Chapter 35. Extent of Assessment of Marine Biological Diversity

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2. **Groups summarized globally: Cetaceans, pinnipeds, seabirds, sea turtles, sharks, tunas, billfish, corals, seamounts, vents and seeps.**

2.1 Marine Mammals

Global assessments of marine mammal distributions are limited by geographic and seasonal biases in data collection, as well as by biases in taxonomic representation due to rarity and detectability. In addition, not all data collected have been published in open-access repositories, thus further constraining our ability to develop comprehensive assessments. Given the financial, logistical and methodological

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but again, satellite telemetry and passive acoustic monitoring are helping to fill in some of the temporal gaps. Although passive acoustic monitoring can be very useful in detecting the calls of certain species, and thus help determine their presence in a region,

Convention) (over 30 species), the Convention on the Protection of the Marine Environment of the Baltic Sea (HELCOM) (11 species), the Convention on the Protection of the Black Sea against Pollution (Bucharest Convention) (2 species), the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) (7 species), the Conservation of Arctic Flora and Fauna (CAFF) (3 species), the North American Agreement on Environmental Cooperation (1 species), and the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) (6 species). Other MEAs that have this remit but are not yet active include the Nairobi Convention for the Protection, Management and Development of Marine and Coastal and Environment of the Western Indian Ocean Region (the Nairobi Convention) (47 species), the Regional Convention for the Conservation of the Red Sea and Gulf of Aden Environment (Jeddah Convention) (lists not yet provided by contracting parties), Convention for Cooperation in the Protection, Management and Development of the Marine and Coastal Environment of the Atlantic Coast of West, Central and Southern Africa Region (Abidjan Convention) (considering adding a species list), and the Convention for the Protection and Development of the MarinDnvironmef(tT0/4an organizations) has established the Seabird Information Network aiming to showcase, and link, different global seabird databases.

2.3 Marine Turtles

The primary global assessment framework for marine turtle species is the IUCN Red List of Threatened Species™ (www.iucnredlist.org). The IUCN Marine Turtle Specialist Group as well as current and future impacts of climate change and pollution/pathogens on marine turtles.

In addition to the two primary global assessment frameworks described above, several other global status assessments exist for marine turtles. The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and the Convention on the Conservation of Migratory Species of Wild Animals (CMS, or Bonn Convention) include all marine turtle species in their lists, meaning that international trade in any products of any marine turtle species is prohibited and marine turtles are categorized as being in danger of extinction throughout all or a significant proportion of their range.

National laws to assess and protect endangered species can also result in global assessments. For example, all marine turtle species (except the flatback, *Natator depressus* which does not appear in the United States territorial waters) are listed globally as either Endangered or Threatened under the United States Endangered Species Act. Recently, the United States designated “distinct [illegible] demographic rates and processes (NRC, 2010) are still required to improve assessments of marine turtle status at global, regional and local scales (Wallace, 2011).

2.4 Sharks, Rays, and Chimaeras

Sharks, rays and chimaeras comprise the Class Chondrichthyes. This group is highly diverse (at least 1,200 valid species) and occur in a broad range of habitats, so a wide range of approaches has been taken to assess the status of individual populations. The most publicly available assessments for chondrichthyans are available from the IUCN Red List. The IUCN Species Survival Commission's Shark Specialist Group (SSG), is a global network of experts in the biology, taxonomy, and conservation of sharks, rays, and chimaeras which continuously conducts global and regional assessments of the Red List Status of chondrichthyans. Established in 1991, the SSG currently has more than 123 members from 33 countries collaborating to assess threat level, collate knowledge, highlight species at risk, and advise decision-makers on effective, science-the top shark fishing nations (Indonesia, India, Spain, Taiwan Province of China, Argentina, Mexico, United States of America, Malaysia, Pakistan, Brazil, Japan, France, New Zealand, Thailand, Portugal, Nigeria, Islamic Republic of Iran, Sri Lanka, Republic of Korea, Yemen), half (11) report 50 per cent or more of their catch at the species and genus level.

The taxonomic and geographic distribution of fisheries assessments of stock biomass and fishing mortality is very sparse. To date, we are aware of 41 stock assessments for 28 chondrichthyan species. The United States and Australia conduct most stock assessments; the majority conducted in the Atlantic Ocean (21), followed by the Indian Ocean (11) and 9 in the Pacific Ocean. Research surveys and shark control programmes are increasingly being used to assess the trajectory and status of shark and ray populations, particularly in the coastal waters of the United States, Europe, South Africa, New Zealand, and Australia. Many of these time series are ongoing and the specific assessment of the status of chondrichthyans is periodic and dependent on research funding.

Emerging technologies, such as satellite tags and acoustic tracking arrays, as well as the widespread availability of digital underwater photography, web-based database capability and photo identification systems, are providing information for better population estimates and refined geographic distributions. The miniaturization and longevity of electronic tags have revealed complex sex-biased migrations, migratory routes and infrequent but biologically important ocean transits connecting populations that were previously thought to be separate. The development of pattern-matching algorithms has transformed collections of photographs into mark-recapture methods for estimating local abundance and spatial dynamics of larger, more charismatic species, such as: White Shark (*Carcharodon carcharias*), Whale Shark (*Rhincodon typus*), and manta rays (*Manta birostris* and *M. alfredi*). Assessment approaches have been complemented by the rapid emergence of worldwide tissue-sampling and population genetics work that has led to an increasing understanding of the variation in gene flow and connectedness of populations within species, and increasingly the degree to which their ecology and life histories shape patterns of genetic relatedness. Genetic

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more charismatic species. Assessments would also attempt to estimate extinction risk. As a result, RFMOs' and others' assessments may differ greatly in their evaluations of the health of tuna stocks.

