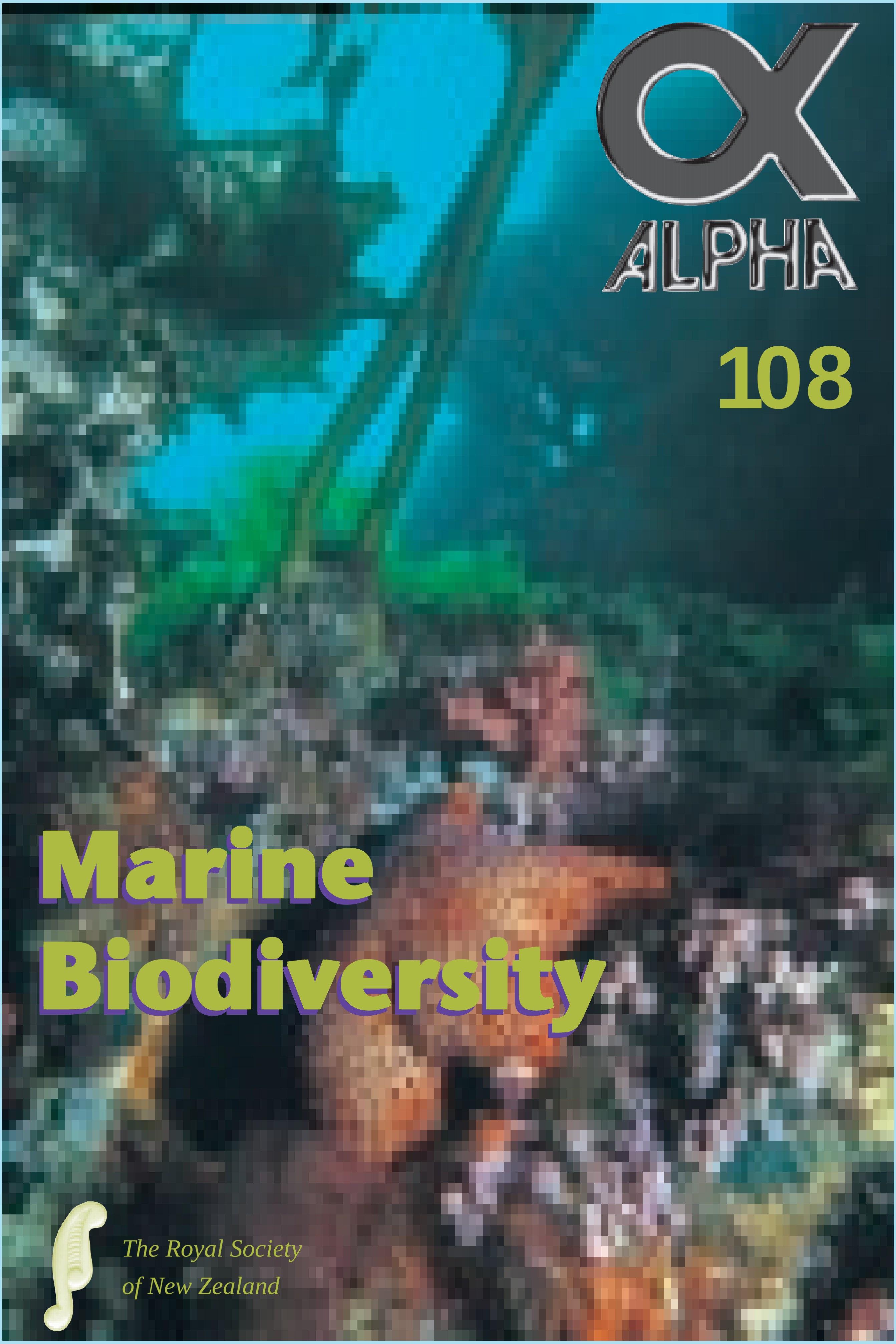


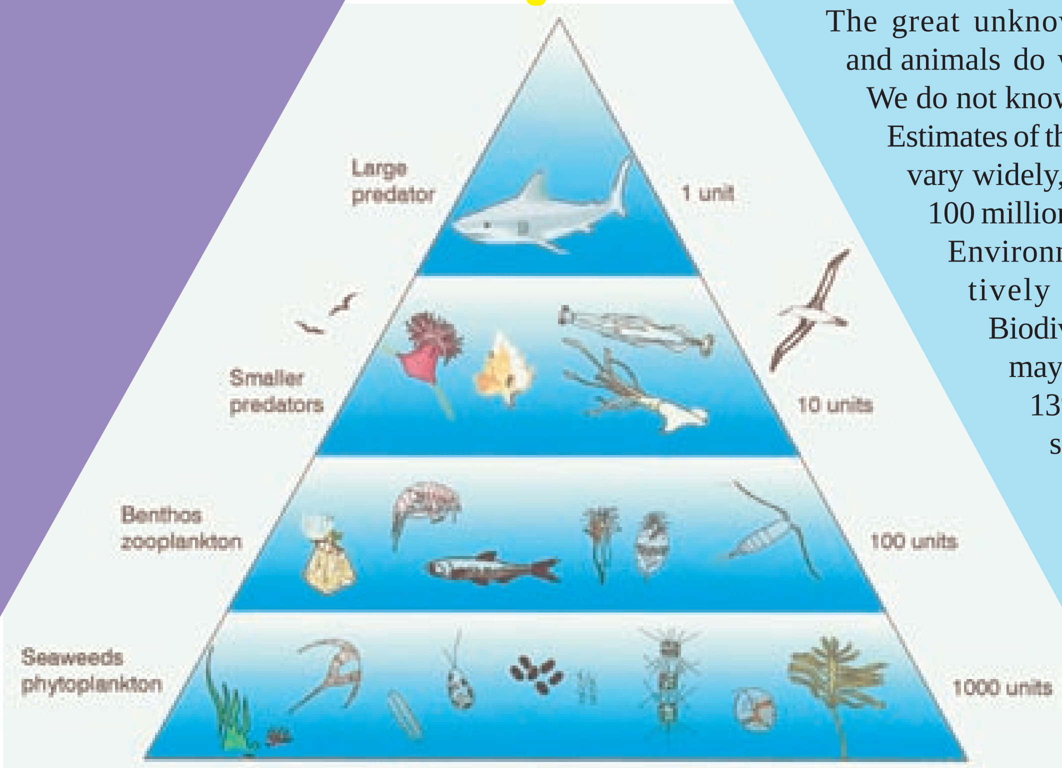
ALPHA

108

Marine Biodiversity

The Royal Society
of New Zealand

Discovery



More than just fish in the sea

The great unknown! Just how many plants and animals do we share planet Earth with? We do not know

Estimates of the numbers of species on Earth vary widely, from 4 million to more than 100 million. In 1995, the United Nations Environment Programme conservatively estimated in the Global Biodiversity Assessment that there may be about 13.6 million. About 13% of these (less than 2 million species), have been formally described since 1753 and 1758, the official starting dates for botanical and zoological names respectively.

Numbers of bacterial species are unknown and may increase this figure considerably. Taxonomists (scientists who discover, classify, and name life) describe only about 13,000 new species each year so it will take most of this new millennium to complete the task of discovery and naming!

Discovering new species in the seas around New Zealand is routine. We have the fifth-largest Exclusive Economic Zone (EEZ) in the world. It's more than 4 million square kilometres and 15 times the land area. Taxonomists at the Museum of New Zealand, Te Papa Tongarewa, report a new record or new species of fish about every two weeks. In the past 20 years, NIWA, Te Papa and university taxonomists have described many new species of seaweeds, protozoans, sponges, corals, hydroids, medusae, bristleworms, bryozoans (lace corals and moss animals), crabs, sea spiders, sea snails, bivalves, sea-stars and sea squirts. New Zealand's marine taxonomists are discovering new species faster than they can name and classify them. It will take nearly a century to finish the task!

TABLE 1. How many species in the sea?

