; http://www.lme.noaa.gov/Portal/)	Temperate Australasia, Southern Ocean
Grant, S., Constable, A., Raymond, B. and Doust, S. (2006) Bioregionalisation of the Southern Ocean: Report of Experts Workshop, Hobart, September 2006. WWF-Australia and ACE CRC.	Southern Ocean

Global International Waters Assessment

Joana Akrofi, Elina Rautalahti-Miettinen

1. INTRODUCTION

The Global International Waters Assessment (GIWA) was a globally comparable assessment of the state and future trends of transboundary aquatic ecosystems and resources. The project was initiated and funded largely by the Global Environment Facility (GEF) and led by UNEP. Other major donors were national organizations of the Finnish, Norwegian and Swedish Governments. GIWA's aim was to produce a comprehensive and integrated global assessment of the ecological status of international waters and the causes of major environmental problems. The assessment was conducted in 66 GIWA regions, focusing on the key environmental issues and problems facing transboundary waters.

2. INSTITUTIONS UNDERTAKING ASSESSMENTS

The project was implemented through collaboration between UNEP and other partners. The University of Kalmar (Sweden) hosted the GIWA Core Team and Coordination Office. A partnership was established with a global network of collaborating institutions and organizations as well as individuals in governmental and non-governmental organizations (NGOs) and the scientific community. A bottom-up and multidisciplinary approach was adopted and involved about 1 500 natural and social scientists from the various regions.

3. SCOPE AND MAIN FEATURES OF GIWA

GIWA has been the largest assessment of a broad array of ecosystem-wide water issues from a transboundary perspective in many parts of the world, particularly developing regions. The GIWA methodology was developed at the start of the project and involved scaling and scoping, among others (http://www.unep.org/dewa/giwa/). One of the main features is that the assessments were integrated for the whole system and considered environmental and socio-economic aspects as well as policy matters.

The GIWA project divided the world into 66 transboundary water regions covering both (transboundary) freshwater bodies and/or marine areas, the latter comprising one or more major drainage basins and adjacent Large Marine Ecosystems (LMEs) where it was considered to be appropriate.

Each assessment focused on five major concerns, freshwater shortage, unsustainable exploitation of fisheries and other living resources, pollution, global change and habitat and community modification. Under these concerns were 22 specific water-related problems (issues), including modification of stream flow, fisheries over-exploitation, eutrophication, loss of habitats and sea level change. The severity of each issue was ranked according to predetermined criteria of "none known, slight, moderate and severe" for each region. Causal chain analysis was essential in identifying and understanding the links between perceived problems and their root causes. Policy options were also evaluated.

Regional teams conducted the assessment based on existing regional data and information, and adapted the methodology to local conditions. In many GIWA regions, the assessment process has strengthened communication among social and natural scientists and managers. It has also fostered transboundary cooperation and new partnerships within the regions as well as between neighbouring regions.

The GIWA reports were subjected to scientific peer review prior to publication. The key products are 35 regional reports[1], most of which are published in print and/or electronically. The GIWA Final Report[2] summarizes the findings of the regional reports in a global perspective and provides information on the GIWA methodology and theoretical background.

4. DATA

It has been noted that the GIWA project depended totally on the available data and knowledge that existed within each of its 66 regions. This dependency resulted in apparent unevenness in the content and quality of the various GIWA reports. It also allowed the project to be completed within a very limited budget for such a large undertaking.

For the most part, data were provided from within each of the regions and sub-regions by scientists who elected to participate in the regional and/or sub-regional meetings convened by the project. While this was a very effective use of limited resources, it might have resulted in some information sources being overlooked or ignored if, for example, their authors or holders did not participate in the meetings.

1 All GIWA reports are available at http://www.unep.org/dewa/giwa/

2 Challenges to International Waters; Regional Assessments in a Global Perspective available at http://www.unep.org/dewa/giwa/publications/finalreport/

5. ASSESSMENTS

A regional approach on the scale of major river basins and adjacent LMEs was successful as a result of the strong involvement of regional teams and local experts. The standardized methodology provided the basis for a global synopsis which links aquatic issues on land and sea.

