WATER & ATMOSPHERE
August 2012

Stamp of approval

The battle for hearts and minds at the fish counter

Taking the fall
Winter weight

Here be dragons
Filling in the blanks

Rosemary Hurst
The nature of nature

WATER & ATMOSPHERE

August 2012

Cover
Hoki is New Zealand's most important commercial fish species. It is caught mainly from middle water depths between 300 and 600 metres. Moist and delicate, hoki meat is exported as frozen fillets, or minced for processed white fish markets, such as McDonald's Fillet'o'Fish burgers.

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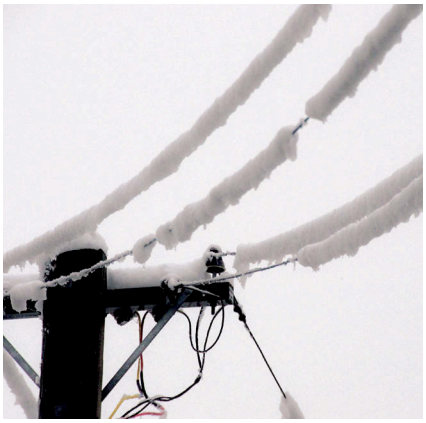

Editorial

Vouching for our fisheries

One by one, supermarket and wholesale chains across western markets have renounced sales of "unsustainable" fish, as they respond to a sea change in consumer demand. Those consumers are in turn responding to campaigns by environmental groups against fishing practices they say destroy fish stocks, kill thousands of unwanted, collateral creatures, and wreck marine ecosystems and habitats.

Retailers have read the mood. In the United Kingdom, leading chains Tescos, Asda, M&S, Sainsbury and Waitrose have all adopted "sustainable and traceable" procurement policies. Since 2008, Greenpeace's Carting Away the Oceans campaign has targeted 20 major US fish retailers. In that time, eight of them have suspended sales of Patagonian toothfish, and 13 have taken orange roughy off their counters. Of seven outlets that sold hoki in 2008, just two continue to do so.

Some 148 wild fisheries – six or seven per cent of world supply – are certified as sustainable by the independent Marine Stewardship Council (MSC), including New Zealand hoki, southern blue whiting and troll albacore fisheries. Meanwhile, environment groups have issued their own evaluations of those and other fisheries, rating them on a 'traffic light' red (no-go)/amber/green (buy with a clear conscience) system.

As a consequence, shoppers in some overseas supermarkets now have to interpret a plethora of certification labels and guides, multiple seafood rating systems and/or the chain's own hybrid assessment.

You can't blame them for being confused: the MSC has certified hoki since 2001, but Forest and Bird and Greenpeace continue to red-list the fish, citing the bycatch of New Zealand fur seals and seabirds, and seafloor impacts from the bottom-trawled Chatham Rise fishery. The Seafood Industry Council's Great Fish Guide, however, assures consumers that the "industry ... helps to keep the balance of the marine environment."

Then, in April, a German study, published in the journal *Marine Policy*, maintained that fully one-third of MSC-certified stocks were in fact overfished. The MSC responded with criticism of the study's methods.

The definition of unsustainable, then, currently depends on who is offering it. There has to be a better way. Nobody pretends that the Quota Management System (QMS) has made every last New Zealand fishery a sustainable exercise. We have good information about the important commercial stocks, but many other species still lack critical population and biology data.

But the QMS did transform what was doomed to become another tragedy of the commons into the basis of a whole new way to perpetuate fisheries. It was the first individual transferable quota scheme to be introduced anywhere in the world, and is still the most comprehensive.

It has nevertheless failed to satisfy some overseas consumers' perceptions and expectations of sustainability. The US chain Wegmans announced this year that it will no longer buy any seafood from the Ross Sea in the Antarctic. Ironically, the Antarctic toothfish fishery is probably one of the best-managed: subject to stringent rules on bycatch, environmental best practice, reporting requirements, tracking and monitoring. Every legally caught fish is documented under a Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) certification scheme.

We know more about the important fisheries than shoppers have been told. NIWA collaborates with the industry, the Ministry for Primary Industries and other research providers to survey abundance, and analyse catch and age information on more than 100 commercial species. We have estimated sustainable harvest levels from complex population modelling of 20 key species. Every year for the last 20 years, NIWA has gone to the Chatham Rise, gathering information not just about hoki, but also about the ecosystem it lives in.

The sustainability debate should be informed, then, by sound science. We need better information on more of our fish stocks, and to apply environmental best practice across every one. Where we can satisfy ourselves that we are fishing sustainably, we should be able to demonstrate that – perhaps with a new certification and branding scheme, as Iceland, Alaska and Canada have done.

We can then take those exports with confidence into the marketplace. The supermarkets have read the writing on the wall – it's time for us to do the same.

John Morgan
Chief Executive

Climate-proofing our towns and cities

When local authorities look to develop or upgrade urban infrastructure, such as roads, bridges, stormwater systems and sea walls, they have to weigh up a raft of weather-related risks: how much rain might it have to cope with? Or gale-force winds? Could it be inundated by surging seas? Or undermined by slipping land?

Getting it wrong can be costly. Even before the Canterbury earthquakes, natural hazards cost $1.5 billion in insurance payouts over 40 years: some 75 per cent of that bill came from weather-related damage. Climate change brings more uncertainty – and urgency – to the equation.

Planning for an increasingly volatile future is now easier, however, thanks to NIWA's Impacts of Climate Change on Urban Infrastructure and the Built Environment Toolbox. It's an online resource to help planners, engineers, asset managers and hazard analysts in New Zealand's urban councils understand and evaluate the potential impacts of climate change on their city. The toolbox applies sound science to the challenge of designing and managing urban infrastructure and buildings to cope with expected weather hazards exacerbated by climate change.

"It's all about helping urban planners and engineers work smarter," says NIWA climate scientist and toolbox project leader, Dr Andrew Tait. "It's about understanding how current and future hazards might impact on assets, and using science-based tools to look at options for reducing risk."

The toolbox comprises 57 downloadable reports, or 'tools', which are logically ordered into five sections, analogous to trays in a toolbox. Each tray represents a stage in an adaptation evaluation process.

- The first tray helps users understand climate change issues, providing general context and background.
- The second tray helps them identify hazards likely to be introduced or exacerbated by climate change.
- The third tray guides assessment of the risks associated with a particular hazard, or mix of hazards.
- The fourth tray helps users identify and evaluate the benefits and costs of adaptation options.
- The fifth tray helps them integrate their hazard, risk and adaptation assessments into local government decision-making and planning processes.

Heavy rain undermined this house at Kelson, Wellington, in a 2006 storm. (*Alan Blacklock*)

"The tools show users what types of information and resources exist, and provide examples of how they can be used," says Tait. "We're helping authorities develop processes for managing climate change impacts, and also helping them overcome barriers to implementing them.

"Climate extremes affect each town or city differently," he adds, "so we're giving councils the ability to refine and assess their specific situation."

In July 2012, Tait demonstrated the toolbox to potential end-users at workshops in Christchurch, Wellington and Auckland, associated with the Institute for Professional Engineers (IPENZ) and the Planning Institute (NZPI). "There was a lot of enthusiasm for the toolbox," he says. "We're hoping that use of the tools will now really take off with council staff and contractors."

More information can be found at www.niwa.co.nz/climate/urban-impacts-toolbox.

This resource was developed by NIWA in collaboration with MWH New Zealand Limited, GNS Science and BRANZ. It was funded by the then Ministry of Science and Innovation, now part of the Ministry of Building, Innovation and Employment.

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In brief

An octopus, squat lobster and brittle star sampled during *Tangaroa*'s Kermadec voyage. (*Rob Stewart*)

Life on the edge: a fragile abundance in the deep

The Kermadec Ridge is an incendiary chain of undersea volcanoes stretching northeast practically to Tonga. In places, it can be a hellish, sulphurous scene of broiling vents and superheated steam, lightless and squeezed by monumental pressure. But NIWA scientists discovered in May that life has found plenty of ways to make itself at home there.

Sampling new sites among the hydrothermal vents and vertiginous canyons, up to a kilometre and a half deep, the crew of NIWA research vessel *Tangaroa* found shrimps, mussels and barnacles all thriving on the very edge of oblivion. They also discovered a new hydrothermal vent.

In some areas, water – superheated up to 300ºC – roars from such vents, kept from turning to steam by the crushing pressure. But just centimetres away, colonies of creatures have evolved ways to gain sustenance from the various dissolved minerals issued from the scalding plumes. They get by on recycled carbon, nitrogen and sulphur in some of the most punishing environs on the planet.

"These animals are adapted to the specific combination of depth, temperature and chemical composition of the venting fluids," says voyage leader, Dr Malcolm Clark. "The work helps us understand the vulnerability of deepsea communities to human activities, such as seabed drilling, fishing and mining."

Clark says the very different conditions and chemical environments of various seamounts mean the animal communities living on them can be equally diverse, even in close proximity to one another. "The implication is that the exploitation of one seamount could have an effect that is not the same as on another close by."

The animal communities also vary markedly between different types of habitat – hydrothermal vents, seamounts, canyons, and the general continental slope – their species composition driven by quite specific environmental conditions. They are also susceptible to a range of human activities, such as fishing or seabed mining, says Clark.

The expedition, funded by the Ministry of Science and Innovation, collected thousands of specimens over a 10,000 square kilometre plot, some of which, says Clark, are "almost certainly something new. Typically, almost 10 per cent of what we catch in the deep sea is new to science, or new to New Zealand." It also sampled canyons never before surveyed, "so the expectation is that there will be many new discoveries, once the samples and photographic data are analysed."

The results will be used in ecological risk assessments to help improve environmental management.

For video of some of the vent and seamount fauna, go to: www.niwa.co.nz/news/niwa-returns-with-undersea-creatures-and-footage-of-never-before-seen-undersea-volcanoes-and-canyons.

Visit www.niwa.co.nz/gallery/tan1206-best-shots to see more creatures from the voyage.

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20 years after: RV *Tangaroa* being launched from the Mjellem and Karlsen shipyard in Bergen, Norway in 1991, and (right) after its major refit in 2010. (*NIWA*)

20 years of science celebrated

1992: the year Charles and Diana split, Bill Clinton became US president, Hurricane Andrew belted Florida, world leaders gathered in Rio for the first Earth Summit and the National Institute of Water and Atmospheric Research was born a Crown Research Institute (CRI).

Drawn together under the Crown Research Institutes Act, the Department of Scientific and Industrial Research and parts of the New Zealand Meteorological Service became affectionately known as NIWA. In 1995, the Fisheries Research Division of the former Ministry of Agriculture and Fisheries also came on board.

Two decades on, 158 founding staff are still with the company today.

That strong institutional knowledge, says NIWA Chief Executive, John Morgan, is a rare commodity now. "In a world where typical staff tenure with employers is now under five years, we're truly fortunate to have 25 per cent of our people with over 20 years' service and experience in the company."

NIWA was born out of a major restructure of the science sector in the early 1990s, led by the then Minister of Research, Science and Technology, Simon Upton. In all, 10 CRIs were established out of former government departments, including HortResearch, Crop and Food Research, AgResearch, ESR, Scion, GNS, IRL and NIWA.

