Water & Atmosphere

April 2014

Hungry for answers

How can we save our sea lions?

Invasion of the lake snatchers

The battle against foreign weeds

Picture a flood

NIWA enlists amateur photographers

Bring me that horizon

What it's like to captain a research vessel

WATER & ATMOSPHERE

April 2014

Cover:

New Zealand sea lion. (*Tobias Bernhard*)

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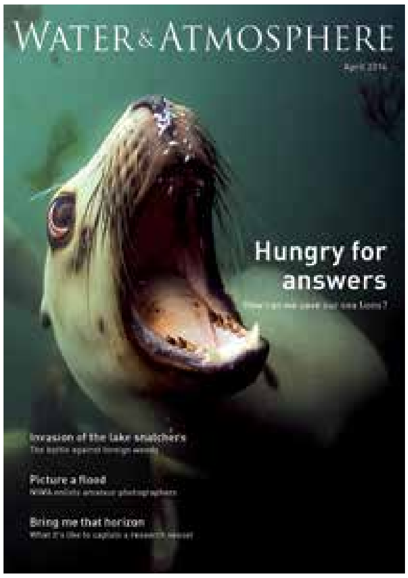
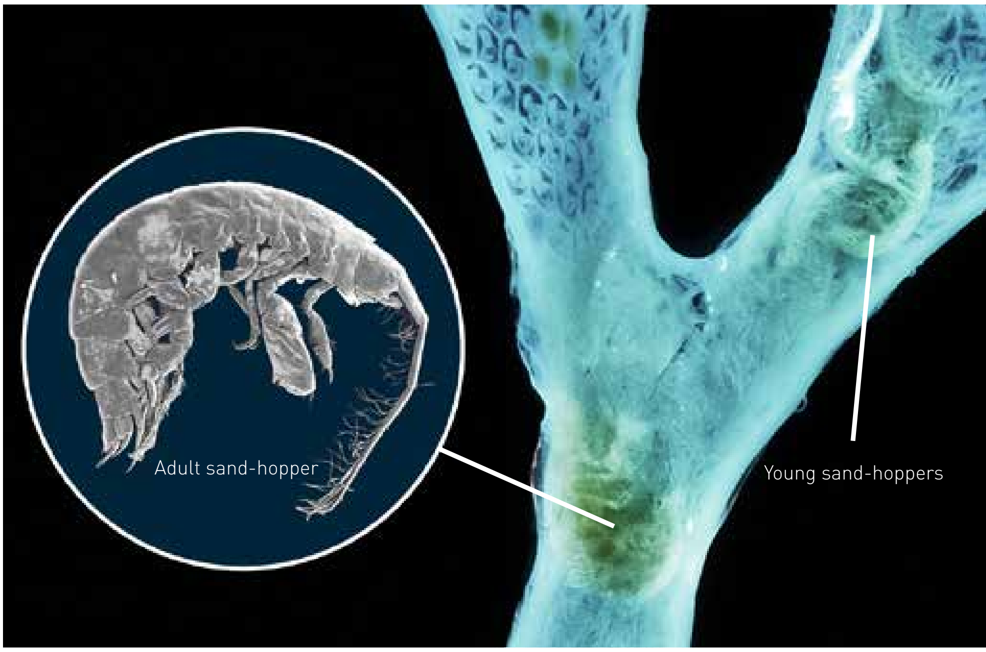
enhancing the benefits of
New Zealand's natural resources



In brief

Drought conditions caused strife for many farmers across the North Island in 2013. (*Dave Allen*)



Sand-hoppers identified living inside bryozoans. (*NIWA*)

We're facing greater weather extremes

New Zealand will get hotter, have more heavy rainfalls, and experience more days when the fire risk is extreme, according to the latest report from the Intergovernmental Panel on Climate Change.

The Fifth Assessment Working Group 2 report includes a chapter on New Zealand and Australia. NIWA climate scientist Dr Andrew Tait is a lead author of the chapter, which says New Zealand continues to demonstrate long-term trends toward higher surface-air and sea-surface temperatures, more hot extremes and fewer cold extremes, and changed rainfall patterns.

Dr Tait says the Working Group 2 report "highlights where we are already seeing signs of climate change impacting on our environment and societies, and predicts what the impacts are going to be as our climate continues to be affected by ever-increasing concentrations of CO_2 and other greenhouse gases in the atmosphere".

"The report is a chance to restate and re-emphasise the climate change vulnerability and adaptation issues that we face."

For the full report see www.ipcc.ch

Deepsea species discovered

A new species of crustacean discovered this month could shed light on relationships between deepsea organisms.

NIWA marine biologists Dr Anne-Nina Lörz and Dr Dennis Gordon said that the sand-hopper they named *Bryoconversor tutus* was found inside another animal it was using for food and protection on the Chatham Rise.

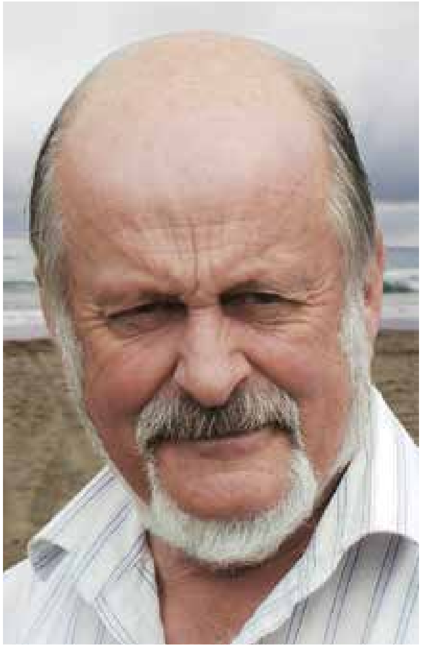
"As a scientist, discovering a new species always gives you a bit of a rush.

"Finding the sand-hoppers living inside bryozoans is particularly significant as we know so little about deepsea relationships compared to marine life in shallower water."

The sand-hopper was discovered inside a moss animal (bryozoan) colony. The sand-hopper species is thought to use the bryozoan as a source of nutrients and protection.

The new species name, *tutus* means 'safe', while the new genus name, *Bryoconversor* means 'bryozoan-dwelling'.

The NIWA scientists identified males, females and young sand-hoppers measuring up to 1cm long living inside a bryozoan 5cm in length. They believe that sand-hoppers reproduce while inside the bryozoan. When it dies, the sand-hoppers move to another bryozoan host.



Fisherman Grahame Lindsay on Papamoa Beach. (*SunLive.co.nz*)

Hadal snailfish. (*University of Aberdeen*)

What is a meteo-tsunami?

The source of giant waves that broke on the beaches of Papamoa last November left residents and scientists scratching their heads. The mystery was solved by NIWA scientist Rob Bell who said that the description fits a rare type of tsunami called a 'meteo-tsunami'.

Bell said that they were effectively a tsunami caused by weather as opposed to something like an earthquake.

"They're generally caused by rapid changes in air pressure, in this case a fast moving squall-line, which affected the sea below it and caused long-waves."

Fisherman Grahame Lindsey, who was nearly taken out by the freak wave, said that the whole sea appeared to be moving towards him.

"It came up to nearly the high water mark," says Grahame. "It was low tide, it was about half past five and it brought the Kontiki in and laid the lines up the beach. It came in; it wasn't just a wave – it was like a tsunami."

Bell said the most likely cause of the Papamoa meteo-tsunami was large swells off to the northeast of Papamoa caused by a low-pressure system.

Life at the bottom

A new study co-authored by NIWA marine ecologist Dr Ashley Rowden has found the first evidence that the biochemistry of fish may constrain how deep they can venture.

The secret to survival is a protein called trimethylamine N-oxide (TMAO). The more TMAO a fish has, the deeper it can go. This study shows that there seems to be a tipping point where TMAO becomes 'uneconomical'.

To test the idea, the scientists had to get hold of a hadal snailfish. It is capable of living at a depth of more than 7000m and none have been caught in 60 years. Rowden notes the find as an example of the unique biodiversity in a special part of New Zealand's marine estate.

"We're incredibly lucky to have a hadal-zone trench like the Kermadec Trench right in our backyard. And it's collaborations with the likes of the University of Aberdeen that make studying these environments possible."

Rowden illustrates the type of pressure that has to be withstood at these depths.

"It's like having all the weight of a cow put on just your big toe. Without high levels of TMAO it is improbable that the snailfish would be able to survive unless it has another means of dealing with the effects of high pressure."

In order for fish to live at greater depths they need high levels of TMAO. However, too much can have negative effects. As TMAO rises proportionally to the depth, there is a point at roughly 8200m where it seems the fish cannot physiologically moderate these effects.

It has long been suspected that the pressures of the world's deepest trenches, which descend to nearly 11,000m, would be too great for a fish to withstand. This study, for the first time, offers a biochemical explanation based on empirical data for the observation that no fish have yet been recorded from a depth greater than 8370m.