The most commercially important tuna species have been assessed recently, either regionally or throughout their range by the above-mentioned tuna Commissions. The Bluefin tunas (Pacific [*Thunnus orientalis*], Southern [*T. maccoyii*] and Atlantic [*T. thynnus*]) have all had a full stock assessment within the last four years through their respective RFMOs. Likewise, Bigeye tuna (*T. obesus*), Yellowfin tuna (*T. albacares*), Albacore tuna (*T. alalunga*) and Skipjack tuna (*Katsuwonus pelamis*) have all been assessed regionally through the RFMO assessment process, as well as globally through the IUCN. Other species, such as Blackfin tuna (*T. atlanticus)* and Longtail tuna (*T. tonggol*) have not had full assessments conducted through their respective RFMOs, although localized assessments in part of their range may have been undertaken. RFMOs for these are the ICCAT for Blackfin tuna, and the IOTC and WCPFC for Longtail tuna.

Less is known on the stock status of tuna species for which there are only small, directed fisheries or for which most of the catch occurs as by-catch. Slender tuna (*Allothunnus fallai*), frigate tuna (*Auxis thazard*), and bullet tuna (*Auxis rochei*) all range widely, but formal assessments have not been conducted by RFMOs in each ocean basin. Black skipjack (*Euthynnus lineatus*), Kawakawa (*Euthynnus affinis*), and little tunny (*Euthynnus alletteratus*) are all regionally distributed (Eastern Pacific, Western Pacific and tropical Atlantic, respectively), and few data are available on range-wide catches over time; this is necessary for a full population assessment. However, the wide ranges of these six species, coupled with relatively low and localized exploitation, caused these species to be classified under "Least Concern" by the IUCN.

Although formal stock assessments have been completed for almost half of the tuna species (7 out of 15), few standardized data sets exist on catch rates over time for the remainder of the species. Improvements in the collection of fishery-dependent data or initiation of fisheries-independent data collection would be necessary to obtain accurate estimates of stock health. In the meantime, relatively stable catches over time for the unassessed species suggest that there is little immediate threat to the viability of any of these species.

2.6 Billfish

Billfish are epipelagic marine fishes distinguished by elongated spears or swords on their snouts. Most of the species have very large, ocean-wide or cosmopolitan ranges in tropical and subtropical waters and all are tied to the tropics for reproduction. However, the Swordfish extends into temperate waters. All are of commercial or recreational importance; hence our knowledge of their distribution comes largely from fisheries. Three species are restricted to the Indo-West Pacific: *Istiompax indica*, Black Marlin; *Tetrapturus angustirostris*, Shortbill Spearfish; and *Kajikia audax*, Striped Marlin. The other three

middle/low biodiversity and interest for international science. Coral reef areas with the most investment in assessments are dispersed throughout the Pacific and tropical Atlantic.

Cold-water or deep-water corals are found globally, but have been most extensively mapped in the North Atlantic, due to extension of fishing and exploration for seabed resources in that region, and New Zealand has undertaken significant coral mapping. With greatest development from 200-1,000 m, and on topographic promontories such as seamounts, they can form large reefs of several 100s of m across and 10s of m above the substrate, but are highly vulnerable to damage and changing chemical oceanographic conditions. Further discoveries on the distribution of cold water corals are continuing to be made, such as in the southern Indian Ocean (Cairns, 2007).

Coral reefs are mentioned as a model ecosystem under Aichi Target 10 of the Convention on Biological Diversity (CBD) (to reverse impacts on climate-sensitive ecosystems). The search for “Essential Biodiversity Variables” (EBVs) to support monitoring for such targets and commitments is gaining momentum, and there is recognition that coral reefs may provide one of the ten globally-consistent sources to support this process, and not only with respect to biodiversity - greater recognition of the ecosystem services contributed by coral reefs (to communities, global tourism, and national/global economies and trade) should secure resources for monitoring of the ecosystem processes/indicators that underpin those services and goods, incentivizing monitoring and assessment to manage them for future benefit. In parallel with the CBD, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystems services (IPBES), and the Sustainable Development Goals may generate increased justification for upscaling coral reef assessments globally.

2.8 Plankton

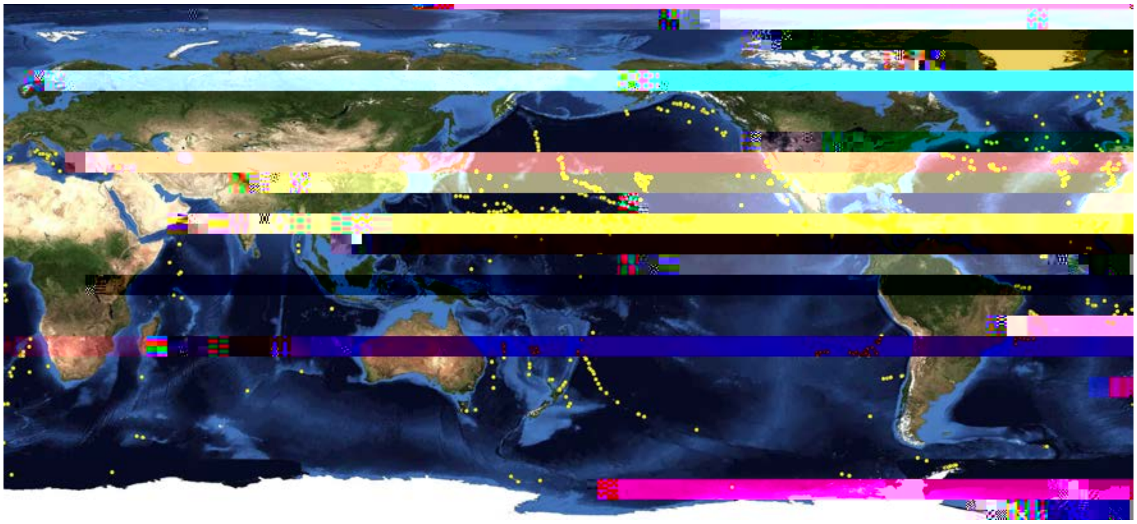
At the global level, the seasonal pattern of Chlorophyll *a* is the best known and most studied phytoplankton-related variable in most marine ecosystems. Long-term studies on seasonal changes in phytoplankton diversity and abundance have been more localized geographically. The Western Channel Observatory (WCO) run by the Plymouth Marine Laboratory and the Marine Biological Association (United Kingdom) holds a marine biodiversity reference dataset for the Western English Channel with some of the longest time-series in the world for zooplankton and phytoplankton. At the Chesapeake Bay, a monthly, continuous 20-year phytoplankton database exists. In the Baltic Sea, historical phytoplankton data on community composition shows long-term changes in comparison to the early 1900s (Hällfors et al., 2013). However, much less is known about how changing diversity affects the productivity and functioning of marine food webs as well as the drivers behind these changes. Some global changes in diversity have been addressed based on the Continuous Plankton Recorder (CPR) data.

