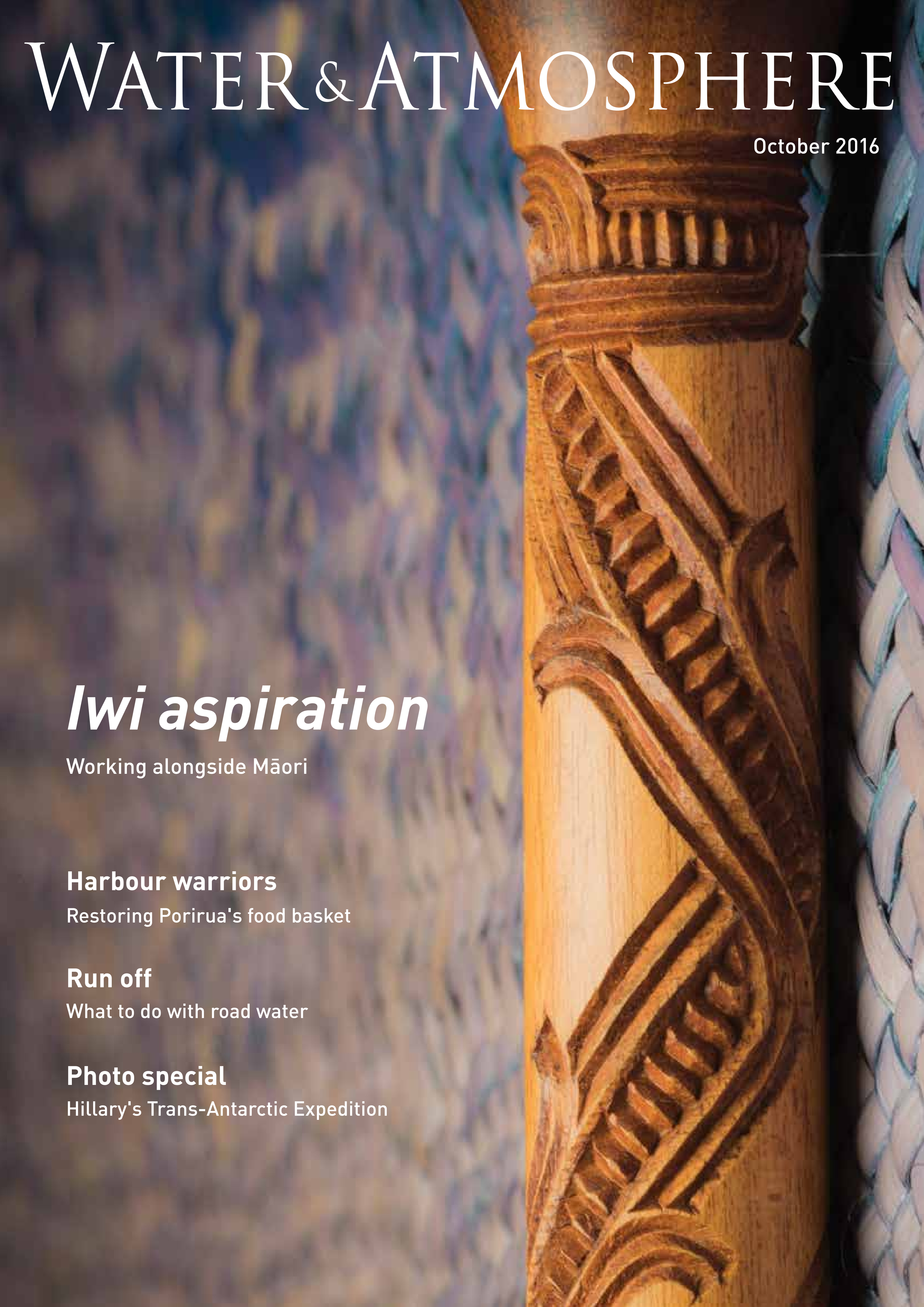

WATER & ATMOSPHERE

October 2016

Iwi aspiration

Working alongside Māori

Harbour warriors

Restoring Porirua's food basket

Run off

What to do with road water

Photo special

Hillary's Trans-Antarctic Expedition

WATER & ATMOSPHERE

October 2017

Cover: Te Kairangi

"Ka pūwaha te tai nei, hoea tahi tātou" – "When there is a break in the waves, we paddle together".

