Biodiversity Update

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Unique branching worm found in New Zealand

A unique deepsea annelid worm can do what many of us wish we could – be in two places at the same time.

The worm, *Syllis ramosa*, belongs to the Syllidae, a family of delicate, colourful polychaetes, often exquisitely beautiful. It lives in the water circulation system of a sponge and has developed a technique of growing lateral branches from its body through channels in the sponge, so it can be almost everywhere at once within its home.

The Tasman Sea branching syllid

The worm is probably a parasite that grazes on the tissue of the sponge using only one feeding head, but it also may be able to absorb nutrients through its skin. The branching phenomenon could be an extreme variant of a method of reproduction used by many syllids where they sprout sexual forms called stolons from their posterior ends. These stolons are specialised male and female individuals that free-swim in the ocean at night in search of a mate.

The first *Syllis ramosa* specimens were collected in the deep sea off the Philippines by the *Challenger* Expedition, but were discovered only after the famous round-the-world ship had returned to England. In 1878, biologists sorting the samples collected from this expedition were surprised to find a branching worm inside a sponge. The worm formed a complex mass and each branch was at lateral right angles to where the walking "foot" (or parapodium) should be. Some of these lateral branches also had their own branches, and a few of these were developing into reproductive stolons. This phenomenon still intrigues us today because no other worm has developed this ability to branch repeatedly.

Plant-like lateral growth is a strange way of increasing body mass for a mobile animal – moving around must be difficult! Most plant-like animals are colonies of individuals that are connected and fixed in one place. However, what is even more interesting is how the genes and hormones that control the development of the worm's body determine the growth of its branches. If *Syllis ramosa* were easier to collect, molecular biologists and endocrinologists would probably be eager to study it. Unfortunately, it is very rare, occurring only inside species of the glass sponge *Crateromorpha* (Hexactinellida), and it has never been seen alive. Its biology is, therefore, a mystery.

No new information had been reported on the branching syllid for many decades. However, a syllid very similar to *Syllis ramosa* was collected at a depth of about 1000 m off New Zealand in the Tasman Sea, and was later found among preserved sponges back in NIWA's sorting laboratory. This is the first time this type of syllid has been found in the (non-tropical) Southern Hemisphere. It was found thousands of kilometres from the previous records so it might be a different, but related, species. However, it was also living in a deepwater *Crateromorpha* sponge.

This sponge is shaped like an inverted umbrella with lateral "ribs" or "pleats" and is about 600 mm long. In the main pleat of the sponge (the basal portion) is a complex, thick mass of branching, thread-like, red-pigmented syllid worm. The head of the worm has not been seen, but if we are lucky we may find it when more sponge tissue is removed.

In New Zealand this worm is associated with a large number of egg-bearing female stolons with swimming setae (stiff bristle-like structures), similar to those found on the worm from the Challenger Expedition. However, the stolons had separated from the main body of the worm and were congregated in the hollow tube that forms the basal stalk of the sponge.

The thick-walled rigid sponge stalk has no openings, except for the narrow indirect connections at its upper end and extending to the circulation system of the sponge. It is hard to understand how the stolons got into this compartment, why they were there, and how they would be able to exit en masse to find partners and spawn. These and other questions are likely to remain unanswered for years to come, but the enigmatic branching syllids are now known to be part of New Zealand's rich undersea biodiversity.

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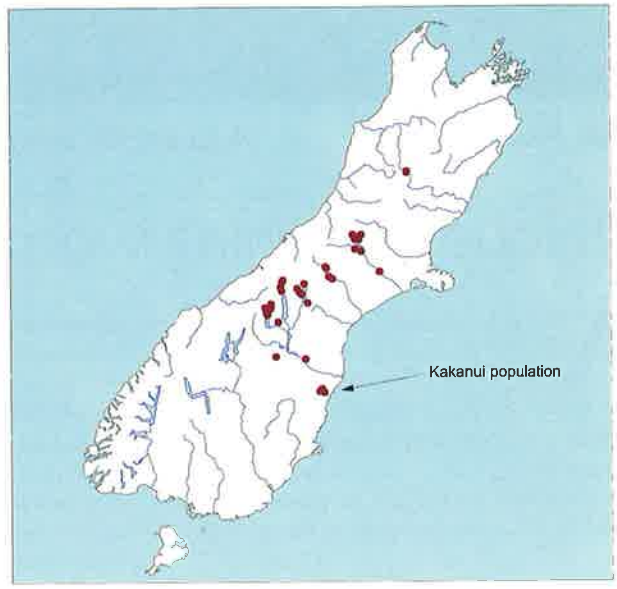
Finding information on freshwater fish