Group	New Zealand		Global
	Described	Known Unreported/ Undescribed	Described
Protista + Fungi	2,010	95	24,540
Seaweeds + plants	687	78	5,970
Sponges	410	255	6,000
Hydroids, corals, etc.	572	395	7,025
Comb jellies	13	6	80
Flat worms, etc.	155	90	6,795
Bryozoans	600	310	5,700
Entoprocts	9	5	150
Ribbon worms	18	6	1,250
Annelid worms	497	244	8,335
Molluscs	2,414	1,174	32,890
Lamp shells	30	0	405
Arrow worms	18	1	100
Round worms	130	60	4,200
Crustaceans, etc.	2,009	381	33,780
Sea-stars, etc.	588	160	6,150
Acorn worms, etc.	4	1	90
Sea squirts, salps, etc.	187	50	1,300
Fish, marine mammals	1,212	140	13,845
All other groups	48	23	1,705
Totals	11,611	3,435	160,310

Diversity of species

Gone are the days when the variety of species could be classified into the animal or plant kingdoms. Now there is doubt about how many kingdoms there are! Five to seven are commonly recognised but there may be more than ten. Recent molecular-genetic studies have revealed the degree of relatedness or separation among different organisms. Traditionally, the presence/absence of a nucleus, particular cell organelles, photosynthetic and other pigments, plus form and shape have been the basis of higher classification. Now, because of major genetic and biochemical-pathway distinctions, three 'Domains' of life have been proposed. Two of these are bacterial (Eubacteria and Archaea) and the third comprises everything else! It is now customary to consider Protista (protozoans and many algae), Fungi, Plantae (green plants) and Animalia as kingdoms, but Protista (or Protoctista) are further subdivided at the kingdom level in some schemes. It may come as a surprise to learn that Animalia are more closely related to Fungi than to other organisms!

TABLE 2. New Zealand's marine species diversity

Group	Described Species	Known unrecorded Species	Estimated Unknown species	Totals (rounded)
Protista, Algae, Fungi, Plants	2,697	173	1,200–2,100	4,070–4,970
Invertebrates	7,702	3,122	4,320–5,440	15,140–16,260
Vertebrates	1,212	140	160	1,510
Totals	11,611	3,435	5,680–7,700	20,720–22,740

