Theme Session C
Mid-ocean ridges and seamounts: oceanography, ecology, and exploitation

Co-Conveners: Tone Falkenhaug (Institute of Marine Research, Norway), Gui Menezes (Dept. of Oceanography and Fisheries University of the Azores, Portugal), and Uwe Piatkowski (IFM-GEOMAR, Kiel, Germany)

Background

In this theme session, papers were presented on recent findings and analyses on mid-ocean ridges and seamounts. Mid-ocean ridges and seamounts are the shallows of the deep ocean and constitute vast habitats for marine life. Though poorly explored, ridges and seamounts have fisheries resources that have been exploited by international fleets for several decades, often in controversial and virtually unregulated operations. Fisheries usually develop before scientific knowledge has been acquired to provide satisfactory advice on management of habitats and resources. This has led to over-fishing, habitat destruction, and calls for global high-seas trawl bans and introduction of area closures or reserves. Defining sustainability criteria based on current knowledge of the resources and impacts of past and present exploitation is exceedingly difficult.

However, several recent and ongoing projects from the ICES area and other waters have provided new information. The aim of this theme session was to stimulate presentation and discussion of recent findings and analyses as well as historical accounts, focusing on the following topics:

- Influence of oceanic topographical structures on deep and shallow hydrography and circulation;
- Photosynthetic primary production affected by ridges and seamounts;
- Are seamounts and mid-oceanic ridges biodiversity hotspots?
- Do species associated with seamounts and ridges show special life history adaptations?
- Food-webs on ridges. Benthic-pelagic coupling and spatial variation;
- Exploitation of ridges and seamounts by fisheries. History, scale and management measures;
- How sensitive are seamount and ridge habitats and biota to exploitation? Can sustainable fisheries be developed?
- New resources on ridges and seamounts.

Summary of the talks

The session included 15 oral presentations and 8 posters, and covered most of the proposed topics: physical oceanography, patterns of productivity, distributions and biodiversity, life history patterns, food-webs, and exploitation issues. The contributions included presentations on phytoplankton, zooplankton, fish, corals, benthic decapods, cephalopods and marine mammals.

Influence of oceanic topographical structures on circulation and biota

Oceanic topographical structures influence hydrography, ocean current systems and distribution of water masses. This will in turn the distribution of plankton and higher trophic levels. Two presentations showed how the topography of the Reykjanes Ridge (Northern Mid-Atlantic Ridge, MAR) separates the northern MAR region hydrographically (C:12, C:16). Large differences were found in pelagic community, as a function of geographical location relative to the axis of the Reykjanes Ridge. Higher densities of chlorophyll, mesozooplankton, macrozooplankton and fish were observed on the western side of the Ridge

indicating greater biological productivity in this area. 8 species including the biomass-dominant species *Sebastes mentella*, were found exclusively over the ridge. It is suggested that special hydrodynamic and biotic features of ridge systems cause changes in the ecological structure of deep-sea fish assemblages relative to abyssal ecosystems (C:16) and that these changes may support enhanced biomass of higher trophic levels found in the near-ridge fauna.

The interaction of ocean currents with seamounts may also provide areas of higher productivity. An interaction between topography, currents and the vertical migration of acoustic back scattering were described around the slopes of the Vema Seamount (South Atlantic). This led to a retention of zooplankton on the lee side of the seamount, and an increase in concentrations of pelagic fish feeding on the accumulated zooplankton (C:11). Two presentations demonstrated that seamounts may attract visitors, such as marine mammals and thus considered as hot-spots of marine life (presentations C:06 and C:13). The high abundance of sperm whales in the otherwise low productive Sargasso Sea were associated with the New England Seamount Chain (C:13). This seamount chain bisects the north-western portion of the Sargasso Sea, and influence the mesoscale eddies associated with the Gulf Stream, thus creating areas of higher productivity within the otherwise low productive Sargasso Sea. In the Azorean EEZ, some marine predators (skipjack and bigeye tuna, common dolphin and Cory's shearwater) were significantly more abundant in the vicinity of some mapped shallow-water seamount summits (C.06). However, only seamounts shallower than 400 m depth showed significant aggregation effects. These seamounts may be considered hotspots of marine life and special effort should be made in order to ensure a sustainable management of these habitats.

