



Deep-sea creatures

by Paddy Ryan

Mythical depictions of life under the ocean featured strange and sometimes grotesque beasts – extravagantly spotted or striped, some with fearsome fangs, some foreshortened, others of monstrous size. Today we know that these visions were not so fanciful: there are such creatures and more in the abyss, which still largely remains a mystery.

Exploration of the deep

For millennia the deep ocean, beyond human reach, was imagined to be populated with fantastic beasts. The ancient Greek word abyss (meaning bottomless) is used to describe the ocean's apparently infinite depths. In 1521 the Portuguese explorer Fernão de Magalhães (Ferdinand Magellan) reputedly lowered a cannonball to around 750 metres in the Pacific Ocean and concluded that it was immeasurably deep. This finding led to the theory that life in the depths was not possible because there were no currents or temperature shifts, and hence no oxygen exchange or nutrient supply.

Samuel Morse's invention of a telegraph system led to the laying of transatlantic and other undersea cables from 1857. When broken cables were raised for repair, they were found to be festooned with life. The discovery of sea lilies in 1864, until then known only from 120 million-year-old fossils, raised the fascinating possibility that other supposedly extinct or unknown species were living in the deep.

Voyages of discovery

In 1872 the sailing ship *Challenger* undertook one of the greatest voyages of biological discovery. For three and a half years it circumnavigated the globe, taking soundings and putting down dredges and trawls. New Zealand waters were included in this amazing voyage. The later named Challenger Plateau, west of New Zealand in the Tasman Sea, was located and studied, and New Zealand marine biologists James Hector and Frederick Hutton described some of the fish collected there. The result of the project was the discovery of 4,717 new species globally, and a greater understanding of the depths.

No further study of the deep sea around New Zealand was undertaken until the 1950s when a retired fisherman, Richard Baxter, managed to catch the lantern dogfish (subsequently named *Etmopterus baxteri*), white rat-tails and basketwork eels. He used a hand line down to 1,000 metres from an open dinghy off Kaikōura.

It was not until the 1970s that exploratory trawling began in depths of 800–1,000 metres. This was quickly followed by commercial trawling of orange roughy, a deep-sea fish. Today, although we have some understanding of the creatures that live in the depths, there is evidence that a vast number of organisms remain unknown. The first intact specimen of the colossal squid (*Mesonychoteuthis hamiltoni*) was discovered as recently as 2003, south of New Zealand in the Ross Sea. This 6-metre specimen was a juvenile; scientists speculate that adult forms could be two or three times larger.

Zones of the ocean

Depending on how deep the sea is, there can be up to five vertical zones in the ocean. From the top down, they are:

- The epipelagic zone. Also called the euphotic zone, this is the top layer, where photosynthesis can still take place. Typically the epipelagic zone extends to 200 metres, but this partly depends on the presence of suspended and dissolved material of various kinds. Virtually all primary food production in the ocean occurs here.
- The mesopelagic zone. This encompasses any last vestige of light in its 200–1,000-metre depth range; there is not enough energy for photosynthesis. The main thermocline (a rapid change in temperature over a small depth range) is here. Below the thermocline the temperature is a relatively constant 2–5°C. At about 500 metres the water becomes depleted in oxygen (known as the oxygen minimum layer). Despite this, there is an abundance of life that copes with the shortage through more efficient gills, minimal movement, or both.
- Bathypelagic zone. This is the region from 1,000 metres to 4,000 metres deep.
- The abyssopelagic zone – from 4,000 metres down to the ocean floor.
- The hadopelagic zone. This lies at the bottom of ocean trenches, the deepest being 11,000 metres. Around New Zealand they can be 6,000–9,000 metres deep.

The mesopelagic zone

Because the mesopelagic zone (200–1,000 metres deep) and those beneath it provide similar habitats worldwide, some of the same species are found in both hemispheres. About 20% of the food made in the epipelagic zone makes its way down to the mesopelagic. Conversely, at night many mesopelagic organisms migrate upwards into the darkened epipelagic zone. This gives the mesopelagic creatures the best of both worlds. They can feed at night in the rich waters of the epipelagic zone and hide during the day in the dark, cold, oxygen-depleted waters of the mesopelagic, safe from most predators.