In brief

Phil Boyd (left) and Cliff Law (right) receive the award from New Zealand IChemE Board member Jenny Culliford (centre). (*Dave Allen*)

Honour for NIWA scientist

NIWA scientist Cliff Law has been awarded the prestigious 2013 Hutchinson Medal, by the Institution of Chemical Engineers (IChemE).

Dr Law, a specialist in marine biogeochemistry, received the medal for his work as a co-author on a paper about ocean fertilisation. His fellow author and medal winner was ex-NIWA scientist Dr Phil Boyd.

The medal was awarded for a paper called *Ocean fertilization: A review of effectiveness, environmental impacts and emerging governance*, published by the journal *Process Safety and Environmental Protection*, in November 2012.

It reviewed the state of knowledge on large-scale ocean fertilisation by adding iron or other nutrients to deliberately increase planktonic production in the open ocean as a measure to mitigate climate change.

Climate scientist, Dr Suzanne Rosier. (*Dave Allen*)

Volunteers sought for climate change experiment

A citizen science experiment for weather enthusiasts has been launched by NIWA, in collaboration with researchers from the UK and Australia.

Volunteers are now sought to participate in weather@home ANZ, a project that will enable people to contribute to scientists' understanding of how climate change might be affecting weather in New Zealand and Australia. All that is needed to take part is a computer and an internet connection.

NIWA climate scientist and weather@home New Zealand programme leader Dr Suzanne Rosier says the aim of the project initially is to improve understanding of how extreme weather conditions such as heatwaves and drought may be changing.

It works by participants volunteering the spare processing power on their computers to crunch weather data from a state-of-the-art global climate model that includes a finely detailed regional model over Australia and New Zealand. Dr Rosier says the computing power harnessed in this way from thousands of volunteers is phenomenal.

"It enables scientists to run these global and regional climate models many thousands of times – far more than would be possible with conventional computing resources."

To register, go to weatherathome.net

Science staff sorting through specimens from the epibenthic sled. (*Deb Osterhage*)

Voyage to Louisville

NIWA's research vessel *Tangaroa* returned from a five-week voyage to the Louisville Seamount Chain in March after completing a biological survey of this rarely sampled area.

The voyage was one of the first of its kind aimed at giving scientists a better understanding about marine ecosystems vulnerable to commercial fishing. The main goal was to verify scientific models that predict the whereabouts of sea animals that indicate the presence of a vulnerable marine ecosystem.

The Louisville Seamount Chain is about 1000km northeast of New Zealand and extends more than 4000km.

Voyage leader and NIWA principal scientist Dr Malcolm Clark said scientists had to be adaptable during the survey, as the size and shape of the seamounts differed from expected, as did the location of the animals.

Samples of some animals were captured using small seafloor sleds. Some live corals were also recovered and will be analysed to determine the effect of ocean acidification on coral growth.

NIWA's helikite was on hand at the Wairarapa Balloon Fiesta providing up-to-the-minute weather information for balloon pilots. (*Tony Bromley*)

NIWA flies high

Among the colour and spectacle of March's Wairarapa Balloon Fiesta, a small but crucial flying contraption stood out from the crowd.

Known as a helikite and operated by NIWA scientists, the helikite provided vital weather information to balloon pilots before they took off.

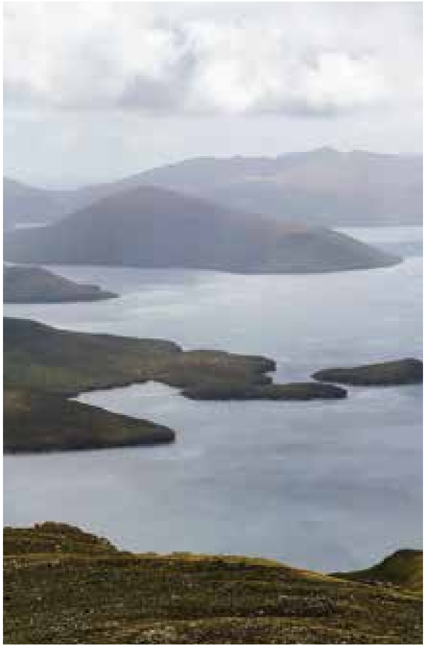
Meteorologist Tony Bromley describes the helikite as a cross between a balloon and a kite that uses helium to achieve lift. It has a range of instruments attached to measure temperature, humidity, wind speed, wind direction and pressure, and the data are constantly transmitted to the ground.

Raised and lowered using a winch, the helikite can be deployed up to a kilometre high in order to provide real-time information for the balloon pilots. It was constantly raised and lowered throughout the fiesta, taking measurements every two to three metres.

Mr Bromley said NIWA provided regular general and more localised weather forecasts for pilots to help them determine the best balloon flying times.

Despite predictions that Cyclone Lusi would disrupt the fiesta, the balloons flew over three mornings and only the Night Glow was postponed.

In brief



Auckland Island. (*Paul Sagar*)

Sir Peter Blake Trust Youth Ambassadors Lucy van Oosterom (left) and Rebecca Gibson (right) on board RV *Tangaroa*. (*Neil Bagley*)

New research base

A research base proposed on Auckland Island would be perfectly situated to observe the effects of a warming climate.

The consortium proposing the base includes NIWA, the New Zealand Antarctic Research Institute, and Victoria and Otago universities.

The remote landmass is New Zealand's most southern island, sitting roughly one-third of the distance between New Zealand and Antarctica. At this latitude, the station would fill in a gap in the recording of global weather patterns.

Closer to home, the benefit of having a better understanding of Antarctic processes could help improve understanding of New Zealand's own weather patterns.

Ambassadors survey Chatham Rise

Rebecca Gibson from Bay of Plenty and Lucy van Oosterom from Kerikeri joined NIWA's 25-day deepsea voyage along the Chatham Rise in January.

They were chosen by the Sir Peter Blake Trust as Youth Ambassadors, to help on board New Zealand's only deepsea exploration vessel, RV *Tangaroa*.

Rob Murdoch, NIWA's General Manager Research, said Rebecca and Lucy worked on the annual Chatham Rise survey. The main aim is to estimate the abundance of hoki, New Zealand's largest fish export, and other commercially important species, as well as other aspects of deepwater biodiversity including fish distribution, abundance and ecology.

Lucy and Rebecca have both studied marine biology. Lucy said it was the perfect chance to combine the aspects she loves about marine biology. "When I first heard about the ambassador position with the Sir Peter Blake Trust and NIWA, I knew I had to apply. Scientific research, education and public outreach – it's what I'm all about."

Spotting a solitary weed colony in Lake Wanaka leads to hand weeding by a NIWA diver, while making sure no fragments escape. (*John Clayton*)

Water patrol

New Zealand waterways are under attack from alien weeds. **Mark Blackham** takes a look at the people and technology patrolling the watery frontline against invasion.

The surface of Lake Ianthe in Westland is ruffled by a terse early morning breeze. The forests at the water's edge are still damp with last night's rain. Two wetsuited divers slip into the water, clutching yellow underwater 'scooters'.

The scooters drag the divers through the water at up to 5km/h, allowing them to patrol swiftly through the water in search of the enemy.

The enemy is various species of alien water plants. They grow faster and stronger here than in their country of origin. They spread across lake and river beds, pushing out native plants and animals. Their dense, tall weed beds reach higher than native water plants, and they can interfere with recreational use of lakes.

Ianthe is typical of the frontline of New Zealand's efforts to keep these species out. On the surface all is quiet – picturesque. Underneath, invasions occur out of sight, allowing the plants to occupy and dominate lakes unchallenged.

Without human patrols of waterways, submerged water weeds are only discovered when they have grown into large, surface-reaching beds – when eradication is almost impossible.

The two scuba divers at Ianthe are from NIWA, contracted by the Ministry for Primary Industries to patrol for an aquatic weed called hornwort. Instead they find another weed, lagarosiphon. The official status of these weeds is 'Unwanted Organism', making them illegal to sell, propagate or distribute. Once these weeds reach a waterway, they grow rapidly, smothering native vegetation and reducing water-bound oxygen for fish (contrary to what the common name suggests).

Lagarosiphon is one of the three worst species commonly known as 'oxygen weeds' infiltrating waterways. Its discovery at Lake Ianthe by patrols illustrates the elusive nature of the enemy; it's hard to know when and where the invasion will come, and by what.

Hide and seek

Detecting new alien freshwater pests within a lake or river is challenging. Underwater invasions occur out of sight, and water-borne dispersal easily and quickly distributes new arrivals from their point of introduction.

Managers of New Zealand's waterways, like regional councils and the Department of Conservation, spend millions of dollars a year on weed patrols and eradication.

Many agencies help patrol waterways. The Ministry for Primary Industries looks for pest species new to New Zealand, and those on the list of 'National Interest' pests. Other agencies sending searchers into the water are the nation's territorial authorities (mostly regional councils), the Department of Conservation and Land Information New Zealand (on unoccupied Crown land). Weeds pose a particular threat to hydro-generation, so power companies are also part of the patrolling network.

John Hook, Acting Manager, Crown Property Management, at Land Information New Zealand (LINZ) says the partnership approach between various organisations is proving successful.

