

## COLD WATER CORALS AND CARBONATE MOUNDS

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**Cold water coral covered carbonate mounds at the Rockall Trough Margins and off the Hebrides in the North Atlantic Ocean form an important research topic for NIOZ scientists since 1998. Since then, the geological, geochemical, oceanographical and biological conditions and processes forcing the development of carbonate mounds and the benthic ecology and environmental conditions of cold water coral reefs are being studied in the framework of a number of EU, ESF and NWO programs. Our research is directed towards establishing the constraints and factors governing the development of carbonate mounds and cold water coral functioning and growth. In the geological domain there is an additional interest to use the carbonate mounds as possible modern analogues for the explanation of fossil carbonate build ups. Since the coral reefs and mounds are increasingly threatened by deep sea trawling activities, protection measures by EU and national agencies require profound and in-depth knowledge of these fragile benthic ecosystems.**

Cold water coral habitats are considered hotspot ecosystems characterized by a high level of biodiversity and presumably other ecosystem functions (Fig. 1). Cold water corals mainly occur on the continental margins of the North Atlantic Ocean (Fig. 2). Quantitative information about cold water coral ecosystems is still very scarce, whereas the coral build-ups are already increasingly threatened by deep sea trawling activities. Protection measures by EU and national agencies require profound knowledge of these fragile benthic ecosystems.



Fig. 1. Crinoids attached to a dense network of dead and live corals on top of a carbonate mound on SW Rockall Trough (Courtesy IFREMER).  
Inset: Coral polyps and framework *Lopheelia pertusa*.

### Methodology

By a series of research cruises with R.V. "Pelagia" the morphology and internal structure of mounds and reefs at the Rockall Trough margin and off the Hebrides (Fig. 2) have been studied with a range

of seismic recording (Fig. 3) and multi-beam bathymetry sounding systems. Subsequently, water column observations, bottom sam-

ples, and seabed measurements were made, as well as video observations from the seabed and coral communities by towed cam-

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Fig. 2. Red dots indicate locations with cold water coral reefs in the northeast Atlantic Ocean. The enclosed area represents the core study areas of NIOZ at the Rockall Bank and off the Hebrides.

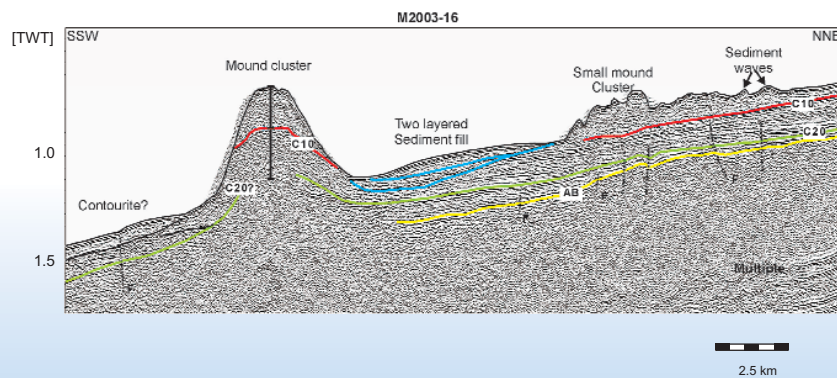


Fig. 3. Seismic structure of mounds and reefs along transect perpendicular to the SW Rockall Trough margin (after Mienis et al., 2006).

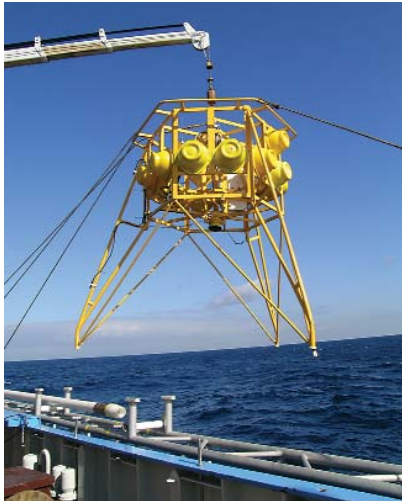


Fig. 4. Benthic seabed observatory BOBO recovered after one year deployment.

era's and by underwater video camera's mounted on sea-floor observatories.

Long and short term deployments of seabed observatories (Fig. 4) are used to measure the local hydrodynamics and the type and supply of food sources for the cold coral communities. The observatories also measure salinity, temperature, time series of current

speed and direction, chlorophyll fluorescence and the amount of particles in the water column.

In addition, experimental studies are carried out directly on board with freshly collected corals (*Lophelia pertusa* and *Madrepora oculata*) to study the feeding behaviour of the coral polyps and the dynamics of the associated micro-organisms (Fig. 5, 6).

### Mound morphology and cold coral occurrence

Seismic and side scan sonar surveys across both margins of Rockall Trough (off Ireland) show the presence of single coral covered isolated mounds as well as of elongated mounded ridges of several kilometres long and up to 380 m high. The mounds occur in a specific depth zone between 600 and 1000 m. All mounds reach a specific depth level below the sea surface, with the highest mounds occurring at the lower slope of the continental margin. Video and bot-

tom samples show the presence of a thriving living coral cover on mound peaks and the upper flanks. Reefs and coral patches however, have been reported to occur at shallower depth as well.

Evidence for gas seepage or fluid flow in relation to mound build-ups and coral presence, as hypothesized in the literature, has not been found, neither in seismic profiles nor on side scan sonar images. Instead, isotopic measurements of corals and associated biota support a direct relationship with surrounding water masses.