A false sea floor

When sonar became widely used during the Second World War, operators detected an apparent sea floor at a depth of 300–500 metres during the day, but nearer the surface at night. This proved to consist of millions of organisms, including fish and zooplankton, which move up through the water at dusk to feed on microscopic plants growing where the sun penetrates. On moonlit nights this layer remains deeper, although the animals within it may respond to clouds passing over the moon. Many species including jellyfish, squid and crustaceans are involved in this vertical migration, but it was mainly fish that gave rise to the echo picked up by the sonar operators. The sound was reflected off their swim bladders – gas bags that enable them to fine-tune their depth without expending a lot of energy. The phenomenon of the false sea floor became known as the deep scattering layer or DSL, because it scatters the sonar signal.

Fish adaptations to the zones

Typically, species such as lanternfish (Myctophids) and bristlemouths (Gonostomatids), which make vertical migrations each day, possess a swim bladder. They also have well-developed muscles and bones, and are usually somewhat streamlined. By contrast, fish that remain as ‘sit and wait’ predators in the mesopelagic zone lack a swim bladder, and have flabby muscles and watery flesh. Because they do not go anywhere, streamlining has either not evolved or has disappeared.

Bathypelagic fish (at depths of 1,000–4,000 metres) are unable to undertake vertical daily migrations because below a certain depth the pressure is too great and the swim bladder is unable to function – gas cannot be produced. Most of these fish lack swim bladders or, like orange roughy, have bladders

that are filled with wax. Sharks do not have swim bladders but are able to move vertically. To plane up and down they rely on strong swimming and the buoyancy provided by their oily livers – oil is less dense than water.

Light-producing creatures

Many mesopelagic animals possess bioluminescent (light-producing) organs known as photophores. In some species the light is produced by specialised tissues, in others by symbiotic bacteria. Many mesopelagic fish, shrimps and squid have photophores on their undersides that match surface brightness. They reduce the light output during cloudy days, and boost it when it is sunny. The photophores may be turned off at night to make the animal relatively invisible.

Bioluminescence may play other roles, as there are often sexual differences in photophore distribution. In some species the typically blue-green light may indicate the species or sex of an animal, while in others the light may attract prey or enable the predator to see its quarry. Faced with a predator, some species of shrimp and squid eject clouds of luminescent ink to produce a replica of themselves, and then swim away while the predator attacks it.

Glow in the dark

Bioluminescence (light produced by living things) happens mostly in the ocean. While a few land animals such as glow-worms use it, it is almost unknown in fresh water. It is a cold light produced by a chemical reaction inside an organism. The loosejaw fish *Malacosteus niger* can produce a red searchlight to spot its prey while it remains unseen.

Vision in the mesopelagic zone

Typically, mesopelagic fish have large eyes that gather ambient light. Some have tubular eyes that are upward looking and give sharp forward but poor sideways vision. A secondary retina extends up the sides of the tube and dramatically increases the field of view. Parallel evolution has produced similar optical solutions in at least one octopus (*Amphitretus*) and some krill (*Stylocheiron*). Some tubular-eyed fish have a yellow filter that enables them to distinguish between natural light and bioluminescence, thereby defeating the counter-illumination systems used by their prey.

Other mesopelagic organisms

Other mesopelagic organisms include copepods and krill (planktonic animals) that eat the faeces of epipelagic copepods and any other matter that reaches that depth. Many krill and shrimp possess light organs. Ostracods, amphipods, arrow worms (Chaetognaths), jellyfish, siphonophores, comb jellies, larvaceans and pteropods are also common. Squid, including juveniles of the giant squid *Architeuthis dux* and the considerably larger colossal squid, are also found here.

The bathypelagic zone

In the bathypelagic zone (1,000–4,000 metres deep) there is a total absence of sunlight. Bioluminescence (light produced by living creatures) is the only source of light.

Food is even scarcer than in the mesopelagic zone above. With less energy available, most of the fish are 'sit and wait' predators, or actively attract prey with bioluminescent lures. Bathypelagic organisms are mostly black, red or transparent, rendering them essentially invisible in the weak biological light.

Bristlemouths and deep-sea angler fish are the commonest fish, typically less than 10 centimetres long. Their small size reduces metabolic demands. Compared with their mesopelagic relatives, bathypelagic fish tend to have lower metabolic rates, less developed gills and muscles, and small eyes – if they have them at all.

Made mostly of water, the fish are not able to be compressed by the great pressure at this depth. While the greatest ocean depth is nearly 11,000 metres, fish have been found only down to 8,400 metres, where the pressure is around 800 times that at the surface. This may be because essential enzyme functions are affected by such pressure.