In its simplest form, the GIWA methodology comprised the following components.

a. *Scaling:* The exercise whereby the hydrological catchments and the receiving seas which make up the GIWA region are identified. Scaling defines the geographic boundaries of the region, identifies key systems and indicates the major geographic features and economic activities conducted within the region. High seas were not covered by the GIWA;
b. *Scoping:* Enables a comprehensive assessment of the current perception of the impacts of each GIWA environmental and socio-economic issue, the current trends and their likely future state. It is based on the available information for the region and on expert opinions through a consensus building process. Scoping is therefore an estimation of the severity of the impacts of the 22 GIWA criteria based issues on a globally comparative basis and which can serve as a mechanism for prioritization. Scoping identifies the critical GIWA concerns and issues in the region by assessing their environmental and socio-economic impacts and produces estimates of the likely environmental and socio-economic impacts by the year 2020. Scoping also helps in establishing priorities among the GIWA concerns and issues;
c. *Detailed Assessment:* Reviews the origins, reliability and applicability of the information and, where feasible uses the results to provide quantitative judgments on the severity of environmental and socio-economic impacts. It substantiates the experts conclusions in the other components as well as identifies and documents the nature and availability of information associated with the selected priority concerns and issues. Finally, the assessment quantifies the severity of the impacts of the selected concerns and issues;
d. *Causal Chain Analysis (CCA):* Traces back to their root causes and the cause and effect pathways associated with each significant concern as well as the socio-economic and environmental impacts. Being policy-oriented, the purpose of the CCA is to identify the most important root causes of each concern and target them through policy intervention for cost-effective remediation or mitigation. The core of the GIWA approach to CCA is to analyse the factors that directly or indirectly shape the

human actions which have an impact on the way water and water-related resources are used;

e. *Policy Option Analysis:* Analyses potential policy interventions to solve or mitigate the concern in question based on the associated root causes identified in the CCA. It includes the evaluation of alternative scenarios which have been developed on the basis of projected actions to address the identified root causes of environmental degradation.

The GIWA Final Report presents the major results of the GIWA regional assessments. Also included is a matrix showing the severity of impacts of all issues globally, which facilitates comparison across regions. The general GIWA findings are summarized as follows:

a. On a global scale, pressures from human activities have weakened the ability of aquatic ecosystems to perform essential functions, which is compromising human well-being and sustainable development;
b. The five GIWA transboundary concerns are serious problems worldwide, and are expected to increase in severity by 2020. Freshwater issues are the top priority for 25 regions, higher than for any of the other concerns;
c. Transboundary pollution has a moderate or severe impact in more GIWA regions than any other concern. Pollution is mainly concentrated in inland and nearshore systems. The most critical transboundary pollution issue is suspended solids, particularly in Latin America, Southeast Asia and Sub-Saharan Africa. Eutrophication, as well as microbial and chemical pollution, is also of particular concern;
d. Over-abstraction of water resources is resulting in rivers, lakes, and aquifers drying up, leading to water shortages in many regions. Water shortage is undoubtedly the top priority for Sub-Saharan Africa;
e. Over-exploitation of living resources was assessed as severe in more regions than any other issue. The environmental impacts of destructive fishing practices are severe in most parts of the world. The issue of excessive by-catch and discards is most critical in Southeast Asia and South America;
f. Modification of habitats is particularly severe in tropical LMEs, especially in Central America, East Africa and Southeast Asia. Habitat and community modification was most frequently identified as the priority concern in Northeast Asia and South America;
g. Negative synergies between the concerns, including global change, were frequently noted in the regions;

h. These concerns have a range of social and economic impacts, which vary in severity among the regions. Notably, the socio-economic impacts of fisheries are significant.

Among the root causes of environmental degradation are population and economic growth, agricultural development, lack of knowledge and public awareness as well as market and policy failures.

Several policy options for addressing the GIWA concerns and issues are analysed. It was found that the complexity and diversity of transboundary systems require the integration of management across countries, sectors and ecosystems. Ecosystem-based management, including integrated coastal zone management, is recognized as an effective policy response for halting or reversing the degradation of large marine and freshwater ecosystems.

The GIWA assessment results have been used as a basis for the UNEP LME report (for those Large Marine Ecosystems (LME) regions assessed by GIWA).

6. PRIORITIZED ISSUES

The GIWA methodology was achieved through an interactive process, guided by a Methods Task team comprised of experts with water, environmental assessment and socio-economic backgrounds. The preliminary versions of the methodology underwent extensive external peer reviews and preliminary testing in selected regions, the results of which were incorporated into the final GIWA methodology.