### Food supply to coral communities; role of internal waves

CTD measurements and benthic lander data indicate the presence of a diurnal tidal cycle at the southwest Rockall Trough margin and of a semi-diurnal tidal cycle at the Southeastern Rockall Trough and the Porcupine margin. Current speeds are up to  $45 \text{ cm}\cdot\text{s}^{-1}$  at depths between 500 and 1000 m. High current speeds not only prevent the corals from getting buried by sediments, but also increase the food supply to the corals. Tidal currents at both margins force the formation of nepheloid layers (layers in the water column with an enhanced amount of particles); the distribution of cold water corals is considered directly related to the presence of enhanced turbidity in the water column, evidencing rapid transport of fresh food particles from the surface water layer to the mounds.

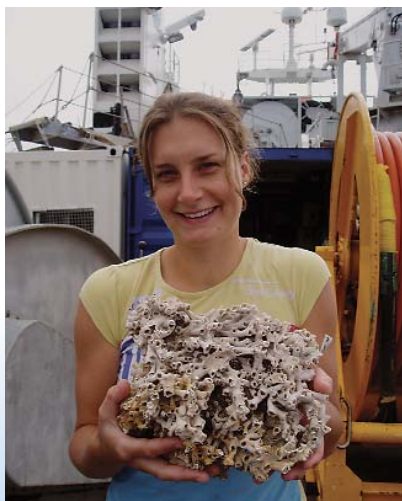


Fig. 5. NIOZ Ph.D Furu Mienis with a piece of coral framework.



Fig. 6. Biologist Mark Lavaley carefully removes freshly collected material from an experimental set-up.

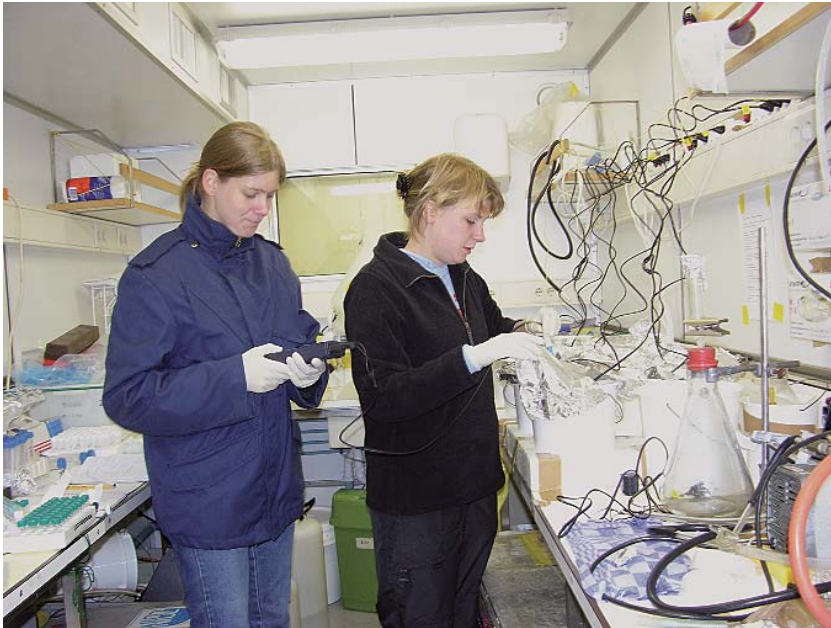


Fig. 7. Students conducting coral feeding experiments in the cool container onboard R.V. Pelagia.

Feeding experiments carried out in collaboration with the IUB (International University, Bremen) indicate that *L. pertusa* is capable of extending its tentacles at flow speeds as high as  $30 \text{ cm s}^{-1}$ . When corals are fed with zooplankton larvae, their tentacle extension and retraction behaviour are inversely related to flow speed, showing that corals catch more prey when flow speed increases. This supports the view that cold water corals occur at the top of the mounds where flow speed is accelerated, which enhances the transport of food particles to the coral polyps.

### Biodiversity and food web structure

Results further suggest that the densities of macro-faunal animals on the coral mound is higher than in the surrounding habitat. This

also holds for the species richness, which can be twice as high on the mounds. The food web of the cold coral community appears to be relatively simple. It is dominated by filter feeding organisms. Almost no detritus feeders were found in the sediment underneath the coral branches. The conjecture of a simple food web is supported by results of  $\delta^{15}\text{N}$  analysis, which show that the isotopic signatures of carnivores at the top and bivalves at the base of the food web differ only by 2 trophic levels. The amount of food available for the filter-feeders on the mounds consists of relatively fresh (i.e. fluorescence from chlorophyll) supply of phytoplankton over a relatively long period of the year with a remarkably early start of the algal spring bloom in February. The source of this material is probably a high productivity zone concentrated above

Rockall Bank from where food is transported to the mounds and into deeper water by strong cross slope currents and internal waves.

Preliminary estimates of whole community respiration by the coral community show rates matching those found on the continental shelf.

### Role of microorganisms

Specific studies were done to address the question of the abundance and diversity of prokaryotic micro-organisms (bacteria, Archaea and viruses) in the deep water coral reefs and their role in coral and sponge functioning (Fig. 7). The first results indicate that the corals *Lophelia pertusa* and *Madrepora oculata* stimulate the growth of bacterio- and viroplankton in the surrounding seawater, probably through the release of mucus (organic slime) and inorganic nutrients to the seawater.

Preliminary results of an experiment to inhibit bacterial growth indicated that corals may take up microorganisms. Radioisotope labelling experiments showed that auto- and heterotrophic prokaryotes (Bacteria and Archaea) play a significant role with respect to carbon uptake and the energy supply of corals and sponges. Moreover, the abundance of microorganisms in coral and sponge tissue is also about 1000 times higher than in ambient seawater, indicating that prokaryotes may play a significant role in the ecology of cold water corals.