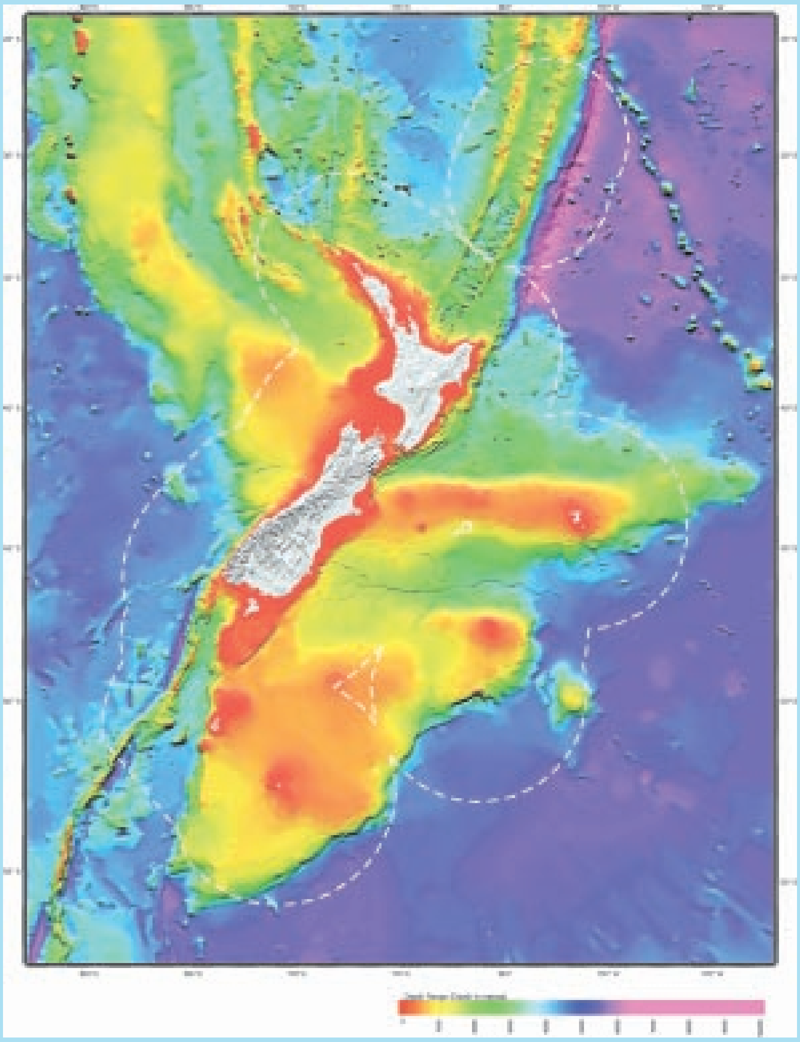
Diversity of marine habitats

There is a wide diversity of marine habitats in our EEZ which has a 30-degree latitudinal range from subtropical to subantarctic and with tectonic activity across a major plate boundary.

The seafloor has very varied relief, with plateaus, rises, ridges, seamounts, canyons, troughs, and a major trench (Kermadec Trench) descending to more than 10,000 m.

In shallow coastal waters biological habitats include mangrove swamps, eelgrass meadows, sand and mud flats, and rocky shores, reefs, and rock walls.

The continental shelf is beyond the depths that scuba divers can routinely reach and is mainly blanketed with sediments, ranging in particle size through mud, sand, gravel, mixtures of these, and boulders. Where the sediments are fine, bristleworms, shellfish, brittle-stars, and small crustaceans tend to dominate the benthos (bottom-dwelling animals). Animals that occur on the surface are called epifauna; those that live in the sediment are called infauna.



A mixed sediment assemblage R.J. Singleton NIWA

Depending on which kinds of organism dominate, bottom (benthic) assemblages are named after them. Assemblages are specific communities or groupings of organisms. Some 17 soft-bottom assemblages have been recognised as being widespread on New Zealand continental shelves, and more are likely to be recognised. Many species, such as clams, some snails, and sea cucumbers are deposit feeders, sucking up mud full of nutritious bacteria, tiny meiobenthic animals less than 1 mm long, and organic muck. A number of species, especially some specialist snails, are predators, boring into shells and bodies of their prey or, in the case of sea-stars, enveloping prey into their stomachs. All of these, in turn, are preyed upon by a range of demersal (bottom-feeding) fish.

Where the bottom tends to be more gravelly, large, sessile organisms that grow upwards are found. These include sponges, stony corals, gorgonians, black corals, hydroids, bryozoans, tube-worms, stalked barnacles, and colonial sea-squirts. These erect forms are suspension feeders, trapping or stinging small non-living particles or living plankton. Many are stunningly developed in areas of high current flow, e.g., Three Kings and Poor Knights Islands, and on shelf edges and seamounts. They provide a variety of microhabitats where smaller species feed and grow.

The bryozoan beds of Tasman Bay, and some other areas of seafloor, can be nurseries for juveniles of commercial fish which shelter and feed there. Unfortunately, these suspension-feeding assemblages are particularly vulnerable to trawling and, slow to develop, they are even slower to recover.

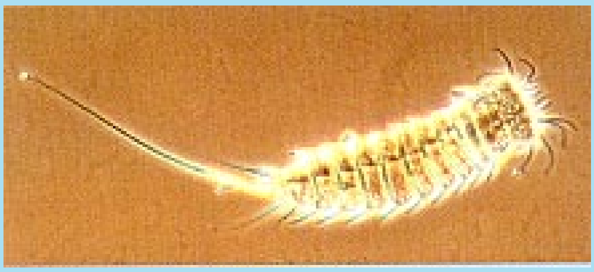
Comb jelly K. Gowlett-Holmes

Above the seafloor lives a wide range of plankton organisms, both plants and animals, solitary and colonial. In shallow sunlit waters they are mostly transparent and often gelatinous, and range in size from bacteria, through unicellular algae and ciliates, to small and large zooplankton. (Bacteria and algae are at the base of oceanic food webs.) The most abundant zooplankton organisms are copepods, tiny crustaceans that are mostly herbivores. Important small carnivores are comb jellies, medusae, arrow worms, and juvenile fish. Large carnivores include jellyfish and large predatory fish like sharks, tuna, and marlin. (Refer to food pyramid on page 2.)

It is in the sea that we find the greatest genetic diversity where there are more 'higher taxa' (phyla and classes) than on land or in fresh water.