Since 1992, NIWA has employed more than 1500 people. It now has around 650 staff spread across 15 New Zealand locations, assets of $130 million, annual revenues of approximately $120 million and an international reputation as an environmental science and research organisation.

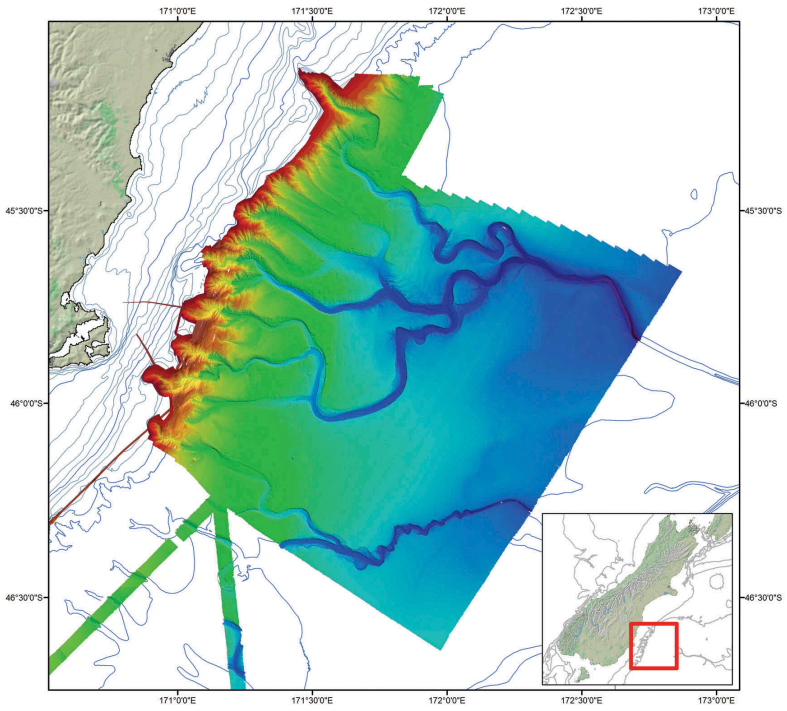
A long-server himself, NIWA's General Manager of Research, Dr Rob Murdoch, joined one of NIWA's predecessors in 1985. He says demand for NIWA's science has continued to grow over the last two decades.

"The issues we are working on – like climate change, making greater use of our natural resources, sustainable fisheries, natural hazards, biosecurity, water quality and allocation – are some of the most pressing concerns for New Zealand. We have the expertise and kit to help address those issues, so demand for our work is greater than ever."

Some of the company's proudest achievements, says Murdoch, include developing hāpuku and kingfish culture for the aquaculture industry, 50 years of observations at the Lauder atmospheric research station, completing nine voyages of discovery to the Antarctic on NIWA research vessel *Tangaroa*, completing a full inventory of New Zealand's biodiversity, creating the first stock assessment model for Antarctic toothfish in the Ross Sea, developing the national river classification system and making significant contributions to the Intergovernmental Panel on Climate Change.

"What is so satisfying about this work is that we're not only helping New Zealand, but also making a huge contribution to the wider international scientific community," says Murdoch. "Two decades on, the international science reputation we've built up is something we are immensely proud of."

In brief



Survey coverage of part of the Otago Canyon complex, offshore East Coast, South Island, extending from Waitaki Canyon in the north to Hooper's Canyon in the south. Image is a sun-illuminated digital elevation model. Depth range 100m (red) to 2000m (purple).

Seabed secrets surveyed

Recent surveying by NIWA's research vessel *Tangaroa* has revealed new undersea features off the Otago coast, along with potential oil and gas resources.

Gas – already our fourth biggest export earner – is set to earn New Zealand $3 billion in royalties from fields already in production. A recent independent report suggests undiscovered reserves could boost those earnings to $12.7 billion.

In 2009, the Government launched its bid to "responsibly develop" those resources, through its Petroleum Action Plan.

NIWA's General Manager of Research, Dr Rob Murdoch, says the Otago coast – including the Canterbury and Great South Basins – holds promise for oil and gas exploration.

"As such, there's a need to better map the region, through appropriate surveys. This will also help provide a basis for environmental management, should oil and gas development proceed."

During the 18-day voyage, *Tangaroa* surveyed 16,000km² of seabed off the Otago coast, using its Kongsberg EM302 multi-beam echosounder and sub-bottom profiling.

The collected data will add intricate detail to a digital terrain model of the seabed. When combined with backscatter (the strength of the return signal) analysis, the findings reveal the likely composition of the seabed and beneath. The echosounder can also identify and track significant gas plumes in the water column, which could indicate the presence of gas hydrates.

Provisional results have revealed some interesting seabed details – including part of a much larger underwater canyon system, ending 1100km east of New Zealand, in a large, deep, apron-shaped sediment deposit.

NIWA geologist, Dr Helen Neil, says the survey will help inform environmental regulation, conservation and natural resource exploitation.

"We now have a far greater idea of the Otago Canyon complex. Canyon fan systems like this are important sources of information, because the sedimentary record that accumulates can be a testament to major tectonic, climatic and sea-level changes," says Neil.

The data also show hints of either gas expulsion, or water escaping from the sediment, along with special deepsea ecosystems.

"The maps show 'pock marks' along the margin at depths of between 550 and 875 metres," says NIWA seabed ecologist, Dr Ashley Rowden, "where methane seepage typically occurs, and which supports particular biological communities."

The survey data will provide some basis for future biodiversity assessments, to establish an environmental baseline, evaluate the potential environmental effects of any oil drilling, and to help develop any special environmental guidelines specific to the area.

"We know something about the animals that live in the shallow areas of the canyons," says Rowden, "but we don't know what is in the really deep parts – particularly in the trough, where oil drilling may occur in the future."

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The rockhopper penguin rookery on Campbell Island has suffered a 94 per cent population crash since 1942. NIWA's trying to find out why. (*David Thompson*)

Tracking a winter wayfarer

Every April, 100,000 rockhopper penguins simply disappear. Nobody knows where they go, but NIWA means to find out. Dr David Thompson will lead a trip to subantarctic Campbell Island in April next year to fit miniature geolocating data loggers to around 80 of the penguins before they vanish for the winter.

Wherever they go, says Thompson, there needs to be plenty of food waiting for them, because the mysterious four-month vacuity is when they build up the physical reserves they need for the rigours of the breeding season, which begins around October. "That gives them a few months to go exploring," he says, "and they're fast swimmers." He thinks it's likely the birds stay at the same latitude, but disperse widely, feeding and regaining condition.

"It could be a crucial stage in the breeding cycle for them. If they have a bad winter, they'll come back to Campbell Island in poor condition. This stage of the annual cycle is likely to be very significant. To know nothing about where this stage takes place is a crucial gap in our understanding."

Rockhoppers seem to have enough troubles as it is: between 1942 and 1985, their numbers on Campbell crashed by some 94 per cent, from around 800,000 breeding pairs to just 51,000, and they've been in steady further decline ever since.

Thompson says that, while they're unlikely to go extinct anytime soon, "this represents a massive decline." He suspects that something – possibly fluctuating ocean temperature – has affected their food supply.

The team will return to Campbell for the start of the 2013 breeding season to retrieve the data loggers, which should then unlock the mystery once and for all: apart from geographical co-ordinates, the devices will also record water temperature, which should help confirm the birds' tracks.

The four-kilogram penguins breed in colonies on rocky coasts, either in the open or amongst tussock. Two eggs are laid in a perfunctory nest of stones and grass: the first egg to be laid often hatches after the second, but the chick rarely survives. Luckier chicks fledge in February, and the adults return to sea for the winter after moulting the next month.

The work has been made possible by a grant from the National Geographic Society.

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In brief

We can inhale more pollutants inside our homes than outdoors. PACMAN will help us find out just how many. (*Getty Images*)

Indoor pollution is not a game

Anyone old enough probably remembers Pacman as a not-very-sophisticated eighties arcade game.

NIWA's version might not keep the kids entertained, but it will tell you some very interesting things about the air you're breathing in your home.

The new PACMAN is a Particles, Activity and Context Monitoring Autonomous Node, otherwise known as a small box, filled with air-quality instruments. It measures the amount of small airborne particles that float around every New Zealand house, and helps track where they've come from.

Airborne particulates are tiny solid or liquid particles, suspended in the atmosphere. Hairs and mucus in our nose and throat generally filter out larger particles, but very small ones – of around one hundredth of a millimetre or the width of a human hair – can settle in the bronchi and lungs, where they can cause health problems.

In New Zealand, poor air quality is blamed for more than 1100 premature deaths a year – mainly through cardiovascular and respiratory impacts – and is reckoned to cost more than $4 billion annually. Most research has so far focussed on air outdoors, but NIWA air quality expert, Dr Guy Coulson, says there's good reason to examine the air in our homes.

"Exposure to pollutants can be much higher indoors than outdoors," he says. "We spend about 80 per cent of our time indoors, so we need to know more about indoor air quality." Work so far has shown that ovens and wood-burning stoves can emit very high levels of indoor pollutants. Even the innocent act of making toast can be an intense source of airborne particles, along with incense, pesticides, pets and solvents. Pine-scented cleaning products can react with sunlight to produce particles.

"We want to know if exposure to short-lived, high levels of pollution is bad for you. We're focusing on particles that get deep into your lungs. Can one, five-minute, exposure to very high levels of pollution have an impact on health?" The highest measured concentrations have come from the poor use of wood-burning stoves or solid wood-burners. We aim to be able to tell whether neighbours' wood-burners are influencing your indoor air quality as well."

PACMAN has been tested in two Auckland homes. University of Canterbury PhD student Woody Pattinson became part of a living, breathing experiment for several months in a 1960s weatherboard house in Waterview, Auckland. A roomful of instruments, including PACMAN, continuously monitored air quality as he went about his everyday chores.

PACMAN's performance was tested against the more expensive specialised instruments, and was found to perform well. NIWA plans to build 15 or 20 more PACMANs, to be placed in volunteers' homes.

Or you can build your own PACMAN: it's been designed with open source hardware and software, and the relevant files are available at: https://bitbucket.org/guolivar/pacman

The research was funded by the Ministry of Business, Innovation and Employment.