NIWA's New Zealand freshwater fish database (NZFFD) is an archive of the distribution and habitats of freshwater fish throughout New Zealand. It includes both historic and contemporary information, and now holds over 17,500 records, making it an essential tool in the understanding and conservation of freshwater fish diversity.

Established in the late 1970s, the database's initial records included fish held in museum collections and information from field surveys carried out by the Marine Department and Ministry of Agriculture and Fisheries in the 1960s and 1970s. Since then, more and more organisations have contributed information to the NZFFD. Information is now received regularly from many NIWA research projects and from the Department of Conservation, regional councils, fish and game councils, universities, environmental consultants, and interested individuals. Having a single, central place for freshwater fish information ensures that it is widely available and properly archived.



Distribution map for longjaw galaxias (source: NZFFD).

Information for the NZFFD mainly comes from field surveys. Although some collectors enter their own information, final processing is done at NIWA to ensure consistency and completeness. The information stored includes the location of fish, an NZMS260 grid reference, the species caught, and their abundance: the date, time, collector, method used, and the area fished are also included. Information on the physical characteristics of the site, such as the size of the stream, substrate composition, and catchment and riparian vegetation are also stored (if collected).

There are two ways of accessing the NZFFD. A web site allows registered users to search and download information directly. The site gives access to all the records, is updated weekly, and has a variety of search options. Users who do not have access to the Internet can contact NIWA directly and have their requests processed on a cost-recovery basis. However, regular contributors to the NZFFD are rarely charged for this service. Users often seek information on the fish species in particular regions or catchments, or the distribution of certain species. It is the distribution of species that is especially useful in biodiversity studies.

The recent discovery of another new species of *Galaxias* is a good example of how the NZFFD can be used to learn more about fish diversity. A species-specific distribution map showed that there was one population of longjaw galaxias (*Galaxias prognathus*) in the Kakanui River catchment that was outside the normal range for this species. Genetic and morphometric studies on this population now show that it represents a species new to science. Information from the NZFFD alerted scientists to this by revealing a discontinuous distribution pattern. Another species currently under investigation is the dwarf galaxias (*G. divergens*).

The NZFFD provides a readily accessible resource for NIWA staff, other fisheries scientists, fisheries managers, and members of the public who want to understand more about New Zealand's freshwater fish diversity. The information that is voluntarily contributed by a wide variety of individuals and organisations is vital to the development of the NZFFD, and is gratefully acknowledged by NIWA.

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Background cover photo:
Gorgonian sea fans (pink Primnoides and yellow ?Mopsella) jostle for space on an underwater rock face, where they filter microscopic plankton from the passing currents. Photo by Malcolm Francis

Rock sponges on seamounts: relicts from the past

NIWA biologist Michelle Kelly and Auckland University of Technology paleontologist John Buckeridge are studying the evolution of rock sponges, their present-day distribution, and how these have been influenced by changes in New Zealand's ocean and climate history.

Aciculites pulchra from east of North Cape, 100 m.

Rock sponges live on deep coastal seamounts and banks off northern New Zealand and are relatives of ancient life-forms, some up to 145 million years old. Unlike bath sponges that are made up of a network of collagen, rock sponges are made of fused silica spicules (needle-like structures) called desmas which make the sponge rigid and tough. Scientists are interested in these sponges because they produce a vast range of chemical compounds and materials that may be used to fight against human diseases.