Animal phyla that occur only in the sea include;

Ctenophora (comb jellies),
Sipuncula (peanut worms),
Brachiopoda (lamp shells),
Phoronida (horseshoe worms),
Echiura (spoon worms),
Gnathostomulida (lesser jaw worms),
Chaetognatha (arrow worms),
Kinorhyncha (mud dragons),
Priapula (little penis worms),
Echinodermata (e.g., starfish, sea urchins, brittle-stars, sea cucumbers, sea lilies),
Hemichordata (acorn worms).
Representatives of all of these occur in New Zealand waters.

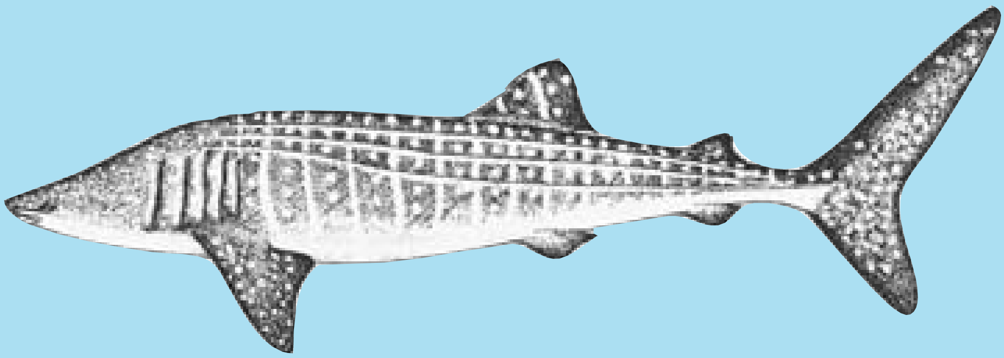


Mud dragon Robert Higgins

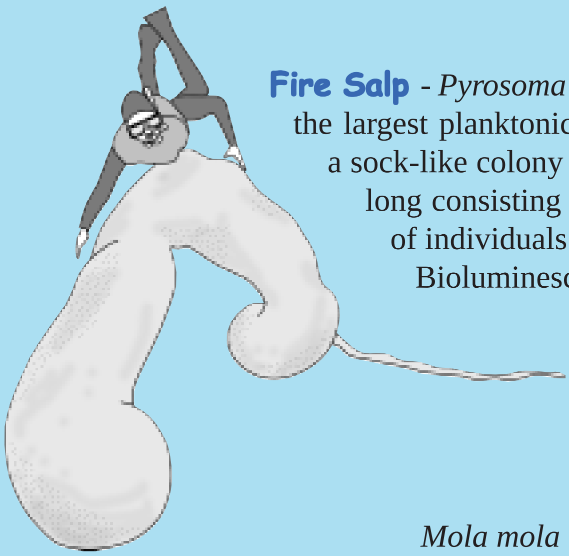
Apart from cyanobacteria (formerly known as blue-green algae), bacteria in the sea are abundant but poorly known. In our EEZ there are roughly 1000 species of foraminifera, 620 diatoms, 230 dinoflagellates, and 150 radiolarians, among others. Macroalgae comprise 470 red seaweeds, 153 brown and golden-brown seaweeds, and 134 green seaweeds. Many of the known protists and algae have not yet been formally named and described and doubtless more have yet to be discovered. Higher-order plants include three natives: two species of seagrass (*Zostera*) and one mangrove (*Avicennia marina*).

Believe it or not!

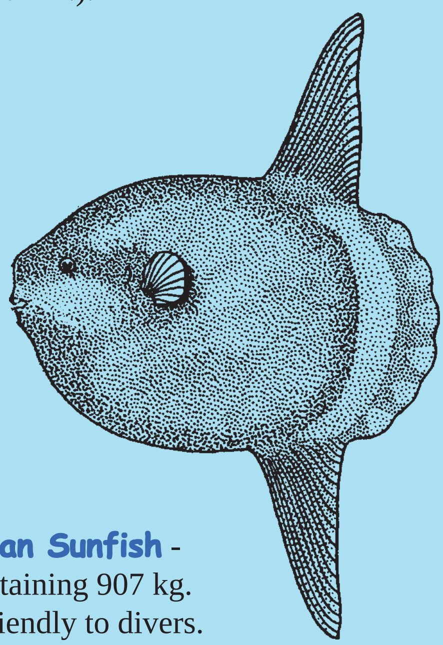
We've got them all! All the largest kinds of marine creatures are found in New Zealand's waters. They are not restricted to New Zealand, being wide-ranging in the oceans, but we can claim them as legitimate members of our fauna.