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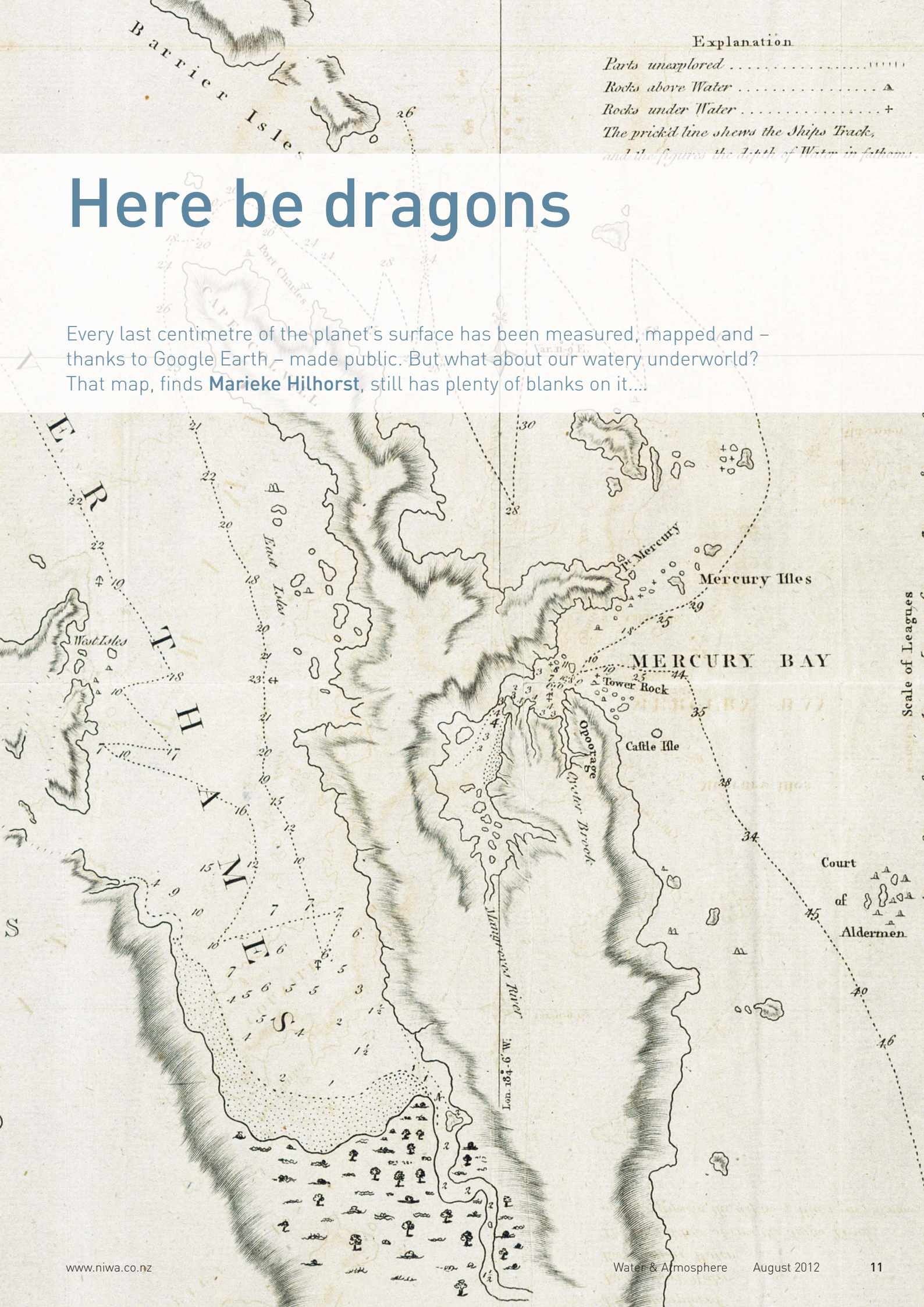
Here be dragons

Every last centimetre of the planet's surface has been measured, mapped and – thanks to Google Earth – made public. But what about our watery underworld? That map, finds **Marieke Hilhorst**, still has plenty of blanks on it....



Here be dragons

New Zealand lays claim to a tract of ocean more than 20 times its landmass – the fourth-largest of any nation. That amounts to four million square kilometres of Exclusive Economic Zone, and 1.7 million square kilometres over the extended continental shelf.

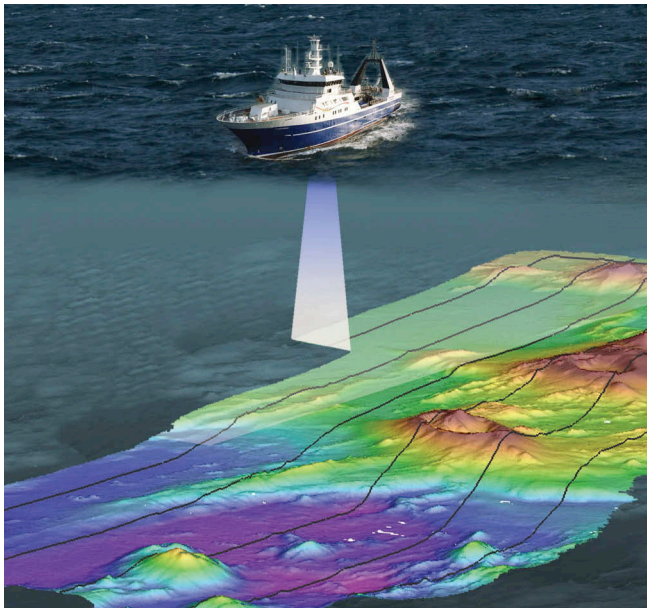
Fully 96 per cent of New Zealand's territory lies below the waves, but we know very little about it: only 24 per cent of that vast underwater real estate has been surveyed – with just 8.7 per cent of it mapped using NIWA's high-resolution technology.

NIWA Principal Scientist, and manager of its marine ecology group, Dr Alison MacDiarmid, says the knowledge gap between New Zealand's dry and wet territory is huge.

"We wouldn't think of doing anything on land if we didn't have information. The first thing Europeans did when they got to New Zealand was to send surveyors everywhere, and start mapping and collecting information on geology and flora and fauna."

So while today's land-based topographical maps are rich in detail derived from aerial photos, satellites and global positioning systems (GPS), the seafloor lies largely unmapped, hidden below an inscrutable surface that masks a rich seascape of ridges, valleys, plateaus, canyons and seamounts.

That, says MacDiarmid, makes us complacent about how we use the ocean. "Imagine trying to do almost anything on land if you didn't have a detailed map; imagine trying to plan or manage the environment. It would be like standing on a mountain top with perpetual cloud blocking from view all the land below you, yet still making decisions about where to put roads and towns and farms and dams. It just wouldn't happen." But, she says, we do it with the ocean all the time.



RV *Tangaroa*'s sophisticated multibeam echosounder can trace the image of a seabed 7.5 kilometres beneath the surface.

NIWA Principal Scientist, Dr Alison MacDiarmid: "We wouldn't think of doing anything on land if we didn't have information." (*Dave Allen*)

Submarine stocktake

Ocean Survey 20/20 is one response to that. Launched in 2004, the comprehensive survey programme is the information backdrop to burgeoning demands on the ocean's resources – including gas, oil, minerals and fish – and part of the solution to a knowledge vacuum around hazards such as tsunamis.

Fifty-six priorities were originally set, covering nine themes including climate, biodiversity and ecosystems, hydrocarbons, fisheries, and natural hazards and risk management. The projects were chosen to address two risks: that uninformed development might lead to environmental damage; and that opportunities might be missed, should valuable resources lay undiscovered.

So far, four priority projects have been completed, as well as detailed seabed mapping to support surveys. David Mole, policy analyst at Land Information New Zealand, which coordinates the programme, says, "There's nothing else quite like it for what it may contribute to New Zealand's future economic prosperity, while ensuring sustainable management of marine resources."

Two more bathymetric surveys, closely aligned to the Ocean Survey 20/20 priority list, will be carried out this financial year, Mole says.

NIWA research vessel *Tangaroa* has been central to the Ocean Survey 20/20 work. In 2010, it traversed the Hikurangi Margin, off the Poverty Bay coast, where the Pacific Plate thrusts four to five centimetres beneath the Australian Plate each year – a clash that could trigger earthquakes and tsunami. NIWA and GNS Science worked together, collecting bathymetric data, along with seismic reflection and magnetic profiles from down to five kilometres below the seafloor. "Given recent events, it's become quite a high-interest survey for future hazard mapping and tsunami planning," says Mole.

Closer inshore, *Tangaroa*, along with NIWA's inshore survey boat *Pelorus,* was also used for a 20/20 survey in the Bay of Islands and along the Northland Shelf. Mole says that

> "Imagine trying to do almost anything on land if you didn't have a detailed map ..."
>
> NIWA Principal Scientist Dr Alison MacDiarmid

coastline is under increasing pressure from competing interests – fishing, aquaculture, tourism and recreation – and from sediments discharged from land.

The survey is a good example of how bathymetry informs evidence-based policymaking, he says. Data on seabed habitats and biodiversity provide both a snapshot and a baseline, and find multiple uses. "Government agencies, iwi groups, regional and district councils, port authorities, conservation groups; they're all able to draw on the information to develop and manage the Bay of Islands coastal resources in a more effective and sustainable way."

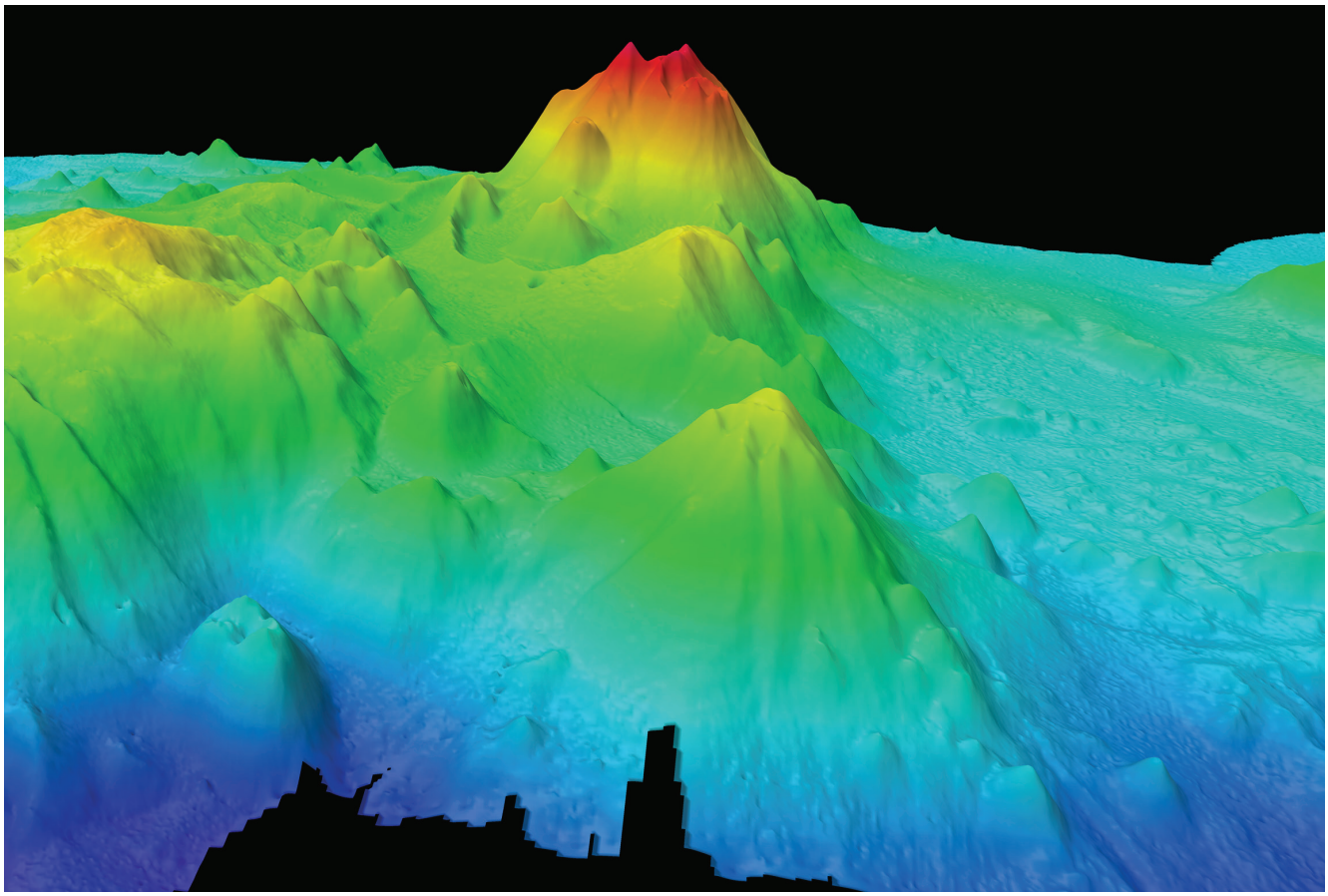
Seeing with sound

Tangaroa floats at the leading edge of NIWA's bathymetric work. Marine geologist John Mitchell is expert in running the vessel's Kongsberg 30 kilohertz multibeam echosounder. As it follows a bearing, transducers beam out a fan of sound, called a 'swath', up to eight kilometres wide, in water from 20 metres to 7.5 kilometres deep. Each 'ping' of sound hits the ocean floor, then bounces back to the ship, where the echoes are broken into 864 individual soundings per ping.