This work by weavers Kerewai Wanakore and Tineka Wanakore-Eruera, and carver Simon Madgwick hangs in the Board Room at NIWA's Greta Point campus in Wellington. (*Dave Allen*)

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NIWA
Taihoro Nukurangi

enhancing the benefits of
New Zealand's natural resources


shellfish gathering

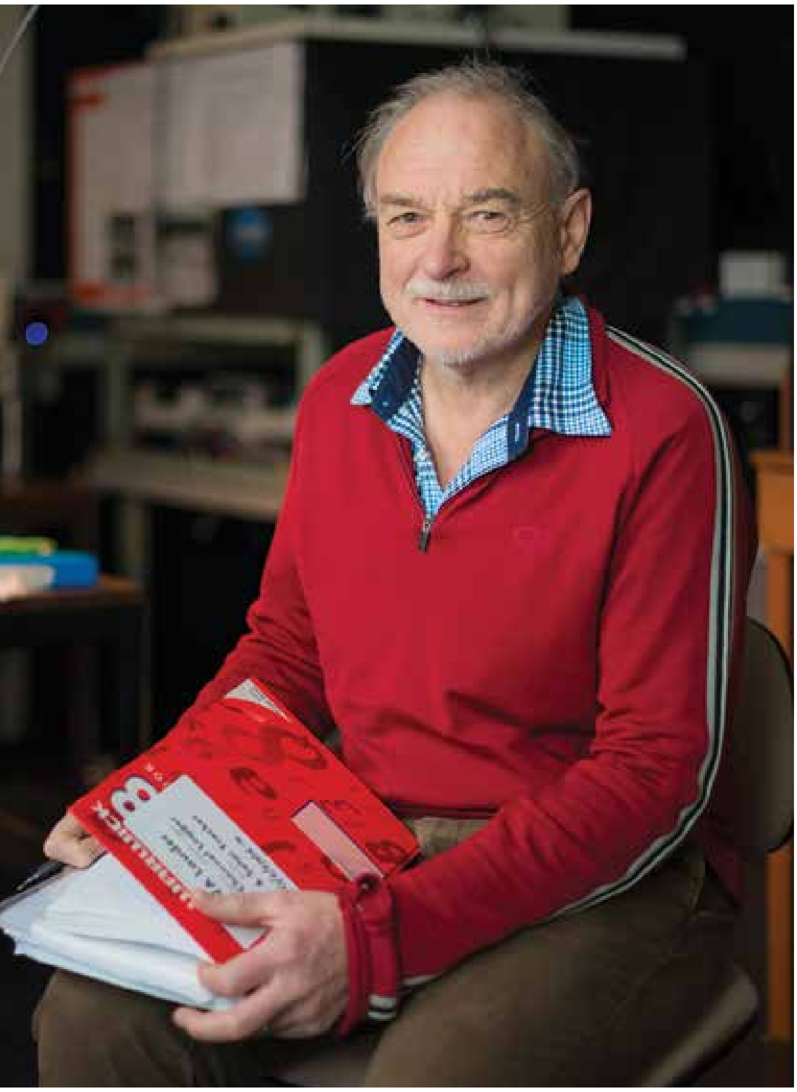
Skin cancer threat remains

An end to the Antarctic ozone hole is not the end of concern for UV-induced skin cancer in New Zealand, according to Ben Liley, atmospheric scientist at NIWA's Lauder Research Station.

"Many of us have the wrong skin type for living even at comparable northern latitudes in southern Europe or the US. We are at even greater risk in New Zealand, where UV intensity is 40 per cent higher," he says.

"The Antarctic ozone hole was only to blame for about three per cent of the difference."

Liley says about half the difference is due to the Earth's orbit and differences in ozone, both high in the atmosphere and near the surface, where it is a product of air pollution. The rest of the UV difference is the subject of ongoing research by NIWA at Lauder. It is expected to be some combination of the effects of cloud and aerosol – small particles from both natural processes and human activity.



NIWA atmospheric scientist, Ben Lily. (*Dave Allen*)

In July this year, research from the Massachusetts Institute of Technology (MIT) confirmed the Antarctic 'ozone hole' had shrunk by around 4.5 million km² over the past 15 years and is opening more slowly each year.

First author of the MIT report Susan Solomon has been a leading world authority on Antarctic ozone chemistry from the earliest days of the ozone hole. She was a visiting scientist at Lauder for some months in the early 1990s, and she has jointly authored more than a dozen refereed journal articles with Lauder scientists.