Perhaps the longest time-series sets exist for planktonic organisms (zooplankton and fish larvae) from the North-eastern Atlantic (North and Baltic Seas, English Channel and Bay of Biscay). It is important to note that plankton monitoring has extended to practically all the regions of the European coast due to the implementation of relatively recent legislation (e.g., the European Water Framework Directive). In this way, the study of plankton taxonomic composition and dynamics is being conducted in many areas that have been poorly studied or not studied at all. Surveys on micro-, nano-, picoplankton

Over the last eight decades the purpose of the survey has also co-evolved, with changing environmental policy, from purely monitoring plankton distributions to addressing and providing indicators for major marine management issues ranging from

The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Figure 2. Start of sustained open-ocean biological time series and records (temporally broken and coastal time series are not included) plotted along the global mean SST time series from 1900 (Hadley Centre). Note that the majority of the time series are less than 30 years long. Station P (North Pacific); VICM



The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Figure 3. The distribution of seamounts with geological or biological sample data (sources: SEEF and SMOL).

The seamounts have a mixture of data types: all have geological information, and 54 per cent have had some level of biological investigation (Kvile et al., 2014). Overall, the seamounts in the North Atlantic Ocean and Mediterranean Sea have been the most studied; other oceans are typically patchy. For example, in the Pacific Ocean, over 60 per cent of seamounts in the database had biological data, but extensive sampling was focused on a few areas: on the Nazca and Sala y Gomez chains in the eastern South Pacific, around New Zealand and southern Australia in the southwest Pacific, and off parts of Hawaii, Alaska and the west coast of the United States in the North Pacific.

The last decade has seen a dramatic increase in the number of seamounts being surveyed. This has in part been due to efforts by the fishing industry to find new fish stocks, but also by major national or international (such as the Census of Marine Life project CenSeam) research programmes carrying out biodiversity surveys (see Figure 4, from Kvile et al., 2014). The CenSeam data can be accessed through the OBIS portal (www.iobis.org) by selecting the Seamounts Online database.

characteristics (e.g., habitat heterogeneity and complexity), more complete and intensive biodiversity inventories, and increased understanding of seamount connectivity and faunal dispersal; (2) New human impact data; these should encompass better studies on the effects of human activities on seamount ecosystems, as well as monitor long-term changes in seamount assemblages following impacts (e.g., recovery);

3.1 *The Arctic*

Despite more than a century of observations on the Arctic's marine life, information on basic species inventories, as well as a quantitative synthesis, has remained fragmented until recently; however, some areas are still poorly known. Renewed interest in marine developments and baseline data from the Canadian Arctic Ocean are very limited in their spatial and temporal extent.

Examples of these collaborations are the

(CHONe) (Snelgrove et al., 2012), a five-year national research programme to establish biodiversity baselines in poorly sampled areas, grew out of the Census of Marine Life. Several other Census projects sampled in Canadian waters: include the Arctic Ocean Diversity (ArcOD) project, and the Natural Geography of Inshore Areas (NaGISA), and the Gulf of Maine Area (GoMA) project. The latter project assembled species lists for that region and worked closely with the Canadian scientists of the Ocean Biogeographic Information System (OBIS) program, which assembled extensive datasets produced by Fisheries and Oceans Canada over several decades.

Current monitoring programmes, largely by the Department of Fisheries and Oceans Canada (DFO), the lead agency responsible for monitoring Canada's three oceans (Atlantic, Pacific and Arctic) and freshwater habitats, will further improve knowledge of Canadian oceans. Many of DFO's monitoring activities were initiated to address operational requirements dealing with commercial exploitation of marine and freshwater populations, but over time many have evolved to provide assessments of the state of local ecosystems in the context of a consistent national approach. A general assessment of aquatic monitoring in Canada, conducted in 2005-2006 (Chadwick, 2006), provides an overview of the diversity of activities carried out by DFO and other agencies.

Most programmes that contribute to biodiversity assessments derive data from: (1) broad-scale regional multispecies bottom trawl surveys that provide information on the distribution and abundance of fish and invertebrate species, (2) oceanographic surveys

In all of Canada's oceans, information sources on habitat structure, invasive species, food web structure and interactions, species at risk, and any effects of cumulative anthropogenic impacts are limited. There are few systematic efforts to assess ecosystem health, particularly in near-shore and coastal areas, and data pertaining to pelagic species other than plankton are restricted in scope and coverage. Finally, almost all marine observations are collected from ships, yet the number of sea days declined by half between 1995 and 2005, while costs have doubled (Chadwick, 2006).

3.3 North Atlantic: The East Coast of the United States

The marine biodiversity of the United States is extensively documented; however, even the most complete taxonomic inventories are based on records scattered in space and time. The best-known taxa are those of commercial importance or large body sizes. Best-known areas are the shore and shallow waters. Measures of biodiversity other than species diversity, such as ecosystem and genetic diversity, are poorly documented. In the North-east Continental Shelf region, scientific sampling of coastal intertidal and shallow subtidal organisms extends back to the mid-1800s. Off-shore, early assessments in the late 1800s and early 1900s include those conducted by the *Fish Hawk*, the *Albatross*, and by Henry Bryant Bigelow.