The time it takes the sound to bounce back is directly related to the water's depth. Meanwhile, the echoes also reveal not just the shape and contours of the ocean floor in high resolution, but also what's in the water column, such as plumes from underwater volcanoes and methane seeps. Moreover, the strength of the return signal (backscatter) indicates what the bottom type, or habitat, may be.

NIWA is still investigating how to best use the water column data, but Mitchell says the prospects are exciting. For example, plumes from active volcanoes may point to potential hazards, while methane seeps indicate the presence of gas hydrates, recently recognised as a potential energy source.

Using the multibeam echosounder is like mowing a lawn, he says. "You gradually go back and forth on parallel tracks collecting data, so you get 100 per cent seabed coverage, and you get a true 3D image of the sea floor." *Tangaroa* can cover



The Hinepuia Seamount on the Kermadec Arc, as revealed by *Tangaroa*'s seabed mapping technology.

Here be dragons

NIWA's bathymetry has revealed that, beneath the surface, Cook Strait still bears the scars of a turbulent past – more than 150 underwater landslides have so far been mapped. (*Dave Allen*)

> "There is amazing geology, volcanology, oceanography and biology associated with seamounts."
>
> NIWA Principal Scientist Dr Malcolm Clark

huge areas: "If we're surveying in deep water, depending on the weather, we can cover up to 2000 square kilometres a day."

The concept is simple enough, says Mitchell, but to interpret the data correctly, he must first judge the signal's speed through water, which can vary wildly throughout the water column according to temperature, salinity and pressure.

What's more, he must direct the sounder accurately, even as *Tangaroa* rolls, pitches and heaves. To that end, the beams are directed by an instrument which can measure angles of just 0.02 degrees, and Mitchell calibrates every component before all major surveys.

Hazards and habitats

One of the many beneficiaries of Mitchell's efforts is Dr Joshu Mountjoy, a NIWA marine geologist. He's analysing data recently collected from New Zealand's largest underwater chasm, the Cook Strait Canyon.

The data reveal much about hazards just off Wellington's coast, including active faults that rise through the canyon system and across the continental shelf.

Mountjoy says more than 150 submarine landslides have been pinpointed, some likely caused by 1855's magnitude 8.3 Wairarapa earthquake, which re-shaped Wellington's waterfront and generated a moderate tsunami. NIWA and GNS Science are now quantifying the tsunami risk from future landslides.

Dr Malcolm Clark is a NIWA Principal Scientist (deepwater fisheries), and self-confessed enthusiast of New Zealand's more than 1000 seamounts. "There is amazing geology, volcanology, oceanography and biology associated with seamounts."

Back in the 1980s, the hunt for orange roughy saw more exploration – and exploitation – of seamounts. "Topography goes hand-in-hand with some fisheries," says Clark. "Where the seamounts are, you'll also find the fish."

Back then, satellite navigation was cutting edge, and GPS was just a notion. "We'd get an occasional fix every few hours," recalls Clark, "and until you got a new fix, it was just dead reckoning. We couldn't stay fishing on a seamount once we'd found it, because without precise navigation, the currents would push the vessel off line, and there was too much risk to the gear."

Multibeam technology he says, has "pretty much revolutionised how we do all our science. When I first saw the images I thought, wow, this is one super-cool piece of technology for deepsea research."

A poster of a 2003 joint New Zealand/Australia survey in the Tasman Sea illustrates just how cool. The rudimentary lines on the 'before' map are piecemeal, stylised, reflecting 'bumps' detected by satellite altimetry sensitive to a gravitational pull on the water above seamounts.

By comparison, the rainbow-coloured 'after' maps not only render the precise location, height and contours of the seamounts, but their hardness and texture. It's that combination that gives Clark important clues about biology, because both are major influences on what survives where. "Habitat mapping is where bathymetry meets geology and biology," he says.

"Animals such as corals and sponges generally need hard substrate, like rocky outcrops or volcanic cones, for their holdfasts. They can't properly attach in deep soft sediments, and because they feed by filtering water, fine sand particles swept up from soft sediments can clog their filters."

So Clark closely studies the strength of the multibeam's backscatter – the return 'ping'. A weak echo usually indicates soft mud, while a strong one suggests rock; together, they give Clark and his colleagues a pixelated image of the substrate that helps them map the distribution of seafloor plants and animals. It all helps enable an ecosystem approach to seamount management, he says, where fishing impacts can be balanced by conservation of sensitive habitat.

Further biological and geological data from small trawls, sediment samples and bottom photographs add detail to the picture. NIWA can now produce intricate charts of water depth (bathymetry), colour-shaded relief models of the seafloor (like an aerial photo) and geo-referenced maps of seafloor habitats and substrates.

It's all a far cry from Captain Cook's lead weight on the end of a rope. W&A

To find out more about NIWA's bathymetry work, go to: www.niwa.co.nz/our-science/oceans/bathymetry/further-information

To see *Tangaroa*'s multibeam technology in action, and to take a fly-through trip of the Cook Strait Canyon, go to: www.niwa.co.nz/video/echo-echo-scanning-the-seafloor-on-rv-tangaroa

For a potted history of bathymetry, go to: www.niwa.co.nz/video/seabed-frontier-a-brief-history-of-bathymetry

To download New Zealand bathymetry charts, go to: www.niwa.co.nz/our-science/oceans/bathymetry

Applying the knowledge

Regional councils are responsible for management of the undersea environment out to 12 nautical miles. Some are currently testing a 'marine habitat assessment decision support tool' developed by NIWA, which draws on the institute's bathymetric data.

"What we needed," says Auckland Council marine scientist, Megan Carbines, "was a tool or criteria for determining what were significant habitats. We were hoping also to get a consistent set of criteria across New Zealand, rather than each regional council developing their own."

Carbines says the co-development of the tool, tailored to councils' needs, offered their scientists an opportunity to interact with NIWA's, and gave them access to emerging information and research, including national datasets they either didn't know existed, or had no practical access to. "That's been a really valuable part of the product."

Currently, Auckland Council is calibrating NIWA's tool against known habitats. "We're trying to look at as many habitat types as we can across a range, from degraded to pristine, and that will give us a whole lot of scores. What we don't have yet is information on how one habitat ranks against other habitats, because you need to have several scores from several places to create a rank." That will be the second phase of work.

Within two years, Carbines expects a national dataset to be created, which environmental managers can use to derive the relative rank and value of different habitat types.

The tool is already adding value, says Carbines, even under development. "Just having those criteria gives people a framework. It triggers you to consider in a structured format, a whole range of things you may not have considered, like the size of habitat, how common the habitat is in the region, the degree of native species, sediment levels and water quality.

"So I guess it's a kind of a check sheet for anyone wanting to undertake a habitat assessment; they've got a list of things they should be considering."

Stamp of approval

Some of New Zealand's most lucrative export fisheries have been certified as sustainably managed. So why have they been blacklisted from critical overseas markets? And, asks **Dave Hansford**, what's to be done about it?

Stamp of approval

Stephen Collier's dad is a longline fisherman. So was his grandad, so when he buys fish, he says: "I won't buy any netted stuff. There's a lot of waste from netting."

Next up to the fish counter at Wellington's Chaffers New World, is Carla Wild, who says she thinks hard about fisheries sustainability, and that: "If there were notices here, telling me what I needed to know, that would influence my choices."

Foodstuffs Wellington Co-op runs the Chaffers store, and seafood merchandise manager George Kosmadakis says Wild may soon get her wish. A national Foodstuffs steering group has formed to "look at issues such as country of origin and eco-labelling. If it's proven to be unsustainable, we won't touch it. For instance, we want to know which fishery our orange roughy comes from."

Overseas, however, shoppers have been demanding – and getting – information about their fish for years. Across the big western consumer markets – Britain, northern Europe, the US – environmental groups have mounted highly effective campaigns against fisheries they've denounced as unsustainable. By targeting eco-conscious consumers, they've driven a crowbar between the fishing industry and its markets, bringing the leverage firmly down on big retail chains in the middle.

Since the mid-2000s, some green NGOs have published annual fish-buying guides, based on a 'shop-by-colour' system. Species are ranked on a traffic-light scale of acceptability, where 'sustainably-caught' species get the green, while others are graded through amber, down to the eco-opprobrium of the forbidden red zone.

It was supposed to make sustainable shopping easy, but nothing is that simple in a global market worth more than US$400 billion. Retailers quickly read the play, announcing they would no longer sell blacklisted species.

A scramble for market supremacy saw Tescos, Asda, M&S and Sainsbury rush to promote their own 'sustainable and traceable' procurement policies.

Apart from the traffic-light guide in their wallet, customers also had to interpret each retailer's own sustainability rating system, over which was superimposed further eco-certification ratings against standards set by independent organisations such as the Marine Stewardship Council (MSC) and Friend of the Sea.

Furthermore, industry commentators say the methodology behind various consumer guides is opaque and nebulous, produced with little or no consultation with the industry itself.

Fish sales turned into a retail war, and the facts took some stray bullets. Jeremy Langley, specialist seafood buyer at the Queen's own grocer, Waitrose, told a reporter in 2009: "There are some MSC fisheries that we don't stock, such as the MSC New Zealand hoki fishery, which conducts bottom trawling, because it doesn't meet our four-point policy." Green groups were quick to cite the snub as a portentous omen, not just for New Zealand hoki, but for orange roughy and other bottom-trawled fisheries.

> **"Ross Sea toothfish is one of the best and most conservatively-managed fisheries in the world."**
>
> NIWA Fisheries Scientist Dr Matt Dunn

But in fact Waitrose never stocked hoki, which is exported frozen. The upmarket chain has only ever sold fresh, unfrozen, fish over its counters. Just the same, its market share jumped to 10 per cent practically overnight.

Bob Zuur is a marine biologist with WWF-New Zealand. He says the proliferation of eco-labelling systems could be counter-productive, "because, quite frankly, some aren't worth the ink used to print them." It simply confuses shoppers, he says, and reduces a noble intent to a cynical ploy, open to exploitation by some producers "who figure that, as long as they can get a label, that's all that's going to matter."

