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Deep discoveries

Katherine Johnson describes the elation of scientists as they unveil a unique array of marine creatures, clinging to life on the edge of extinct volcanoes off Tasmania's southern shores.

Seamount species photographed by Karen Gowlett-Holmes, CSIRO Marine Research.

This basket star, *Gorgonocephalus* cf *pustulatum*, unfurls its many-branched arms to catch drifting particles of food, forming a net up to a metre across.

Mention coral reefs, and most people picture colourful fish darting between corals, sponges and shells in the tepid waters of the tropics. Few of us envision reefs where the sun never shines. A place where, amid an inky blackness, deep-sea corals provide refuge for a host of slow-moving and often remarkable species, many of which are new to science.

But such a place does exist, founded on extinct volcanic cones known as seamounts which rise steeply from the seafloor, their summits often more than a kilometre from the ocean's surface. Sometimes the seamounts are clustered together in ranges; other times they are solitary. Whatever their form, they provide a unique environment in an otherwise watery wasteland.

Most of the seafloor at depths below 1000 metres is an open plain marked only by the burrows of marine worms and other animals. In contrast, seamounts host a rich and diverse assemblage of life forms. The reason is the unusual abundance of food. Ocean currents converge at the pinnacles, concentrating plankton and dissolved organic material near the mountain slopes, supplying a travelling smorgasbord to anything able to live there.

Life in these frigid, deep-sea waters, where light no longer penetrates, and water pressure exceeds 100 atmospheres, cannot be called easy. If a person were to descend the depths in a submersible, and place a polystyrene coffee cup on the seafloor, it would shrink under the weight of water to thimble size. At these depths, extreme evolutionary adaptations are essential and creative life forms emerge.

Deep-sea life is characterised by bizarre body forms and extraordinary physiologies. Add isolation to the list, as is often the case with seamounts, and endemism emerges: evolution of unique life forms that are found nowhere else.

A cluster of seamounts 80 km south of Tasmania is attracting particular interest.

The seabed south and west of Tasmania was first surveyed in early 1994 by the French research vessel L'Atalante for the Australian Geological Survey Organisation (AGSO). The cruise produced detailed maps of the seabed to depths of 4500 m, covering a total area three times the size of Tasmania.

The study was led by AGSO's Dr Neville Exon. It found the region consisted of a number of extinct volcanic cones, 65 of which peak at depths between 660 m and 1940 m from the sea surface. The average height of these undersea mountains is 400 m, and the gradient of their slopes ranges from 20 to 30 degrees.

Many of the shallower seamounts in the area closest to Tasmania are known intimately to orange roughy fishers who have harvested the region since the 1980s. A number of the newly mapped hills, however, with summits 1200 m or more from the sea surface, are new to fishers and scientists.

'We knew there were fishing grounds in this area, but we didn't know there was this whole swarm of little volcanoes – thought to be about 30 million years old – that were very pristine in structure,' Exon says.

'As the research vessel travelled over the seabed, the maps literally rolled out at your feet, in real time, showing perfect little cone-shaped hills that none of us had expected to see. For me that was incredibly exciting.'

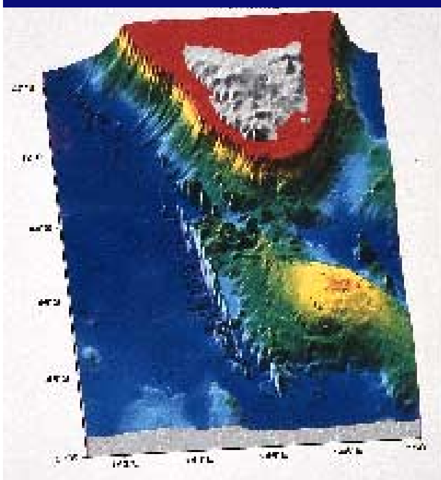
The pilot study aboard the French research vessel showed that this sort of marine-bed mapping, so important for management of offshore areas, is feasible for the whole of Australia's Exclusive Economic Zone.