Considering the significant regional disparities in terms of the quality, quantity and availability of data, and socio-economic and environmental conditions, an innovative approach was required to achieve global comparability. The assessment focuses on the impacts of five pre-defined concerns in transboundary waters: freshwater shortage, pollution, habitat and community modification, overfishing and other threats to aquatic living resources, and global change. These encompass a diversity of issues which were grouped under the five concerns. In total, the impacts of 22 issues were evaluated (see Table 1).

The assessment integrated environmental and socioeconomic data from each country in the region to determine the severity of the impacts of each of the five concerns and their constituent issues. The assessment was

Table 1: **Pre-defined GIWA concerns and their constituent issues addressed within the assessment**

GIWA concerns	Environmental issues
Freshwater shortage	Modification of stream flow Pollution of existing supplies Changes in the water table
Pollution	Microbiological Eutrophication Chemical Suspended solids Solid wastes Thermal Radionuclide Spills
Overfishing and other threats to aquatic living resources	Overexploitation Excessive by-catch and discards Destructive fishing practices Decreased viability of stock through pollution and disease Impact on biological and genetic diversity
Habitat and community modification	Loss of ecosystems Modification of ecosystems
Global change	Changes in hydrological cycle Sea level change Increased UV-B radiation as a result of ozone depletion Changes in ocean CO_2 source/sink function

Source: UNEP – http://www.unep.org/dewa/giwa/publications/finalreport/annexes.pdf

implemented by conducting two participatory workshops that typically involved 15 to 20 environmental and socio-economic experts from each country in the region. During these workshops, the regional teams performed preliminary analyses based on their collective knowledge and experience. The results were substantiated with the best available information, which is presented in the regional reports.

The GIWA final report noted that Transboundary pollution had a moderate or severe impact in more GIWA regions than any other concern and has by far the gravest impact on human health.

The over-abstraction of water resources is resulting in rivers, lakes and aquifers drying up, leading to water shortages in many GIWA regions. For Sub-Saharan Africa, it is undoubtedly the top priority.

Over-exploitation of living resources was assessed as severe in more GIWA regions than any other GIWA issue.

The world's aquatic habitats have been extensively modified, particularly on land, with a consequential reduction in bio-diversity and an alteration of community structures in many regions throughout the world.

The report noted the negative synergies between the concerns, including global change. Considering the close links between many of the GIWA issues, habitat and community modification could often be considered a downstream consequence of the impacts of the other GIWA concerns.

7. CAPACITY OF INSTITUTIONS TO UNDERTAKE GLOBAL ASSESSMENTS

As previously noted, a bottom-up and multidisciplinary approach was adopted and involved almost 1 500 natural and social scientists from around the world. Regional teams conducted the assessment based on existing regional data and information, and adapted the methodology to the local conditions. The capacity of these teams to apply the GIWA methodology was developed through a hands-on approach. GIWA helped to create scientific and managerial capacity in developing countries and fostered interdisciplinary and international communication and cooperation. It also fostered transboundary cooperation and new partnerships within the regions and between neighbouring regions. A GIWA network of institutions and experts was established, but whether this network remains available and will be functional for future assessments is unknown.

8. LESSONS LEARNED

To summarize from the GIWA Evaluation[3] report, the lessons which could have changed the outcome of the GIWA project include:

a. The separation of the methodology development from the application of the methodology into two project phases; and
b. The clearer definition and more active involvement of the client – the GEF Secretariat – in the conduct of the project. Such involvement should not have been so overt as to bias execution of the project, but on the other hand, it would have provided better direction to the project's execution so that the results better met the GEF Secretariat's needs.

3 GIWA Evaluation report available at http://www.unep.org/eou/Reports/Environmental_Assesment/GIWA.asp

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The Role of GESAMP in Marine Environmental Assessment

The Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) Task Team

1. INTRODUCTION: STRUCTURE AND OPERATION OF GESAMP

The Joint Group of Experts on the Scientific Aspects of Marine Protection (GESAMP) which was established in 1969 is sponsored currently by eight UN organizations[1] with the mission "*to provide authoritative, independent, interdisciplinary scientific advice to organizations and Governments to support the protection and sustainable use of the marine environment*".