"It becomes a marketing badge," agrees NIWA fisheries scientist Dr Matt Dunn, "rather than a scheme to encourage responsible behaviour."

He suspects instead that eco-labelling "is more about gaining an advantage over the competition, and making consumers feel a little better about shopping at that particular store."

Nevertheless, it's forever changed the way fish is traded and marketed.

Last year, in separate TV documentaries, celebrity chefs Jamie Oliver and Hugh Fearnley-Whittingstall condemned certain fisheries practices and products. UK sales of their recommended alternatives promptly skyrocketed: Sainbury's reported that revenues from pollack leapt by 167 per cent. Sales of mackerel at Asda jumped by 115 per cent.

Eco-labelling then, can be a jackpot, but it can also be a Jezebel. In the US, Greenpeace has strenuously pressured retailers to repudiate Patagonian toothfish – marketed as Chilean sea bass – and its close relative, the Antarctic toothfish, which is caught by New Zealand vessels in the Ross Sea.

In 2011, they landed 730 tonnes – a catch worth $20 million in export revenues. The Antarctic toothfishery is subject to stringent rules on bycatch, environmental best practice, reporting requirements, tracking and monitoring. Every legally caught fish is documented under a Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) certification scheme.

Carla Wild scans for her supper at Chaffers New World fish counter: "If there were notices here, telling me what I needed to know, that would influence my choices." (*Dave Allen*)

Earlier this year, NIWA, with industry assistance, surveyed the Ross Sea population for the Ministry for Primary Industries (MPI), and found healthy numbers. The results will feed into population projections and management strategies, and the institute is also investigating the fish's place in the Ross Sea ecosystem, and any consequences of its removal for other creatures.

"The Ross Sea toothfish is one of the best and most conservatively managed fisheries in the world," says Dunn. It also has the endorsement of the MSC, which, after giving it a score of 89.7 out of a possible 100, certified it as sustainable in 2010 after two years of peer review and analysis, and independent adjudication.

To no avail. In 2010, US chain Ahold announced it would not buy or sell toothfish. It was later joined by Harris Tweeter, Wegmans and Safeway – which alone runs more than 1800 stores in the US, Canada and Mexico.

MSC certification wasn't enough to legitimise toothfish in the opinion of Greenpeace, which, in its *Carting Away the Oceans* report this year, said: "If human beings are to find a way to truly live sustainably, we will need to accept the fact that going to Antarctica to procure food is simply untenable – certified or otherwise."

"That, to me," says Dunn, "is more about ethics than how you manage a fishery." But the finer points of any such arguments are not especially well-illuminated by a traffic-light wallet card. For instance, Dunn happily buys New Zealand hoki, comfortable in the belief that the fishery is "an example of us doing extremely well," but the fish has nevertheless been banished to the red zone of consumer fish guides published by both Greenpeace and Forest and Bird. "It's difficult," he says, "to understand why that should be."

> "The public faith issue is challenging."
>
> SeaFic Trade and Information Manager Alistair Macfarlane

Among other things, Forest and Bird cites hoki's yo-yoing Total Allowable Catch (TAC). Thirteen years ago, it was close to 250,000 tonnes a year: throughout the 1990s, annual catches averaged 220,000 tonnes. But it seemed hoki couldn't sustain that rate of loss – by 2007–08, the TAC had dropped to 90,000 tonnes.

What followed is either a triumph of sustainable management, or a damning indictment of it, depending on whom you talk to. The fishing industry claims kudos for cooperating with the then Ministry of Fisheries on a series of TAC reductions that it maintains led to the recovery of the hoki stock (last year, Minister Phil Heatley upped the Total Allowable Commercial Catch (TACC) by 10,000 tonnes to 130,000 tonnes). Some environment groups instead cite the fishery as another example of overfishing, and regard the early quota slashes as a desperate attempt to claw the hoki fishery back from total collapse.

"People often point to that drop in biomass and cite it as a failure of fisheries management," says Dunn. "That doesn't mean it failed: it declined below the target level, so they modified the management, and it came back. That's good management. That's responsive management."

Stamp of approval

A haul of hoki. A fast-growing fish, hoki is found at depths between 200 and 800 metres, living for up to 25 years. Young hoki reach adulthood in around four years. (*NIWA*)

Minding a fish stock that closely, he says, needs intensive monitoring. "If you're going to fish a stock hard, as they're doing with hoki, then you need plenty of tools to give you a very good idea of where you are. You need to be accurate and precise." NIWA has gone out to the Chatham Rise and surveyed hoki stocks every year for the last 20 years for the Ministry of Fisheries, now MPI. "The consequence of that is that we have first-rate scientific information about the status of the hoki stocks," says Dunn.

The MSC certified hoki in 2001, and re-certified it in 2007. Both times, it was challenged by Forest and Bird, leaving the Seafood Industry Council's Trade and Information Manager, Alastair Macfarlane, wondering just what he has to do to satisfy NGOs and shoppers.

"The public faith issue is challenging. The MSC is hailed internationally as the gold standard for testing well-managed, sustainable fisheries. But it continues to be criticised by some NGOs. Greenpeace is on the record as saying that, while it likes the idea of third-party certification, it hasn't found one that it likes yet."

Environment groups have become de facto gatekeepers to some important markets, he says. "So you pass the sniff test with supermarkets and processors, but you're still not necessarily out of the woods."

The Deepwater Group Ltd manages the interests of hoki, squid and orange roughy quota holders in New Zealand. It's spent millions getting hoki certified by MSC, and more recently, southern blue whiting. Hake and ling are currently under evaluation. But in the case of hoki at least, the costs and benefits would seem estranged. "On the face of it," reflects Macfarlane, "it doesn't look like we've got that much out of it, but the experiences have been salutary."

In Canada, he says, "the Greenpeace red list has been adopted by a number of supermarkets. They've said they'll stop selling MSC-certified fish – notwithstanding that they stated in the same breath that they support MSC certification. Now they've gone ahead and 'de-listed' seafood like hoki – which they never sold anyway."

Bob Zuur says some markets are no longer convinced by government assurances that New Zealand's are some of the best-managed fisheries in the world – that we can no longer rest on the laurels of a 26-year-old fisheries regime. "Along with the Icelanders, we literally led the world during the 1980s with the Quota Management System (QMS). What have we done since then?

"I've heard it repeatedly said that New Zealand has the QMS and fisheries legislation, so what more could we possibly need? And that's the problem right there: that's an example of some of the thinking that still persists."

> "Retailers and consumers have changed the game massively."
>
> WWF-NZ Marine Advocate Katherine Short

Critics of the QMS point to the fact that fully a third of landed catch comes from stocks about which we know little, even though they've had quota allocated. But it's one of the hard realities of the business that, while industry is prepared to fund research on lucrative species like hoki, other species simply don't return enough to warrant the investment. "In terms of protecting the value of New Zealand stocks," says Dunn, "the science and the management are correctly aligned with the value. But if you do that exercise against species and stocks, it's not. For two-thirds or more of the stocks – even though they're mostly minor fisheries – we have little information."

Eco-labelling concerns itself, too, with issues the QMS was never designed, nor intended, to deal with: the non-target impacts of fishing – bycatch of seabirds, marine mammals and other, unwanted fish, and the destruction or modification of habitat.

"From the point of view of eco-labelling schemes," says Dunn, "which are concerned with all those things, the QMS is not well-aligned."

"Our problem in New Zealand," says Macfarlane, "is that we have a large number of small fisheries, which don't have the revenue stream to support the scientific effort. The moment you have to account for that spending against the value of the fishery ... that fishery may well turn out to be bankrupt. Which isn't to say that it's not a biologically-sustainable fishery."

That's another reason why MSC certification is problematic. It's an exhaustive, costly process, and only top-shelf fisheries can afford it. Now, says Macfarlane, Australian supermarket giants Coles and Woolworths are about to pull off the gloves and go to war, each wielding sustainable seafood policies as a brand proposition. New Zealand inshore fisheries – snapper, tarakihi and the like – rely heavily on Australian sales, but the vast majority are uncertified. "If that's the name of the game, then we have a challenge to meet that demand. We have to find another solution. Technically, MSC is extremely robust, but from a commercial viewpoint, it can't be applied across the board."

His hopes, and those of the industry, increasingly rest instead with Global Trust. A supply chain and management certification company, it tests fisheries largely against the United Nations Food and Agriculture Organization's Code of Conduct for Responsible Fisheries. It's already certified some Icelandic, Canadian, Alaskan and Western Australian fisheries.

"We're interested to see whether it might form the basis of a standard for the New Zealand fisheries system at large," says Macfarlane.

The industry's expectation, he says, is that "the risk management settings from MPI will pass (Global Trust) muster." The same management settings; the policies, the controls, in force over hoki, he argues, also apply to "a whole lot of other fishing activity in the EEZ. In principle, it's the same management system right across the inshore fisheries. So why can't we make it work there?"

But it's still at what he calls a "bench test stage". The industry first has to closely examine the Global Trust regime, "and see how it will fit into the legal and institutional framework we have here. Then, the case for individual fisheries within that needs to be examined."

However, Global Trust also has its detractors in the environment sector. Internationally, WWF has conspicuously backed MSC, and Katherine Short continues to do so. A colleague of Zuur's at WWF-NZ, she's worked on sustainable fisheries since 1996. "In terms of the definition – the understanding – of fisheries management, MSC remains the standout." In her view, "the culture change that is necessary; the improvement in the science, the relationships, the policy, the technology, the legal framework [demand] that full third-party independent procedure. MSC is the only one that does it that way."

New Zealand deep and middle water fisheries are managed jointly under a memorandum of understanding between industry quota holders, under the umbrella of The Deepwater Group Limited, and MPI. Collectively, says Geoff Tingley, a principal scientist at MPI, they've "decided that [Global Trust] is a good thing to do. Fishing industries seek certification to get certain benefits: usually to either obtain market access, or retain it, or to get a preferential price arrangement." That, he says, will support the export drive the country needs, "and the Ministry's interest is in supporting the industry to do that within a sustainable fisheries framework. It's a good thing for New Zealand. Also, it gives us a check on how well we're managing our fisheries."

It's unlikely all New Zealand fisheries will simply get the Global Trust tick at one stroke. More research, more validation will almost certainly be needed, but where the science spotlight might fall, says Macfarlane, "at this point, frankly, we don't know." But, he says, the exercise "may help us fine-tune just where the effort should be best focused."

A lead contender will likely be data-deficient fisheries, and what Macfarlane calls "barriers to making a complete assessment of a particular stock. We know we have a lack of data already – the likelihood is that this exercise will simply confirm that."

Dunn agrees that something needs to be done about what he calls "data-poor" fisheries. "I think we could do a much better job of assessing stocks of species about which we

Some environmental groups continue to oppose hoki's MSC certification, citing the drowning of an estimated 714 fur seals in offshore trawl nets between 2002 and 2008. (*Dave Hansford*)

know comparatively little. There are opportunities to bring in – or find ways to bring in – information by inference, either from other, similar species, or the same species elsewhere.

"For instance, if we're missing some element of data about one population, then we'll use data from the next nearest one. We've done that with orange roughy many times. But I think there's a better way to do that. I'd like to see more development of the understanding and the tools to actually bring stock assessments across these other species.