Liley says a generation of NIWA scientists contributed to research behind the historic announcement. In an early contribution to the international effort, NIWA's nitrogen dioxide (NO_2) measurements at Lauder debunked a theory that the ozone hole was caused by a natural cycle in NO_2 related to the sun-spot cycle.

The recent paper by Solomon and colleagues shows the continued importance of observations like those at Lauder. "Several statistical indicators of the Antarctic ozone since 2000 fall just short of the expected 95 per cent statistical proof, due to a Chilean volcanic eruption in 2015. Aerosol in the stratosphere from very powerful eruptions provides a reaction surface for the chemistry that destroys ozone."

A laser radar instrument at Lauder, operated in collaboration with Japanese colleagues, profiles the atmosphere to about 50 km altitude weekly. It provided excellent data on the Calbuco aerosol cloud, helping researchers to separate the impact of the volcano from other ozone chemistry.

Liley says the MIT announcement confirms a triumph of human collaboration to quell an environmental disaster of human making.

"The Montreal Protocol has been hugely successful. Its success is a testament to the collective efforts of all involved. Global collaboration has been required to measure ozone and a host of other trace gases of natural and human origin to both test the models directly and provide ground-truth for satellite-borne instruments."

"It provides a model and some hope for the global effort required to halt and if possible reverse anthropogenic global warming and all of its associated problems."

Liley points out that ozone affects the dynamics and photochemistry of the global atmosphere, so despite the end of the "ozone hole" its interplay with global warming justifies ongoing research.

Wellington is set to enjoy a warm spring, along with most of New Zealand. (*Dave Allen*)

Ready, set, go – it's time for a warm leap into spring

It's time to close the door on winter – spring has arrived bearing gifts of warm winds and sunshine. NIWA forecaster Ben Noll says subtropical winds flowing south from near New Caledonia made the start of the new season feel more like November or December.

Mr Noll said strong high pressure passing over the top and then northeast of New Zealand had drawn warmth southward. This pattern could repeat several times during the first half of September.

As a result, a couple of rounds of record-breaking maximum and minimum temperatures were possible, he said, with temperatures rising to between 5°C and 10°C above the average maximum daily temperature.

"Some places may approach 25°C as a classic foehn wind develops."

The warmer temperatures forecast for early September are caused in part by more sunshine. The sun's altitude at solar noon is higher in the sky than it was a bit over two months ago at the Winter Solstice, allowing for more direct solar radiation.

This type of weather pattern is typically one that brings mostly dry conditions to the east of the South Island, a region that continues to suffer from below normal rainfall and soil moisture. The warmer than usual weather may also contribute to some ski field snowmelt, especially at Mt Ruapehu; however, since many South Island fields have healthy snow bases, the effects there might not be quite so harsh.

Meanwhile, winter has left a trail of records in its wake and has certainly made its contribution to 2016 being the warmest on record in New Zealand for the first eight months of the year.

The highest winter temperature was 25.1°C, at Napier on 10 June. This was also the highest winter temperature ever for Napier. Gisborne also experienced its highest winter temperature on record with 23.2°C, also on 10 June.

Winter's lowest temperature was -17.8°C, at Takahe Valley (near Te Anau) on 7 August. Auckland's wettest June hour on record was between 1 pm and 2 pm on 29 June when 26.6 mm of rain bucketed down on the city.

Waipara West in the north of Canterbury was tracking toward its second driest winter on record with just 73mm of rain through to 28 August. This is 43 per cent of normal winter rainfall. And Timaru was tracking for its sunniest winter on record since 1930 with 510 hours through to 28 August.

In brief

Marine ecologist Dr Kim Goetz with one of six highly sensitive acoustic devices that have been deployed in and around Cook Strait. (*Dave Allen*)

Songs in the strait

NIWA marine ecologist Dr Kim Goetz is searching for the sounds made by marine mammals as they pass through Cook Strait.

Kim and her team have deployed six acoustic moorings to record the sounds made by whales and dolphins.

The moorings are made up of a string of hydrophones anchored to the sea floor. They will spend six months collecting acoustic data before being retrieved to download collected data and redeployed for a further six months.

"This has never been done this way in New Zealand. For me, as a biologist, it's exciting to answer some of these really basic questions," Dr Goetz says.

"More than half the world's whales and dolphins are found in New Zealand waters yet very little is known about their migration paths, their behaviour and where they go."

While NIWA is focusing mostly on whales, Dr Goetz said leopard seals from Antarctica have been seen in New Zealand recently.

