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Bio376

Understanding The Unknown World of Deep-Water Corals

Some of the most biodiverse ecosystems on Earth are made up of corals. Coral reefs, often referred to as “underwater rainforests”, are home to over a quarter of all marine species despite occupying less than 1% of the seafloor. Each reef is made up of multiple different species of coral which provide shelter, food and breeding grounds for the surrounding wildlife. Unfortunately, reefs are getting smaller with over 50% of coral reefs showing signs of damage and over 20% being damaged beyond repair (Wilkinson, 2009).

Corals, which are distant relatives to jellyfish and sea-anemones, are made up of multiple clusters of genetically identical colonies of tiny organisms called polyps. Polyps have soft, sac-like bodies and mouths that are encircled by tentacles which are used to catch prey- a feature that is common among all Cnidaria (Roger, 1999). Hermatypic, meaning reef building, corals form hard calcium carbonate exteriors from the dissolved calcium and carbonate ions in the water to protect their delicate bodies. Polyps are constantly building new exteriors underneath their old ones, a process known as accretion, which in turn expands the size of the reef. Simultaneously however, the corals erode away naturally by other animals, such as crabs and marine worms, which eat at or live inside the corals (Wilkinson, 2009). The growth of the reef is thus the result of how much accretion is left after the corals have been eroded.

The formation of the calcium carbonate layers requires a lot of energy. Some corals, such as the ones found along the Great Barrier Reef, obtain their energy from a photosynthetic algae, zooxanthellae, which lives in the polyp’s tissue (Sebens and Johnson, 1991). The polyp and the zooxanthellae have a symbiotic relationship in which the coral provides inorganic nutrients, like carbon dioxide, and protection for the zooxanthellae, while the algae provides energy for the polyp (Dubinsky and Jokiel, 1994). Zooxanthellae undergoes photosynthesis, a process which uses sunlight and inorganic nutrients to form glucose, a form of energy. The energy obtained from the zooxanthellae allows the corals to grow quickly, with some of the fastest growing corals building up to 20cm of calcium carbonate a year (Wilkinson, 2009). However, since the algae is photosynthetic, it requires constant light for it to produce energy. As a result, only corals that are found 20-30 degrees north or south of the equator can house zooxanthellae, since tropical waters have year-round sunlight (Dubinsky and Jokiel, 1994). A common misconception among marine scientists is that coral reefs can only form alongside zooxanthellae, and thus are limited to warm and shallow waters. However, this could not be further from the truth.

More than two thirds of all coral species live deep beneath the ocean’s surface where the temperatures are cold, and sunlight is sparse (Cairns, 2007). Reaching depths of 6000m and habiting near-zero Arctic waters, deep-water corals can survive in a large range of environments (Roger, 1999). Some deep-water corals are hermatypic and form reefs which house significant levels of biodiversity in the deep ocean. Although deep-water reefs are not as large as shallow-water reefs, they can still reach enormous sizes occupying areas of $120km^2$ or more (Cairns, 2007). Despite their abundance, very little is known about deep-water corals since they are difficult to research in their natural habits without destroying them or their surrounding environment (Roger, 1999). However, unlike most deep-water corals, *Lophelia pertusa* can be found along multiple depths, ranging from the shallow continental shelves at 80m below sea level to the much deeper oceanic depths at 3000m. Moreover, *L. pertusa* are abundant throughout the northern Atlantic Ocean making them the most accessible and well-studied deep-water coral. The Lophelia reefs can house over 1,300 species of fish and invertebrates providing them with safe breeding grounds and nurseries as well as protection from predators and water currents (Roger, 1999). Although these ecosystems are not well understood, cold-water reefs are an integral part of marine life.

Despite having been first sighted in 1758 by Carl Linnaeus, *L. pertusa* have remained a mystery to marine scientists as it was never understood how these organisms were able to obtain the energy to grow at such depths (Roger, 1999). Unlike shallow-water corals which contain zooxanthellae, deep-water corals do not contain a photosynthetic symbiotic partner which provides the energy they need to grow (Hovland and Risk, 2003). Instead it's been hypothesized that deep-water corals feed on small organisms such as small crustaceans and krill (Wilkinson, 2009). Although sessile, corals have the ability to hunt using the nematocysts, an organelle containing toxic venom, found in their tentacles. When small organisms pass by the corals, the sudden water movement stimulates the nematocysts which stun the prey (Sebens and Johnson, 1991). However, Sebens and Johnson (1991), had found that hunting cannot provide enough energy for the deep-water corals to grow, since many species of coral are not successful hunters and each hunting event expels a lot of energy. Another popular theory was the Hydraulic Theory which claimed that *L. pertusa* obtain their energy from nutrients found in deep water currents (Hovland and Risk, 2003). The deep ocean is filled with numerous species of bacteria and abundant in nutrients like phosphates and sulfates. Therefore, in areas with constant current-flow, deep-water corals would be exposed to a large amount of nutrients allowing for their growth (Hovland and Risk, 2003). However, isotopic analyses of the compositions of the *L. pertusa*'s tissue have found that their diet was not compatible with isotopes found along the deep ocean, but rather consisted of isotopes found in surface waters (Van Oevelen *et al*., 2016). Expanding on the Hydraulic Theory, Hovland *et al*. (2012), hypothesized that deep-water corals get their energy from sinking surface-plankton. Hovland *et al*. (2012) found that in topographically high areas in the ocean, such as seamounts, the currents were able to trap plankton-rich waters from the surface and slowly move them down-slope to the bottom of the ocean. These plankton-rich waters were maintained by the constant flow of the currents and the corals would feed on the plankton as a way to obtain energy. Although Hovland *et al*.'s (2012) theory is plausible, it doesn't explain how corals in topographically low areas obtain their energy.