But the most exciting for Exon is the prospect of Australia developing the capability to do this research using its own facilities, either by putting the mapping equipment onto an existing Australian vessel, or having a boat specifically designed for marine sea bed survey work.

A haul of surprises

At about the same time as the L'Atalante expedition, researchers from CSIRO Marine Research in Hobart, led by Dr Tony Koslow, conducted an acoustic survey of the orange roughy fishing grounds in the area. Orange roughy congregate on the seamounts around south-eastern Australia and New Zealand between 700 and 1400 m. Together with deep-water oreos, they form the basis of one of the largest and most valuable

The first maps of the seamounts off Southern Tasmania, produced for the Australian Geological Survey Organisation by L'Atalante using a multibeam sonar system. The maps revealed a number of extinct, submarine volcanic cones which have since yielded a treasure trove of previously unknown species. Marine-bed mapping is feasible for the whole of Australia's Exclusive Economic Zone.



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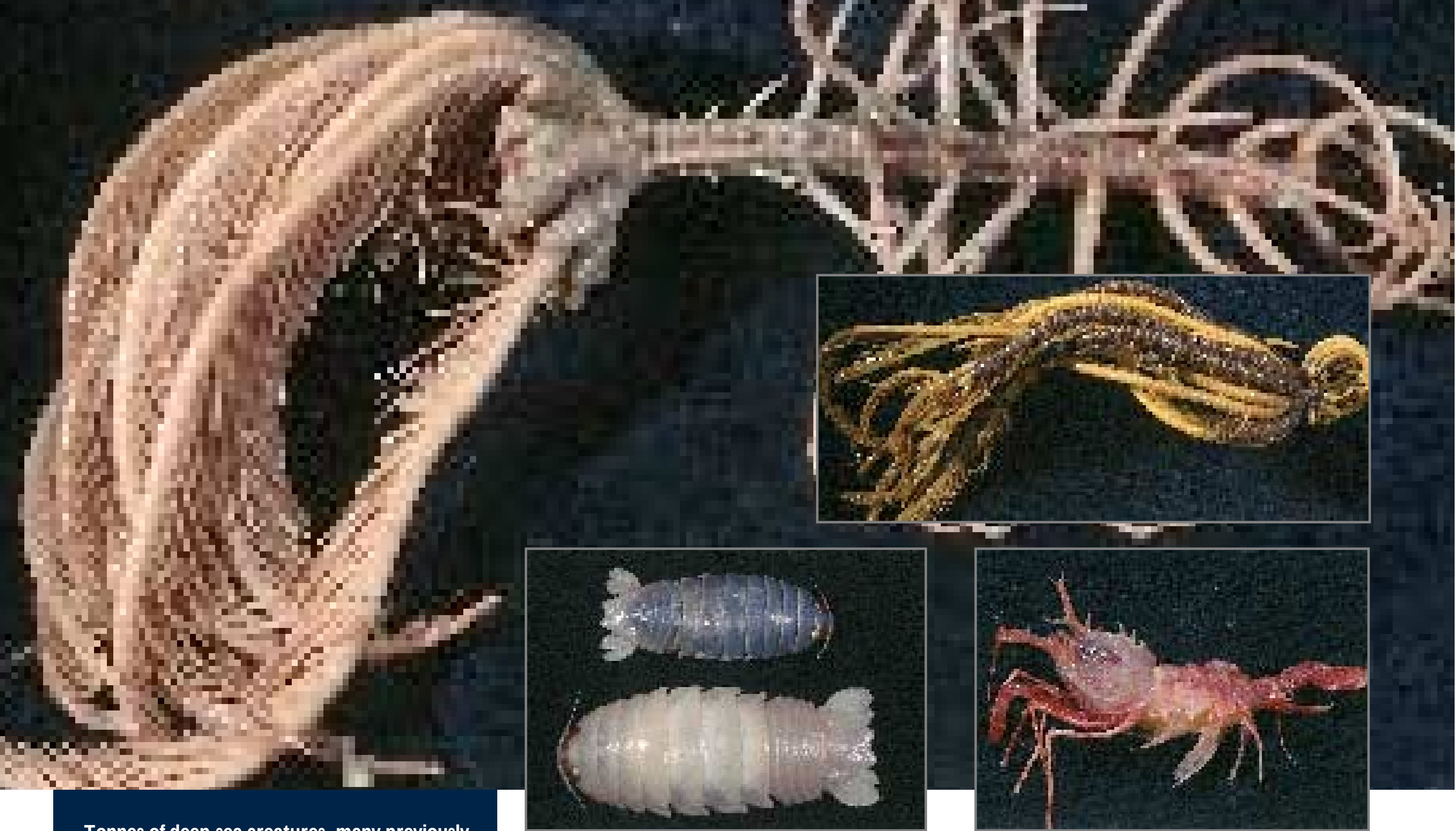