(left) Reidispongia coerulea *from the Northland continental slope, 250 m.*

(right) Fused siliceous desma spicules of Reidispongia coerulea.

NIWA research vessels have made several hundred voyages over the years, but no rock sponges have been found south of the Chatham Rise on New Zealand's east coast, or south of the northern boundary of the Challenger Plateau. Over the past 2 years, however, Michelle Kelly has identified and documented 33 species of rock sponges from northern New Zealand compared to just one previously known species, *Aciculites pulchra*.

During this study we also found the skeletal remains of a diverse rock-sponge assemblage trapped in fossil glass-sponge skeletons along the mouth of the Tutuiri Stream on Chatham Island. Similar microfossils have also been found in limestone from Oamaru. The Chatham Islands and Oamaru microfossils are both thought to be about 25–40 million years old. This suggests that in ancient times these sponges must have lived further south when this part of New Zealand was much warmer.

Otago University geologist Dr Daphne Lee also found the first sponge body fossils recorded in New Zealand of approximately the same age in limestone, at the mouth of the Kakanui River in Oamaru. These fossils were deposited throughout a thick limestone band and may have been transported there from their habitat, most likely an underwater volcanic seamount, by a flow of debris. Identifying the fossils requires patience and some scientific "guesswork" because the silica has been largely replaced by calcite. The most exciting part of this discovery is that the fossils are almost identical to a sponge (genus *Pleroma*) found on isolated underwater banks to the northwest of New Zealand.

As part of this study we are now comparing living populations of rock sponges in northern New Zealand with their fossil counterparts in the South Island, and sequencing DNA from living sponges to determine their family ties. These new collections of rock sponges, and remote photography of rock-sponge populations living on seamounts today, are providing valuable insights into ancient paleo environments.

The New Zealand Royal Society Marsden Fund funds this research with help from the NIWA Seamounts Programme.

Tutuiri Stream, Chatham Island.

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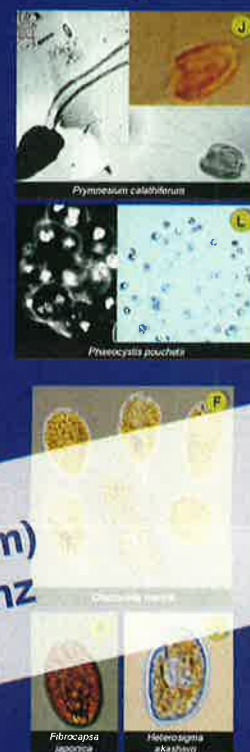
Nuisance marine microalgae in New Zealand

A band of thick surface foam in Wellington Harbour caused by the collapse of the 1998 toxic *Karenia brevisulcata* bloom.

Dinoflagellates

Diatoms

Microflagellates



Major currents around New Zealand

Nuisance microalgae in New Zealand

The spring 1999 pink surface bloom caused by *Noctiluca scintillans* in Shelly Bay, Wellington (looking across to NIWA at Greta Point).

Microalgae are single-celled plants which range in sizes from about 0.001 mm to 1 mm. Free-living planktonic forms live in the upper part of the water column, while epiphytic/benthic forms attach to seaweed or the seafloor. Most microalgae are dinoflagellates, microflagellates, and diatoms. When planktonic microalgae occur in massive numbers they are said to form "blooms" (collectively termed "red tides" in the past), which sometimes discolour surface water, turning it pink (photo above), red, brown, or even milky.

As part of the life cycle, especially in dinoflagellates, resting cysts are often produced when nutrients are depleted at the end of the bloom. These cysts remain in the sediment until favourable conditions return. They then germinate and may form new blooms. Most of these naturally occurring blooms are harmless, but they can cause massive loss of marine life when dissolved oxygen in shallow water is depleted by decaying cells.