Regardless of the mechanism, deep-water corals obtain their energy very slowly making their accretion rates very low. At most, *L. pertusa* grow at a rate of 1cm a year, with some being documented to grow as little as 0.2mm annually (Hovland *et al.,* 2012). As a result of their slow accretion rates, deep-water coral reefs are more susceptible to habitat destruction than shallow-water reefs.

In 2001 the Convention for the Protection of the Marine Environment of the North-East Atlantic declared the *L. pertusa* reefs and other deep-water reefs as threatened habitats in need of protection (Fossaa and Skjoldal, 2010). The main threat came from anthropogenic activity, primarily deep-water trawling. Trawling is a form of fishing which involves dragging nets along the ocean floor which not only breaks up and destroys the reef, but it also alters the species composition of the ecosystem (Armstrong and Van den Hove, 2008). Reefs are delicate ecosystems thus even minor changes in their species composition can have catastrophic effects on the corals. Redfish, which breed in the reef, are the main target for most fisherman as they have high economic value. However, redfish have been shown to play a very important role in regulating the reefs' predators. Redfish hunt crabs and marine worms, the natural predators of deep-water corals (Armstrong and Van den Hove, 2008). With reduced amounts of redfish controlling the population size of crabs and marine worms, the *L. pertusa* would be eaten-away and eroded quickly, furthering the demise of the reef. With extremely slow accretion rates, the destruction from trawling could require thousands of years to recover. Some scientists believe that trawling has destroyed more than 40% of all Lophelia reefs in Norway, one of the highest density regions for deep-water corals (Armstrong and Van den Hove, 2008). In 2003, Norway had forbidden fishing in designated areas to help conserve the remaining reefs (Fossaa and Skjoldal, 2010). Due to the lack of knowledge regarding *L. pertusa*'s growth, it is unclear how long it will take the reefs to recover (Armstrong and Van den Hove, 2008). Since the ban, Norway has not noticed any significant changes in reef size or density which many scientists claim is a success (Fossaa and Skjoldal, 2010). It may take hundreds of years before the reefs start showing any signs of expansion. In the meantime, the priority for preservation has been on preventing further declines in reef sizes (Wilkinson, 2009).

Studies on *L. pertusa* have provided a window into understanding how deep-water corals live. The impact that reefs have on their environment is vast as they are homes to thousands of different species worldwide. Alas, fishing has resulted in the mass destruction of these delicate ecosystems and it is still unknown how long it will take for them to fully recover. Without proper knowledge and understanding about how deep-water corals get their energy to grow, it is difficult to fully comprehend the impact that anthropogenic actions have on the reef's growth (Hovland and Risk, 2003). Further research analysing the isotopic composition of deep-water coral tissue should be conducted among multiple different species of coral to look for patterns in possible adaptations to the colder and darker waters (Van Oevelen *et al*., 2016). Currently, scientists are looking for more cost-effective and environmentally- friendly methods to study these ecosystems so it will be a few years before new information regarding their growth surfaces (Wilkinson, 2009). Although some countries, such as Norway, have taken precautionary actions to help revive the damaged reefs, a lack of knowledge and awareness about deep-water corals could result in the permanent extinction of these underwater rainforests.

References

Armstrong, C., and Van den Hove, S. (2008). The formation of policy for protection of cold-water coral off the coast of Norway. *Marine Policy, 32*(1), 66-73.

Cairns, S. (2007). Deep-water corals: an overview with special reference to diversity and distribution of deep-water scleractinian corals. *Bulletin of Marine Science. 81***,** 311-322.

Dubinsky, Z., and Jokiel, P. L. (1994). Ratio of energy and nutrient fluxes regulates symbiosis between zooxanthellae and corals.

Fossaa, J. and Skjoldal, R. (2010). *Conservation of cold-water coral reefs in Norway* (pp. 215-230). Oxford University Press..

Hovland, M., and Risk, M. (2003). Do Norwegian deep-water coral reefs rely on seeping fluids?. *Marine Geology*, *198*(2), 83-96.

Hovland, M., Jensen, S., & Indreiten, T. (2012). Unit pockmarks associated with Lophelia coral reefs off mid-Norway: more evidence of control by 'fertilizing' bottom currents. *Geo-Marine Letters*, *32*(5), 545-554.

Rogers, A. (1999). The biology of *Lophelia pertusa* (Linnaeus 1758) and other deep-water reef-forming corals and impacts from human activity. *International Review of Hydrobiology. 84(6)***,** 315-406.

Sebens, K. and Johnson, A. (1991). Effects of water movement on prey capture and distribution of reef corals. *Hydrobiologia*, *226*(2), 91-101.

Van Oevelen, D., Mueller, C., Lundalv, T. and Middleburg, J. (2016). Food selectivity and processing by the cold-water coral Lophelia pertusa. *Biogeoscience. 13 (4)*, 5789- 5798.

Wilkinson, C. (2009). *Status Coral Reefs of World 2008 Executive Summary* (pp.5-19). Global Coral Reef Monitoring Network.