Chapter 52 Synthesis of Part VI Marine Biological Diversity and Habitats

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1. Biodiversity itself

Biodiversity has natural patterns globally, at all levels from phytoplankton to top predators, including fish, marine reptiles, seabirds, and marine mammals. Main factors that underlie these patterns include depth and proximity to coastline, latitude, habitat complexity and primary productivity, temperature and substratry. 2.1(a) (Chapter 34). These

and aquaculture (Chapter 12) is one of the major challenges to conservation and sustainable use of marine biodiversity.

3. Trends in biodiversity for species and groups of species

Superimposed on these patterns at all scales are temporal trends. Biodiversity is not static, hence both random variation and multi-year trends would occur without anthropogenic pressures (for example, Chapter 36C, Figures 8,9,10, which show substantial variation in chlorophyll and zooplankton well offshore of the main influences of land-based inputs, and Chapter 36F, Table 1A; Chapter 36D.2.1, 36G.2, 36H.2.1, 36H2.2, showing substantial variation in bottom-up productivity in the open ocean and high-latitude seas where anthropogenic nutrient inputs are not large enough to be major drivers of basin-scale trends).

Human uses of the ocean have imposed much greater temporal trends on all biodiversity components. This Assessment found evidence of these temporal trends due to human drivers in every regional assessment and for all components of biodiversity, with some emergent patterns. They are summarized below.

3.1 Phytoplankton and zooplankton

Natural regime shifts have changed baseline bottom-up productivity to some extent, and the species composition of the phytoplankton and zooplankton to a greater extent (e.g., Chapter 36C, Figures 1, 3, 4) on the change in plankton community composition. Changes in species composition of lower trophic levels have broader ecological consequences, because such changes have been found to affect pathways of energy flow to higher levels, affecting species of fish, reptiles, birds, and mammals (e.g., Chapter 36A.7 [Gulf of St. Lawrence], Chapter 36G, Figure 1, both showing changes in food-web structure; Chapter 36A.3, 36D.2.1, 36D.2.2, and 36H.2.2, all showing changes in animal community composition in response to productivity drivers).

In coastal areas, human pressures on bottom-up processes were documented in all the divisions of the ocean described in chapter 36. Scales can be local to, occasionally, that of full semi-enclosed seas; the largest effects are documented where human populations are most dense (Chapter 36A.7 [Mediterranean, Baltic and North Seas], Chapter 36C, Figure 36C-6), but local effects are even seen in high-latitude seas (Chapter 36G [Trends]; 36H.1).

Many documented cases were found where high levels of contaminants or land-based nutrient runoff dramatically reduced diversity of species (Chapter 36C, Figure 36C-1; Chapter 36E.2; see also Chapter 20) or diminished or sometimes eliminated diversity due to hypoxia (see Chapter 36C.2(c) on hypoxia; Chapters 20, 44).

Many documented cases were also found where adoption of appropriate policies to address sources, along with funding for monitoring, correcting problems at source, and when necessary clean-up of affected areas, has reversed these trends and achieved good environmental quality (examples in Chapter 36A.7 [North Sea, Baltic Sea, Chesapeake Bay]).

(Chapter 11), indirect impacts due to fishing gear and aggregate extraction (Chapter 36A.7 [North Sea]; 36D.2.3; Chapters 11, 42, 43 [corals], 44 [estuaries], 51 [seamounts]), and indirect effects due to pollution, sedimentation, etc. For example, loss of coral cover has been linked to catchment disturbance (Chapter 36D.3; Chapter 43), and species loss due to pollution is widespread in many estuaries (Chapter 44). Salt marshes have been drained, diked, ditched, grazed, sprayed for mosquito control, and invaded by a range of non-native species that have altered their ecology (Chapter 50). Many examples were found of high pollution, etc., altering benthic communities extensively and changing both species composition and biomass/productivity (Chapter 36A.7, 36B.4 [hydrocarbons]; 36C.2b; Chapters 20, 44). Trends in benthic populations or communities are often used as indicators for effects monitoring, because some benthos are sensitive to specific pressures and have high local patchiness of occurrence in specific response to those particular pressures.

This Assessment also contains many documented cases where adoption of appropriate policies to address sources, along with funding for monitoring, reducing the threat at source, and when necessary taking actions to remediate or restore damaged populations, communities or habitats, have reversed these trends and achieved good environmental quality (Chapter 36A.4.b, 36B.4.3, 36D). For example, coral-reef fish populations have been shown to recover within MPAs after they have been declared (Chapter 43) and management of shrimp aquaculture that prohibits clearing of mangroves and replanting of new forest has resulted in an improved condition of that habitat (Chapters 12, 48). Climate change also affects benthic biodiversity, but documentation and understanding of pathways and consequences are at an early stage (Chapter 36A.3, 36G.3).