There are also a few harmful species (3% of all recorded species in New Zealand) that produce fish-killing toxins (e.g., ichthyotoxin, haemolysin), or toxins that threaten human health when contaminated seafood is consumed (e.g., paralytic shellfish poison (PSP), neurotoxic shellfish poison (NSP), amnesic shellfish poison (ASP), diarrhetic shellfish poison (DSP), and ciguatera seafood poison (CSP)). At times, outbreaks of marine life kills are accompanied by toxic aerosols that cause human respiratory illnesses (e.g., the very extensive *Karenia brevisulcata* (= *Gymnodinium brevisulcatum* Chang) blooms between Wellington Harbour and Hawke Bay in 1998).

Major algal blooms, which may extend for hundreds of kilometres along the New Zealand coast, are often triggered by surface nutrient enrichment caused by upwelling and/or deep mixing, and are sometimes linked to unusual large-scale weather events. It appears that coastal currents around New Zealand also contribute to along-shore long-distance transport of some of these blooms. (Diagrams A-L on the right, which show where nuisance microalgae have been recorded, are based on published information readily available in New Zealand.)

Where these nuisance microalgae have been found

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NIWA, PO Box 14-901, Wellington, New Zealand
NIWA Poster No. 3 (2001)

New fish species invade our estuaries

Bridled goby
(photo: Ross and Diane Armstrong).

The list of exotic marine organisms that have made New Zealand coastal waters their home continues to grow as more new species are discovered. Most of these invasive species are invertebrates or algae that have probably arrived on the hulls of ocean-going ships or yachts, via ocean currents, or in ship ballast water. The effect of these species on the biodiversity and functioning of our marine environment is not yet known.

Last summer, NIWA scientists sampled 25 estuaries around northern New Zealand for juvenile fish as part of the Foundation for Research, Science and Technology programme "Fish Usage of Estuarine and Coastal Habitats". The aim of this study was to classify the habitats of juvenile estuarine fish, such as snapper, trevally, kahawai, flatfish, and mullets, but it was also a good way of surveying invasive fish species. Two possible invasive species were found ≡ the Australian bridled goby (*Arenigobius bifrenatus*), and the exquisite sand goby (*Papillogobius exquisitus*).

We found juveniles and adults of both bridled and exquisite gobies, which show that these species have adapted to New Zealand conditions and may be successfully breeding. Bridled gobies were relatively abundant in the muddy upper reaches of the Waitemata Harbour (41 fish caught). Only a single specimen was collected outside that range in Whangarei Harbour, although we have recorded them previously in the Whangateau and Mahurangi estuaries. The bridled goby is most likely to have arrived in New Zealand via ship ballast water because of its limited distribution and its presence in New Zealand's busiest international shipping port.

The exquisite goby is more widespread and occurs on the west and east coasts of northern New Zealand (73 fish caught). This suggests that the species either arrived in New Zealand via ship ballast water some years ago, followed by widespread colonisation of northern estuaries, or hitched a ride with the East Australian Current. To the untrained eye an exquisite goby looks very similar to our endemic goby – *Acentrogobius lentiginosus*. Also, its estuarine habitat is often overlooked, so it may have been here for some time without our knowledge.

Sorting a beach seine catch.

The bridled goby was first recorded in 1998 from Whangateau and Waitemata Harbour in Auckland by researchers from the University of Auckland. Jan Doak took the first underwater photographs of the exquisite goby in 2001 from Matapouri Inlet in Northland. A third species, the dart goby (*Parioglossus marginalis*), was recorded by NIWA scientist Bob McDowall in wetlands on Great Barrier Island and at Tom Bowling Bay, North Cape, in 2000. Previously, all three species were only known to live in the shallow bays and estuaries of temperate Australia. So how did these small estuarine gobies arrive in New Zealand, and how widespread are they?

For decades, subtropical marine fish species have been recorded around offshore islands northeast of New Zealand. Many of these species survive for only a few months before being killed off by cold winter conditions; others survive through winter but are unable to establish breeding populations. However, temperate fish species are more likely to survive and reproduce in New Zealand where the conditions are similar to those in southern Australia.

We do not yet know what impact the invasive goby species are having on the animals of New Zealand's harbours and estuaries, but we plan to find out how well established they are, and what their role is in estuarine ecosystems.