Tonnes of deep-sea creatures, many previously undescribed, were collected last year from seamounts off Tasmania in experimental trawls by the Southern Surveyor. Taxonomist Karen Gowlett-Holmes from CSIRO Marine Research photographed the specimens soon after they were landed aboard. The photographs are important as they record the live colours of the animals which are mostly lost when they are preserved. The discoveries sparked a worldwide hunt for taxonomists with special knowledge of the animal groups collected, and specialists are yet to be found for some groups.

Main picture: A stalked crinoid or sea lily, *Diplocrinus sibogae*. Stalked crinoids are an ancient group which used to be common, but disappeared from shallow waters in the same extinction that wiped out the dinosaurs. This is the first record of this species from Australian waters; it was previously known only from deep water near New Caledonia.

Inset top: A crinoid. This type of crinoid lacks a stalk, but all crinoids feed by catching drifting food particles in their feathered arms.

Inset far right: This deep-water armoured shrimp, a new species of *Paracrangon*, is about 8 cm long. More than 60% of the shrimps, prawns and crabs found on the seamounts are likely to be new to science. While these creatures live in near darkness, most have large eyes, probably to see light emitted by other animals, particularly predatory ones!

Inset right: These scavenging isopods or fish lice, 5-7 cm long, are attracted to anything dead on the sea floor. Many were caught feeding on the bait in fish traps.

fisheries in these countries, with more than half a million metric tonnes landed since the 1980s.

Using the FRV Southern Surveyor, the only Australian vessel capable of supporting research to depths of 2000 m, the CSIRO scientists also did three experimental trawls on lightly-fished seamounts to sample the seabed fauna. The haul was surprising.

Under the artificial lighting of the Southern Surveyor, creatures from the deep, dark sea were spilled out onto sorting tables.

Among them were several tonnes of deep-sea coral and a dozen specimens of four previously undescribed species of fish: two deep-water cod from the genus *Paralaemonema*, and two deep-water lings. *Paralaemonema* had previously only ever been found on seamounts in the South Atlantic. The find highlighted how little was known about the seamounts south of Australia.

CSIRO fish biologist Dr Peter Last says the excitement of exploring unknown ecological communities is unparalleled.

'There is a general perception that the Australian seas are well-explored,' Last says. 'However an indication of how little is known about the deep-sea is that new species are being discovered faster today than the early explorers recorded fishes from our seas two centuries ago.

'It is a startling statistic, but we know more about the types of fishes living around Antarctica and Heard Island than we do about the fish species around much of Australia. And at ocean depths below 1500 m – which is more than 70% of the entire Australian marine jurisdiction – we know almost nothing.'

In 1995, Environment Australia, the Australian Fisheries Management Authority and the fishing industry agreed to provide interim protection to the group of newly mapped seamounts, pending further investigation of their environmental and economic significance. The decision provided the time needed to assess the impact of fishing on previously-fished seamounts, and to determine whether the deep-water reserve would protect the fauna found on the shallower, fished seamounts.