Surface shock

Adapted to great depths, bizarre-looking fish from the bathypelagic zone look even less pretty when hauled to the surface, where the pressure is several hundred times lower. Their eyes bulge, and gases in their system expand, causing the fish to burst.

Feeding strategies

Because only 5% of the food produced up in the epipelagic zone reaches the deep sea, many deep-sea fish will eat anything that comes their way, exhibiting extraordinary adaptations to enable this. The swallower eel (*Saccopharynx lavenbergi*) and the gulper eel (*Eurypharynx pelecanooides*) have gigantic jaws, mouths lined with many teeth, and highly elastic stomachs that can accommodate prey larger than themselves.

Related to the gulper eel is the remarkable monognathid eel (*Monognathus bertini*), with a hooked fang made from fused frontal bones and linked to what may be venom glands. Glands in the snout and dorsal fin secrete substances that attract shrimps which the eel grasps, forces against the fang and injects with venom. This meal provides enough nutrients for the eel to mature, after which the lower jaw degenerates and the eel eventually dies.

Female deep-sea anglerfish typically have a bioluminescent lure on a dorsal spine or the chin. Prey are attracted to the lure and ingested with the inrush of water as the fish opens its huge mouth.

Mating

Finding a mate is also difficult in the deep ocean. Angler fish have developed an unusual solution. The female releases pheromones that the tiny male fish home in on. When they reach the female they bite her and hold on, never to let go. In some species the male's jaw fuses with the female tissue, the two circulatory systems join up and the male degenerates until he is little more than a bag of testes subject entirely to the hormonal regime of his host. Being smaller, the male requires much less food, leaving more for the female's reproduction requirements.

Other deep-sea fish are hermaphroditic (with male and female sex organs), ensuring that a chance encounter between any two fish will provide both eggs and sperm. However, most deep-sea invertebrates do not use such strategies. They may depend on bioluminescence to attract each other.

Sea-floor life

Benthic communities

Biologists refer to species dwelling on the sea floor at any depth as benthic organisms or 'the benthos'. They are also known as bottom dwellers. Fish are common in benthic communities in the mesopelagic and bathypelagic zones, but there are none on the deeper sea floors of the abyssopelagic and hadopelagic zones. Energy is in scarce supply here, deriving mainly from falling food that has made it past all the waiting mouths above.

Bacteria are probably the base for most benthic food chains, as they are able to release nutrients that other life forms cannot make use of directly. For example the armour-like exoskeleton of zooplankton such as krill contains carbohydrates locked up in the tough chitin or cellulose that only bacteria can break down. These nutrients can then be used by slightly larger organisms referred to as the meiofauna, which live in the fine sediment that covers most of the deep-sea floor. They in turn concentrate nutrients and make them available to larger organisms. The occasional bonanza, such as a dead whale, may provide food for decades.

Cold seeps

Cold seeps occur in places along the edge of continental shelves between 300 and 600 metres deep. Methane (natural gas), hydrogen sulphide and other compounds seep out of the sea floor in a stream of bubbles at about the same temperature as the surrounding water. The original source of some or all of the methane is archaea (similar to bacteria) living in sediments as deep as 750 metres under the sea floor. Other archaea and bacteria use these compounds for energy by a process called chemosynthesis. There is a specialised ecosystem of creatures such as clams and tubeworms based on these chemosynthesising organisms.

Hot deep-sea vents

Also known as hydrothermal vents, these are similar to geysers, producing superheated, mineral-laden water. They are found along zones of tectonic or volcanic activity such as mid-ocean ridges where hot magma is near the sea floor. The minerals are used by chemosynthesising organisms, forming the basis of a unique community that does not depend on sunlight. The giant tubeworm *Riftia pachyptila*, found around vents, can grow 1.5 metres long, yet has no mouth or anus and only a vestigial gut. Both *Riftia* and the large clam *Calymene* harbour dense colonies of bacteria. The relationship is mutually beneficial: the animals get a food source, and the bacteria get a place to live.

Nutrients at deep sea vents are much more abundant than at cold seeps, and the surrounding sea floor is crowded with life forms.

Emerging from the deep

In New Zealand's southern waters around Fiordland, light is reduced by humic-stained fresh water on the surface, enabling species that usually live in deeper water to be observed within a safe scuba-diving range. The sponge *Symplectella rowi* may be found at depths of 30–50 metres on cliff walls in Doubtful Sound. In other parts of Fiordland a small mollusc (*Melanella luminosa*) is frequently found on the scarlet sea cucumber (*Ocnus brevidentis*), itself a species normally living at much greater depths.