"It would be great to hear them because they're very vocally unique."

Principal Scientist, Forecasting, Chris Brandolino. (*Dave Allen*)

Record year set to continue

Climate change, warmer sea temperatures and subtropical northerly winds have banded together to make 2016 the warmest year on record.

Temperatures from January to June this year were 1.3 degrees Celsius above average, making it the warmest first six months of the year to date.

The record temperatures were set to continue as NIWA forecasted a warmer-than-average winter.

Ocean temperatures have also been more than 1 degree Celsius higher than average in some areas since February, with the effects of this rolling into winter.

"Warmer seas around the country will push hotter, more humid air across most of the country," NIWA forecaster Chris Brandolino explained.

"This results in extra moisture and energy which could arrive in storms and extreme weather conditions."

From July to September, temperatures were 60-70 per cent likely to be higher than average. Seasonal rainfall totals are about equally likely to be near normal or above normal for all regions of New Zealand.

President of the New Zealand Marine Sciences Society, NIWA's Dr Helen Neil (left), with NIWA marine ecologist Dr Judi Hewitt. (*Dave Allen*)

Marine science success recognised

NIWA scientist Dr Judi Hewitt has been awarded the prestigious New Zealand Marine Sciences Society (NZMSS) Award.

Announced in July at the NZMSS conference, the award recognised Judi's international reputation as an outstanding leader in marine ecological field experiments.

Judi has published more than 130 peer-reviewed journal articles and is an editor for two international journals. She is best known for her skills in using advanced statistics to address challenging ecological questions.

Judi is in demand internationally and, in addition to science leadership roles at NIWA and with the Sustainable Seas National Science Challenge hosted by NIWA, she is also a professor of marine biology at the University of Helsinki.

The NZMSS said Judi was an excellent science communicator, delivering lectures and talks around New Zealand and overseas and was also an outstanding role model and mentor for young women in science.

Italian scientist Davide Di Blasi (left) and NIWA's Darren Stevens (right) on FV *Janas* during the mid-winter toothfish survey. (*Dawie Potgieter*)

Toothfish secrets uncovered

A winter fisheries survey of the Ross Sea has allowed scientists to collect Antarctic toothfish embryos for the first time.

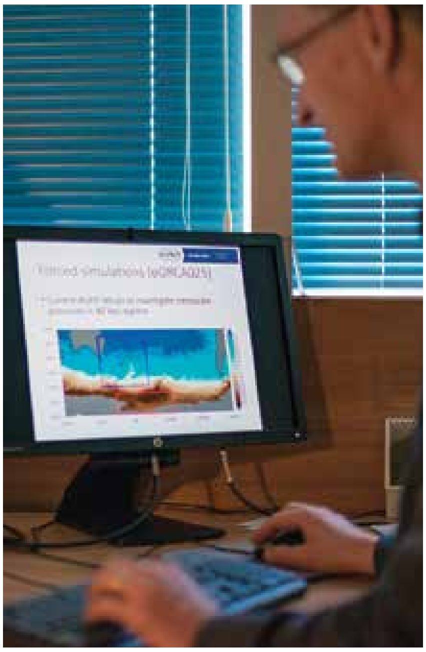
Working with the Italian National Programme of Antarctic Research on Talley's commercial fishing vessel *Janas*, NIWA scientists collected the embryos using plankton nets which can sample to depths of 500m.

NIWA fisheries scientist Dr Steve Parker said the discovery of developing toothfish embryos was important for several reasons.

"Finding them documents the spawning season of the fish, confirms some areas where spawning was suspected to occur, and, most importantly, provides information about the depth at which the drifting eggs reside in the water column."

NIWA has also fertilised eggs from captured adults, providing a known start time to observe developmental rate.

The information discovered will also be used to improve stock assessment and ecosystem models and advance management of the Ross Sea fishery.



NIWA leads a project simulating future climate in the Southern Hemisphere. (*Dave Allen*)

NIWA to test future climate simulations

The Deep South National Science Challenge has announced $1.5 million in funding for seven new scientific research projects. The projects will help New Zealanders better understand their future climate.

NIWA will take the lead on one of these projects, focusing on improving the simulation of stratospheric chemistry in the New Zealand Earth Systems Model.

Taking place over two years, the project looks at climate change in the Southern Hemisphere. NIWA scientists will simulate current climate and possible future climates under different scenarios of greenhouse gas emissions.