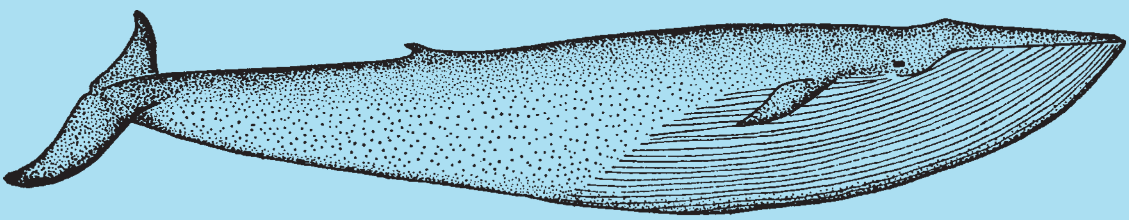
Whale Shark - *Rhincodon typus* - the largest cartilaginous fish, attaining 15 m length. (Recently discovered in New Zealand waters, Clinton Duffy, pers. comm.).



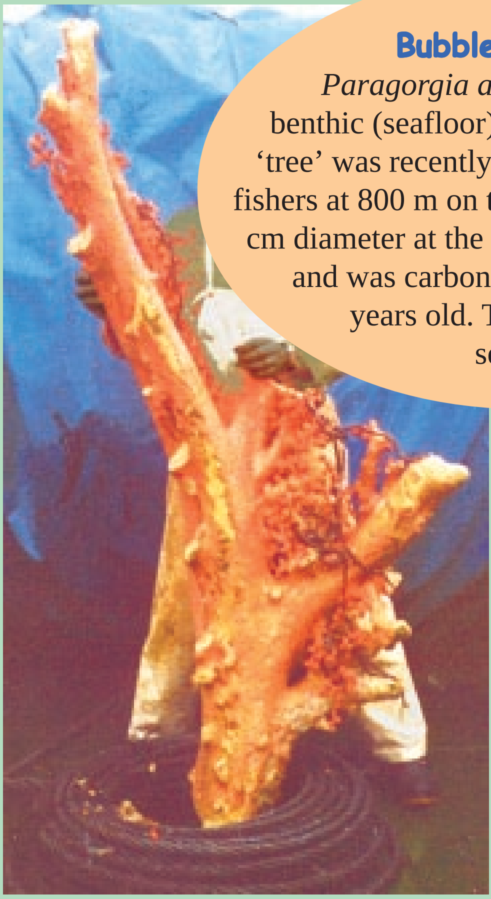
Fire Salp - *Pyrosoma spinosum* - the largest planktonic organism, a sock-like colony up to 20 m long consisting of millions of individuals. Bioluminescent.



Ocean Sunfish - *Mola mola* - the heaviest bony fish, attaining 907 kg. Friendly to divers.



Blue Whale - *Balaenoptera musculus* - attaining 34 m length, the largest animal ever and larger than any dinosaur. A pod of up to 30 individuals was recently seen off the West Coast, and isolated individuals are regularly sighted offshore.



Bubblegum coral - *Paragorgia arborea* - the largest benthic (seafloor) organism. One broken 'tree' was recently taken by orange-roughy fishers at 800 m on the Snares Plateau. It is 45 cm diameter at the base, stood over 7 m tall, and was carbon-14 dated as 300–500 years old. The 'kauri' of our seafloor.

Giant Squid - *Architeuthis dux*. It is the largest swimming invertebrate, locally attaining up to 13 m length, including tentacles.

These are icon species of our seas; to be recognized, regarded and protected by every New Zealander in the same way as the kiwi, kowhai and silver fern.