Better knowledge on community structure is critically important for the management of areas of high biodiversity. The Burdwood Bank is the only reproductive area of the Patagonian toothfish (*Dissostichus eleginoides*) known in the Southwest Atlantic. This is a region of high biodiversity that has so far successfully avoided human impact. Presentation C:02 showed that Burdwood Bank has a rich fauna of cephalopods and fish, characterised by distinct assemblages structured by depth and hydrography.

Seamounts can be considered as islands in the deep, and the same theory used to predict patterns of island diversity can be applied to seamounts. This leads to the hypothesis that seamounts could be places where speciation leads to many new forms (presentation C:05). A review of all seamount studies from all oceans estimated that 11.6% of fish on seamounts are endemic. However, estimating the number of endemic species on seamounts is fraught with difficulties caused by sampling constraints. At present we have only a weak scientific basis on which to plan conservation and management of seamounts.

Life-history studies

Seamounts and mid-oceanic ridges are fishing areas of an international fleet of trawlers and long-liners. Many of the fish species have life histories that make them particularly vulnerable to overfishing. Better knowledge on life-histories and early life stages of commercial species is critically important for the management of these recourses: Two presentations (C:04, C:09) and four poster (C:22, C:28, C23, C:25) presented life-history and demographic characteristsics of deep-sea resources. The orange roughy (*Hoplostethus atlanticus*) is a deep-sea fish with a long life-span. Due to heavy fishery on seamounts, many stocks have been substantially depleted. However we still lack necessary knowledge on the recruitment, life-history and behaviour which is needed for the management of this species. Presentation C:04 provided new information on abundances and habitat choice in juvenile orange roughy. The juveniles were initially found on the bottom, near known spawning grounds, at 850–900 m. This information will be important to provide more accurate recruitment models. The ontogenetic habitat-shift in orange roughy may also help explain observed dynamics in fishery catches on seamounts (poster C:28). The Antarctic toothfish *(Dissostichus mawsoni)* is one of

the important deepwater resources of Antarctic. However, information on the reproduction of this species is lacking, such as habitat, time, and periodicity of spawning. C:09 presented results from histological analysis of the maturity of ovaries from Antarctic toothfish in the Indian Ocean area of the Antarctic. No mature females were found in the period of fishery (December–February), indicating that spawning period occurred later in the season. The demography and distributions of demersal fishes and deep-sea sharks on Atlantic seamounts south of the Azores is the focus of the DEECON project (*Unravelling population connectivity for sustainable fisheries in the Deep Sea*) presented by the poster C:22. The distribution and zoogeography of early life-stages of fish (eggs and larvae) were presented by two posters: C:23 on seamounts in Central-eastern and north-east Atlantic and C:25 at the Senghor-seamount, Cape Verde Islands.

Obtaining individual-level measurements for understanding population dynamics, or describing life history patterns in fishes is time-consuming, and often such information is limited to length. Presentation C:14 demonstrated that data on individual lengths may provide valuable information on the life-histories of deep pelagic fishes. Analyses on material from pelagic trawl hauls from the northern Mid-Atlantic Ridge show that length distributions in many deep-pelagic fish species are characterized by negative skew. This suggests that deep-pelagic fishes have a low mortality rate relative to the rate at which they grow towards their asymptotic size.

Trophic studies

Understanding the food-web structure and organic cycling of deep-pelagic ecosystems requires integrated methods in order to identify the diet of species. Three studies were presented on trophic interaction, using different methods such as stable isotopes (C:07, C:18), microscopical and molecular analysis (poster C:27).

A north-south gradient in the fatty acid composition and stable nitrogen isotope values was found in *Calanus finmarchicus* along the mid-Atlantic ridge, indicating latitudinal variations in diet and trophic position of this species (C:07).