The research will allow scientists to improve climate models and further develop long-standing relationships with Australian colleagues also interested in climate-ozone links.

Funding for the New Zealand Earth Systems Model was announced in November. The model, once developed, will help advance understanding of Southern Hemisphere influences on the global climate.

The public can submit seaweed photos to the Nature Watch website. (*Dave Allen*)

Public to play scientist

Members of the public are turning their hand to science to learn more about the effects of pollution on seaweed.

NIWA has asked people to assist in collecting sample material for a study of seaweed. All they will need is access to the sea, a smartphone or a camera and computer.

Using the website Nature Watch, the public can submit photographs of seaweed and details of where and when it was found. The photographs can then be used as sample material for NIWA scientists to assess the impacts of pollution on seaweed.

NIWA is looking for photographs of large brown seaweeds and algae commonly found on New Zealand beaches. It is also searching for specific shots of the seaweed such as stems and reproductive structures.

Large brown seaweeds provide important coastal habitats, but in some parts of the world they seem to be declining. As they are difficult to press and preserve, they are not collected as often as smaller seaweed.

Panorama: John Morgan

When things change

When you've spent a long time viewing something a particular way, it's hard to recognise when it changes.

In this issue of *Water & Atmosphere*, Marino Tahi, NIWA's Māori strategy manager, says that Māori organisations have changed significantly – they have become very sophisticated in the way they merge their aspirations for Māori and environmental wellbeing with their commercial opportunities.

For some time now we have seen the sophistication in the critical role Māori play in the co-management of freshwater and the rehabilitation of lost or faded Māori values and ecosystems.

Tangata whenua are looking for constructive and proactive approaches that reflect iwi aspirations in matters such as freshwater management, and we're seeing challenges confronted and innovative solutions implemented.

This step change is palpable in the national strategies and commercial collaborations Māori are pulling together in red meat, fisheries, forestry, and manuka honey. These are being driven by Māori business networks such as the Federation of Māori Authorities (FOMA), Te Tumu Paeroa, Tuhono Whenua, and the Poutama Trust.

For Crown Research Institutes, the sophistication can be seen in Māori demand for multi-disciplinary science and advice to underpin strategic planning and investment decisions.

They want monitoring and data to aid planning and decision making that improves productivity, regulatory compliance, and the ability to meet market, shareholder and community expectations.

This demand poses an intriguing challenge for the science sector. We certainly have the expertise, but across the board there are too few Māori scientists who can work at the interface between Te Ao Māori and the science world. It's not enough to be well-intentioned. Māori want people who share their aspirations and values, and understand the Māori world view.

As well as understanding cultural and commercial imperatives, Māori and tribal development requires people skilled in sciences (biophysical/social), policy and planning, knowledge visualisation and data delivery.

NIWA's Māori development and engagement team – Te Kūwaha – does have critical mass and has a long-established reputation for working closely with iwi to incorporate science and mātauranga, and to help foster and develop young Māori scientists.

The 12-strong unit sees itself as science and commercial specialists who know how their Māori partners operate and think. They share the values of kotahitanga (partnership), manaakitanga (caring, hospitality), whānaungatanga (fostering relationships) and kaitiakitanga (stewardship or guardianship of the environment).

The team works with iwi and Māori businesses to maximise the value of their interests in agribusiness, fisheries, aquaculture and energy sectors.

When people change, you need to see the transformation before you can respond and change with them.

John Morgan is Chief Executive of NIWA

Collective value

NIWA is working alongside Māori to develop gateways to science and technology partnerships that are helping grow the Māori economy.

Dr Shannan Crow (left) and Dr Phil Jellyman (right) collecting longfin and shortfin eels in Lake Ellesmere/Te Waihora. (*Dave Allen*)

Collective value

For NIWA scientists two days spent on a course at Raglan recently ended up being as personally rewarding as it was professional.

At Raglan's Poihakena Marae, 26 staff were immersed in tikanga Māori, learning protocol, history and values that have added a depth of understanding that was previously elusive.

The course was run by the Te Kūwaha team, NIWA's 12-strong Māori environmental research group, with the aim of showing colleagues that a better understanding of the Māori world is not only an asset, but essential.

The scientists learned how to introduce themselves in Māori, including the reasoning behind the importance of including where they came from, and the value placed on personal connections, especially in business.

The course, said one participant, gave him a far greater understanding of where Māori were coming from and why they saw the world differently, and he now felt far more confident meeting groups he needed to deal with in his job.

