5.8 Biodiversity in natural marine ecosystems: patterns, functioning and conservation

Abstract

Marine ecosystems cover over two thirds of the Earth's surface and occupy a volume that vastly exceeds that of terrestrial ecosystems. Life appeared in the oceans, and the oceans remain the greatest repository for the diversity of life at the level of phyla.

In general, the diversity of marine environments is lower than that of terrestrial environments, primarily as a consequence of the high mobility of the organisms, the wide passive dispersal of their organisms by currents and the low structural heterogeneity of the environment. Marine ecosystems are characterized by low biomass and very high ratios of production to biomass, while terrestrial ecosystem have biomass several orders of magnitude higher, and a much lower production/biomass ratios. Food webs are more complex in the sea than on land.

The productivity of marine systems ranges from algal reefs and upwelling areas that support the richest fisheries on earth, to nutrient-poor regions in the centres of the largest oceans, where biomass and production are extremely low. Marine disturbance regimes range from constant actions by large waves or annual scouring by ice flows, to the nearly constant physical conditions of the deep-sea benthos. Thus the marine environment provides an ideal opportunity for comparative evaluation of the predictions of the dynamic equilibrium model (Huston, 1979) explaining biodiversity patterns. The four marine systems that will be discussed in relation to the dynamic equilibrium model are the rocky intertidal zone, central oceanic regions, deep-sea benthos and coral reefs.

Biodiversity can be examined at all organizational levels, from the large-scale diversity of ecosystems to the genetic diversity within a particular population. In most cases, studies on biodiversity focus on species diversity as the primary indicator of changes. Species diversity may be divided into four components:

- species richness - the number of species present;
- species evenness - the relative abundances of different species
- species composition - the nature of the species present (i.e. species list)
- species interactions- the effects of a species on the composition of the community and its temporal and spatial variation

One of the major current topics of debate is that of functional redundancy, i.e. more species are present in communities than are needed for efficient biogeochemical and trophic functions. Recent data however show that this is not the case and the higher the number of species in a community, the greater the efficiency of biogeochemical processes.

Most of the threats in marine biodiversity are in the coastal zone: habitat loss, global climate change, overexploitation and other effects of fishing, pollution, eutrophication and related problems such as pathogenic bacteria and algal toxins; radionuclides; species introductions/invasions; water-shed alteration and physical alterations of coasts, tourism; marine litter; and the fact that humans have little perception of the oceans and their marine life. All the reviews agree that the most critical threat is habitat loss.

Declining yields in many fisheries and the decay of treasured marine habitats such as coral reefs have heightened interest in establishing a comprehensive system of marine protected areas (MPAs). In designing a system of marine reserves and protected areas, the complete spectrum of habitats supporting marine biodiversity should be included with emphasis on safeguarding ecosystem processes. One of the best-supported goals of MPAs is to conserve and restore marine biodiversity - that is, to maintain species diversity and the natural balance of species interactions. Connectivity among reserves should be a factor in the design of MPA networks to prevent genetic isolation of populations and to ensure that dispersal of early life stages and re-colonization are facilitated. Moreover, properly networked MPAs will promote

habitat linkages necessary for various life stages and ensure continuity of life processes within MPA networks.

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