"The scientific monitoring and advice provided by NIWA is integral to ensuring that programmes are evidence-based and that resources are well directed."

The search is a very hands-on effort; experienced people have to enter the lakes or waterways to look for the weeds.

Mary de Winton, a freshwater ecologist at NIWA, says there's no substitute for direct observation.

"We are using new tools like drop cameras and sonar, but there still has to be a time when a person actually eyeballs the weeds."

In fact, she says that the 'intuition' of people is critical to the patrols looking for first incursions.

"Great divers have an instinct – they're able to think like the plant. They know where plant fragments are introduced, where they might float to and where they might wedge and grow."

Once found, NIWA's biologists make recommendations for eradication.

"We suggest control options that suit the weed and the conditions. How you eradicate it depends on the weed species, how much of it there is and characteristics of the site – like the profile of the shoreline.

"Eradication can take many forms," explains John Hook.

"The approach we take varies slightly for each area, but generally involves a combination of herbicide control, suction dredging and hand weeding."

After weeds are destroyed, NIWA personnel return to the waters to monitor if, and how quickly, the weed re-establishes itself.

To assist in their battle, the agencies are looking for improved methods to detect new pests at an early stage of establishment when it is most feasible to eradicate them. Early identification is essential because even when a new infestation is found, most control options require that all colonies are located for treatment. The earlier they are found, the fewer weed colonies that need to be destroyed.

Mary de Winton says the organisation is always looking to improve its techniques, as well as its tools.

"We're always learning from our experiences, and constantly modifying techniques to do it better."

Good news from the front

The good news from the frontline is that nine freshwater species designated as 'Notifiable Organisms' have not yet been detected. Five aquatic weeds threatening lakes, rivers and wetlands have been entirely eradicated from New Zealand.

Where weeds are taking hold in Hawke's Bay, eradication efforts give reason to think some battles can be won. And, in the South Island, hornwort has been eradicated from all six known sites.

NIWA enlists

Science is at the forefront of the battle against freshwater invaders, developing strategic and tactical defences. NIWA designs and tests surveillance strategies and approaches, and prioritises the bodies of water to survey, where to look and how frequently. It also identifies the best tools to control, contain or eradicate pests.

Scientists on the frontline

One of the most notable features of this war is that the scientists are themselves the frontline soldiers.

Mary de Winton is part of the team of about 10 biologists at NIWA who don wetsuits to conduct the searches themselves.

"This is frontline, hands-on science. To spot the weeds, you've got to know a lot about them. And the more we do this, the more we learn."

Mary wasn't really a diver before she started the job.

"I'd had some experience, but I've had a lot of training through NIWA, and acquired a lot of diving hours.

"It's not very glamorous but the dark holes and murky water are compensated by some beautiful locations."

Honing the weapons against water weeds, a diver observes the behaviour of a gel additive that can be added to aquatic herbicides to improve their placement. (*Rohan Wells*)

Mary de Winton says it has been rewarding to see the hornwort reduced. "We are down to just a few shoots being found, so the risks of spread to other lakes has been eliminated."

At Lake Tutira, grass carp have been introduced to eat hydrilla, a submerged aquatic weed that forms dense weed beds. The weed displaces native plant species and sucks oxygen out of the water at night, making it almost impossible for native fauna to live there.

Hydrilla is not exactly a grass carp delicacy, but they happily eat it.

Ian Gear, from InGearGlobal is overseeing the eradication of hydrilla from four Hawke's Bay lakes for the Ministry for Primary Industries.

He told *Water & Atmosphere* that the grass carp had already chewed back great swathes of the weed within the first five years of introduction.

"Locals are already saying they have noticed a very significant decline in the amount of weed. That's making the area habitable again for native fish and mussels along with trout. There are anecdotal reports that trout in the lake are getting bigger."

Recording the decline of weed and return of other species is in the hands of NIWA. Early monitoring confirmed that the grass carp quickly removed hydrilla weed beds across the littoral (close to shore) zone of the lake. NIWA's subsequent monitoring has found that some areas have then been colonised by native plants, and there was an increase in freshwater mussels.

Within three years of grass carp being released into the lake, live mussels were being recorded in water as deep as 8m. Previously, when the dense hydrilla weed beds were present, only dead or empty mussel shells were found at these depths.

Juvenile mussels grow in clean sand, so it is suggested that the increased abundance of mussels is due to an increase in available habitat since the removal of hydrilla.

Gear hopes that when NIWA carries out the annual survey in April 2014, it will find that the invasion is well beaten back.

"At this rate we'll need only another five years to eradicate the weed. But we'll need another 10 years from that point to make sure it's gone completely."

Gear says the NIWA results are proof that grass carp are a good eradication option. "This is the leading example of what grass carp can achieve. They are a good solution to restoring lakes invaded by exotic weeds they find palatable."

A key advantage to grass carp is that their ideal breeding conditions are limited. "Grates prevent them leaving the lake, but if they did escape, they won't find conditions outside the lake suitable."

Science programme leader for NIWA's Freshwater Biosecurity Programme, Dr John Clayton, watches a retreating shoreline as the team drive to the next site in Lake Rotoaira. (*Rohan Wells*)

The success at Lake Tutira will help inform people about the concept of using grass carp.

"People are wary about the unknown and unfamiliar, but they're willing to learn. It only took 18 months from commencing conversations with stakeholders to getting agreement from everyone to release the fish into the lakes.

"When we tell people about the success at Lake Tutira, it raises awareness of what they can do with grass carp," Gear says.

De Winton says grass carp are clearly a useful tool that is appropriate for some weed problems.

In the Bay of Plenty, close proximity of the lakes and their popularity for recreation, makes transfering invasive weeds easy.

Aquatic weeds such as hornwort, egeria, lagarosiphon and elodea are now well established in some lakes. Hornwort has spread through large areas of Lake Ōkāreka, for example, that the Bay of Plenty Regional Council (BOPRC) says it may never be eradicated. NIWA is currently investigating whether eradication is feasible.

Regional Council Manager Land Management Greg Corbett says the infestation has got to the point where they may not be able to eradicate it.

"While we have asked NIWA to test and trial new approaches for surveying and controlling hornwort, we may need to learn to live with it always being there. We will decide whether to attempt to eradicate it once NIWA has reported back to us later this year. In the meantime we are working with our partners to intensively control all hornwort we find.

"We have had success in Lake Okataina with reducing hornwort, but it does take years to manage once an infestation has occurred."

Spread mainly by boats and trailers, three Rotorua Te Arawa lakes contained hornwort by 1990. It has infested another four lakes since 2005, and there are only four lakes where this invader has not yet been sighted.

BOPRC carries out annual surveillance for water weeds, but experienced difficulties in pinpointing the exact location of the recent infestations. In some cases it was evident the weed had been present for some time before it was detected.

LINZ funds an annual spray programme within the Rotorua Te Arawa lakes. BOPRC advises LINZ on areas of lakes that would benefit from spray work.

Steph Bathgate, Land Management Officer at the BOPRC, told *Water & Atmosphere* that there is regular monitoring of 10 lakes, and an immediate response team dives any of the lakes when weeds are sighted.

"A considerable amount of monitoring and control goes into containing, managing and preventing further spread of aquatic pests."

When hornwort fragments were found at Lake Rotomā (which is free of the plant) in 2013 and 2014, divers checked weed cordons and boat ramps to determine the extent of the spread. They found no further plant fragments.

"We aim to contain and minimise the further spread of new and existing infestations of aquatic pest plants to lakes. People from a variety of agencies within the Bay of Plenty work hard to keep it that way," Steph Bathgate says.

Testing times

In response to the influx of weeds across Rotorua Te Arawa lakes, BOPRC asked NIWA to test the effectiveness and efficiency of surveillance methods, including direct observation and remote detection of submerged weeds. The lessons learnt will also be applicable to surveillance for other macroscopic pests, such as alien snails, or possible future invaders.

Long lengths of shoreline are scanned for weed by snorkel divers towed behind a boat. But their detection abilities are limited when viewing through deep or dirty water. At these times, scuba divers are towed underwater on 'manta boards'. Alternatively, they use underwater scooters to cover the ground quickly.

Grid-based or focused searches like those used for airborne sea rescue searches are particularly thorough when used by free-swimming divers looking for weeds. But the cost of thoroughness is time and resources.

A method being trialled is dropping cameras into the water from boats to conduct spot checks. It is less effective than direct eyesight because of the limited focus of cameras and their tendency to shake when moving through water.

Sonar is an alternative method of remote observation (see below), but has limited detection ability when new invaders are in low numbers.

NIWA is testing the efficiency of these different methods by looking at detection rates for items that mimic weeds (such as tree branches). The testing team places branches within a trial area at a Rotorua Te Arawa lake, then assesses how many are found using the available techniques.

The team tries out the methods in various conditions, such as the clarity of water and the amount of existing vegetation.

Sounding Horowhenua

Lake Horowhenua used to be surrounded by podocarp forest at the centre of a wetland. It is now surrounded by farms and Levin township. Until the late 1980s it was used as a discharge for Levin's treated sewage. Fixing the resultant eutrophic state has become a local goal and community effort, aided by a $1.27 million clean-up fund for the lake.