In the last decade, the Gulf of Maine Area Program of the Census of Marine Life assessed this ecoregion, plus the southern and western Scotian Shelf, the continental slope to 2,000 m, and the western New England Seamounts. In the South-east Continental Shelf region, assessments began during the United States colonial period (seventeenth and eighteenth centuries). Early offshore studies focused on finding exploitable fish populations. In the late 1800s, exploratory surveys were aimed primarily at bottom-living organisms. Since the mid-twentieth century, the United States National Oceanic and Atmospheric Administration (NOAA) and its predecessor agencies (e.g., the Bureau of Commercial Fisheries) have explored habitats and their natural resources off the coast of the south-eastern United States. Beginning in the 1950s, several ships conducted exploratory fishing surveys using trawl nets; they found concentrations of snappers, groupers, and other economically valuable fishes, along with other significant fishery resources (drums, flatfishes, mullets, herrings, shrimps). Additional surveys using dredges, grabs, and other benthic samplers collected invertebrates and new species.

Valuable fish surveys have been carried out by the NOAA Marine Resources Monitoring, Assessment and Prediction (MARMAP) and Southeast Area Monitoring and Assessment Program (SEAMAP) monitoring programmes. Significant regional invertebrate surveys of the South Atlantic Bight (SAB) were conducted under the auspices of the Bureau of Land Management (BLM) and the Minerals Management Service (MMS). From the 1970s until now, surveys of the continental shelf and slope off North Carolina and in the tropical western North Atlantic have been made by the Duke University Marine Laboratory (DUML) and the Rosenstiel School of Marine and Atmospheric Sciences

(RSMAS) of the University of Miami, respectively. The RSMAS collections and archives (Marine Invertebrate Museum: http://rsmas.miami.edu/divs/mbf/invert-museum.html) document the biodiversity of the Atlantic and Gulf of Mexico's tropical and deep-sea species and include material from the Straits of Florida and the Florida Keys National Marine Sanctuary. Marine resource agencies of the individual states have also conducted faunal and fishery surveys within state waters, particularly within estuaries (Fautin et al., 2010).

3.4 North Atlantic: The Gulf of Mexico

The most recent survey of the Gulf of Mexico's biodiversity appeared in book form (Felder and Camp, 2009), and as an open-access online database for utilization by anyone, as well as for updating and expansion by taxonomists (see GulfBase at www.gulfbase.org/biogomx; Moretzsohn et al., 2011). Over 15,400 species are listed in the database, with full biological and zoogeographical information for each species.

Historically, environmental studies or assessments on the Gulf of Mexico's biota can be divided into four different periods: (1) Exploratory Period (1850-1939), (2) Local Coastal Study Period (1940-1959), (3) Multidisciplinary Investiry.())16(tDnu)-4(p)6 S 8.05 0 TddBDC (o)-821yxcp96(1

The fourth period marks its beginning with the publication of the comprehensive inventory of all Gulf of Mexico species (Felder and Camp, 2009; an affiliate Census of

3.7 North Pacific: focus on the West Coast of the United States

3.7.1 The Gulf of Alaska

There have been many scientific expeditions to the Gulf of Alaska over the years since early times and a historical review of scientific exploration of the North Pacific Ocean from 1500 to 2000 is available. Early explorations were carried out mostly for mapping and species identification (i.e. fishes, birds, and invertebrates). Marine survey expeditions in the late 1800s include the United States steamer *Tuscarora* in the Aleutian Trench, the *Albatross*, and the Harriman Alaska Expedition from Seattle through Prince William Sound, out to the Aleutians, and north along the Russian Federation available long-term data are a product of fishery management efforts, mostly funded by NOAA. Biodiversity databases of this region are listed in Fautin et al. (2010). Two major assessments in this region are the California Current Ecosystem Long Term Ecological Research (CCE LTER) and the California Cooperative Oceanic Fisheries Investigations programme(CALCOFI), both focused on the pelagic realm. The CalCOFI programme is a 60+ year survey including zooplankton with strong relations to biodiversity and a world-recognized data base allowing analysis of temporal trends (Kang and Ohman, 2014).

3.7.3 Insular Pacific–Hawaiian Large Marine Ecosystem:

Initial surveys of the Hawaiian Islands began in the early 1800s by French, Russian, and United States expeditions. The first plankton samples were taken by the *Challenger* in mid-1875, while major collections from Hawaii were initiated by the *Albatross* Expedition in the early 1900s. Between 1923 and 1924, four trips were made with the *Tanager* to survey 13 Hawaiian Islands, Johnston Atoll and Wake Island. Results from the *Tanager* expedition were published in Marine Zoology of Tropical Central Pacific, and included crustaceans, echinoderms, polychaetes, and foraminiferans. Between July and September 1930, an expedition led by P.S. Galtsoff to Pearl and Hermes, surveyed the abundance of pearl oysters for potential commercial use, and also noted the corals, algae, sponges, molluscs, crustaceans, and echinoderms.

Since these early cruises, conducting inventories of the biota of Hawaii has largely been the responsibility of the Bishop Museum, which at present has been designated the Hawaii Biological Survey (HBS). Surveys have occurred in targeted sites in the main Hawaiian islands, such as Kaneohe Bay and Pearl Harbor on the island of Oahu, and waters around the island of Kahoolawe.

Since 1995, surveys have also covered Midway Atoll, French Frigate Shoals, and Johnston Atoll. Electronic datasets for Hawaiian marine biodiversity include: http://hbs.bishopmuseum.org/ (Hawaii Biological Survey); http://cramp.wcc.hawaii.edu/ (Reef Assessment and Monitoring Program); http://www.nbii.gov/portal/community/Communities/Geographic_Perspectives/Pacific_Basin/ (National Biological Information Infrastructure (NBII), Pacific Basin Information Node); and http://www.nbii.gov/portal/community/Communities/Habitats/Marine/Marine_Data_ (OBIS-USA)/. Intensive biological inventories have been carried out on fishes, stony corals, crustaceans, and molluscs (Fautin et al., 2010).