Gelatinous zooplankton, such as medusa and siphonophores constituted a large propotion (WW) of the net-catches on the Mid-Atlantic Ridge, MAR (poster C:21). Gelatinous zooplankton may play a significant role in the food-web on the ridge. Fish belonging to the family Microstomatidae are known consumers of gelatinous zooplankton and were found to be a biomass dominant family on the MAR. The ability to identify gut contents molecularly (DNA) will greatly increase our understanding of the deep-pelagic ecosystem and the role of gelatinous prey (poster C:07).

Seamount benthic ecosystems may be tightly coupled with surface productivity. Stable N isotope and radiocarbon compositions of bamboo coral skeletons from 3 seamounts southeast of Tasmania indicated a strong trophic link between the surface and the corals at 1000 m depth (C:18). These results demonstrate the utility of deep-sea corals to track seamount biogeochemical processes over long time-scales and provide an important baseline against which future climate change in the region can be evaluated.

Exploitation and impact

Seamounts are the focus of important commercial fisheries based on fish species that form large aggregation in association with them. Intensive studies and exploitation on seamounts of the Atlantic Ocean were initiated by Russia in the 1970s and 1980s. C:10 presented historical data on Russian commercial fisheries from seamounts on the Mid-Atlantic Ridge, Corner and Rio Grande Rises, South Azores and Madeira –Canary Island areas, the Vavilov, Walvis and South Antilic Ridges for the period 1973–1992. The highest catches and fleet efficiency were typically observed during the first years of the fishery and then declined. It was concluded that

the fish stocks on these seamounts are probably in a depressed state that will not permit significant increase of catch within the next few years.

Different opinions prevail on the exploitation of deepwater resources. While calls for enhanced conservation measures are strongest, claims are also put forward that ridges and seamounts have substantial unexploited resources. New fisheries are still developing in seamounts areas, like those targeting the deep-water red crab (*Chaceon affinis*, poster C:31) and the shrimp *Pleisonika edwardsii* (poster C:30). Information on distribution, abundance, population structure and maturity of these species on Azorean seamounts were provided by C:31 and C:30, which will help to evaluate fishery potential and sustainability of these resources.

The benthic environment on seamounts is distinct from that found on the surrounding seafloor, and may be disturbed to anthropogenic activities like bottom fishing. Following the United Nations General Assembly Resolutions (UNGA, 2005; UNGA, 2007), several management measures in order to protect vulnerable ecosystems in the high seas, are being implemented by Regional Fisheries Management Organizations. In 2007, several seamounts located in North-west Atlantic, including New England and Corner Rise Seamounts, were closed by NAFO to all fishing activities involving demersal fishing gears (NAFO, 2006). The by-catches of benthic invertebrates from an Experimental Trawl Survey in this area in 2004, indicated that the impact of trawling on seamounts could be important (presentation C:3) . It was concluded that the closed area agreed in 2007 to protect the bottom habitats of the seamounts within NAFO Regulatory Area (Divs. 6EFG) should be maintained and improved.

Conclusion

The contributions to this session demonstrated the significance of topographic features in the ocean for biodiversity and distributions of organisms. All presentations provided new and valuable information on these ecosystems, from which previous information is limited. Even if several recent and ongoing projects from the ICES area and other waters have provided new information, there is still a need for more scientific knowledge on the living resources and ecosystems of mid-ocean ridges and seamounts.

The following conclusions were made, based on presentations and discussions:

- Topographic features in the sea are areas of high biodiversity, and may often be considered as “hot-spots” in the ocean.
- Mid-oceanic ridges and seamounts are fishing areas of an international fleet of trawlers and long-liners. Many of the targeted fish species have life histories that make them particularly vulnerable to overfishing.
- Better knowledge on life-history is critically important for the management for sustainable use of these resources.
- The increased levels of exploitation may increase the risk for loss of habitat and biodiversity. Some areas may require special protection, but this also requires better knowledge of the ecosystem.
- We know very little about the food-webs around seamounts and mid-ocean ridges. New techniques may help us improve our knowledge on trophic interactions.
- ICES recognises that the knowledge base for providing advice to governments and commissions managing activities in the North Atlantic is too weak, and the same is the case in a global context within the UN.