Marino Tahi, who took over as manager of Te Kūwaha about 12 months ago, should allow himself a moment or two's satisfaction that the noho marae course was so well received.

But he is the first to acknowledge there is a long journey ahead. Right now, Te Kūwaha is in a rebuilding phase.

Since Tahi joined NIWA – after a decade as Māori partnerships manager at Landcare Research – he has embarked on a carefully planned strategic mission aimed at ensuring NIWA is properly positioned to work alongside Māori organisations as they build their assets, expertise and profit margins.

"Māoridom is very sophisticated these days," he says.

"NIWA is not the only game in town and we need to have scientists that straddle the Māori and Pakeha world. If Māori want a science provider, they need one that can understand their aspirations and work in partnership to bring knowledge systems together."

NIWA Manager of Māori Strategy and Engagement – Marino Tahi. (*Dave Allen*)

Understanding how the Māori economy works is fundamental to how well NIWA succeeds in this area.

Some basics:

- The Māori economy is worth about $40 billion annually.
- The growth rate of Māori trusts and tribal groups can be two to three times faster than similar Kiwi entities.
- In the primary sector Māori investment makes up 36 per cent of the forestry industry, 12 per cent of sheep and beef, 30 per cent of lamb production, 10 per cent of kiwifruit, 10 per cent of dairy production and 40 per cent of the fishing quota.

In other words, and as spelt out in a 2013 Te Puni Kōkiri report, the Māori economy is a significant and increasingly important contributor to the New Zealand economy. That report put its total value at $42.6 billion, up from $36.9 billion in 2010.

Chris McKenzie can reel off these figures without pause. He has been NIWA's Māori economy expert for about six months. A former political strategist for Māori Party leaders Tariana Turia and Te Ururoa Flavell, he was also chairman of central North Island iwi Raukawa, and has led treaty claim negotiations and built commercial companies.

He is also a gifted orator. At the noho marae course at Raglan, he had his audience spellbound as he told them the history of his tribe, Ngati Raukawa, their Treaty of Waitangi claims and settlement and subsequent economic development.

He says New Zealand is now witnessing a maturity within Māori enterprises in which land is more productive, businesses are turning a profit and growth rates are outstripping other organisations.

"Gone are the days when Māori organisations owned one farm. Most trusts now own three to five farms and are growing all the time – so we only do big now and we're very collaborative."

McKenzie acknowledges there are challenges working with Māori organisations, particularly in bridging the cultural divide, but he believes NIWA is well placed as long as it looks beyond one-off small projects and sees the value in working collectively.

Tahi also acknowledges the sophistication of Māori business, but cautions that NIWA is not the only player. "We have to define our point of difference in the Māori space."

Both men are keenly aware that growth in the Māori economy presents huge opportunities for NIWA.

"Every year as the tribal financial asset bases grow, some of that money is going into environmental projects. My point is that while Māoridom is a small part of the economy, the work

NIWA staff at Raglan's Poihakena Marae. (*NIWA*)

they are doing is increasingly in an area where NIWA has expertise," McKenzie says.

Fishing, farming and aquaculture offer huge potential for Māori; significant money has been invested by iwi and other Māori entities and is now at the stage where science and technology is needed to boost the level of productivity.

But what sounds like a perfect fit isn't quite that easy. McKenzie says Māori don't tend to shop around for support and will try to build capability internally where they can. He points out that a collective of Māori fishing companies frequently sends young Māori scientists to train in Japan.

That is partly why Tahi's strategy for Te Kūwaha places heavy emphasis on strengthening the quality of NIWA's relationships with Māori to ensure the work it does is "transformational rather than transactional."

"It's in the name itself," says Tahi. "It translates as 'the gateway' or portal – NIWA's portal into the Māori world. The reality is that Te Kūwaha relies on the wider organisation and its capabilities and likewise, the organisation relies on Te Kūwaha to achieve some of the Māori objectives in research programmes."

Te Kūwaha, along with iwi, share the values of kotahitanga (partnership), manaakitanga (caring, hospitality), whānaungatanga (fostering relationships) and kaitiakitanga (stewardship or guardianship of the environment).

The team, comprising programme leaders, researchers and support managers, leads Māori-centred research and its science staff also contribute to mainstream scientific research. Tahi says the team members see themselves as specialists who know how their audience operates and thinks.

"In the commercial sector NIWA has a strong presence, but in the tribal sector there are definite advantages to having a Māori shop window within the NIWA range of products."