3.8 North Pacific: focus on Japan

In Japan, nationwide censuses of biodiversity of coastal areas, such as tidal flats, coral reefs, seagrass and algal beds, were conducted by the Ministry of the Environment, and showed long-term decline of these important habitats during the 1970s-1990s. However, the survey frequency was insufficient to identify the causal mechanisms of changes in relation to various environmental factors. Since 2002, the Ministry started a new type of monitoring programme, called "Monitoring Sites 1000" which aims to monitor the 1000 most important ecosystems in Japan over the whole 21st century. In this programme, ca. 50 coastal sites, including tidal flats, rocky intertidal shores, seagrass beds, algal beds and coral reefs are being monitored annually over the long term. These data will be utilized for various purposes, such as the prediction of coastal ecosystem response to global climate changes and other more local factors, as well as the impact assessment of the catastrophic disturbance by the 2011 earthquake and tsunami.

However, the number of sites is too small to set out in detail the changes in the coastal areas of the entire Japanese coast. In the meantime, local prefectural governments, fisheries agencies and certain NGOs have been conducting assessments of local coastal habitats of their areas, although the systems for sharing the information gathered are

Other largectenophores, tunicates, polychaetes and other worms, as well as small size invertebrates) remain a challenge to specialists; as a result these taxa continue to be inadequately known from Indian seas. However, considerable knowledge on the taxonomy of groups, such as seaweeds, seagrasses, mangroves, scleractinian corals, crustaceans, molluscs, echinoderms, fishes, reptiles and marine mammals, is available in India.

Most of the marine biodiversity data come from surveys that sample up to 200 meters. There are large data gaps for smaller taxa and for large parts of the shelf and deep sea ecosystems, including seamounts (Wafar et al., 2011). The data provided in this paper warrant continued taxonomic research on the least-studied and unknown groups, in light of current threats to marine biodiversity. The full extent of biodiversity in any of the world's oceans may never be known, and the rate at which our understanding is increasing (Keesing and Irvine, 2005) is likely to be lowest in Indian seas. The impacts of climate change will alter coastal marine ecosystems, affecting the range of species and their ecology at a rate faster than it is possible to record their presence and abundance (Keesing and Irvine, 2005). In conclusion, it is evident that comprehensive taxonomic coverage of the marine biota of the entire region remains a monumental task, beyond the capacity of existing local taxonomic expertise.

Thus, to gain an appreciable knowledge on the patterns of diversity in the region, it will be necessary to identify indicator species to assess responses to unpredictable climate change. It would be quite appropriate to plan systematic studies rather than continue the present system of haphazard and opportunistic description of new species as and when they are discovered.

Within the largest Indian Ocean basin, the International Indian Ocean Expedition (IIOE) was held during years 1962-1965. This expedition was one of the greatest international, int marine biodiversity. However, this listing is far from complete. Some well-known taxa, such as reptiles, birds and mammals, are simply omitted from the tabulation. Other larger and/or more economically valuable taxa, such as seaweeds, flowering plants, fishes, corals, larger molluscs and crustaceans, etc., are probably fairly accurately represented.

However, many smaller and difficult-to-identify taxa are not included in the lists at all (for example, Nematoda, Copepoda and Ostracoda) or are likely to be severely under-represented, and probably less than half of the actual numbers of marine species present in the region have been described. Notable regional differences in sampling effort are found: Kenya, United Republic of Tanzania and southern Mozambique are the best-sampled regions, and northern Mozambique and especially Somalia are the least studied. In all regions, sampling effort declines rapidly with depth and distance from the coast; the deeper continental slope and abyssal habitats are almost completely unexplored. Regional taxonomic capacity is ve4(nhlimi(d)6(ab c)4d3h(n)-4x)4(amp)-

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3.12 South Pacific: focus on Australia and New Zealand

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organisms are being assessed on several cross-Tasman transects from commercial vessels using standardized mid-water acoustic survey techniques supported by periodic mid-water trawls. These tw

With the declaration of Australia's Commonwealth Marine Reserve network (http://www.environment.gov.au/marinereserves/), survey emphasis is shifting from discovery to monitoring (or establishing the first quantitative baseline). Non-destructive sampling approaches, including autonomous underwater vehicles (e.g., www.imos.org.au/auv) and possibly genetic approaches, will be important additions to what will remain Australia's most prevalent deepwater activity – commercial fisheries which will continue outside the marine reserve network and inside the network in multiple-use areas, collecting data from their fishing operations and additionally, through cooperation with scientists, to routinely collect scientific information. In shallower waters it is likely that standardized citizen science will become increasingly valued.

3.12.2 New Zealand

The New Zealand's EEZ is one of the largest in the world. Despite important exploration efforts begun more than 200 years ago by James Cook followed by Louis Duperry and Dumont D'Urvillefor, Charles Darwin, the Challenger, and continued at present, much of this region remains unexplored biologically, especially at depths beyond 2,000 m. The major oceanographic data repository is the National Institute of Water and Atmospheric Research (NIWA), which is also data manager and custodian for fisheries research data owned by the Ministry of Fisheries. Museum collections in New Zealand hold more than 800,000 registered lots representing several million specimens. During the past decade, 220 taxonomic specialists (85 marine) from 18 countries engaged in the review of New Zealand's entire biodiversity, which ended in a major three-volume publication (Gordon, 2009). Current marine biodiversity in New Zealand surpasses the 17,000 species, and a list of all described New Zealand marine Animalia is available through OBIS (Gordon et al., 2010).

Multiple surveys (2000-

and demersal continental shelf fauna, from 15 to 100 m depth. The Venezuelan Atlantic Front was until recently almost completely unexplored, and the little information available concerned commercially valuable species of fish and shrimp.

In the southern part of the continent, the local and regional academic community also had important historical representatives and in the 1900s, research on coastal biodiversity received a strong stimulus due to the immigration of many European scientists who contributed to knowledge and capacity-building mainly through their involvement in local universities and natural science museums. Although a few research institutions were established in the region early in the twentieth century, such as the Smithsonian Tropical Research Institute (STRI) in Panama (1923), the most important stimulus to regional, autochthonous marine science was given by the establishment of several marine research institutions, mostly in the 1950s and 1960s. These institutions changed the way that marine science was done by incorporating time series of the environmental variables and their effect on biodiversity into the traditional taxonomic studies.