Threats to marine biodiversity

More than half the world's population lives within 100 km of the sea and has a direct impact on coastal environments. Deforestation and many forms of land use can result in tonnes of sediments polluting the sea, smothering seaweeds and other seafloor life. Industrial pollutants, sewage, and flotsam are also constant threats. Coral reefs, coastal rocky reefs, seagrass meadows, and other marine habitats all over the world are declining in extent and in species richness.

About 51% of the world's coasts are under moderate or high threat from development, and 58% of the world's coral reefs, 50% of mangrove forests, and 8% of seagrass meadows are degraded or heavily threatened. Fishing has the largest and most devastating effect on marine life through overfishing and/or habitat destruction or modification. In the open ocean, enormous nets can catch hundreds of tonnes of one or more species in a single haul. On the seafloor, trawls of various designs 'plough' the seabed, overturning rocks and boulders, crushing and breaking corals, bryozoans, sponges, and other erect growths. Oxygen-poor sediments are stirred up and smother many organisms, increase respiratory stress, and disorient fish. The largest trawl tows can exceed 100 m in width over many kilometres.

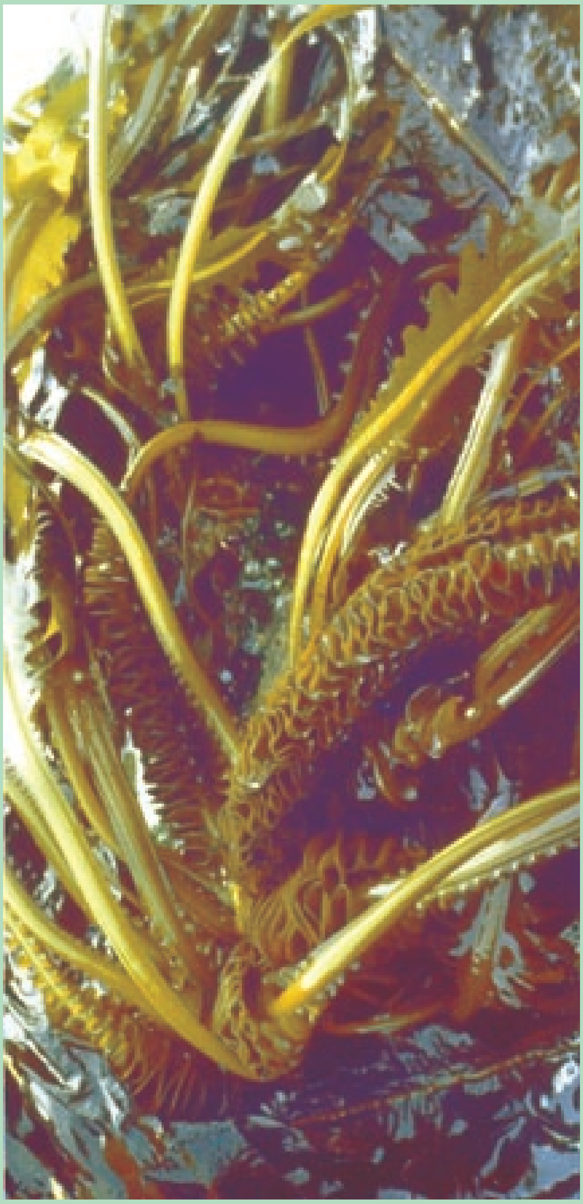
Globally 25% of commercial fish stocks are overfished and large areas of continental shelf are being disturbed too frequently by fishing gear to allow recovery. This, and the impact of land derived sediments are major threats to coastal biodiversity.

Fishing haul

H. Bagley NIWA

Alien invaders

Another potential threat to biodiversity is alien invaders, but their impacts in the natural environment are difficult to determine. Over the past 200 years, more than 160 species have been recorded as having entered New Zealand's coastal waters. Some did not survive. Those that did become established have either not spread beyond their point of arrival, are restricted to ports and harbours, or appear to be benign. The Japanese seaweed, wakame (*Undaria pinnatifida*), which apparently arrived in 1987, is now widespread. Its effects on native marine organisms are still being monitored. [See Alpha 92 – Marine Invaders.]



Undaria pinnatifida

Why record marine biodiversity?

Human health, aquaculture, fisheries, marine reserves, and biosecurity can all benefit from the knowledge provided by marine taxonomy.