Weed harvesting was one of eight projects cleared to use the clean-up fund. The first stage of the harvest was finding the weed.

NIWA has just completed a survey using sonar to determine areas of weed in Lake Horowhenua that could be harvested for amenity and nutrient remediation purposes.

Sonar technology was once the domain of the military, but is becoming cheap and accessible enough to be used for the battles against weeds.

Sonar uses acoustic messages, 'pings', which bounce off objects in the water such as weeds, the lake bed or river bed. The returned signals can be measured and visualised to show the location of weed beds within the water body, their density and their height in the water column.

Mary de Winton says one of the more useful features is that sonar can be used to show weed to the side of the research boat as well as straight down.

As well as revealing where dense vegetation is, sonar can be used to document changes after weed eradication efforts. It can also pick out patches of alien weeds where these grow much taller than native freshwater vegetation.

Sonar surveys are generally 'ground-truthed' – which means NIWA divers manually check the presence, composition and extent of weed development at a selection of sites before accepting or interpreting the sonar data.

Over 79 per cent of Lake Horowhenua was covered by the boat-based survey using sonar. The survey mapped vegetation bio-volume (space occupied by weed in the water column). This allowed the extent of dense weed to be defined and measured.

NIWA's sonar survey will provide information to identify harvester requirements and help optimise a weed harvesting strategy.

By the numbers

0.5km/h to 1.5km/h – average speed of free-swimming diver

3km/h to 5km/h – top speed of underwater scooter

5km/h to 6km/h – the maximum tow speed for divers behind a boat (before your mask is ripped off!)

2m to 4m – the most common invasion depth by lagarosiphon

28 per cent of 344 lakes – found by NIWA to contain one or more of six alien submerged weeds

9 freshwater species – plants, fish, molluscs and crustaceans designated as 'Notifiable Organisms' that have not yet been detected in New Zealand waters

30 – the number of aquatic plant species banned from sale and distribution in New Zealand

6+ – number of lakes where NIWA staff have found new weed incursions since 2005

Sonar power

83/200 kilohertz – the sound frequencies used to detect vegetation

15 to 20 per second – rate of 'pings' sent from the sonar unit

25m – the maximum horizontal distance sonar can scan from the boat under favourable conditions

10m – the height of the tallest alien weed bed measured in a sonar survey by NIWA

Home by Christmas?

In most battles there's a sense that there may be a day that those on patrol can pack up their kit and go home.

But Steph Bathgate says research shows that even if you think you've won, re-infestation can still occur.

"You can never be 100 per cent sure of success with controlling aquatic pests. The environment they inhabit can be cryptic and ever-changing, so having a complete understanding of extent of infestations can be difficult."

Bathgate warns that people using waterways have a responsibility not to make the job of the weed patrols harder.

"People must ensure they are not part of the infestation process by spreading plant fragments and fish eggs via equipment they use in the lakes."

(*Top left*) NIWA field staff Ryan Evison and Marty Flanagan out and about during flooding in Christchurch. (*Pieter Havelaar*) (*Top right*) Christchurch under water – with flooded areas in blue. The darker the blue the greater the flooding. (*Bottom half*) Some of the more than 500 photographs sent in by Christchurch residents.

Flood in pictures

Each month, NIWA issues its official climate summary, noting the weather patterns of the previous month, recording highs and lows and including commentary about temperature, rainfall and sunshine hours.

In the commentary for Christchurch next to the official rainfall records for March are the words “well above normal”.

In fact, a rain gauge in Riccarton, Christchurch, endured its wettest March since records began in 1863. And, of the 200mm that fell during the month, 123mm came down on just one day. That made 4 March the greatest one day March rainfall on record for that location.

So much rain inevitably caused considerable flooding throughout Christchurch and much of the surrounding area. Schools were closed, slips blocked roads and homes were inundated, including at least 100 houses in the surburbs of Woolston, Richmond, St Albans and Mairehau.

As the water came down, NIWA scientists got to work. They were out in the elements analysing floodwater levels and mapping the worst-affected suburbs.

But in the days that followed, they realised the scale of the floods was so great they could do with the public’s help. So they sent out an appeal via local and social media, for photographs. Residents were asked to email any photos they had of the flooding, especially the peak water levels.

Coordinating the project was Dr Graeme Smart, NIWA’s principal scientist of natural hazards and hydrodynamics.

“We had an incredibly quick and extensive response. We were very grateful that so many people were so willing to help,” he said.

In the space of a few days, more than 500 photos were received and work began on refining a flood map of the event using some of the evidence provided by residents.

The first step in the project has been to establish the exact location of each photograph. Then the water level in each photograph has to be calculated. Where the water can be seen against a recognisable landmark such as a doorstep or fence paling, a survey team will be sent to determine the precise level.

If the edge of the water is shown on a field, road or footpath, the information needed is determined from existing ground level information gathered by post-earthquake, airborne laser surveys.

Other information is also being collated from a record of emergency callout locations and from technicians who were sent out during the flood itself.

Once all the information has been added to the map, the floodwater depths are then used in conjunction with a scientific model known as RiskScape, to calculate the human and economic costs of the flooding.

For instance, in the suburb of Mairehau, the calculations predict an estimated 47 houses were affected by the March flood. Using the provisional data, Riskscape calculates they will cost $1.28 million to repair with $900,000 lost in content damage.

When the cost of the cleaning up is added in, the cost of house flooding in Mairehau totals about $2.2 million.

RiskScape also indicates that if floor levels of the vulnerable buildings had been raised by 10cm, the cost of the house flooding in Mairehau would have been halved. And if floor levels had been raised by up to 45cm there would have been no house-related flood damage.

Dr Smart said using the modelling programme, scientists could artificially raise floor levels to see how much the damage is reduced.

“This is particularly useful for deciding on priorities for building flood protection works,” he said.

Rainfall in March

March 4

123mm at Riccarton

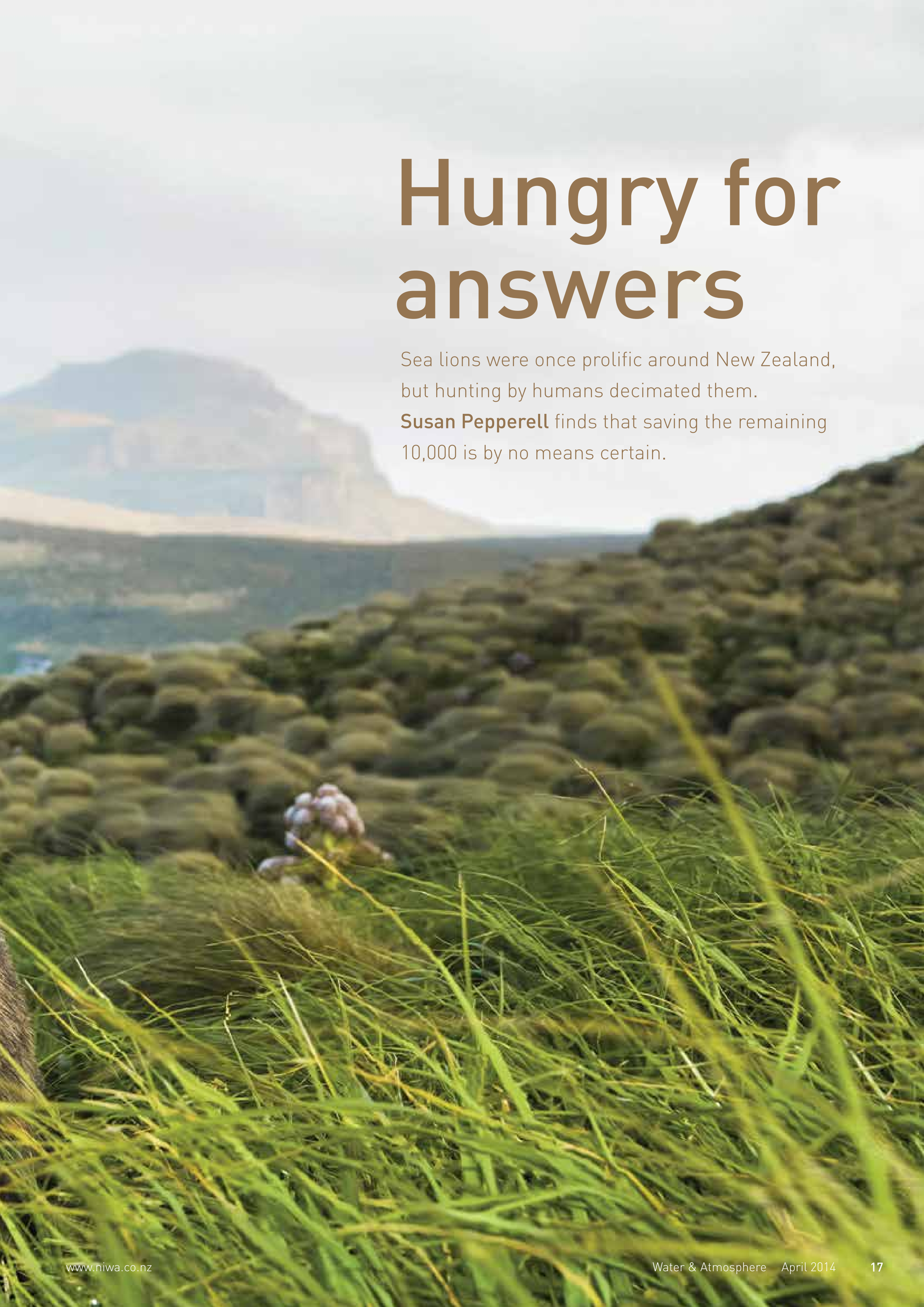
153mm at Lyttelton

All of **March**

200mm at Riccarton

www.niwa.co.nz/climate/

A mature bull New Zealand sea lion poses between naps amongst the tussock below the 'Penguin Bay Hilton' hut on Campbell Island. (*Kyle Morrison*)



Hungry for answers

Sea lions were once prolific around New Zealand, but hunting by humans decimated them. **Susan Pepperell** finds that saving the remaining 10,000 is by no means certain.