Exquisite sand goby (photo: Jan Doak).

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A mystery of the sea finally solved

The biologically rich open ocean holds many secrets. One mystery that scientists have been trying to solve is the nature of the large number of green cells, about the size of fish eggs, that have been found in plankton net tows (mesh size 0.2 mm) around New Zealand. Scientists referred to these unknown cells as "green eggs" because of their size and colour. It was not only their mysterious appearance that interested them, but also their potentially important role as a food source for larval fish. What were they?

NIWA scientists have discovered that these are algal cells by using alcohol or acetone to extract pigments from them. The colour from these substances resided in the cells' chloroplasts, which shows that they are photosynthetic. The "eggs"are actually non-mobile cysts that are produced by a green microalga called *Halosphaera viridis*. The cysts are large for microalgae, ranging from 0.35 to 0.85 mm in diameter when mature. Each mature cyst has a relatively small nucleus at the edge of its cell, while the small immature cysts have a prominent nucleus in the centre of their cells.

A mature cyst with cellular contents divided into small round discs (arrow heads). Each of these discs produces many flagellated mobile forms.

Life cycle

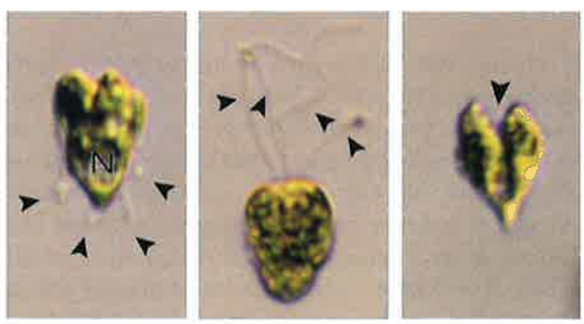
The different stages of the alga's life cycle can be seen in laboratory cultures. When the cysts are mature the entire cellular content of each cyst divides into small round or oval discs (each with its own nucleus), which stay close to the edge of the inner cyst wall. The cysts then continue to divide, with each disc producing flagellated cells that will eventually be released into the open sea. These cells make up the mobile phase of the life cycle.

In our cultures the length of the flagellated cells range from 0.020 to 0.028 mm (20–28 µm) long, with the width usually a little over half the length. Near the front of each cell there is an anterior depression with four swimming hairs (flagella). Tiny scales cover the swimming hairs and the cell body. Asexual reproduction occurs by splitting the single mobile cells. Using this method, the species can multiply and achieve very high concentrations in the open sea. Cells in the swimming phase can be directly enclosed in a cyst when individual cells round off and lose their swimming hairs.

Food web studies

Halosphaera viridis is not known to be toxic and is one of many diverse phytoplankton species found in the open ocean. Since the mid 1980s we have found large numbers of this non-mobile cyst in samples collected during oceanographic and fisheries surveys, especially around the South Island, Cook Strait, and coastal waters of the North Island. The mobile flagellated form is often picked up in coastal waters around New Zealand.

These cysts have been included in our marine food-web studies because of their large size and abundance in the open ocean (where there are hundreds per square metre). It is clear that these "egg-like" cells are, either directly or indirectly, an important source of food for animal populations further up the food chain, e.g., larval hoki. Now that we have correctly identified this alga and characterised the stages of its life cycle, we can better understand the role it plays in local marine food webs.



(left) A live, flagellated form with four swimming hairs towards the back of the cell (arrow heads), and a nucleus (N). (middle) A preserved cell showing four swimming hairs (arrow heads). (right) A flagellated form splitting in two.