Each sponsoring organization provides a Technical Secretary, who, together with the Administrative Secretary and the Chairperson and two Vice-Chairpersons, comprise the Executive Committee of GESAMP. The Administrative Secretary is appointed by the International Maritime Organization (IMO) and chairs the work of the Executive Committee. The co-sponsored GESAMP office co-ordinates all activities and is based at the IMO. At present, it is manned by an officer seconded from the Government of Sweden who is supported by the IMO Technical Secretary and the Administrative Secretary.

Over the past three years, GESAMP has changed its structure and work methods radically to become more visible, transparent and proactive. Emphasis is placed on networking and collaboration with other organizations and processes as well as ensuring a wide geographic distribution of GESAMP experts. GESAMP has speeded up its response to emerging issues and specific requests through actions such as setting up Task Teams at short notice as in the case of the Assessment of Assessments (AoA) and sharpened inter-sessional arrangements.

GESAMP is a flexible mechanism which draws its members from a growing pool of experts depending on the particular expertise needed in each case. Registration to the pool is through nomination by sponsoring and other UN organizations, their Member states, regional organizations, international

1 IMO, FAO, UNESCO-IOC, WMO, UNIDO, IAEA, UN, UNEP

scientific bodies and non-governmental organizations (NGOs) and sitting GESAMP members. Self-nominations are acceptable provided individuals meet the following necessary criteria:

a. Postgraduate degree or equivalent experience in a relevant discipline;
b. Recognition and excellence in a field of experience;
c. Willingness to declare any conflicts of interest;
d. Ability to serve in an independent, individual capacity; and
e. Willingness to serve on a voluntary basis.

GESAMP studies and assessments typically are carried out by specialist working groups and involve experts who are not members of GESAMP. Working groups are initiated and administered by a lead agency (one of the sponsoring UN organizations) and may be co-sponsored by one or more outside organizations. Reports by working groups may be considered by GESAMP for publication in the *GESAMP Reports and Studies* series after external peer review by both scientists and the anticipated user community.

To improve its ability to respond to new and emerging issues, GESAMP may establish Task Teams which can be convened at short notice and have fewer experts and shorter time-frames than working groups such as the task force for the AoA (see below).

2. GESAMP CONTRIBUTIONS TO MARINE ENVIRONMENTAL ASSESSMENT

With well-established links to other international organisations and scientific bodies, GESAMP has a long and distinguished history of contributions to the science of marine environmental assessment. The preparation of environmental assessments is central to the GESAMP mission. Key elements of the mission are to:

a. Integrate and synthesize the results of regional and thematic assessments and scientific studies to support global assessments of the marine environment;
b. Provide scientific and technical guidance on the design and execution of marine environmental assessments; and
c. Provide scientific reviews, analyses and advice on specific topics relevant to the condition of the marine environment, its investigation, protection and/or management.

The following is a synopsis of GESAMP's previous assessment-related activities.

2.1 Global assessments on the state of the marine environment

GESAMP has produced three global assessments (GESAMP 1982, 1990, 2001a) comprising comprehensive and rigorous analyses of trends and conditions in the marine environment. The last of these reports – *Protecting the Oceans from Land-based Activities* (GESAMP 2001a) was initiated by the United Nations Environment Programme (UNEP) as a contribution to the first Intergovernmental Review Meeting on the implementation of the Global Plan of Action to combat effects of land-based activities (GPA/LBA) which took place in November 2001.

In parallel with the production of the report on land-based activities (GESAMP 2001a), GESAMP prepared a concise, non-technical report entitled *A Sea of Troubles* (GESAMP 2001b) summarizing the key issues arising from the former, as well as the general state of the global oceans, for the benefit of policy-makers.

2.2 The GESAMP approach to global assessments

The global assessments carried out by GESAMP typically involved 25–30 experts in different fields, including invited specialists from both the natural and social sciences. The reports were based on information from regional reports and the scientific literature, as well as expert opinion. For the 2001 report on land-based activities (Reports and Studies No. 71), the work was coordinated by an editorial board made up of the lead authors for the main report chapters. The peer review involved approximately 75 external reviewers and all comments were considered at plenary working group sessions. As with all GESAMP reports, the draft, peer-reviewed manuscript was then reviewed by GESAMP before being given final approval.

As a contribution to the AoA launched by the UN General Assembly (Resolution A/60/30) in November 2005, GESAMP recently completed a review of assessments and studies relating to pollution in the open ocean from shipping and the atmosphere. The work was undertaken by the specially convened Task Team referred to above, which was made up of appropriate specialists and completed its report in six months.