Adds Macfarlane: "We have a lot of secondary indicators about the status of fisheries. We now have decades of catch-per-unit-effort data. That's an awful lot of information being collected that we don't always make full use of."

Yes, says Tingley: "The QMS gives you quite a good idea of what's caught, and that's a really important parameter, but it's not the only one. You need to know other things as well: about stock status, distribution, whether it can be regarded as a single or a multiple stock. That's hard enough to do in a major fishery, without getting into bycatch."

Whether it's MSC or Global Trust, both demand that consideration be given – and all efforts made – to minimise fishing's impact on associated ecosystems and habitats. And that's where things get really tricky. "That's interpreted in different ways by different people," says Dunn. "Some people interpret that as 'don't kill seabirds and dolphins'. New Zealand has been quite effective at doing some of that: seabird mitigation measures here are world-leading."

Maybe, but, asks Bob Zuur, "What about the associated dependent ecosystems? How well are they being managed? That's the real question. If we're talking about a more environmentally focused fishery, then we really need to start thinking about ecosystem-based fisheries management.

"At the moment, we're treating non-stock impacts as externalities – something you attend to after the fact, once you've focused on managing your commercial stocks. That's actually quite different to ecosystem-based management, in which all of these elements are considered at the same time.

"Some of NIWA's research is quite multidisciplinary – their work on the Chatham Rise is a good example of that, and in the Southern Ocean, which has been much more ecosystem-focused – but the problem is applying that science in what is largely a policy vacuum."

"The endgame," according to Matt Dunn, "is to better understand what's there, and whether we're screwing up any connections in the food web." Dunn points out that, to some extent, research on high-value stocks like hoki and orange roughy also sheds light on associated species, but a closer look is needed outside commercial fisheries, "where the industry itself is unlikely to go."

> "Do we aspire to lead the world? I think we can, and we should."
>
> WWF-NZ Marine Biologist Bob Zuur

To that end, NIWA has looked for any connection between the number of hoki caught, and the fortunes of their prey, "and fundamentally," says Dunn, "nothing seems to have changed – they seem to be operating in the same way. They're eating the same stuff, which implies that the links to their prey are still intact. It's not like anything dramatic has happened."

As far as some green NGOs are concerned, however, New Zealand fisheries start from the back of the grid, because most of our important stocks are caught with nets, either close to, or on, the seabed. Such bottom trawling is anathema to them, and bottom-trawled fish like hoki and orange roughy get the red light by default.

"So whatever you do," says Geoff Tingley, "whatever certification you get, however much you manage or protect the seabed, Greenpeace are not going to support any fishery that puts mobile gear on the bottom. There has to be some rational approach. If the industry stopped bottom trawling, the amount of fish available to put on peoples' plates would be dramatically reduced. It's a technique fundamental to catching wild fish."

Nevertheless, he points out that there's still "room for improvement and change throughout the world, there's room for better management of impacts, and for more science to demonstrate the thresholds between acceptable and unacceptable impacts."

"It's important to remember," says Dunn, "that inshore fisheries are naturally highly disturbed environments anyway. And the animals that live there have evolved to live in highly disturbed systems. Bottom trawling, in that sense, simply constitutes another disturbance."

However, he says: "We do need to better understand whether fishing gear has a truly damaging impact on the ecosystem or the sustainability of the fish stocks, but that's a big research question. In the meantime, it's sensible to continue to develop fishing methods that increasingly minimise impact on the environment." He admits that, in some instances, a solution may not be forthcoming: "Clearly, in other environments, bottom trawling is devastating: if you're going to trawl through centuries-old coral forest with big heavy nets and steel bobbins, you're going to flatten everything. It's not resilient in that way."

If biodiversity is your concern, he says, by all means protect it. "But don't confuse that with the process of fishing – if you fish it, it will be modified. The question is how you deal with that. Food security is going to become a big issue. A hundred and thirty thousand tonnes of hoki provides a lot of protein every year: where else would you get that from, if not from hoki? The priority here is sustainable fisheries. If you want to specifically manage biodiversity, maybe you do that through a separate process. But you have to accept that, where you are fishing, things are going to change."

Unfortunately, some of those changes include the deaths of protected species caught by accident. An estimated 100 New Zealand sea lions – with a threat listing of 'nationally critical' – drown each year in squid and southern blue whiting trawl fisheries. Pup production at the Auckland Islands, their main breeding area, has declined by 50 per cent in the last 13 years. Forest and Bird lobbies strongly for "zero mortality" of sea lions, but, says Macfarlane, "If the standard being promoted will not tolerate a single mortality, then it is fundamentally an unattainable standard. It creates a dispute that simply cannot be resolved."

So the risk remains that, even should the industry attain Global Trust certification, it may still be vilified. Does that mean that hoki and orange roughy might never gain acceptance in US and European markets?

"History would suggest that it does," concedes Macfarlane.

That's because, says Katherine Short, "It's not just about certification. It's about culture change. We can no longer claim to have the best-managed fisheries in the world. The world has shifted, and we know much more about marine ecosystems now.

"Consumers have changed the game massively. It's no longer about mitigating the environmental effects of fishing – that's an old paradigm. We've got to turn this issue on its head: it's about deciding what you actually want as a nation responsible for 95 per cent of the country that's underwater. Then it's a case of working backwards from that: maybe, we only fish here, and leave this bit alone.

"In our minds [at WWF-NZ], that doesn't mean restricting, or shutting down, or minimising the value of the fishing industry: it just means thinking about it from a different perspective."

"Taking a more balanced, ecosystem-based approach to fisheries is becoming a management goal. But it isn't easy. For example, closing areas to fishing was once put forward as a silver bullet for combined fisheries and ecosystem management. But leaving one half un-fished won't necessarily keep the other half intact," says Dunn. "I think that misses the point. It all needs to be intact, because we rely on ecosystem services to keep it going. You've got to get it right, because we rely on that system to provide fish."

Whichever approach we take, says Zuur, it will need good science, and more: "it's about making sure that science is articulated and disseminated – placed in the public domain in a robust and credible manner. Ideally, against clearly defined performance standards, so we can assess how fisheries are performing, even if they're not MSC-certified. And I think NIWA has a critical role to play in that.

"Do we aspire to lead the world? I think we can, and we should. We've got it all set up in New Zealand to take the next leap forward, to ecosystem-based fisheries." W&A

Taking the fall

The collapse of the Southland Stadium in 2010 highlighted how little we know about snow-loading hazards. Can New Zealand buildings stand up to a heavy dump? **Greta Shirley** finds out ...

A hot shower may well have saved Keiran Fahy's life. The Invercargill insurance broker had been at the covered Southland Stadium all morning, coaching kids' tennis. "We didn't really have much indication of what was going on outside," he recalls.

If they had, they would have seen Invercargill hit by one of the most severe snowstorms in living memory. Over Friday 17 September, the low pressure system tracked south and east across the Southern Ocean, loading with cold Antarctic air before turning north. In the early hours of Saturday, gelid and sodden, it crossed the Southland coast, unleashing 16 hours of heavy snowfall, followed by intermittent snow, rain, hail and sleet.

At 11.00 am, anxious parents showed up at Fahy's tennis class, keen to get their kids home before the snow got too deep.

He decided to take a shower. Minutes later, the stadium roof collapsed, dragging with it sections of the east and west walls, and the main roof 'spine' trusses.

Inside, Fahy heard "a hell of a lot of noise" before the stadium gave a convulsive shudder. "The roof came down as one, and it created a hurricane going down the corridor."

Outside, parents and kids reported a loud "explosion" as the building collapsed into the space they'd just left. Doors at the eastern end of the courts blew open, and roof panels flew past. Fahy, still not fully aware of his peril, headed for the exit.

"People outside were doing a bit of a head count," he says, "and saw me wandering out. They used a few expletives to express their need for me to hurry up.

"The whole show was just wide open. There was no roof there at all. That's when I said a few four-letter words myself."

> "The roof came down as one, and it created a hurricane ..."
>
> Kieran Fahy

In Yarrow Street, the roof of Wren's paint shop also succumbed, as did part of the Windsor New World supermarket. Roof trusses in Farmers department store and The Warehouse both groaned under the weight of the extreme snow fall. Evandale Gardens and two workshops owned by Southern Transport were also damaged. Somehow, nobody was killed or injured.

Let it snow, let it snow, let it snow ...

Snow is precipitation in near, or below, freezing temperatures.

Snow hazards generally happen in our mountain areas, the central North Island, and the south and east of the South Island, but snow occasionally falls elsewhere. Last year, snow fell in Wellington, Hamilton and even central Auckland.

Analysis of NIWA's historic weather events database (hwe.niwa.co.nz) shows that a total of 39 snowstorms have damaged property and infrastructure, or killed livestock and/or people.

Four of these occurred prior to 1945, three during the 1970s, one in the 1980s and four in the 1990s. Twenty-seven snowfall incidents have been recorded since 2000.

Recent significant snowfalls include:

June 2006 – Canterbury

September 2010 – Southland

July 2011 – Canterbury

August 2011 – Canterbury and Wellington (snow also fell in Auckland and Hamilton)

June 2012 – Canterbury

In September 2010, the roof of Invercargill's Southland Stadium succumbed to the weight of up to 600 tonnes of snow, during one of the worst storms to hit the province in decades. A Department of Building and Housing report – released in May this year – found that the stadium fell well short of safety standards, and that the roof should not have failed. (*Southland Times*)

Within hours, NIWA scientists were collecting snow data from around the stadium – that would later be used by the then Department of Building and Housing (DBH) in an investigation into the collapse.

The New Zealand Building Code sets out the minimum performance standards buildings have to meet – such as the strongest earthquake they must endure, or how much snow or wind they can withstand. "What the Code does," explains Cameron Smart, Engineering Projects Manager of the Institution of Professional Engineers New Zealand (IPENZ) "is give you different methods for demonstrating compliance."

The joint Australia/New Zealand standard – AS/NZS1170.3 (with some Building Code amendments) is a verification method for defining the snow load to be used when designing a building.

Follow the calculations outlined in the standard, which figure in location, altitude and building type, and you get a minimum ground snow load (Sg), measured in kilopascals (kPa). Sg is the pressure snow would ordinarily exert on the ground and, therefore, what the building must also withstand. Hospitals and other populous buildings must be able to cope with higher snow loads than a private house.

The Southland snowfall wasn't an isolated event. In June 2006, a large storm dumped record snows on parts of Canterbury, collapsing several buildings and disrupting electricity networks, communication and transport systems. At DBH's request, NIWA also researched the snow loads exerted by that storm, which reached 1.2kPa at a Timaru weighbridge – four times the acceptable one-in-25-year limit in the Building Code of the time.

NIWA's subsequent report highlighted instances where observed ground snow loading had even surpassed the one-in-150-year standard, and said that the snow densities specified in the AS/NZS standard were a "key deficiency." That was the first time doubts were expressed about the building standards, says NIWA meteorologist, Dr Richard Turner. "People started asking a little bit more about where the numbers had come from."

NIWA recommended that a systematic data collection system be set up for future severe low-elevation snowstorms, and that variations to the standards might also be required. For example, it has been observed overseas that snow density increases with snow depth and yet the AS/NZS standard ignores this effect.

