Food and Agriculture Organization of the United Nations
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Fisheries and
Aquaculture Department

Deep-sea ecosystems

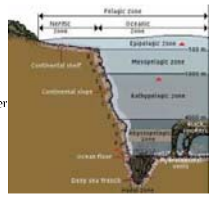
The deep-sea habitat

The deep-sea is the largest habitat on earth. The area reaches over 4 000m in depth and covers 53% of the sea's surface, which in turn covers 71% of the world's surface! The continental slopes alone occupy 8.8% of the world's surface, compared to 7.5% for the continental shelf and shallow seas (see Figure below). It is a predominantly dark and cold environment with much lower productivity than shallower ones.

Deep-sea species

The "deep-sea" water mass can be subdivided into four depth zones:

- mesopelagic (150-1 000m);
- bathypelagic (1 000-3 000m);
- abyssopelagic (3 000-6 000m); and
- hadal zone, below 6 000m depth, in the deep ocean trenches.



From a demersal, or seafloor perspective, the deep-sea region consists of the continental slopes (starting at the shelf break), the continental rise which extends down to the abyssal plane at around 6000m, and the trenches. The seamounts stand out of the abyssal plain.

No light penetrates beyond 1 000m and even at depths of 150m light levels are reduced to one percent of those at the surface, insufficient to support photosynthesis. Thus, organic material must be convected into the deep waters, which occurs in various ways. Dead phytoplankton and nekton sinks, and though much is consumed as it settles, sufficient amounts enter the deepwater to sustain much of the biomass there.

Many species undergo extensive diel vertical migration, a pattern of feeding in the surface waters at night and moving down during the day to reduce predation. In this way, surface production is cascaded through progressively deeper layers. Of relatively minor productive importance is organic material from large carcasses sinking to the seafloor, e.g. dead whales, and sulpha-based organic production associated with deep-sea seafloor hot-water vents. Nevertheless, the concentration of organic material decreases exponentially with depth.

In contrast to former views, it is now known that seasonal effects in surface layers are transferred into even deeper ocean regions. Therefore, despite the physical uniformity of the deep oceans, an annual production signal exists that results in seasonal migrations and reproductive cycles in deep-sea fauna.

Marine biodiversity

Deepwater fish comprise three major groups:

- *pelagic* fish living largely in midwater, with no dependence on the bottom;
- *demersal* (seafloor) fish, living close to and depending on the bottom; and
- *benthopelagic* fish, living close to the bottom but undertaking short migrations in the watermass (e.g. for feeding).

In general, the deep-sea demersal fish come from phylogenetically much older groups than the pelagic species (the first existing demersal species were present around 80 million years ago). While most of the demersal deep-sea families are found worldwide, the existence of isolated deepwater basins bounded by the continents and mid-oceanic ridges has resulted in regional differences believed to be a consequence of continental drift and subsequent ocean formation.

Demersal species are distributed according to depth. Those species that inhabit the continental slope and rise are spread along ribbon-like depth regions along the perimeters of the oceans. Where deepwater pelagic species and demersal species co-occur, they usually prey on each other.

In order to cope with the relatively cold and dark conditions in the deep sea, species that live there have adapted in a variety of ways. They are a diverse group of species with different life histories, productivity rates and distribution patterns. However, much remains unknown about deepwater fishes and new discoveries are continually made, such as the megamouth shark (a 4.5m and 750kg shark) and the six-gilled ray, both of which represent previously unknown families.

The importance of deep-sea species and ecosystem biodiversity has led to concerns about their increased vulnerability as a result of fishing activities. Physical vulnerabilities can occur when fishing gears come into direct contact with the seafloor or structural elements of the ecosystem. Functional vulnerability can occur, for example, as a result of the selective removal of a species which may change the manner in which the ecosystem functions.

Some features of an ecosystem, particularly those that are physically fragile or inherently rare, may be vulnerable to most forms of disturbance, but the vulnerability of many populations, communities and habitats may vary greatly depending on the type of fishing gear used or the kind of disturbance experienced. Vulnerability is not an absolute concept: disturbances could be considered acceptable at a given time and/or location but considered to cause unacceptable damage at other times and/or locations.

Particular ecosystems are likely to show increasing vulnerability when fishing intensity increases. However, the relationship between fishing intensity and vulnerability may not be linear and proportional. In some ecosystems this relationship is more “step-like,” with abrupt changes occurring once thresholds are crossed.

Ecosystem components identified as particularly vulnerable include sponge-dominated communities, coldwater corals, and seep and vent communities. These are often associated with topographical, hydrophysical or geological features such as summits and flanks of seamounts, hydrothermal vents and cold seeps.

Coryphaenoides armatus (Macrouridae) from 4800m in the Porcupine Abyssal Plain, NE Atlantic.

Photo courtesy of Alan Jamieson, University of Aberdeen, UK