The reserve status is unique on a world scale. There is only one other deep-water reserve, a deep-sea area in Hawaii set aside to help conserve the black coral communities fished for making jewellery.

In January 1997, the CSIRO team of researchers, again led by Koslow, did their first biological survey of the newly-discovered seamounts in research funded by Environment Australia and the Fisheries Research and Development Corporation.

'We feel like first explorers, travelling to unknown corners of the globe,' Koslow says. 'But this is the 1990s, and we are still discovering great areas of unexplored territory.'

Koslow says the researchers expected to find a relatively diverse deep-sea community and, if they were lucky, even a few new species. But what they discovered was more exciting than anyone had anticipated.

Wearing overalls and wellington boots, and looking more like fishermen than the stereotypical scientist, the researchers excitedly sorted through the samples: an urchin here, a fish there, coral fragments scattered across the sorting bench and a myriad of weird and wonderful unidentified creatures, all carefully preserved and sent to experts for identification.

'We found so many new species that taxonomists around Australia, and several from overseas, are still identifying them,' Koslow says. 'There are new species in virtually every animal group that we are examining, from corals and hydroids to crabs and fish.'

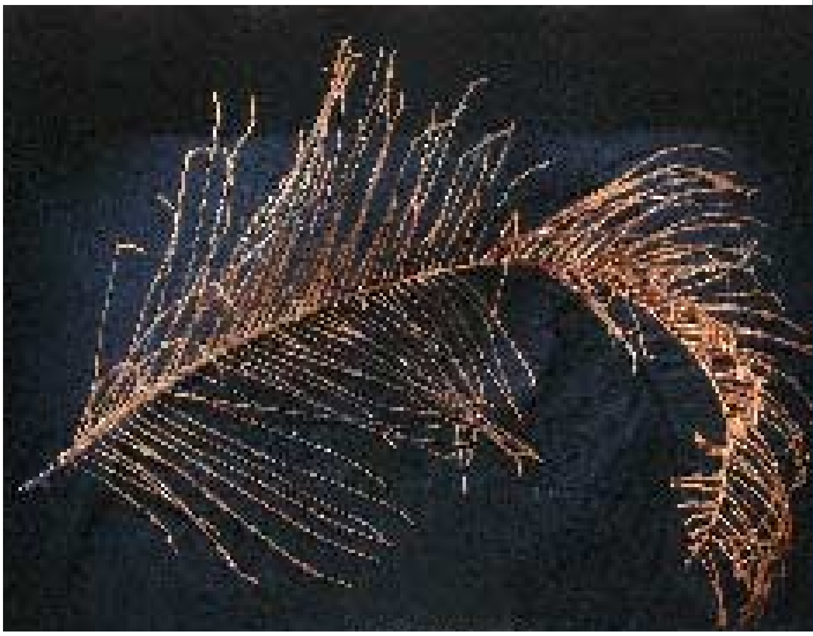
For example, of 13 species of hydroids – corals without skeletons – found on the seamounts, nine appear to be new to science.

The exact number of new species found in the other groups will be known by the end of the year. But what is proving to be as interesting as the sheer number of new species is the high level of endemism: these new species are found on these particular seamounts and nowhere else, not even off the coast of New Zealand.

'This is surprising because organisms in the deep-sea generally have fairly wide distributions – on the order of the ambit of an ocean basin – because there are few barriers to dispersal,' Koslow says.

But seamounts are unique deep-sea environments: like islands in the ocean. One false move and offspring are lost to the deep blue-yonder with little chance of finding another seamount. As a result, many of these species seem to have evolved mechanisms to restrict their range to the seamounts that support them.

For example, an urchin retrieved in the January samples was found to brood its young beneath it, appearing to have bypassed the need for a larval stage altogether.