2.3 Thematic assessments and studies

To this point, GESAMP has produced 49 reports encompassing a variety of marine environmental features, processes and conditions with many providing valuable inputs to subsequent environmental assessments. For example,

the report *Atmospheric Input of Trace Species to the World Ocean* (GESAMP 1989) provided new insights into the atmospheric contribution to contamination of the oceans. Of direct relevance to the Assessment of Assessments and the UNGA Regular Process are the *Guidelines for Marine Environmental Assessments* (Reports & Studies No.54).

This set of publications represents an evolution over four decades in the understanding of how information on marine environmental conditions should be presented to meet the varied needs of its diverse audience.

3. OBSERVATIONS ON THE ASSESSMENT PROCESS

Through its global marine state of environment reports, GESAMP has noted that the effectiveness of assessments depends on the attention given to design in facets such as scope, structure and quality criteria during the preparatory phase. Undertaking an assessment is essentially a scientific exercise, involving both natural and social scientists. The final stage of the process should involve a detailed intergovernmental review of the scientific findings, analysing policy implications and identifying measures necessary to redress degradation.

The Group has also identified a number of technical, financial and policy barriers which preclude or slow down improvements in the quality, relevance and reliability of global assessments. Identification of these barriers has indicated a need for major improvements in the planning and management of assessments before new comprehensive global assessments are initiated.

Amongst the technical barriers identified were:

a. A serious and worldwide shortage of reliable and comparable data on key indicators of environmental quality, including risks to marine life and human health;
b. A lack of long-term datasets essential to the identification and analysis of temporal trends;
c. Excessive time between data collection and publication of monitoring reports;
d. Inadequate, or inadequate application of standards, criteria and reference values for the interpretation of chemical and biological data; and
e. Limited, or inaccessible statistics on the changing patterns of human activities which influence environmental conditions, particularly in coastal areas through activities such as industry, recreation, use of habitats and resources.

4. FUTURE WORK

In view of its experience in assessment and its interdisciplinary pool of expertise in marine and social sciences, GESAMP is well-equipped to contribute to a new Regular Process for the assessment of the marine environment. The Group could, for example, review the state of knowledge on particular topics and/or examine the methods used to carry out assessments to find ways to improve their reliability and value. Subject to the necessary financial support and availability of relevant data, GESAMP might work with other organizations in reviewing and assessing marine environmental conditions, identifying matters of particular concern and developing scientific advice for use by policy-makers, governments and agencies.

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London Convention on the Prevention of Marine Pollution by the Dumping of Wastes and Other Matter

Alan Simcock

1. INTRODUCTION

Disposal of waste at sea had long been practised for a variety of wastes. Disposal of dredged material at sea goes back several centuries, because of the need for dredging to provide sufficient depth of draught for ships. It became common for coastal communities in some countries to dispose of sewage sludge from sewage-treatment works by loading it onto boats and dumping it at sea. Similar means of disposal were used to dispose of mine waste from coastal mines. Likewise, ships which had reached the end of their useful lives were often scuttled at sea.

Dumping of waste at sea became a matter of concern in the late 1960s when new waste streams were added to these established practices. A number of countries introduced stricter rules on the disposal of hazardous waste on land. One effect of this was that waste-producers began to use dumping of hazardous waste at sea from industrial processes as a means of disposal.

At the same time, concerns grew about the potential impacts of established forms of dumping, particularly about hazardous substances from industrial processes that were included in sewage sludge, the eutrophication effects of the dumping of sewage sludge, and the presence of toxic substances in dredged material and in ships that were scuttled.

2. PRIORITY ACTIONS

As a result of these concerns, international agreements, such as the 1972 Oslo Convention on the Protection of the Marine Environment from Pollution by Dumping from Ships and Aircraft, were adopted in the run-up to the 1972 United Nations Stockholm Conference on the Human Environment. In June 1972, that Conference called for global steps to be taken to address the issue. In consequence, the London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter was adopted in November 1972, with simultaneous signatures in London, Mexico City and Moscow. It came into force in August 1975.