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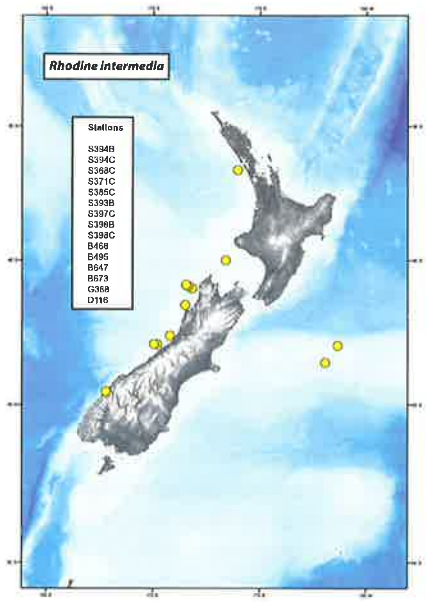
New on-line global atlas of marine biodiversity

After 4 years of planning and preparation, work has begun on a global ocean atlas of marine species distributions.

Known as the Ocean Biogeographic Information System (OBIS), the atlas will contribute to another new initiative called the Census of Marine Life (CoML). CoML was first conceived as a Census of Fish to help address the questions, What lived in the oceans? What lives in the oceans? And what will live in the oceans? It was then expanded to include all of marine life. OBIS will be an on-line atlas that allows a user to find information about species or localities. For example, a user will be able to ask where any marine species is found (see figure) and how many there are, or what lives in any part of the ocean and in what numbers. Users will also be able to overlay species and environmental information to discover the relationship between species distribution and other factors.



Why is this needed? Currently there is no adequate system to retrieve ocean biological information. The few databases that exist do not summarise known distributions and abundance of marine life in a user-friendly way, or encourage the frequent use and comparison of datasets. The founder and coordinator of OBIS, Dr J. Frederick Grassle from Rutgers University in New Jersey, has said: "An on-line, user-friendly system for absorbing, integrating, and assessing data about life in the oceans will stimulate taxonomic and systematic research and generate new hypotheses concerning evolutionary processes, factors related to maintenance of species distributions, and roles of marine organisms in marine ecosystem function." The inclusion of historical information will allow us to make comparisons between past and present species distributions in relation to human and environmental influences, and give us some power to predict future losses and gains of marine life.

There are no good maps anywhere of marine biodiversity. It is not surprising that the rich marine life of the deep sea is seldom considered in biogeographic classifications, but even classifications of coastal areas based on marine life are still poorly developed.

CoML, championed by Jesse Ausubel of the Sloan Foundation in New York, is a 10-year, billion-dollar (US) initiative that got underway last year when eight 2-year grants were awarded by the National Science Foundation for projects that will be linked through OBIS. Other grants are likely to be awarded to encourage holders of large datasets (whether marine institutions or taxonomic specialists) to compile and share their data. It will take many decades of marine sampling, taxonomic work, and data archiving to achieve the level of resolution desired for OBIS to work well at a global level or even at regional levels.

There are a number of challenges to be met before we can achieve this. At the first meeting of the International OBIS Steering Committee (made up of members from the U.S., U.K., Canada, Japan, Germany, Australia, and New Zealand) at Rutgers University in August 2001, several of these were discussed. The committee is now identifying user groups and additional providers, determining mechanisms for data rescue, clarifying relationships with major international organisations, refining standards and protocols for interoperability and data-sharing, and encouraging the formation of OBIS national committees in different countries or regions.

Benefits to New Zealand

NIWA is in an excellent position to contribute to and benefit from OBIS. We now have extensive information on marine plants and animals and are continually improving and building databases on marine life and environmental factors. For widely distributed economic species that occur not only in the New Zealand Exclusive Economic Zone but elsewhere, GIS-integrated information from extra-territorial waters should enhance existing knowledge-based management tools in our own region (e.g., for fish and protected species like black corals and red hydrocorals).

OBIS is currently developing technical tools to achieve interoperability and it could be a model for the development of New Zealand's own National Aquatic Biodiversity Information System (NABIS). NIWA's direct involvement in OBIS will give immediate access to knowledge of technical developments that may be able to be used or adapted locally.

NIWA has long benefited from access to U.S. satellite and physical-oceanographic data for the wider New Zealand region, and this is increasingly being used to explore relationships with species distributions. NIWA is developing closer ties with oceanographic partners overseas. The success of OBIS and CoML will depend on the number and level of international partnerships.

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