These creatures all were found at about 1000 m below sea level.

Top: The meshwork colony structure of the colonial coral, *Solenosmilia variabilis*. Huge colonies of this coral form reefs on the tops of the seamounts, and are the basis of the seamount community.

Above: The squat lobsters and craylets are a group known to contain many undescribed species in deep water. Only one of the 10 species collected by the Southern Surveyor could be identified. All the rest are likely to be new to science. The long-legged specimen is *Gastroptychus* sp. The short-legged one, *Uroptychus* sp, lives only in association with black coral, to which it clings tightly.

Left: The tip of a single frond of black coral. Such colonies can reach more than 2 m in length.

Above: A sea urchin brooding young. Animals living in the deep sea usually adopt one of two survival strategies: lay many eggs and hope they survive as they drift about in a current, or lay a few and keep them close to protect them. This sea urchin has adopted the latter strategy.

Above right: Images of the coral reef communities were captured with a drop-camera designed to withstand the enormous pressures of the deep ocean. They reveal the diversity of life on the seamounts.

Right: The skeleton of this 4 cm glass sponge consists of spicules of silicon dioxide. The sponge attaches to rocks or corals and is probably a new species.

Far right: A top shell, 3-4 cm across. Probably a new species, this carnivorous grazer eats encrusting animals such as sponges.

'It is a strategy that makes sense in an environment where a larval stage – which can see the animal drift in ocean currents for weeks, months or years, depending on the species – is a liability,' Koslow says.

The high level of endemism apparent on these seamounts has important conservation implications. Koslow says it means that the seamount fauna of each region will have many unique elements, and local disturbances may be enough to threaten entire species.

The big picture filters out

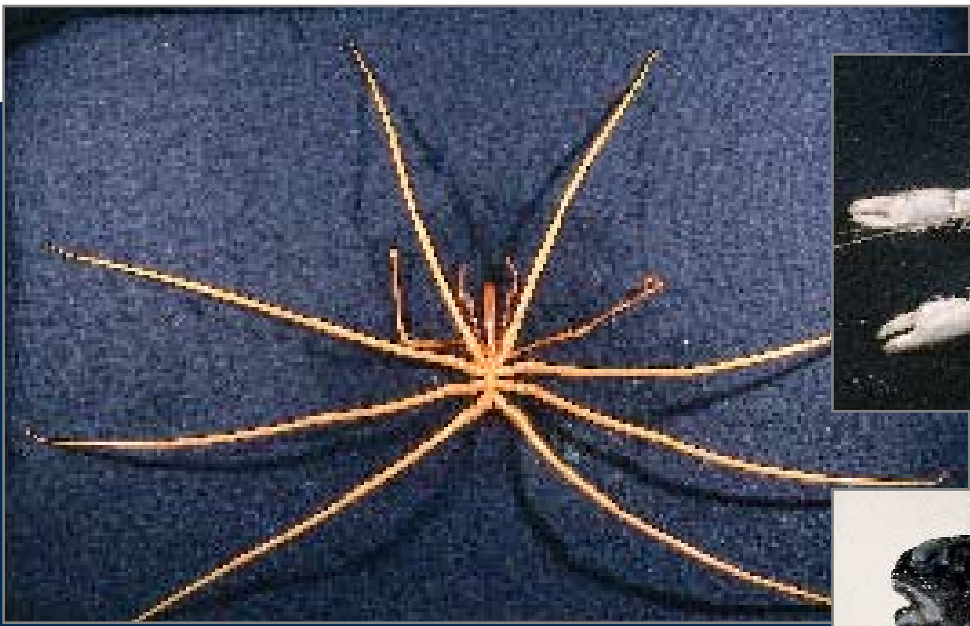
As well as studying the seamount specimens individually, the scientists are picturing the deep-sea community as a whole by taking photographs with a drop camera as the research vessel drifts over the seamounts. The camera can withstand the enormous pressures of the deep ocean, filming the underwater scene from less than a few metres from the seafloor.