In 2008, the Building Code was duly strengthened for low-altitude sites in Canterbury and Southland.

Turner, and his NIWA colleague, applied hydrologist, Dr Christian Zammit, are fascinated by the white stuff. They gather important information for DBH by measuring snow depth and density at different locations.

"We call it a snow mobilisation exercise," says Zammit. "When the big storm hit Canterbury in June this year, we went out measuring snow-related information, such as depth and vertical density at specific locations. We also propose doing this type of measurement at existing climate stations, so we can build up a time series that allows us to evaluate additional information, such as the return period of a snow event."

Says Zammit, the Department and others are also interested in the adequacy of the current snow standards, which "are based mainly on Australian and American snow data, because of the lack of information here."

Understanding how much snow falls, says Adrian Bennett, and how dense it is, is critical to designing buildings, "so they perform satisfactorily throughout their lives, don't collapse and don't endanger occupants." Bennett, Manager of Building Science and Research at the Ministry of Business, Innovation and Employment's Building and Housing Group (formerly DBH), says that, while the current standard includes snow loads, "in recent times, there appears to be an

> **"Prior warning is our next best weapon."**
>
> NIWA Chief Scientist, Natural Hazards, Dr Murray Poulter

increased frequency of significant snow events in sub-alpine areas. This means the snow load data need to be updated, and the design information improved."

Cameron Smart is less convinced: "Having worked in the snow and wind areas for quite some time, it seems to me the present standard, modified by the Code, is about right. But the way ground snow load is translated into load on a roof – that's worth looking at." He's also curious about precisely how snow accumulates against the sides of buildings, and "one very dear to my own heart" – what happens when wind combines with snow.

Zammit and Turner, however, favour erring on the side of caution, especially after the Christchurch earthquakes put the spotlight on building resilience. "We're not seeing buildings collapsing regularly from snow," accepts Turner, "but it's a bit of an unknown because we lack good long-term measurements in New Zealand."

Zammit says current standards are probably adequate in 95 per cent of cases, but we need a lot more data before we can be sure, especially at low elevations: "anywhere below 200 metres, where snow is only going to occur perhaps once or twice a year, but could possibly have huge consequences."

New Zealand snow is still something of an unknown. For example, does our maritime weather environment make it wetter or drier, heavier or lighter? Snow depth and density, says Zammit, do not always correlate: "For the same snow depth, you could get anything between 75kg per cubic metre for fresh snow, up to 400–600kg for wet snow."

How a warming climate might impact on future snow storms is also unclear. NIWA modelling suggests we will see a general decrease in snow at high altitudes, but a warmer climate will also bring more precipitation, which could mean we'll see more extreme snow events at lower altitudes.

NIWA's Chief Scientist, Natural Hazards, Dr Murray Poulter, says there's more that could be done to improve "how accurately we estimate the probability of ground snow load, and combined high wind-snow load events." Also, he says, we need to better quantify "how snow, ice and wind interact with infrastructure, such as buildings and power line networks."

Prior warning, he says, is "our next best weapon. We've adapted a weather model to predict snow amounts, using NIWA's specialist environmental monitoring service EcoConnect. In the future this tool could be used to help alert utility operators of possible infrastructure damage from snow, and the need to have repair crews on standby."

Stadium Southland was, in fact, designed to meet snow load requirements first published in 1992, and still in effect when it was built in 1999 (the 2008 revisions were much more stringent).

An investigation into the collapse, commissioned by DBH and conducted by engineering consultants Ashley Smith (StructureSmith Ltd) and Dr Clark Hyland (Hyland Consultants Ltd), included a site examination, laboratory testing and 3D computer analysis. It concluded that snow

The Southland Stadium lies flattened after the September, 2010, snow storm. Department of Building and Housing subsequently identified faulty remedial work to fix sagging roof trusses, along with welding that was either substandard or missing altogether. Police found no evidence of criminal liability. Invercargill City Council now faces a $27 million lawsuit from the building's owners. (*Southland Times*)

NIWA's Christian Zammit measures snow depth in Christchurch. The difference between wet and dry snow for a given depth, he says, can be as much as 500kg per cubic metre. (*Nelson Boustead*)

load alone couldn't explain the structure's failure. Problems with remedial works during construction, construction defects and design issues were also implicated in its downfall.

Smith and Hyland calculated snow load at the time was around 0.3kPa. A day after the collapse, NIWA measured the average ground snow load at 0.45kPa, although it's possible that was bolstered by sleet, rain and further snow subsequent to the collapse. Had the stadium been built to 2008 standards, the design roof load for the building would have been 0.63kPa – a 60 per cent safety margin.

DBH therefore concluded that the 2008 Code requirement, still in force, remained sufficient. Other Smith and Hyland recommendations, including that DBH provide guidance on the design of roofs subject to snow loading, were accepted. The Department is also considering a requirement that public buildings carry snow alarms to warn occupants when loads reach specified limits.

The report was referred to the New Zealand Police and Department of Labour for further consideration, and to IPENZ – the body responsible for industry competence.

The New Zealand Insurance Council put the final cost of the Southland storm at more than $50 million, including a $20–25 million repair bill for the stadium.

The hairs on Keiran Fahy's neck still stand up when a truck goes past. "It's that same sort of shuddery feeling, as when the roof came down, forcing air down the wee narrow corridor near the stadium changing rooms. That tickles me up a bit."

Anything more we can learn about snow events and snow loads, he reckons, is a good thing. "At the end of the day, the stadium was built within the confines of the regulations they had to design to at the time. I guess all you can be thankful for is that no one got killed or injured ... with a bit of luck, they'll learn this time round, when they build the new one." W&A

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Wiki science: how you can help gather more snow data

The public can help gather data under a NIWA system which analyses snowfall at low elevations around New Zealand. The results will tell us more about how snowfall occurs, and will help quantify snow-related risks.

During the South Island snowstorm in June this year, NIWA received more than 40 measurements from the public, from Dunedin to Rangiora.

If you live below 400m elevation, and it snows, send us your measurements of the snow depth and snow water equivalent.

For more instructions – visit http://sciblogs.co.nz/waiology

Antarctica

In mid-September, Christchurch hosts the NZ IceFest; a celebration of our relationship with Antarctica. In this issue, we salute that relationship with a portfolio of images portraying the frozen continent, and NIWA's work to better understand and protect it.

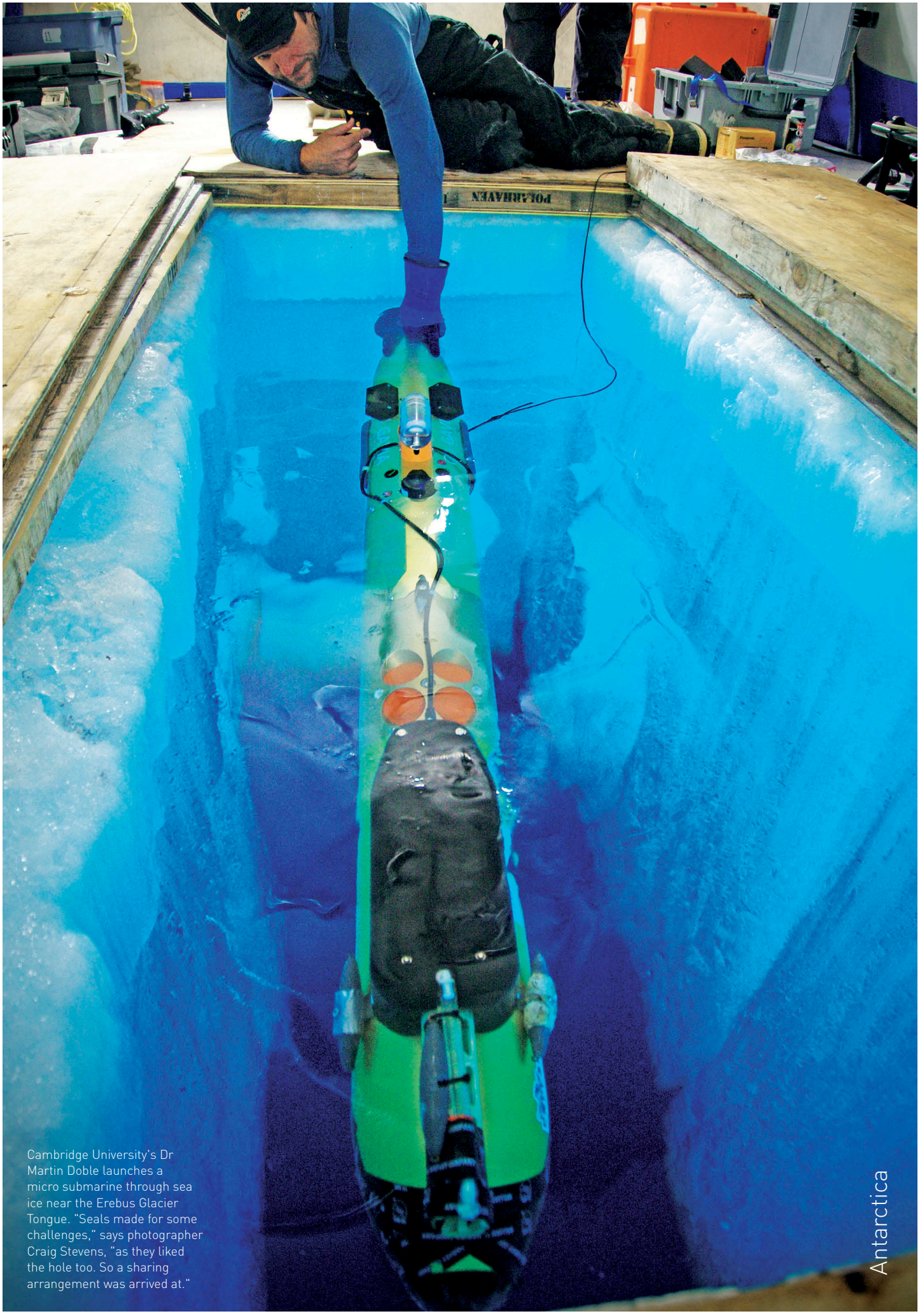
Emperor penguins investigate a sea ice field camp off the Erebus Glacier Tongue in McMurdo Sound. All images by Craig Stevens.

Antarctica

Sundogs grace an Antarctic sky over the Erebus Glacier. Sundogs happen in very cold temperatures, when airborne ice crystals form residual bright spots in a halo around the sun.

Sea ice breaks up off the Italian base in Terra Nova Bay.

A view along the 20m-high front of the Nansen Ice Sheet. To the right is Terra Nova Bay: in the distance, Inexpressible Island and Mount Melbourne. Even in winter, strong winds keep these waters free of ice.



Cambridge University's Dr Martin Doble launches a micro submarine through sea ice near the Erebus Glacier Tongue. "Seals made for some challenges," says photographer Craig Stevens, "as they liked the hole too. So a sharing arrangement was arrived at."

A true Pisces: Rosie Hurst

Watching TV as a kid was time well spent for Rosemary Hurst, she tells **Dave Hansford**

It was probably inevitable. As a kid, in her native England, Rosemary Hurst was fascinated by anything nature had to offer. Her idea of a birthday treat was a visit to the Science and Natural History museums in London.