Te Kūwaha's top priorities are strengthening relationships, building capability within the team, particularly in marine science, and enhancing bicultural development within NIWA. He has ambitious plans for the group, wanting to expand it to about 40 people, with a strong succession plan in place.

McKenzie also says there is a need for "expert navigators" who can steer the organisation through the Māori business environment.

"What is important for NIWA is not to get a navigator in when it's near crisis point. I think that ensuring everybody understands the specific needs of tribes is an issue with science in general. Strangely enough, although many entities are trying to make a dollar, sometimes that is not the overall priority.

"NIWA has a tendency for social good, good environmental outcomes and to an extent, commercial outcomes, but aligning the values correctly with Māori entities goes a long, long way I think.

"NIWA people are the absolute experts in their area, but if you go to see a Māori organisation you can't just go as the expert, you have to go open enough to understand where the organisation is going.

"If you crack that code you will enjoy a long-lasting and loyal relationship as they grow."

Warriors of the harbour

Just 20 minutes north of Wellington, where SH1 meets the coast, lies Te Awarua-o-Porirua Harbour, the largest estuary in the lower North Island. This network of inlets, wetlands and shell banks was once a rich food basket for local iwi Ngati Toa. Veronika Meduna reports that the iwi has now joined forces with councils and NIWA to restore the ecosystem to its former health.

Overlooking the glistening harbour from atop the Onepoto hills near his local marae, Ngati Toa kaumatua Taku Parai recalls how his people arrived and settled in the area.

Led by famed warrior Te Rauparaha, they had made their way south from Kawhia. When they reached the high ridge that frames the two arms of the Porirua Harbour, they saw a land of plenty.

"The harbour was our Countdown," says Taku Parai. "We used it as our food source. Shallow water food came from the inner harbour and the deeper food we wanted was out in Cook Strait."

He says his older brother, now 87, still remembers walking the hills that surround the harbour as a child to collect conger eels and kaimoana.

"The pipis used to be big and beautiful and the best in the country when I was a kid, and I just caught the tail end of that opportunity and ability to get food from the harbour."

"The harbour to me is a huge issue and I won't be satisfied until my grandchildren can go back to it and eat pipis" – Taku Parai. (*Dave Allen*)

Back in 1888, Ngati Toa had the foresight to write a letter to the colonial government, warning that the harbour's health would soon decline as more and more settlers were arriving. The iwi called for its protection in its pristine condition, but a decade later a hospital asylum was built, which resulted in waste being pumped into Porirua Stream.

"While we were gathering shellfish at this end, they were pushing it out into the harbour and our people started dying of typhoid," says Taku Parai.

Then, in the 1950s, road construction straightened some of the coastline and truckloads of rocks and debris were dumped across flounder beds.

"And, after the war, we needed people to help with the reindustrialisation of the country and housing was built in Porirua East. Where did they put the dirt from that reclamation? Into the harbour."

The continued degradation of the harbour and estuaries took away the integrity and mana of his people, he says. "The harbour to me is a huge issue and I won't be satisfied until my grandchildren can go back to it and eat pipis."

With ongoing changes in land use, which now include the construction of the four-lane Transmission Gully motorway, new residential housing and forestry plantations ready to be harvested in parts of the catchment, it was clear that there would be more impacts on the harbour and that something had to be done. To this end, back in 2012, Ngati Toa joined forces with three local authorities, NIWA and the community group Guardians of Pauatahanui Inlet to launch the joint Porirua Harbour and Catchment Strategy and Action Plan.

The aim is to implement a management plan for the harbour, and underpinning the endeavour is a robust science programme that addresses three major issues: sedimentation, pollution and habitat degradation.

A hand-coloured engraving by Samuel Brees shows Porirua Harbour as it was in 1847. (*Ref: E-070-011. Alexander Turnbull Library, Wellington, New Zealand*)

"The biggest issue is sedimentation. If we could tackle that, we would reduce pollution and improve success rates for habitat restoration projects," says Dr Megan Oliver, a senior environmental scientist at Greater Wellington Regional Council.

The two arms of Porirua Harbour – the Onepoto Arm and the Pauatahanui Inlet – are quite different systems. The Onepoto Arm has seen more development, while Pauatahanui Inlet is still convoluted, with stretches of natural coastline, but both parts have been receiving excess sediment from erosion-prone farmland, construction sites and forestry.

Pollution comes into the harbour as occasional sewer overflows and stormwater runoff in pipes and in the Onepoto Arm in particular, and littering can be an issue at the mouth of Porirua Stream.