Hungry for answers

Last December, Dr Brittany Graham received one of the best Christmas presents she could ever have wished for.

Three dusty boxes that had been sitting untouched for years in a cupboard at Massey University arrived at her Wellington office – the result of a plea to scientist Laureline Meynier for material on which to conduct some state-of-the-art scientific research.

The boxes contained several hundred New Zealand sea lion teeth, each individually bagged and labelled with the animal's age, sex and where it was caught.

There it was: the raw material that would enable Dr Graham, a NIWA marine ecologist, to go back through time and help solve why a once healthy, prolific species is now struggling.

"These teeth are such gems, to have access to them is an incredible opportunity."

Teeth can tell scientists a lot about a species. They have bands that grow annually, a bit like rings in tree trunks, that Massey staff had previously analysed to determine the animals' age. Because the sea lions were captured between 1987 and 2005 and were of different ages, they represent an impressive record.

Dr Brittany Graham with some of her treasured sea lion teeth. (*Dave Allen*)

Dr Graham is drilling into the teeth, taking tiny samples from the bands to analyse using highly sophisticated new pieces of technology at NIWA. Using teeth as historical libraries would reveal a whole new layer of information about what these sea lions ate, where they ate it, and possibly if there were changes in ocean conditions over their lifetime.

"This is a way of looking into the past we haven't used before. These teeth will provide information not only on whether ocean conditions have changed, but also whether there have been changes to the structure of the marine food web.

"We can now look back through time and understand what was happening in the marine food web around the Auckland Islands and deduce if any changes have affected the New Zealand sea lions. In other words, this is a new tool that provides a glimpse at the past 20 years from a sea lion's perspective."

New Zealand sea lion teeth were once valued by Māori as fish hooks. Remains have been found in pre-European Māori and Moriori middens, indicating they were once used as food.

Fur seal hunters first came to New Zealand for several years from 1788 when Sydney-based merchants realised they had a potential commodity for trading. By 1797, interest had waned because the Bass Strait seal colonies were closer and more accessible.

But by 1803, the seals of Bass Strait were almost all gone, and the hunters again looked south. Fur and leather was in demand in England as was oil. The boom times for the fur seal trade lasted until about 1810 with reports of 140,000 killed in the Antipodes Islands in just three years. It is likely that sea lions, known also as hair seal and later as Hooker sea lions, were targeted once the fur seal stocks were depleted.

Records show three vessels returned from hunting on the Auckland and Campbell Islands in 1825 with 3670 sea lion skins. By the next year the trade was all but over and the population almost wiped out.

It took until the end of the 19th century for it to show signs of recovery, but while fur seals are now abundant, the picture remains alarming for sea lions.

There are about 10,000 sea lions left and that figure is dropping. Once prevalent around the New Zealand coastline, nearly all breeding now occurs on the Auckland Islands, and to a lesser extent Campbell Island, in the sub-Antarctic. Sea lions display strong fidelity to breeding and foraging sites and recolonisation on the mainland is likely to be slow. Despite this, small colonies have recently re-established on the Otago Peninsula, the Catlins and Stewart Island, giving cause for optimism.

The Auckland Islands colony is the largest and most intensively studied; it has also been declining rapidly for a number of years. This year, only 1575 sea lion pups were born here, around half the number born in the late 1990s. Pup counts at Campbell Island have grown rapidly over the same period, but scientists are uncertain as to why the two colonies are faring so differently.

New Zealand sea lion. (*Rob Murdoch*)

Precision drilling

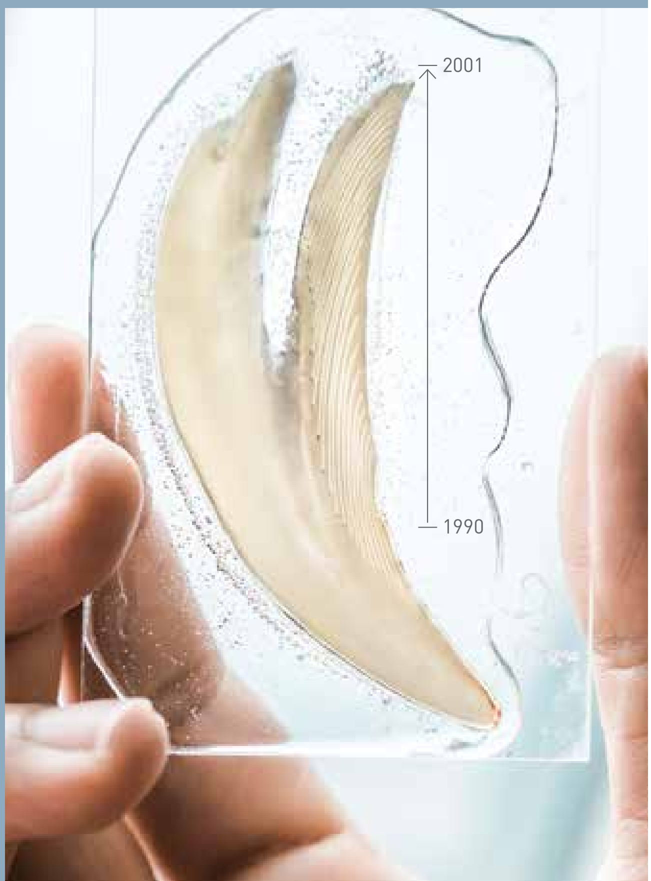
Drilling a sea lion's tooth is exacting work. First, the tooth is cut in half lengthwise, then the pieces are highly polished to remove any external contaminants before a 2mm-thin slice is removed and mounted on a slide.

"Then we take some very detailed, high-resolution images of the thin section so we can best locate the different growth bands to micro-drill", says Dr Brittany Graham.

The next procedure is to prepare the drilled material for stable isotope analysis. It requires many steps using different chemicals, temperatures and extractions to ensure the sample is in the best form for analysis.

The final material is analysed using a mass spectrometer. By linking a gas chromatograph to this high tech equipment, scientists are able to obtain isotope signatures of individual compounds. This specialised equipment is part of NIWA's newly improved and expanded ecological isotope laboratory, spearheaded by Dr Sarah Bury.

The data produced from this type of analysis takes understanding one step further.



A thin slice of a tooth taken from an 11-year-old male sea lion captured in 2001. The track lines are drill paths along annual growth bands, with two tracks taken each year, providing information dating back to 1990. (*Dave Allen*)

Two adult female New Zealand sea lions trek across the uplands of Campbell Island as a light-mantled sooty albatross cruises along the cliffs between Ramp Point and Cattle Bay. A mid-summer's snow dusts Mount Dumas in the background. (*Kyle Morrison*)

Hungry for answers

Female sea lions produce just one pup a year and must feed it for almost a year after birth. This is only possible by regular breaks in nursing to find more food. The need to return regularly to feed their pup tethers the mother to feeding grounds near the breeding colonies. This may leave them vulnerable to factors which alter the quality and quantity of prey. At times, the female will skip breeding to ensure a continuous supply of milk to the pup they do have.

In 1997, sea lions were officially declared a threatened species. More than 15 years later, the reasons for their dire state remain unclear. A number of possible causes have been identified but there is much still to learn.

Is the fishing industry to blame? Are too many fish being caught, leaving sea lions without enough food? What about squid fishing? Have the numbers caught in the nets of the Auckland Islands squid fishery driven the decline? Is disease affecting pup mortality? How has climate variability or change affected their environment? Are great white sharks, possibly their only natural predator, driving down numbers? Is something else going on?

Depending on who you ask, the answer is all of the above but in different combinations and emphasis. Opinion varies as much among scientists as it does among environmental advocates and fishing industry representatives. Politicians have also weighed in.

Last month, Conservation Minister Dr Nick Smith announced he was developing a threat management plan for sea lions. Its purpose, he said, was to "review all the risks and explore all possible measures to ensure their survival". Everyone, he said, had to work together.

