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Courtesy P Tarr

3.1 Characteristics of marine environments

Species richness is typically related to the complexity and stability of the environment:[1,2] groups of individuals become reproductively isolated and adapted to particular ecological niches within a habitat, precipitating speciation.[3] The greater the diversity of these niches, especially in a relatively constant environment, the greater the opportunity for speciation, and the greater the resultant species richness.

The oceans of the world are often seen as vast, stable, homogeneous masses of water offering little in the way of diverse or complex habitats. In contrast to other major environments, such as land and freshwater, oceans are physically continuous. All marine water circulates, making it possible for species to disperse over vast distances. Seawater temperatures vary much less than do air temperatures over land, while the chemical constitution of seawater is remarkably constant, so much so that its salinity and other chemical traits are thought to play a very small role in marine ecology.[4,5]

Because of this apparent evenness, the potential for speciation and diversification seems low. This is indeed partly true of the open ocean, which despite its vastness is home to a paltry 2% of the world's marine species[4]. However, the apparent homogeneity of other marine habitats belies the complexity of chemical and physical processes which occur below the surface largely out of view. Currents, tides, waves, mixing of waters, upwelling and the effects of relief features on the ocean floor combine to create remarkably varied and variable habitats.

Littoral and pelagic habitats are among the most biologically patchy and variable of all. The Committee on Biological Diversity in Marine Systems[6] reports that hundreds of benthic invertebrate species co-occur within a square metre of deep-sea floor. Some even consider the sea to have a higher ecosystem diversity than the land[7,8] and to be far richer biologically than is generally appreciated.

Lack of information on biological diversity in the marine environment reflects the extent to which the world's oceans are unknown. Basic description of marine biodiversity lags behind that of the terrestrial environment, and the identification of new families, orders and even phyla of marine species continues apace.[6]

The diversity of organisms in marine environments is the product of millions of years of evolutionary history. Oceans are particularly rich in higher taxa, with representatives of 28 phyla identified so far. This includes 13 phyla endemic to oceans, with only one known phylum unrepresented. In contrast, freshwater environments harbour 14 phyla with no endemics, and terrestrial systems harbour 11 phyla, one of which is endemic.[9] This extraordinary diversity in higher taxonomic categories reflects the origin and early diversification of life in the ocean. Marine biodiversity thus represents an ancient and fascinating heritage, of which we are the privileged custodians.

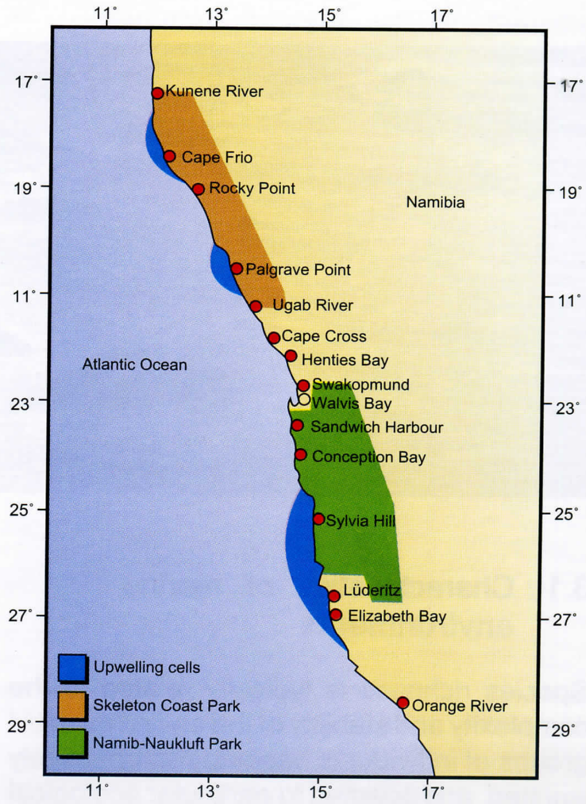
3.2 Namibia's marine environment

Influence of the Benguela system

Namibia's marine environment is dominated by the Benguela Current system, which extends along the eastern edge of the southern Atlantic between Cape Agulhas (35°S) in the south and the Angolan port of Namibe (15°S) in the north. Although the boundaries vary seasonally, the system features cool surface waters and high biological productivity. Warmer waters to the north (Angolan Current), south (retroflection zone of the Agulhas Current) and west (south-Atlantic gyre) enclose the system.[10]

The driving physical process in the Benguela system is coastal, wind-induced upwelling. Prevailing south to southwesterly winds off Namibia tend to move nearshore surface water northwards and offshore, while cool, central water from a depth of about 300 m wells up to take its place.[11] The deeper water is rich in inorganic nutrients which allow phenomenal growth of phytoplankton. As these microscopic plants form the base of the marine food chain, their enormous productivity supports some of the highest concentrations of marine life found anywhere in the world.

Off Namibia, the rate and intensity of upwelling fluctuates with seasonal variations in wind patterns. Bottom topography and the seaward extent of the continental shelf also influence upwelling, with the most intense upwelling being found where the shelf is narrowest and wind strongest. Such conditions prevail especially off Cape Frio, Palgrave Point, Conception Bay and Lüderitz (map 3.1), although upwelling can occur along almost the entire Namibian coast. The largest and most intense upwelling in the Benguela system is near Lüderitz.



Map 3.1 The Namibian coast, adjacent protected areas and upwelling cells

Upwelling is one of the few ways in which nutrients trapped in the deeper oceanic layers are brought to the surface, where they can be taken up by phytoplankton and incorporated into organic compounds. The major nutrients are various forms of inorganic phosphorus, nitrogen and silicon. When organisms die, the organic matter sinks and decays, releasing inorganic nutrients back to the sea. The region near Walvis Bay (map 3.1) is one of the most important sites of nutrient cycling in the system.[11]

The continental shelf sediments of Namibia consist of large areas of *diatomaceous* (diatom rich) muds, supporting little or no marine life but with high concentrations of organic matter and sulphur.[12] Between Cape Cross and Lüderitz the shelf sediments may contain as much as 15% organic carbon, which is exceptionally high.[11] The sulphur concentrations result in periodic, localised sulphur 'eruptions,' causing fish mortalities and giving the sea a turbid turquoise colour and pungent smell. These phenomena are