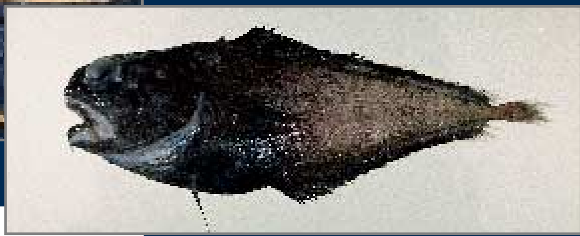
The photographs are the first images of these reefs more than a kilometre beneath the sea surface and reveal the sheer abundance and diversity of life on the seamounts.

They show that filter feeders – animals that draw the water around them into their bodies and filter out tiny animals and plants for food – dominate the community. In particular, the colonial stony coral *Solenosmilia variabilis* is particularly prevalent and forms a dense matrix of living and dead coral as new members of the colony grow up and over older members to reach as far into the current as possible.

Once in the current, these corals can feast on the ready supply of food carried by ocean currents that concentrate at the pinnacle of seamount slopes.

The dense coral matrix provides the perfect platform for other filter feeders, such as hydroids and sponges, several species of solitary stony corals, and various





bamboo, gold and black corals, some of which grow to several metres in height and omore than 100 years old.

More motile feeders, such as crinoids (or feather stars), use the coral platform as a perch from which to reach up into the deep-ocean currents – the lifeblood of the deep-sea.

The thick coral matrix also provides invaluable shelter to animals that would otherwise be unable to live on the exposed seamounts.

Various galatheid or slipper lobsters hide within the coral matrix, using their long feeding appendages to reach out for food from the relative safety of their burrows.

It is a unique ecological community, where togetherness is the name of the game. But it is also fragile.

'Given the slow rates of growth of many of the deep-sea organisms, and the low recruitment rates from outside the local seamount environment, even small-scale disturbances can disrupt the balance,' Koslow says. 'And once disturbed, these deep-sea reefs could take centuries to regenerate.'

The first stage in conserving the biodiversity of the deep-sea is understanding what is there.

'The fact that it will take a team of taxonomists a full year to identify all the new species we found during one research cruise is an indication of how little we still know about the reefs of the deep-sea,' Koslow says.

Who would have thought that more than a century after the first major marine expedition – the Challenger Expedition of 1872-1876 when British scientists took the first samples from the deep-sea – that marine biologists aboard modern research vessels would still be exploring unknown areas of ocean and discovering new species on such a scale?

More about the deep sea

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abstract

Marine bed mapping by the Australian Geological Survey Organisation in 1994 revealed extinct volcanic cones known as seamounts south and west of Tasmania. Surveys by CSIRO found new species in various animal groups, from corals and hydroids to crabs and fish, many endemic to the region. The volume of discoveries highlights how little is known about marine species around Australia, particularly those of the deep sea. The high level of endemism highlights the uniqueness and isolation of the seamount environment, factors affecting the evolution of its inhabitants. A drop camera used to picture the remote environments revealed abundant, diverse communities dominated by filter feeders.

Keywords: marine environment; marine animals; sea bed; seamounts; biological surveys; Tasmania.

Top: A squat lobster or craylet, *Munidopsis* sp.

Above left: These long-legged individuals are called pycnogonids, or sea spiders: the latter is a misnomer as they are quite unrelated to true spiders. Most species feed on animals such as sea anemones, bryozoans and corals. Shallow water species of pycnogonids are rarely much larger than 2-4 cm across, but deep water species can get very large, sometimes well over 50 cm. The abdomen of these animals is so reduced that parts of the intestines and gonads must extend into the legs to fit.

Above: *Paralaemonema* sp., or deep-sea cod. A surprising number of fish are restricted to deep-sea habitats.

Below: This sea anemone, probably a new species, lives fixed to rocks and extends its tentacles to feed.