So, what to do?

NIWA's Dr Jim Roberts is among a small group of scientists trying to answer that.

"I've been thinking about sea lions pretty much constantly for the last two years," he says, insisting that he still thinks they are "the nicest species to work with".

Dr Roberts has been undertaking postdoctorate work at NIWA focusing on developing statistical models to identify the causes of sea lion decline at the Auckland Islands. This includes a project funded by the Department of Conservation to develop models to identify key demographic rates, for example survival and pupping rates, that may be driving population change.

The demographic models make use of observations of sea lions that have been marked in some way. Since the early 1980s, pups born at the Auckland Islands have had plastic tags attached to their flippers a few weeks after birth. Every year a field team returns to the breeding rookeries to record which ones have returned and monitor their breeding behaviour.

"We can develop demographic models that use these data to assess changes in survival through time based on the proportion that return year after year," Dr Roberts says.

Dr Jim Roberts collecting scats and regurgitates for a diet study on New Zealand sea lions at Campbell Island. Preliminary results indicate that their diet is very different from that of the Auckland Islands sub-population. (*MA Lea*)

Using this 'mark-recapture data' scientists can also estimate changes in reproductive rates through time and shifts in age at first pupping, which also explain some of the variability in pups born each year. Dr Roberts says it is frequently overlooked that the pup counts were increasing through the mid to late 1990s, so they need to find out what changes occurred in the demographic rate which could help to explain the more recent decline.

"Assuming you have a closed population, then changes in population size must be driven by local births and deaths. So, if you have a decline in the number of pups being born, one explanation might be that a reduction in survival has lowered the number of breeding age animals.

"Another might be that the proportion of breeding age females producing pups each year has declined and survival of the species has remained the same. Or it could be a combination of the two."

The model estimates of pupping rates for the Auckland Islands colony are very low for a seal species, and low fecundity is likely to be one of the main causes of population decline. Fewer pups being born is thought by scientists to be caused by changes to the amount of food available to lay down the blubber required to rear a pup. Changes in diet may also account for the variation in the condition of lactating females and the quality of milk they have produced since the late 1990s.

Commercial squid fishing began in the sea lion foraging areas in the late 1970s, with estimated captures of the mammals topping 100 in some years. But in about 2003, Sea Lion Exclusion Devices or SLEDs were introduced. Essentially they operate as a trap door in the net, allowing the sea lion to escape, and have been fitted to all squid trawl nets fishing at the Auckland Islands since 2004.

Hungry for answers

Dr Roberts says while the SLEDs have been successful in reducing the number of sea lions caught, and research has indicated that encounters with SLEDs are not likely to cause major injuries, no one really knows what proportion of those that make it through survive.

Even so, mortality rates of sea lions caused by fishing are likely to have reduced at the same time the population has been in steep decline.

In addition to the reduction in pupping rate "we are also seeing a decline in survival in the Auckland Islands which may also explain the decline in population size. It also seems there has been a reduction in survival of those up to two years old since the early 1990s, with particularly low survival of cohorts born after 2005.

"If there is variation in pup survival that's really interesting because pups are dependent on their mothers for food. It may be telling us that females are unable to find the resources they need."

Then there's disease. First a bacterial epidemic was detected which, in 1998, killed 600 pups at Dundas, the largest colony in the Auckland Islands. In 2002 and 2003, many dead pups were found to be infected with *Klebsiella pneumonia.*

The next phase of the project will relate changes in survival and pupping rate variation in pup mass, maternal condition, milk quality, fishery captures, the incidence of disease and others to identify the ultimate causes of the decline.

"We now have multiple strands of evidence pointing towards nutritional stress – potentially driven by changes in the quantity and quality of food negatively affecting the productivity of the Auckland Islands sea lion population," Dr Roberts says.

Sea lions eat an array of species including octopus, squid, hoki, red cod, rattails, jack mackerel, crustaceans, salps, fur seals and penguins.

"They have an extremely varied diet and it's very different depending on where you look." They eat what's available, and what's available not only varies across the foraging distribution of the species but also through time, over seasons and from year to year.

Dr Roberts says as our understanding of what's driving sea lion population change improves, scientists are increasingly recognising the importance of both describing and understanding changes in the ocean climate of the Campbell Plateau and how these may relate to our apex predators.

"Everything is interlinked and we need to better understand how our marine ecosystems are plumbed together."

One way of achieving that is to develop multi-species models that can be used as a fisheries management tool to assess the potential drivers of change to the marine food web.

Analysis of ancient DNA at Otago University has indicated sea lions were once more genetically diverse and bred all around New Zealand. It is likely that the reduction in the number of breeding populations will have affected their resilience to catastrophic events and habitat changes. Dr Roberts believes sea lions are possibly more vulnerable than we think with their eggs "in only a few baskets".

But his research, and that of other scientists, appears to be shedding new light on what's causing the population change in sea lions and other apex predators inhabiting New Zealand waters.

On the sub-Antarctic islands the animals rule. But they need the help of scientists working together – and the willingness of all players in the Southern Ocean to keep it that way.

Southern elephant seal tracking is part of NIWA's Threatened Marine Megafauna project, funded by MBIE. (*Rod Murdoch*)

A New Zealand sea lion pup of just a few days old plays with mum's whiskers at Sandy Bay, Campbell Island. (*Kyle Morrison*)

When a sea lion leaves home, where does it go?

Scientists now have a few ideas, thanks to an electronic tagging project and some good glue.

Before you can stick a tag on a sea lion, you have to wait for it to moult. Then you glue it to the top of the back and keep your eye on a computer screen.

New Zealand's first scientific effort to track sea lions began in 2012 with a NIWA-led project that saw five animals electronically tagged at Campbell Island. Last year, another seven were tagged and in July this year, the aim is to tag at least 10. All have so far been juvenile sea lions, but the aim is to tag larger animals this year.

Project leader Dr Leigh Torres, who had previous experience attaching tags to albatrosses, says that the data have, so far, shown that once a sea lion establishes a pattern of feeding, it will confine itself to that area. And once they find a pattern of feeding that works for them, they confine themselves to it and continue to fish there for consecutive years.

"The site fidelity they showed was a surprise. We were also surprised by how much feeding happened on the shelf closer to shore. We expected them to go further away," Dr Torres said.

"They all have different feeding strategies and will target different prey. But they all show site fidelity."

This year, the intention is also to look at how the sea lions interact with the southern blue whiting fishing season centred around Campbell Island that takes place from August to October.

The aim is to determine how foraging patterns might change with the arrival of the fleet, and how much each overlaps.

"Over time we will start to understand how foraging habits might shift."

It's a small world after all

Despite being the oldest type of living organism on earth, it's only recently that scientists began uncovering the significance of bacteria in the world's oceans. **Mark Blackham** looks at NIWA's exploration into the role of marine bacteria.

Bacteria have been described as the 'dark matter' of the biological world – a poorly understood phenomenon that is an unseen force on life on Earth.

It has been estimated that 4 million species of bacteria, most unknown to science, can be found in one metric ton of soil. NIWA's Wellington Regional Manager, Julie Hall, says that bacteria are just as plentiful in the world's oceans.

"There are billions upon billions of these guys in the ocean," Hall says. "We now know a lot about the critical roles they play in the ocean environment.

"As the technology for studying these microscopic organisms evolves, so does our understanding of who they are and what they do."

Even though they weigh less than a quadrillionth of a gram each, the total weight of all bacteria in the world is roughly one billion tons. That's about equal to the weight of all plants on Earth. It means bacteria form half of all biomass in the oceans.

These invisible creatures also pack a powerful punch. Name a chemical element or compound of elements and there are bacteria using it, releasing it, recycling it and transforming it. "This movement of elements through living matter, the atmosphere, oceans and sediments is called cycling and they're hugely important processes. Without bacteria, life wouldn't exist."

In fact, almost any chemical reaction can be done by at least one group of bacteria. Bacterial decomposition, for example, is a core part of nutrient cycling. Another group called cyanobacteria carry out photosynthesis. They take carbon dioxide from the air, turn it into organic parts of their own cells and release oxygen just like plants.

Some can take nitrogen gas from the air and turn it into organic parts of their own cells – they can also perform the reverse. They even affect the weather: some bacteria play a key role in the sulphur cycle, which is linked to cloud formation.

Isolating marine bacteria for further studies. (*Alan Blacklock*)

Counting marine bacteria. (*Alan Blacklock*)

The secret to marine bacteria having such a huge impact on the environment is their adaptability to live pretty much anywhere. Hall calls them Earth's 'ultimate survivors'.

"In hydrothermal vents they have to be able to survive at 350 degrees centigrade. Others can be found in the very salty waters of the Dead Sea, sea ice or even places without oxygen."

They can thrive on a diet of just oil, something only discovered after the 2010 oil spill into the Gulf of Mexico. The oil, although low in nitrogen, provided them with a rich food source, and they were able to compensate for the lack of nitrogen by getting it from the air. The population exploded. Scientists estimated that it took only one day for bacteria to reduce a gallon of oil to a half gallon.