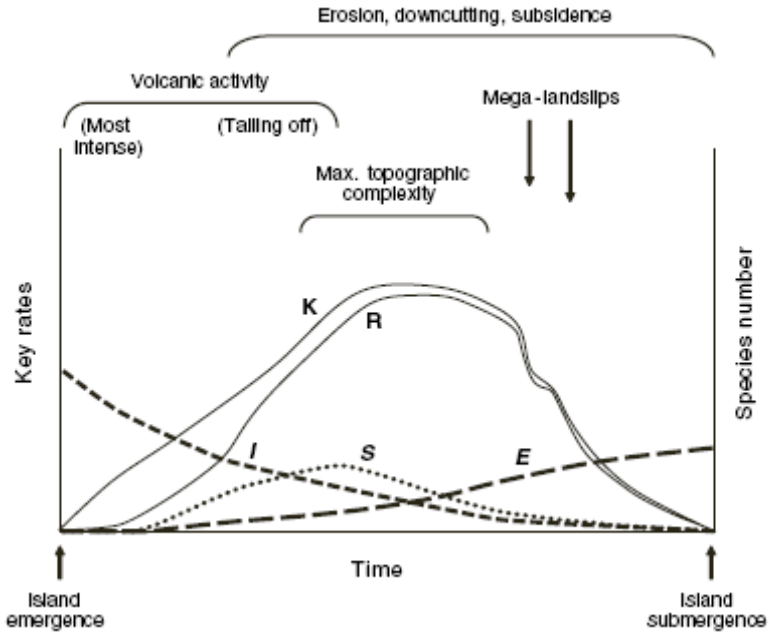

Figure 3. A graphical representation of the general dynamic model as proposed by Whittaker *et al* (2008). As in Figure 2, I and E represent the immigration and extinction rates of species. S is the rate of speciation, K is the carrying capacity and R is the realised species richness resulting from a combination of immigration, speciation and extinction. Unlike a terrestrial island, underwater seamount islands would reduce in height mainly through subsidence with little erosion. Undersea landslips could still be possible and there is evidence for these. (From Whittaker et al., (2008)).

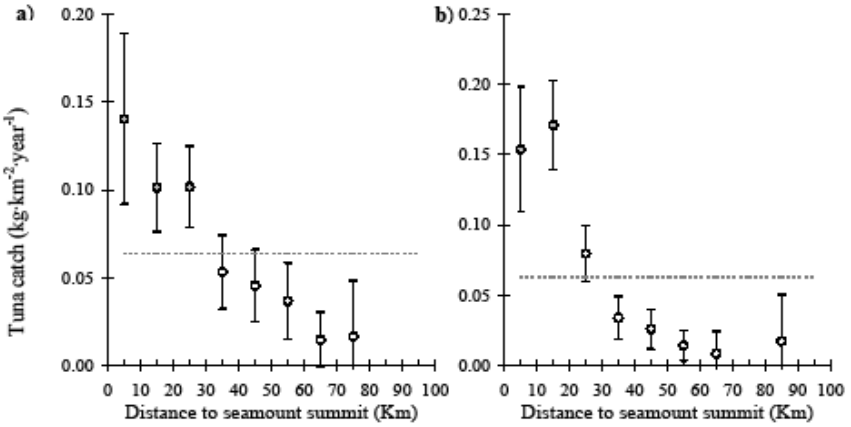

Fig. 3. Tuna catch per square kilometre per year (±95% CL) in relation to the distance to the nearest seamount summit in the Azores. a) skipjack, b) bigeye tuna. Bin size is 10 km. Light grey circles are significantly higher (Dunnett test) than the overall mean (light grey line).