The objective of the London Convention is to promote the effective control of all sources of marine pollution and to take all practicable steps to prevent pollution of the sea by dumping of wastes and other matter. Currently, 85 states are Parties to this Convention. The main obligations of states under the Convention are to:

a. Prevent the dumping of certain substances (the "black list", which has included, since 1994, all radioactive substances and, since 1996, all industrial waste);
b. Regulate the dumping of other substances, with particularly strong controls on certain other substances (the "grey list"), through the application of the assessment provisions in Annex III of the London Convention;
c. Appraise the effectiveness of the regulatory assessment process through compliance monitoring and field monitoring of effects; and
d. Report to the Secretariat of the Convention (which is housed in the International Maritime Organisation (IMO)) on dumping permits issued and amounts permitted to be dumped.

The London Convention also contains obligations on Parties to assist one another with building capacities to regulate properly the control of dumping and the administration of dumping licenses.

By 1996, many states considered that the work under the London Convention had progressed far enough to allow a major revision of the approach to the control of dumping at sea. A protocol to the London Convention was therefore developed. As adopted in 1996, this London Protocol adopts the approach of banning the dumping at sea of all material, subject to certain exceptions. In addition, an important new development in the Protocol was Annex 2, which sets out a comprehensive waste-assessment process. This has applications in a generic form beyond disposal at sea. The London Protocol entered into force in March 2006. States may be Parties to both the Convention and the Protocol, although it is thought that the Protocol will eventually replace the Convention. Currently 37 states are Parties to the Protocol.

The provisions of the London Convention and the London Protocol provide internationally agreed rules and standards for the purposes of the obligations of states to control dumping at sea under Article 210(6) of the UN Convention on the Law of the Sea.

Both the London Convention and the London Protocol provide for meetings of the representatives of the Contracting Parties. These meetings have agreed to work together, and in practice hold joint sessions.

3. ASSESSMENT ACTIVITY

To assist it in its work, the Consultative Meeting of the London Convention set up a Scientific Group, consisting of scientists representing those Contracting Parties who wished to be represented. Observers were permitted from a number of relevant non-governmental international organisations, both representing relevant industries and from environmental organisations. When the London Protocol came into force, the Meeting of Contracting Parties agreed to set up a similar Scientific Group. The two Scientific Groups have agreed to work together, in practice holding joint meetings. The reports of the Scientific Groups are submitted to the London Convention Consultative Meeting and the London Protocol Meeting of the Parties.

Much of the work of the London Convention Scientific Group over the past 30 years has been in developing means for assessing how states should exercise their licensing controls over the dumping of wastes and other substances that may be dumped at sea. Assessment guidelines have been developed for all significant kinds of material which are still permitted for disposal and these can be obtained through the London Convention website (see below). Since the entry into force of the London Protocol, the Scientific Groups have been heavily involved in developing advice to the two governing bodies on two current issues:

a. the storage of carbon dioxide in sub-sea geological formations for the purpose of sequestering it from the atmosphere;
b. the use of various fertilisers (particularly iron) to fertilise the sea, and thus enable it to take up larger quantities of atmospheric carbon dioxide. (Based on a Statement of Concern on ocean fertilization, the governing bodies adopted resolutions prohibiting all such activities apart from legitimate scientific research, and agreed to work towards legally binding decisions in 2009).

The Scientific Groups have also been concerned for some time to follow up the reporting obligations of the Contracting Parties under both the London Convention and the London Protocol. Annual reports are published by the Secretariat. Efforts are being made to increase the number of Contracting Parties that submit reports to the Secretariat, so that the annual reports can

be improved. When better coverage has been achieved, the intention is to assess what these reports show.

The reports from Parties and their presentations to the annual meetings, also cover measures taken to monitor the effects on the marine environment of dumping that has been permitted. Since 2008, a Compliance Group, set up under article 11 of the London Protocol, is meeting annually to advise on overall improvement in compliance, including the effectiveness of measures to regulate dumping.

4. DATA

The annual reports published by the Secretariat provide summaries of data submitted by the Parties, showing, for those Parties that have reported, the numbers of dumping permits issued and the material authorised to be dumped. In some cases the quantification of that material is in terms of tonnage. In other cases, such as the scuttling of ships, it is in terms of numbers. From 2001, the Secretariat reports are available on the websites of the London Convention and London Protocol.

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All material about the London Convention and the London Protocol can be found on the appropriate sections of the IMO website:

http://www.imo.org/Environment/mainframe.asp?topic_id=1488

http://www.imo.org/Environment/mainframe.asp?topic_id=1336