Scientists are now hoping to glean valuable insights into how bacterial technology can be used for cleaning up future oil spills.

Hall says there are still many questions that NIWA scientists are looking to find answers to.

"We need to learn more about the community patterns and functions of these necessary organisms, as well as predict how they may respond to environmental changes impacting life on Earth. This information is vital in furthering our scientific endeavours outside of microbial ecology."

Ocean acidification caused by increasing atmospheric carbon dioxide is a current area of focus for NIWA. A team is studying how ocean acidification affects bacterial processes and what any change to the acidity and temperature of the ocean might mean in the future.

"We're predicting that less carbon from the upper ocean will get into the deep ocean. More and more is being recycled in the upper ocean and at the same time producing more carbon dioxide. When there is less carbon in the deep ocean, it affects the organisms in the deep that rely on the carbon as a food source.

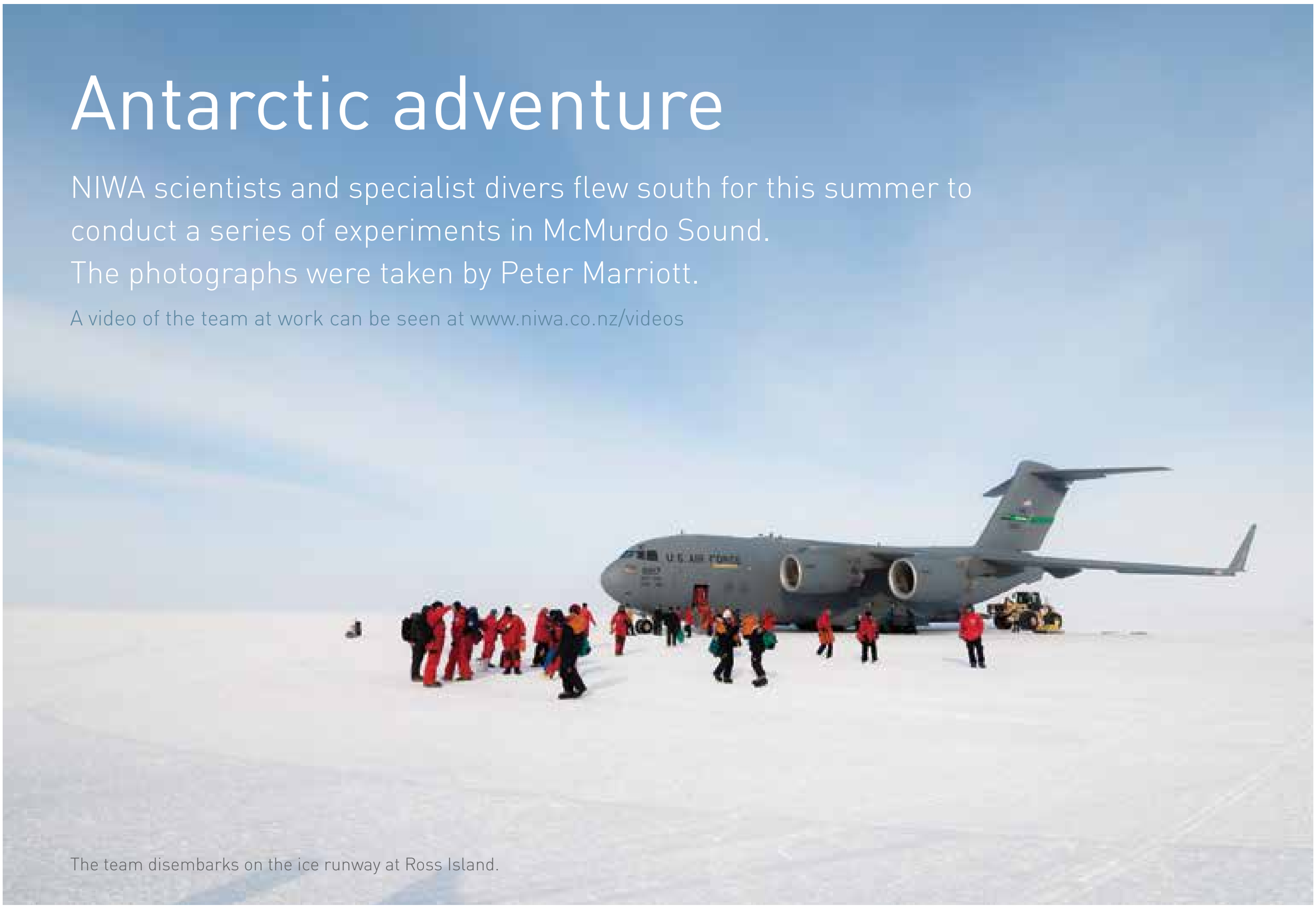
"And with more carbon dioxide in the upper ocean, it adds to the carbon dioxide already absorbed by the ocean and leads to an increase in ocean acidification. Until we make sure the microbial processes are okay, there will be consequences further up the food web."

Hall says unlocking the secrets of bacteria will play a huge role in developing a better understanding of how the planet works. "Bacteria have taught us a lot in just a few years. But we know we're just scratching the surface."

Antarctic adventure

NIWA scientists and specialist divers flew south for this summer to conduct a series of experiments in McMurdo Sound. The photographs were taken by Peter Marriott.

A video of the team at work can be seen at www.niwa.co.nz/videos

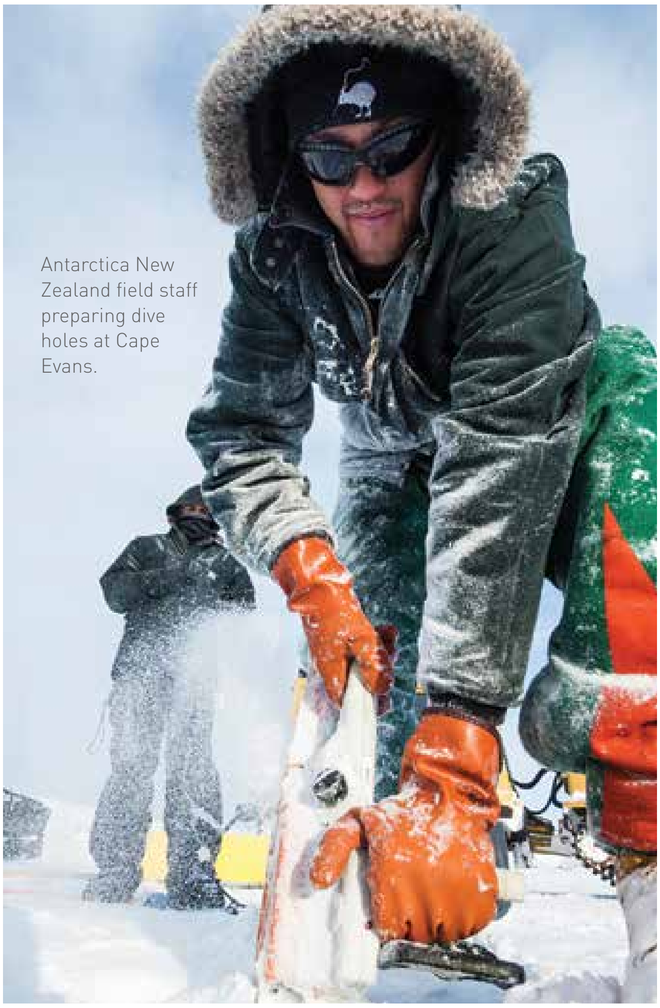


The team disembarks on the ice runway at Ross Island.

Emperor penguins keep an eye out for visitors.

Chambers were installed under the ice, and temperature and acidity of the seawater within them manipulated, to enable the team to better understand the potential effects of climate change on coastal sea-ice ecosystems.