In the 1960s, the Food and Agriculture Organization of the United Nations began to develop projects giving an impetus to fisheries, especially in the southwest Pacific, an upwelling zone of extraordinary productivity that was responsible for 20 per cent of the world's fisheries by the end of that decade. In the 1980s and 1990s, centres for marine biodiversity research were created along the coasts of several countries, especially Brazil, Argentina, and Chile. The natural history museums in South America have been fundamental to preserving the regional marine biodiversity patrimony, both in collections and in the literature, and are considered to be taxonomically indispensable.

Some of the most relevant museums are the Museo de La Plata and the Museo Argentino de Ciencias Naturales (Argentina), the Museo de Historia Natural (Quinta Normal) in Chile, the Museo Dámaso Larrañaga and the Museo de Historia Natural in Uruguay, and the Museo de Boa Vista (Brazil). Other important collections are held at research institutions such as the STRI in Panama, the Instituto del Mar del Perú (IMARPE) in Peru, the Instituto de Investigaciones Marinas y Costeras (INVEMAR) in Colombia, and at universities.

Today, South America benefits greatly from regional cooperation. One example of cooperation was the Census of Marine Life that incorporated the region into several of its field projects (e.g., Shore Areas, Antarctic Life, Continental Margins, Marine Microbes (ICoMM), and the Mid-Atlantic Ridge Ecosystem (MAR-ECO) projects), which all contributed greatly to increasing the knowledge of marine biodiversity in the region. South America also has contributed nearly 300,000 records to OBIS from almost 7,000 species through its regional node.

At present, some of the main marine biodiversity assessments carried out in the region are:

(1) SARCE: South American Research Group in Coastal Ecosystems (regional); since 2010. Aimed to study biodiversity and ecosystem function in the intertidal zone of rocky shores:

makers. One of the flagship projects was the five-year Census of Antarctic Marine Life (CAML), which investigated the distribution and abundance of Antarctica's marine biodiversity, how it is affected by climate change, and how change will alter the nature of the ecosystem services currently provided by the Southern Ocean for the benefit of mankind. In this framework and within the International Polar Year 2007-2009, 19 research voyages were coordinated by CAML, involving more than 400 biologists from over 30 nations.

The CAML community explored the unknown bathyal and abyssal Southern Ocean (SO) and many shallow sites. Within the project about 16,000 SO taxa were identified and included in a database of Antarctic Marine Life; see the SCAR-Marine Biodiversity Information Network (www.scarmarbin.be). The CAML projects barcoded more than 3,000 species, a SO Plankton Atlas was established, life underneath the collapsed Larsen A and B ice shelves was studied and many scientists worked on the biodiversity, biogeography and conservation of various marine taxa.

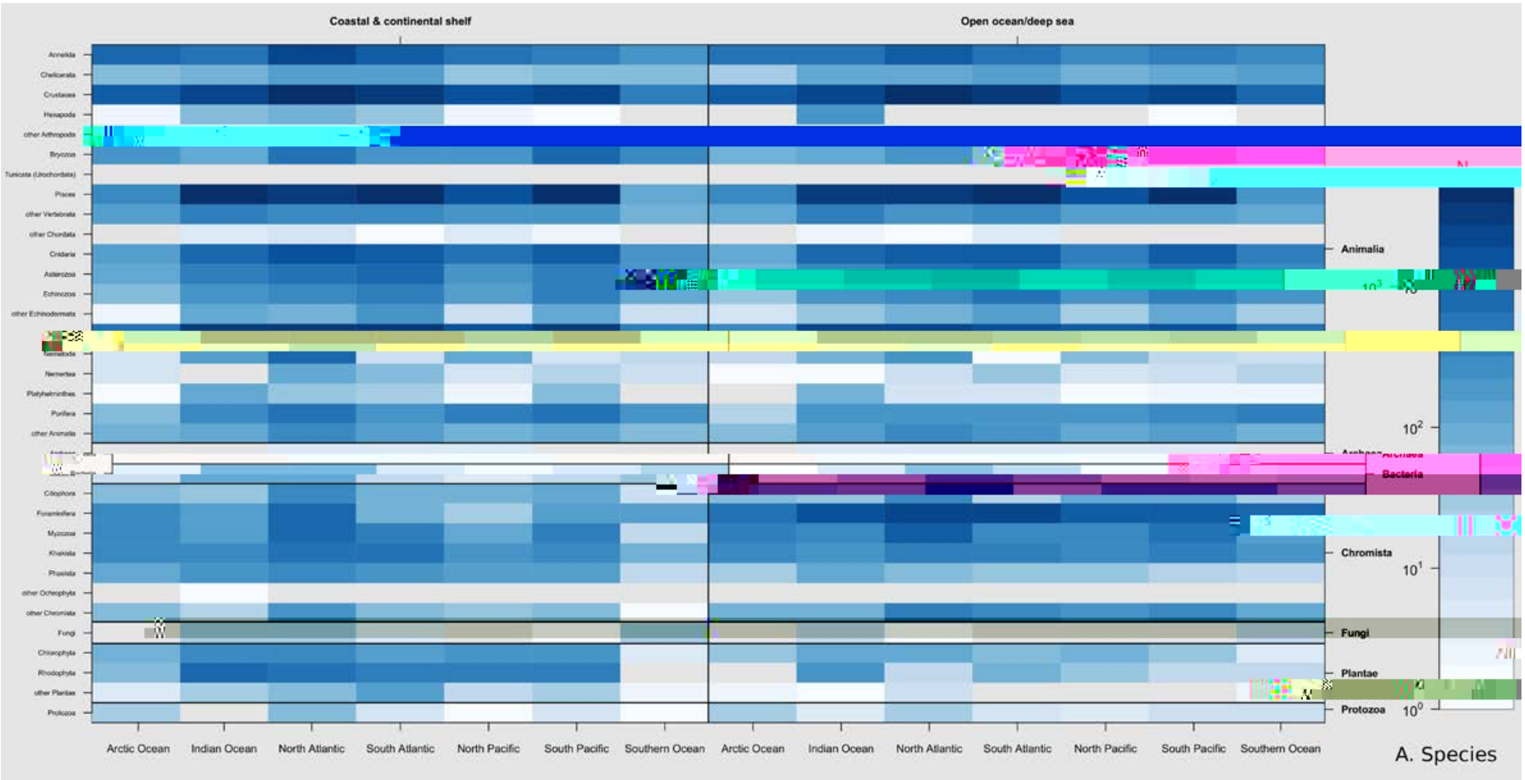
Moreover, more than 700 species new to science were discovered (Brandt et al., 2007) and new and unknown habitats were explored, e.g., the SO deep sea, and the Amundsen Sea. The lasting legacy of CAML is a benchmark, a system (or database) for monitoring change in the SO. Another major legacy of the CAML project and the SCAR Marine Biodiversity Network is the Biogeographic Atlas of the Southern Ocean (De Broyer and Koubbi, 2014) which compiles in more than 80 chapters an extensive review of the state of knowledge of the distributional patterns of the major benthic and pelagic taxa and of the key communities in the SO within an ecological and evolutionary framework. The Atlas relies on vastly improved datasets, and on insights provided by innovative molecular and phylogeographic approaches, and new methods of analysis, visualisation, modelling and prediction of biogeographic distributions. A dynamic online version of the Biogeographic Atlas will be hosted on www.biodiversity.aq.