For offshore benthos, the overwhelming pressure is the impacts of fishing gears. Trends were documented in all regions, and the commonality of these trends has led to the occasional characterization of all mobile bottom gear as a destructive fishing practice. Many types of seafloor habitats and benthic communities, particularly those comprised of soft bodied and leathery species, do show recovery from bottom trawling when the pressure is released, although just as with the fishery communities that are being exploited, full recovery may requires years to decades. During periods of disturbance and recovery the relative species composition is changed, as long-lived species are reduced in abundance and dominance. However, as long as recovery can commence rapidly and is secure, such perturbations are sustainable and the habitats are considered to have resilience (Chapter 36A.3, 36B.4, 36C.3.b; Chapter 11). However, some special types of habitats and benthic communities are not resilient. Pressures, causing changes to seabed structure or increased mortality of species that are more hard-bodied and that create habitat diversity through burrowing or creating three-dimensional structures, may cause large and lasting trends in the benthic community. Productivity can be reduced and recovery, if feasible at all, could take many decades to centuries (e.g., cold-water coral communities, especially these highly vulnerable to sensitive benthic habitats are in place for the high seas and many national jurisdictions. For example, some States and intergovernmental entities have adopted measures for the protection of seamounts and other deep water habitats within EBSAs, VMEs and MPAs, as discussed in Chapters 42 and 51. But this has not been done in most parts of the ocean, since the task of identifying such areas of particular importance to biodiversity is incomplete in some parts of the ocean. In addition, the necessary scientific and technical information is sometimes not available to the relevant States and intergovernmental organizations.

As with the plankton in the water column, invasions of alien species pose a risk of altering benthic biodiversity on scales from local and coastal to seas or large stretches of coastlines. The same processes of natural transport of reproductive propagules, range changes in response to climate-related changes in ocean conditions, and accidental transport with shipping or tourism have all been documented, with resultant major changes in benthic and occasionally pelagic community structure at scales at least of bays of hundreds of kilometres of coastline documented in all regions where sampling is adequate to detect such effects (Chapter 36A.3, 36B.4, 36C.3.b). In addition, a few cases are recorded of intentional introduction of larger invertebrates to develop new harvesting opportunities, with subsequent expansion of the species well beyond the area of introduction (such as Kamchatka crab in the Barents Sea Chapter 36A).

The shipping industry is actively seeking to improve practices and reduce risk of transferring species to new areas, and cost-effective risk-management practices are available (Chapters 17, 27). Detection of new benthic species requires intensive and often costly monitoring, for which capacity is limited in many areas. Once alien species are established, their elimination and remediation of the impacts have proven to be very difficult, costly, and rarely feasible.

3.3 Fish and pelagic macro-invertebrates

As with the other species groups, fish communities have always varied in abundance over time, sometimes by orders of magnitude, especially for small pelagic species in areas with variable oceanographic conditions (examples in Chapter 11, Chapter 36A.4, 36B, 36C, Figure 36C-4; 36D [salmon]; 36D.2.4). In several ocean basins changes in major portions of fish and invertebrate communities are well documented, and these are often related to corresponding changes in the physical ocean (Chapter 36A.4, 36C.3.a.iv, 36G.4).

Range changes of fish and macro-invertebrates in response to naturally changing ocean conditions are also documented in all regions (examples in Chapter 36A.4.4, 36C.3, 36G.4, 36H.2.3). The responses of fish populations and communities to climate change have been a particular priority for mid- and high-latitude parts of the ocean, with documented effects on productivity, timing of life history processes (e.g., Chapter
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change in the oceanographic conditions (examples in Chapter 36.A.4, 36C, Figure 36C-4; 36D.2.4).

Another type of documented trends in ranges of fish and invertebrate species are invasions of non-native species (example in Chapter 36C, Figure 36C-7) almost certainly associated with shipping. Some of the invasions by large pelagic invertebrates, such as comb-jellies, have completely changed the fish community on the scale of bays, and of the entire Black Sea (Chapter 36A.7, 36C.2). Although the magnitude of the disruptions from such invasions may diminish over time due to both natural ecosystem processes and management interventions, it has not been possible to eliminate or reverse such changes quickly, if at all, and costs have been high both in terms of costs to try to control the invading species, and in foregone benefits from the disrupted fish community (e.g., Black Sea). Prevention of introductions is by far the most logical and cost-effective option, and is receiving attention from the shipping industry. Again, however, resources are needed to implement and ensure adherence to best practices.