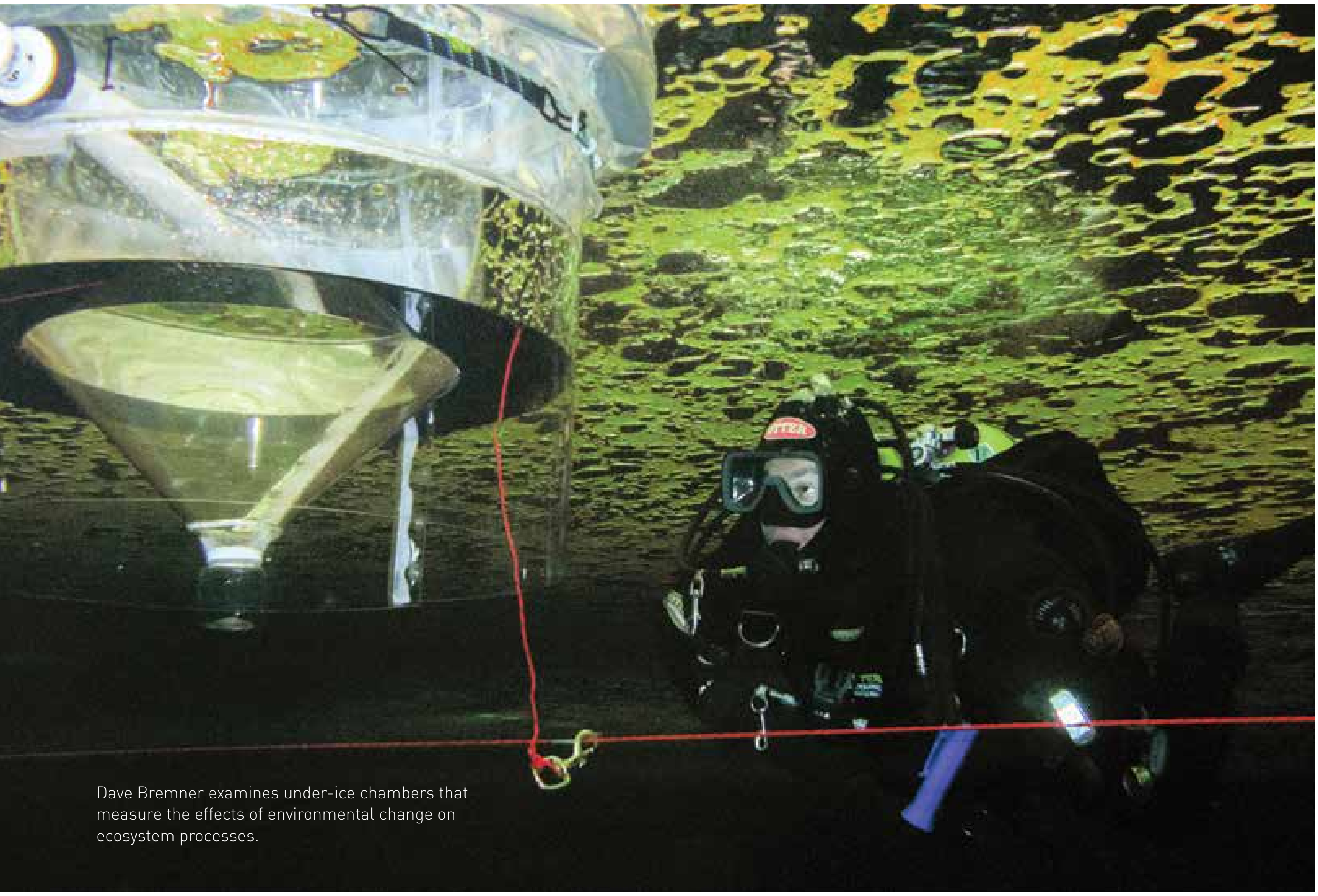

The Barne Glacier, Cape Evans.


Antarctica New Zealand field staff preparing dive holes at Cape Evans.


Odontaster validus in a feeding frenzy under on the sea floor.

Antarctic adventure

Cape Evans.



Dave Bremner examines under-ice chambers that measure the effects of environmental change on ecosystem processes.

Profile

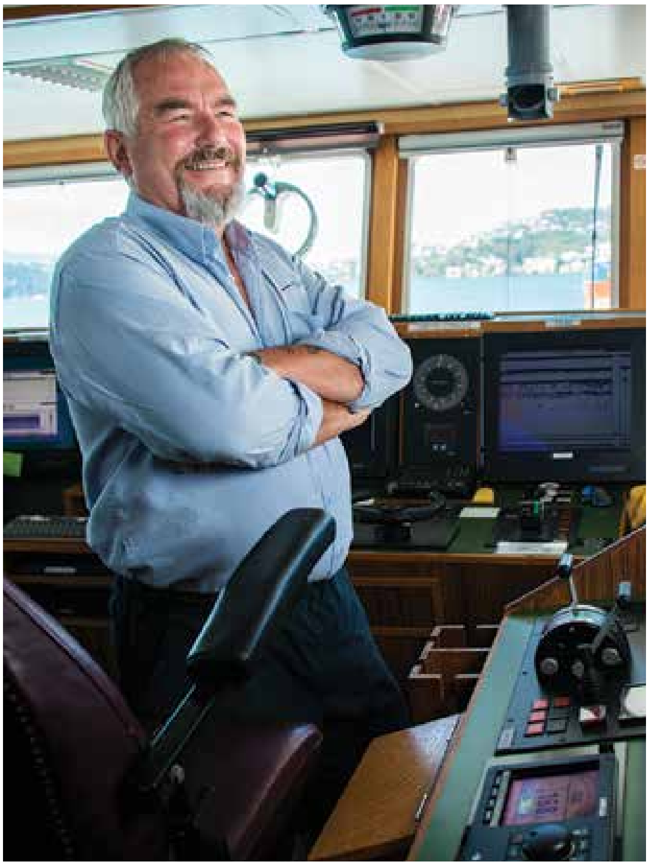
Bring me that horizon

After 23 years and an estimated 400,000km sailed on NIWA's flagship research vessel *Tangaroa*, Captain Evan Solly still relishes the prospect of each new voyage.

From the wide arc of RV *Tangaroa*'s bridge, Evan Solly has witnessed some incredible sights.

The genial Nelsonian was Leading Hand in 1991 when *Tangaroa*, pristine and state-of-the-art, left Norway and circled the globe to become the pride of New Zealand's fisheries research fleet.

In the years since, he's ventured from the sultry tropics to the heaving Southern Ocean. He sailed on NIWA's inaugural research voyage to Antarctica – an "amazing" experience – and has returned to the ice many times since. He helped oversee *Tangaroa*'s multi-million dollar refit in Singapore in 2010, and has circumnavigated New Zealand more times than he can remember.



Evan Solly and NIWA's research vessel *Tangaroa* have got to know each other pretty well. (*Dave Allen*)

All the while, he's observed and assisted the work of New Zealand's leading marine, fisheries and coastal scientists "from the most privileged perspective possible".

"It's a unique and amazing lifestyle," he admits. "Few other roles can compare."

Parallel courses

In many ways, Solly and *Tangaroa* have charted parallel courses since 1991.

Before *Tangaroa* was built, Solly spent his formative seafaring years on the Ministry of Agriculture and Fisheries' research vessel *James Cook*. But it was in the familiar surrounds of the NIWA flagship that he gained the skills, expertise and certifications needed to scale the ranks of Leading Hand, Third Mate, Second Mate, Mate and – since July 2012 – Master.

At the same time, *Tangaroa* has supported an increasingly diverse and complex range of research and commercial work. The introduction of new technology, like the DP2 dynamic positioning system fitted in Singapore, has also created new roles and challenges for the crew.

"My role has changed and grown as *Tangaroa*'s role has changed," Solly says. "I've had to stay familiar with the vessel and all her workings.

"Sometimes she'll still surprise me with something, but over the years we've got to know each other pretty well!"

Seafaring genes

Evan Solly was born into a family of seafarers. His father and grandfathers on both sides of the family made their living on the ocean.

"I was aware from an early age of the excitement – and the challenges – this lifestyle presents," he says. "It can be tough on family."

Most of the time, Solly says, he doesn't dwell on the risks associated with negotiating some of the most unforgiving waters on the planet: "I just plan for them."

"If you prepare well, if you make sure the vessel is well-maintained and ready, then *Tangaroa* makes you feel pretty safe out there.

"But," he admits, "when you're in Antarctic waters, where the weather can be horrendous for weeks on end, you become most aware of your isolation and vulnerability. You become aware of how far away from family and civilisation you are.

"Without the patient support, belief and understanding of my partner Sandi I could never have achieved what I have. It takes a special kind of person to handle the pressure this profession puts on a relationship. Sandi is absolutely amazing."

So what motivates Solly to remain at *Tangaroa*'s helm?

"Every voyage is different," he says. "Every journey gives me that sense of anticipation of something new to see and do.

"In the early days," he adds, "we were doing mainly fisheries research, and one voyage tended to blend into another. But as NIWA's science has expanded, *Tangaroa*'s workload and the environments we visit have diversified significantly.

"We're supporting different aspects of oceanography and geology; we're undertaking varied commercial work in some amazing places.

"I get such a unique perspective on the planet, particularly around the coastline of New Zealand. It's still my favourite part of the world. It's so lovely; so interesting."

He recalls a secondment to NIWA's coastal research vessel *Kaharoa* to help BBC and Discovery Channel TV crews capture images of giant squid, using a manned submersible vehicle.

"I was operating off the Kaikoura Coast at night, with dolphins swimming all around me. I remember thinking: it doesn't get much more special than this."

Solly maintains a keen interest in the science. An increasingly complex and demanding job means there's not as much time as there used to be to 'pick the brains' of the scientists on each voyage. "But the work they do is fascinating and so important. Each project offers special challenges to me as captain, and it's very satisfying to play my part in what they're trying to achieve."

The perfect foil

Off the water, family life in Nelson and the DIY demands of a 140-year-old house keep Solly well and truly occupied.

"It's the perfect foil," he says. "Apart from walks on the beach, I try to stay away from the sea as much as possible. The time I have between voyages is all about family, all about relationships.

"It allows me to keep the right perspective."

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:

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

NIWA employs approximately 600 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:

Sunrise over the central Pacific. (*Dave Allen*)

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