Echinoderms

Echinoderms are the most obvious deep-sea species. They include starfish (sea stars) and brittle stars, sea urchins and sea cucumbers. Sea cucumbers may move by swimming or squirting water. Others walk on the sea floor using tube feet. In 1986 a new group of echinoderms, the Concentricycloidea, was

discovered on wood in deep water off the New Zealand coast (although some taxonomists no longer consider them a new class).

Crustaceans of various kinds, polychaete worms and bivalve molluscs are also reasonably common. Some deep-sea invertebrates – most notably some isopods and pycnogonids (sea spiders) – are gigantic.

Fish

Among the benthic fish species is the strange tripod fish (belonging to the family Triacanthidae), which has long feelers on its pectoral and caudal fins. The ventral and caudal fins act like a tripod, holding the fish on the sea floor, while the pectorals are held sideways and detect any water movements caused by prey. These fish are virtually blind. Other bottom-dwelling species are fished commercially and end up on the table – grenadiers (or rat-tails), orange roughy, oreos and cusk eels (sold as ling). Less savoury characters include hagfish, brotulas, toadfish and snailfish.

Fishing in the deep

In New Zealand, hoki (*Macruronus novaezelandiae*) are typically trawled from depths of 200–800 metres. Between 1990 and 1995, catches averaged a staggering 200,000–240,000 tonnes annually. Hoki, also known as blue grenadier, is now New Zealand's most valuable export fish. Ling (*Genypterus blacodes*, belonging to the cusk eel family) are bottom-dwelling fish typically caught by trawls (which are believed to damage the sea floor) or longlines (which may entangle seabirds). Prior to significant coastal fishing in New Zealand, ling were commonly regarded as inshore fish and were frequently caught inside harbours. Today they are regarded as a deep coastal species, usually taken in depths of 250 metres.

Orange roughy

Orange roughy (*Hoplostethus atlanticus*) are trawled from depths of 700–1,000 metres and caught when they come together to spawn. The orange roughy was first reported from New Zealand waters in 1957, when it was given the unappealing name of 'slimehead'. This was changed for marketing purposes when commercial quantities were taken in 1979. Catches peaked at around 54,000 tonnes in 1988–89. Since then new information about their biology has led to the imposition of quotas inside the New Zealand Exclusive Economic Zone. Most fish biologists now believe that orange roughy are long-lived (up to 150 years) and slow growing; fishing is being managed to take this into account. The biggest fishery is on the Challenger Plateau, while many areas on the Chatham Rise are no longer economic for fishing. There is concern that stocks are being over-fished.

Patagonian toothfish

The Patagonian toothfish (*Dissostichus eleginoides*) lives in waters south of the New Zealand subantarctic islands. To increase marketing appeal it was renamed Chilean sea bass. It grows to just over 2 metres long and 100 kilograms in weight, and can fetch a high price in Japan and the United States. The fish were originally trawled, but longlines are now used for adult fish. As a result many seabirds become entangled in the lines. Most fishing occurs at depths between 400 and 1,500 metres. Poaching of these valuable fish in Australian and other waters may threaten the viability of the fishery. Populations typically survive 2–3 years of harvesting before the fishery collapses. In 2004 the New Zealand government recommended a plan of action to stop illegal, unregulated and unreported fishing of the species.

External links and sources

More suggestions and sources

Batson, Peter. *Deep New Zealand: blue water, black abyss*. Christchurch: Canterbury University Press, 2003.

Broad, William J. *The universe below: discovering the secrets of the deep sea*. New York: Touchstone, 1998.

More links and websites

Giant and colossal squid facts

<http://www.tonmo.com/science/public/giantsquidfacts.php>

Information about colossal and giant squid, including images. This is part of a site which has information about cephalopods (octopus, squid, cuttlefish, etc.).

The bioluminescence web page

<http://www.lifesci.ucsb.edu/~biolum/>

An explanation of bioluminescence, with illustrations and explanations of the different ways many marine species produce and use light.

The NORFANZ voyage 10 May to 8 June 2003

<http://www.environment.gov.au/coasts/discovery/voyages/norfanzi/index.html>

This site documents a joint Australia and New Zealand expedition to investigate the deep sea around Lord Howe and Norfolk islands through to northern New Zealand, and presents photographs and information about many of their finds.

The voyage of the Challenger

<http://life.bio.sunysb.edu/marinebio/challenger.html>

This page from the State University of New York at Stony Brook outlines the voyage of the Challenger in 1872.

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