Human health and aquaculture. A number of microalgal species, both native and foreign, are toxic, causing a range of effects depending on the species (e.g., amnesia, paralysis, gastrointestinal upsets, even death) if people ingest wild shellfish. Ongoing monitoring programmes aimed at protecting people and the aquaculture industry are able to be carried out.

Marine organisms as sources of significant biochemicals. Sponges, bryozoans, sea squirts, and other organisms produce biochemicals that are cytotoxic, anti-cancer, antibiotic, antiviral, biocidal, or useful in cosmetics. Accurate taxonomy is crucial in natural products research.

Ecological management. In ecological surveys, listing "Worm A, Worm B, Worm C", etc. is useful only if voucher specimens are retained for later comparison.

Alien marine species and biosecurity. There are two lines of defence in biosecurity; one is prevention but this can never be perfect. The second line is early recognition. This is important for two reasons: if recognition occurs at or soon after introduction, eradication or control measures can be carried out; secondly, early recognition makes it easier to determine the provenance and carrier of the alien species. This can suggest control measures to prevent the introduction of other species. This is why constant surveillance is necessary.

Marine conservation. The identity, distribution, and abundance of most marine organisms, other than some fish species, are poorly known. Knowing what is representative, widespread, unique, or rare and threatened is helpful in the process of selecting areas of seafloor for marine reserves or assessing threatened-species status.

Scientific studies. New Zealand seas have large numbers of species, genera, and even some families and orders found nowhere else in the world. Some species have distinctive attributes, like archaism ('living fossils'), a special habitat association, special ecological roles or taxonomic novelty.

Special habitats, special critters

Bizarre habitats are found scattered about the New Zealand sea floor. Most unusual and novel creatures are found there.

Whale carcasses. Dead whales can take a year or more to decay. A specialised biota is necessary to break down everything from blubber to bone. One bacterial species, able to produce fat-digesting enzymes at the low temperatures and high pressures found in the deep sea, has recently been isolated. It has potential use in cold-water detergents. A new family, genus, and species of limpet (*Osteopelta mirabilis* - 'wonderful bone shield') was discovered on whale-bone by Bruce Marshall of Te Papa. Many other species live only on this unusual habitat. Believe it or not, there are even tiny narrow-bodied species of limpets adapted to live on fish bones!

Crusts and chimneys associated with a cold seep 200 metres deep on the Otago coast A. Orpin NIWA

Cold seeps. In buried seafloor sediments, some biological substances transformed by heat, pressure and bacteria are chemically transformed and percolate upwards through the sediments to be released as organic-enriched fluids and gases. At the seafloor, sites of release are associated with carbonate cements and crusts formed by chemical gradients, plumes of methane gas, and distinctive faunas. There are numerous cold seeps in New Zealand, either associated with deep tectonic burial of organic-rich sediments or shallower ground-water percolation on the continental shelf. Methane-rich seeps are home to vestimentiferan tubeworms and new genera and species of shellfish.

Sunken wood. Driftwood gets carried into the deep sea via undersea canyons. This sunken wood is then bored by shipworm and colonised by lignin- and cellulose-digesting bacteria. In turn these are fed upon by a variety of tiny crustaceans and molluscs unique to this habitat. In the mid-1980s, the scientific world was excited by the discovery of a truly bizarre creature in sunken wood from 1100 m off Castlepoint and Hokitika. In the shipworm borings were found several specimens of a medusa-like echinoderm, the largest a centimeter across. Lacking a mouth and arms, it represented a new class of Echinodermata - the Concentricycloidea, or sea daisies, distantly related to starfish. A second species, with a mouth, has since been found in sunken wood off the Bahamas.

Without doubt more unusual and exciting discoveries will be made.

Acknowledgements

Written by Dr Dennis P. Gordon, FLS, National Institute of Water and Atmospheric Research Ltd (NIWA).
Editor: Colin Walker. Cover photo: Malcolm Francis, NIWA
Thanks for review from: Kathryn Hicks, Royal Society of New Zealand
Design and typesetting by Robert Lomas
Photographs, graphics and diagrams courtesy of NIWA.

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ISSN 0111–1957 2001