The development of molecular techniques is a technical advance which promises to revolutionize work on the diversity and biogeography of Antarctic marine biota. CAML supported these efforts through its DNA Barcoding program. This technology is rapidly evolving and becoming ever more sophisticated. In particular such work is starting to uncover a wealth of cryptic species within what were once regarded as single, widely distributed species. Not only does this work increase the known species richness of the SO, but it also changes biogeographic patterns (typically reducing the range size or depth range) and hence affects our interpretation of the evolutionary history of the fauna. Along with these techniques, recent advances in satellite and aerial imagery will also become important for mapping and visualization and will help improve knowledge of marine ecosystems in the Southern Ocean. The Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) is regarded as a model for regional cooperation and maintains scientific research programmes (including ecosystem monitoring) to address risks to commercially exploited fish stocks in the SO using an ecosystem-based approach.

crustaceans, molluscs, and fishes. However, knowledge of marine biodiversity is not only related to surveys but also to the availability of local and regional taxonomic expertise, and to commercial value (e.g. fish and crustaceans). Here we examine the current global availability of biogeographic knowledge across all major marine taxa, using OBIS (OBIS; IOC of UNESCO, 2014) data.

Overall, the figure includes data for 228,935 accepted marine species across all taxonomic kingdoms (Figure 6). Forty per cent (90,921) of these species, including at

Figure 6. Summary of the current global availability of biogeographic knowledge across all major marine


Coastal & continental shelf
Open ocean/deep sea
Animalia
Chromista
Fungi
Plantae
Protozoa
Arctic Ocean
Indian Ocean
North Atlantic
South Atlantic
North Pacific
South Pacific
Southern Ocean
A. Species