Even then, the sea had a particularly strong pull. Trips to her grandparents' place by the sea near Southampton, were like going home. "I was always really fascinated by nature programmes on TV," she recalls. "Especially the underwater ones." Rosie tuned in to the pioneers of scuba – Hans and Lotte Hass, Jacques Cousteau.

Six weeks at sea, then, aboard the liner that carried her to New Zealand, aged nine, weren't just exhilarating: they were decisive.

Today, Rosie is NIWA's Chief Scientist, Fisheries; a specialist in middle depth and inshore fisheries, resource surveys and stock assessment, climate effects on fisheries, and fish communities.

She gained a zoology degree from Wellington's Victoria University – eventually. "My original PhD was on terrestrial ecology, but it didn't work, so I switched back to marine." She never regretted it.

Rosemary Hurst (right) circa 1995.

> "Sustainability of the environment is becoming more important."
>
> NIWA Chief Scientist, Fisheries, Rosemary Hurst

If the passenger liner had been a revelation, research vessels were the start of something even bigger. "I was very keen to work in that space." Even if her studies hadn't worked out, she says, "I knew I'd end up working in the marine environment somehow – I would've trained as a ship's officer or something like that."

There was no need: she started work at the then Ministry of Agriculture and Fisheries in 1979. In 1995, she joined the nascent NIWA, and was made a regional manager in 2000.

Come leisure time, you might expect Rosie to head inland for a change of scenery, but no: she and husband John jump aboard the yacht he built 20 years ago, and head for Abel Tasman. Their two daughters are now in their early twenties, but, she says: "They still love it."

Rosie loves getting out with her dogs on Wellington's walkways. She's also a keen photographer, and when she's not capturing her daughter's hockey games on pixels, she's down at the sea again: "I enjoy landscape and wildlife photography – in New Zealand, that's pretty much about birds. But I also like to photograph anything to do with the sea: anything to do with nature, really."

But while she's in her element beside – or on – the sea, an ear injury as a child means she can't dive under it. "I certainly enjoy snorkelling, though."

Like any scientist, she likes to ponder the big questions. "For me, that's about the idea of sustainability: making sure that whatever we do in the sea is sustainable in the long term. Not just around fisheries – if New Zealand is going to get into marine mining, or even in terms of climate change – ensuring any impacts are well managed is of great concern."

She's not about to run out of work – or wonder – anytime soon. "There are a lot of things we still don't really understand," she says. "How the various components of

Rosie Hurst in her favorite place. "I knew I'd end up working in the marine environment somehow." (*Dave Allen*)

our marine ecosystems interact, and how resilient – or how vulnerable – they are to change and disturbance. These are complex issues that we need to be able to understand better in order to be able to provide advice to managers."

She marvels at the digital technology that allows her daughters "to satisfy their curiosity, in ways we never could. They simply type in a search field, and up comes the answer: it's amazing. When you think about how it was for us; we had to go down to the library. There wasn't a lot of instant gratification."

Modern technology has also shown her much more of the hidden side of the sea she loves. "The capability we have now, to be able to go down to quite extraordinary depths, and see what's down there, is fantastic. Up until 15 years ago, we were really just scratching the surface. But now we can collect samples from depths of thousands of metres, deploy underwater cameras and acoustic equipment and get a much better view of what's down there.

Rosie's own relationship with the ocean is based on love and respect, but she's not sure that humans on the whole "have conducted ourselves honourably in our relationship with nature. I think we can be proud that, in New Zealand, we've taken some important steps to manage our fisheries sustainably. It makes you feel more comfortable, living in a country where sustainability is high on the agenda." However, she adds, "That's not to say that we couldn't do more."

There's still work to do, she points out, on issues "like fishing impacts on other parts of the ecosystem. Consumers are now more aware of the broader issues, with the advent of certification standards. Sustainability of the environment is becoming more important – not just sustainability of the fisheries."

So what's a fisheries scientist's favourite dinner?

"Hāpuku," offers Rosie, without pause for thought. "It has a nice flavour, and beautiful texture."

Any cooking tips? "Pan fry it very lightly, so that it's just cooked."

You read it here first ....W&A

Q&A

Casting the knowledge net

How does NIWA support fisheries management?

NIWA provides research and advice to enable the sustainable management of New Zealand's commercial and recreational fisheries. It does so in two ways: by monitoring and assessing key fish stocks, and by monitoring the effects of fishing on the aquatic environment.

Some information on commercial fish stocks comes from industry records of catch and effort, as well as observer data on the size and age of fish caught. That information is supplemented by independent research, such as trawl, acoustic, potting and photographic surveys, and estimates of recreational harvest. NIWA research vessels *Tangaroa* and *Kaharoa* conduct regular abundance surveys of deepwater species, such as hoki, and inshore species off the east and west coasts of the South Island.

Fisheries scientists then model the population abundance of key species, and future catch scenarios. The results enable the Ministry for Primary Industries (MPI) to make recommendations on Total Allowable Catch (TAC), under New Zealand's Quota Management System.

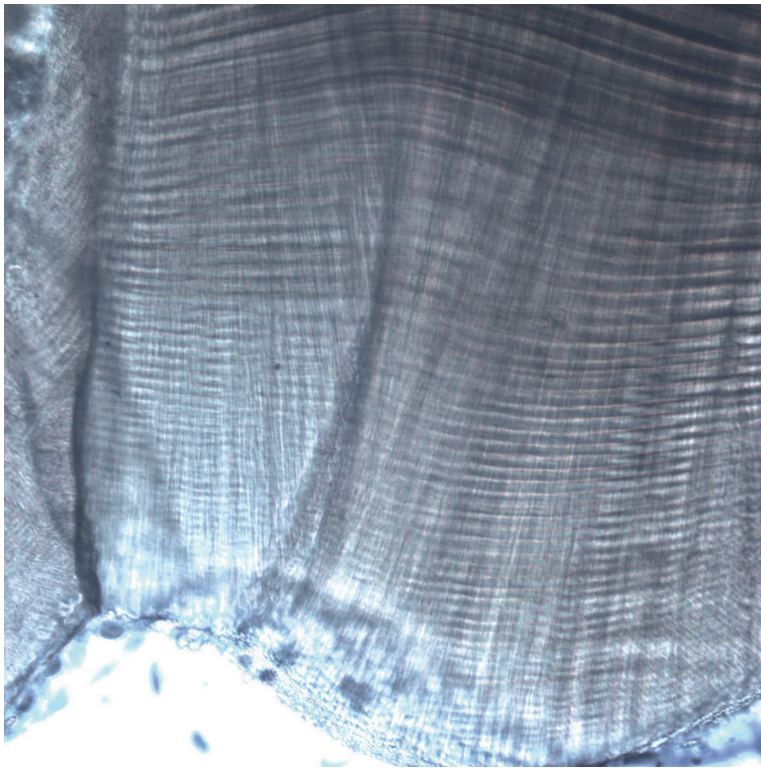
NIWA also researches the effects of fishing on protected species, such as seabirds, marine mammals, sharks, and corals, and any impacts on other bycatch, benthic communities, food webs, and marine biodiversity. We are also developing our capability to model ecosystems and explore mitigation options to reduce the impacts of fishing gear.

How do we count fish in the ocean?

NIWA researchers assess fish abundance in many ways. Two of the most common methods are trawl and acoustic surveys.

Trawl surveys provide high-quality data on the relative abundance of species vulnerable to bottom trawls. NIWA's inshore and deepwater research vessels tow nets (using the same standard procedures each time) at randomly-selected locations. The catches are analysed, and the results scaled up by the area surveyed, to get a measure of the overall number of fish.

Acoustic surveys use echosounders, which transmit sound waves into the water, then measure what is reflected back. Some species of fish produce a characteristic acoustic signal. Scientists interpret such data, and use their knowledge about the biology and acoustic scattering properties of the different species of fish present to estimate their numbers in a given area.



The otoliths of the black oreo dory are notoriously diffcult to age, but examination under a compound microscope revealed that this 33cm male, caught at 700m near the Chatham Islands, was around 60 years old. (*Caoimhghin Ó Maolagáin*)

Regular trawl or acoustic surveys allow abundance estimates to be plotted over time – a vital input into future yield calculations. Other methods, tailored to particular species, are used for scampi (seabed photography), paua (diver searches) and intertidal shellfish (beach transects).

Surveys are carried out within New Zealand's 200-nautical mile Exclusive Economic Zone, and beyond. Research in international waters helps the New Zealand Government and other stakeholders meet their international stock monitoring and assessment obligations under a range of conventions and agreements.

How are fish aged?

Researchers determine the age of bony-headed fish by examining their otoliths – or 'ear bones'. These calcified structures exhibit growth rings, similar to those in a tree stump. Under a microscope, otoliths show paired light and dark zones, with each pair generally marking a period of one year. Counting them can be painstaking, because the zones sometimes merge, have complicated micro-structures, or are irregularly spaced.

NIWA ages about 20,000 fish annually, and growth curves (plots of fish size versus age) using otolith observations have been created for about 60 species of fish.

Similar rings are also found in bivalve and mollusc shells, and NIWA researchers use them to estimate growth in some species.

How does NIWA assess the impact of fisheries on the environment?

NIWA monitors and analyses trends in the impacts of commercial fishing bycatch, which may include other fish species, or invertebrates such as protected corals, and seabirds. Trawl surveys also enable trends in the abundance of many bycatch species to be independently monitored.

Habitats of particular significance or vulnerability are given special attention. These include spawning, pupping and egg-laying waters, or nursery grounds. The concentration of fish in the early part of their life in these areas means even small environmental impacts can have a large effect on fish populations later on.

NIWA also evaluates the effectiveness of any changes in fishing practices aimed at reducing damage to vulnerable habitats.

Indicators are used across the world to monitor changes in environmental conditions and the state of the ecosystem. NIWA is working closely with MPI to develop a suite of indicators appropriate for New Zealand's fisheries, incorporating information on fish community composition, size structure and food web links.

All of the impacts of fisheries on the environment are considered within Environmental Risk Assessment (ERA). NIWA researchers are developing ERA approaches for deepwater fisheries, and have already contributed to New Zealand risk assessments for hoki, Maui's dolphin, seabirds and seamounts.

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NIWA
enhancing the value of New Zealand's natural resources

NIWA (the National Institute of Water & Atmospheric Research) was established as a Crown Research Institute in 1992. It operates as a stand-alone company with its own Board of Directors, and is wholly owned by the New Zealand Government.

NIWA's expertise is in:

- Aquaculture
- Atmosphere
- Biodiversity and biosecurity
- Climate
- Coasts
- Renewable energy
- Fisheries
- Freshwater
- Māori development
- Natural hazards
- Environmental information
- Oceans
- Pacific rim

NIWA employs approximately 650 scientists, technicians, and support staff. Our people are our greatest asset.

NIWA also owns and operates nationally significant scientific infrastructure, including a fleet of research vessels, a high-performance computing facility, and unique environmental monitoring networks, databases and collections.

Back cover:

A snorkeller is surrounded by jellyfish in a marine lake on the Palauan island of Eil Malik. After millions of years of isolation with no natural predators, the jellyfish have lost their stinging defences, making for a surreal visitor experience. (*Paul Champion*)

NIWA
Taihoro Nukurangi