Trends in fish populations are linked to contaminants, pollution, and particularly habitat degradation due to land-based sources. However, population-scale effects have been restricted to nearshore areas or semi-enclosed seas where contaminant, pollution and/or sediment levels are high and water quality is degraded, with many fish populations and communities particularly susceptible to reduced oxygen levels in the water due to both climate change and increased nutrient enrichment (Chapter 36A.7 [Gulf of St. Lawrence, Chesapeake Bay, Gulf of Mexico]; 36B.2, 36C and F). However, the concern exists that long before population-scale impacts of contaminants may be apparent, fish may accumulate levels of contaminants in their flesh that pose health risks for consumers (Chapters 10, 15). In addition, it was noted earlier that some specialized habitats that are hotspots for fish and invertebrate biodiversity are also particularly attractive for other human uses. Downward trends in fish populations associated with such habitat losses are documented in many coastal areas (Chapter 36A.7 [all cases]; 36F).

Regardless of the cause of habitat loss or degradation, fish populations and communities have been documented as recovering when effective remediation measures have been taken (Chapter 36.A.4, 36C, Figure 36C-11; Chapter 41). Again, however, costs of remediation have often been high, time lags long, and prevention of loss or degradation is usually the more cost-effective option, with less uncertain outcomes than remediation initiatives.

Exceeding all of these other causes of trends in fish populations and communities are the effects of fishing. Fishing necessarily changes the total abundance and size/age composition of the exploited populations, with effects increasing as bycatch rates increase and as fishing becomes more intense and more selective of only particular species and sizes. The search for levels and methods of fishing that have sustainable impacts has gone on for over a century (Chapters 10, 11). Nevertheless, overfishing has not been eliminated, and downward trends in exploited populations, sometimes to depleted levels, can be found in all regions (Chapter 36A.4, 36B.4, 36D.2.4). Estimates of the economic cost of such depletions are available (Chapters 11, 15), but ecosystem costs from the biodiversity impacts of overfishing exist as well. If genetic diversity of populations is depleted, resilience to naturally varying environmental conditions is reduced (Chapter 34; Chapter 36A.4). Also as the abundance of large fish in a community is reduced through fishing at levels that allow few fish to live long enough to reach their full potential size have been proven to be effective for many types of gear, through changes in gear design (e.g., excluder devices), fishing practices (e.g., surface deployment of longlines), and other methods. However, implementation of mitigation techniques often requires training in their use and is specific to the species, fisheries, and areas where the fishing occurs. Hence additional measures, such as periodic and area closures in areas of high bycatches, or closures of fisheries when allowable bycatch numbers are exceeded, are often applied, with or without gear-based measures (Chapters 38, 39). Downward trends in marine reptile, seabird, or marine mammal populations due to bycatch impacts can be stopped and population increases facilitated by the appropriate combination of these mitigation measures, but require expert study of the nature of the bycatch problem and evaluation of the potential effectiveness of alternative mixes of may only show up gradually, but may be hard to reverse. Moreover the impacts may be non-linear once they start species use those particular areas for some or all life history processes. If those specialized structural features are disturbed intentionally or collaterally by human activities, their ability to serve those functions for all the species ice habitat (Chapter 46) caused by global warming). Also coral bleaching is widespread and has affected the quality of coral reef habitat in all areas of the oceans (Chapter 36D2.3;

the threats have been adequately managed, the habitats and their biodiversity protected, and at least some recovery from past perturbations has been recorded. For example, 24 estuarine case studies reported that management has resulted in improving estuarine health (Chapter 44) and declaration of MPAs has prompted the recovery of ecosystem and fish populations in coral reefs (Chapter 43). Although the benefits of coordinated planning and management of pressures cannot be overemphasized, targeted and proactive measures can have high payoffs if even one pressure is reduced effectively (e.g., seasonal closures of fisheries to protect spawning aggregations (Chapter 11); stopping mangrove habitat conversion for aquaculture (Chapter 48)) biodiversity on local to basin-wide scales to be exposed to cumulative effects of multiple pressures interacting in ways that are usually poorly understood.

Certain types of species, such as marine mammals, seabirds, marine turtles, large sharks and fragile benthic taxa, such as corals and sponges, and certain types of habitats, including coral reefs, hydrothermal vents, estuaries, mangroves, and others, are both particularly sensitive to pressures from many types of human activities and attract human uses in large part because of their biodiversity characteristics. These are often the components of biodiversity showing the strongest declines over time, and thus pose particularly great conservation concern.

Notwithstanding the widespread negative trends in biodiversity and the number and ubiquity of anthropogenic pressures associated with those trends q4(nt)10(hr(ic)4(u)-3.9(l6(pri)-3.9(e)-1(s)
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