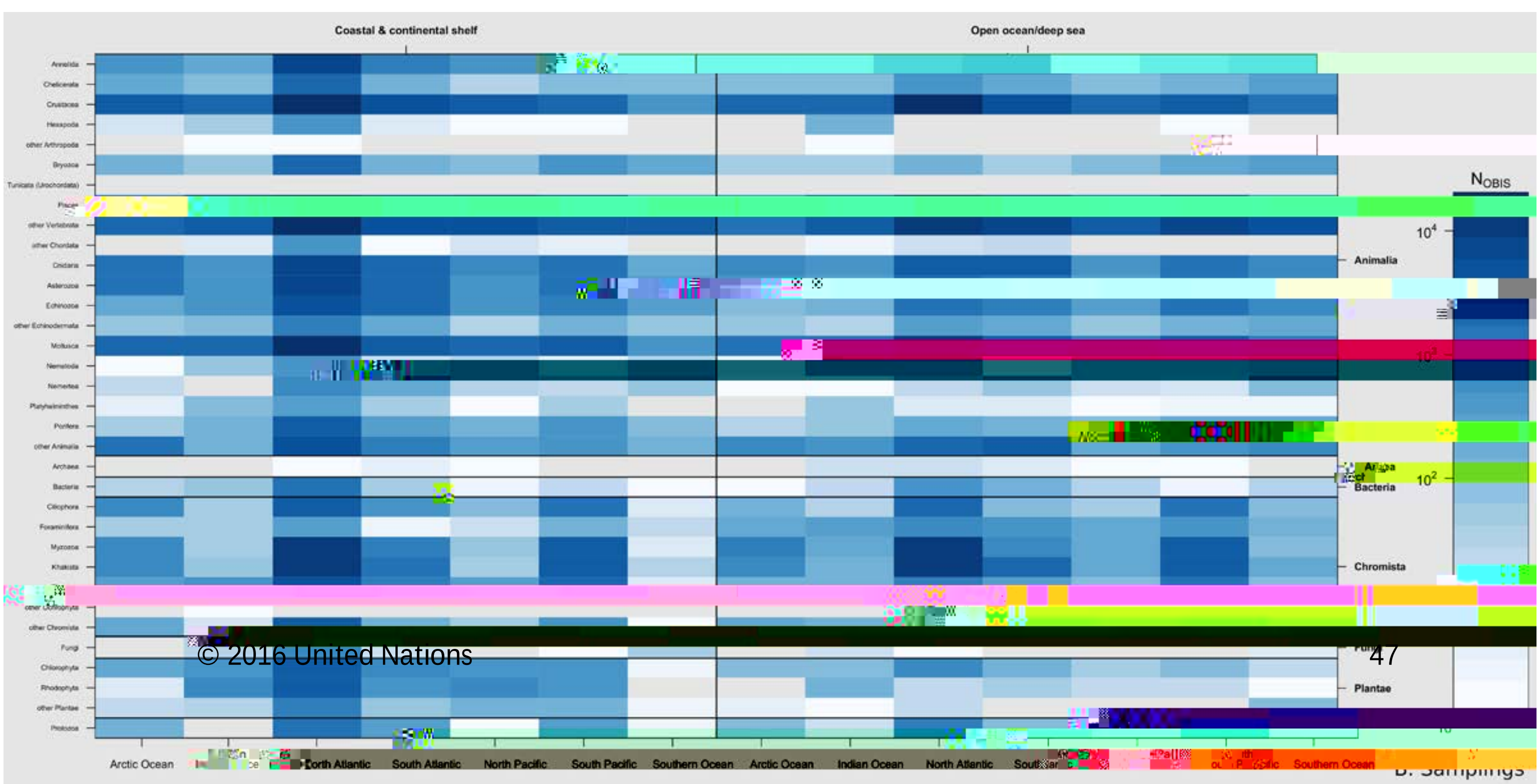

Coastal & continental shelf
Open ocean/deep sea
N_{OBIS}
Animalia
Bacteria
Chromista
Plantae
Arctic Ocean
North Pacific
South Pacific
Southern Ocean

Figure 7 provides a visual representation of our knowledge measured as number of observations for species (7A), sampling (7B), and records (7C) for the different taxonomic groups comparing coastal and continental shelf environments versus open ocean and deep sea waters for the seven ocean basins. In general, it is clear from Figure 7A that fishes, along with crustaceans and molluscs, are the most diverse groups in all ocean basins. Figures 7B and C show that the North Atlantic is the best-known ocean basin for all groups. (www.iobis.org). These figures also demonstrate that, for each of the ocean basins, knowledge is significantly higher in the coastal and continental shelf environments in comparison to the open ocean and deep sea environments which reflects the same situation exposed by Costello et al. (2010), four years later despite important efforts in advancing deep sea research. To analyse geographic completeness, we show an estimate of the number of species using the Chao index for the different seas within the seven ocean basins using the OBIS database. It is evident from this graph that the best sampled areas have been in the northern hemisphere, and that the southern hemisphere, with the exception of the Southern Ocean, has been poorly sampled (Figure 8).

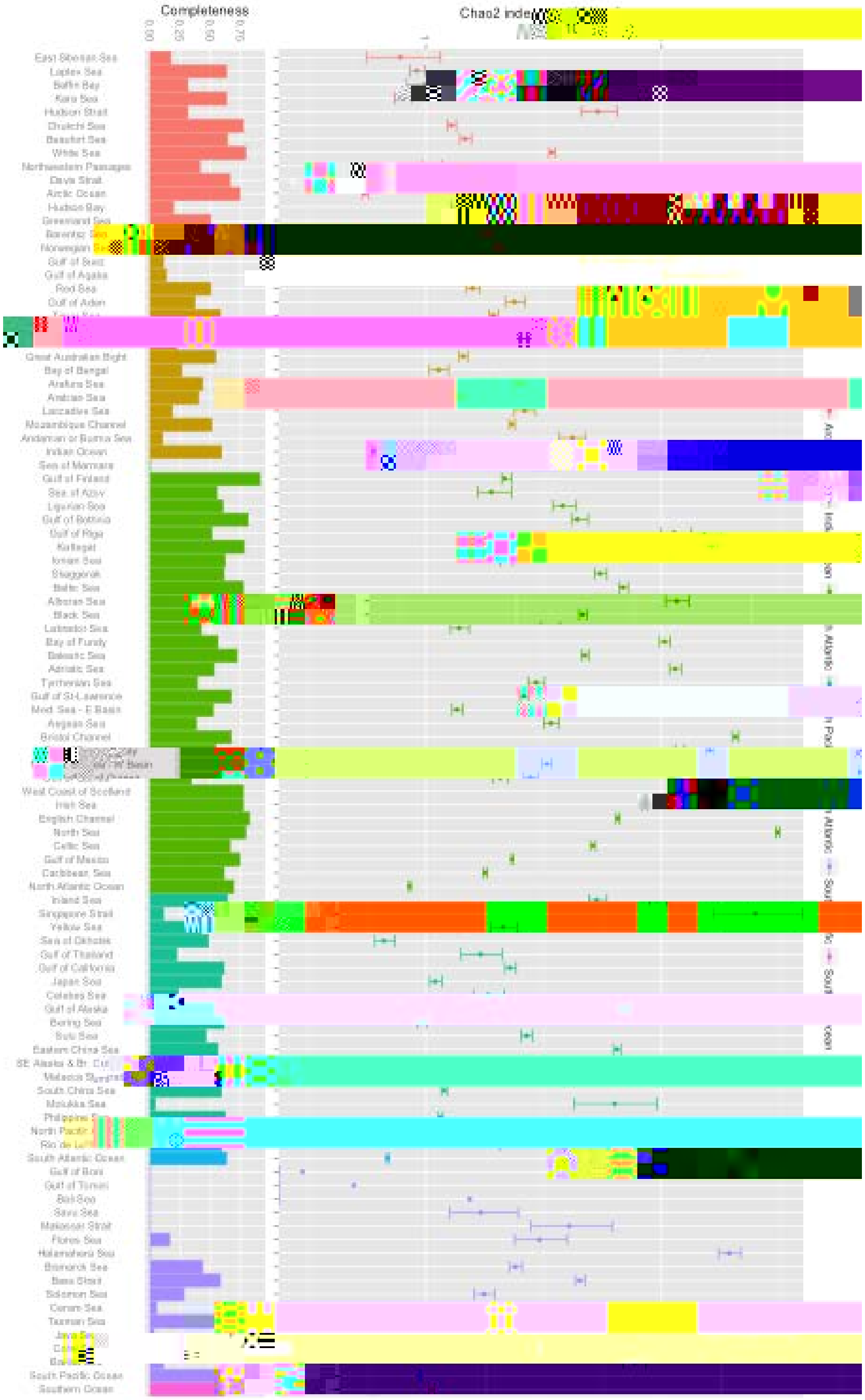


Figure 8. Estimate of the number of species, using the Chao index, for the different seas within the seven ocean basins using the OBIS database (www.iobis.org).

Final remarks

comparisons; (3) increase sampling effort, exploring new habitats, and identifying and mapping biodiversity hotspots; (4

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