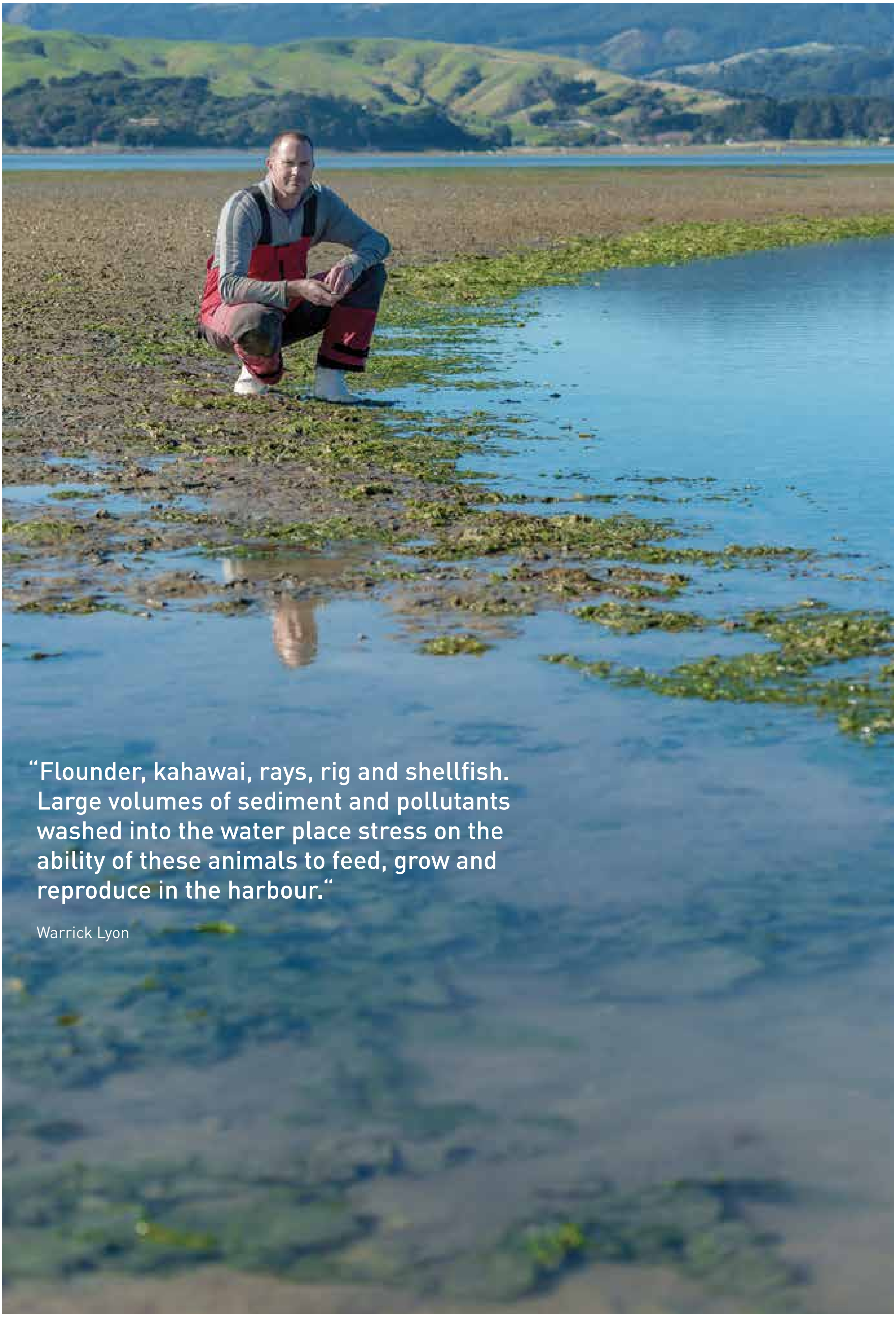
Research by NIWA and Greater Wellington shows the two estuaries don't share sediment flows and neither drains entirely during each tidal cycle, which means there are large subtidal areas and contaminants that are not completely flushed out. Contamination hotspots at the Porirua city's main outfall show levels of zinc, copper and lead that exceed guidelines in some areas.

To establish baselines for sediment flows and contamination, Greater Wellington has installed turbidity meters in the major streams that contribute most of the sediment, and, in 18 spots throughout the harbour, buried plates track the annual accumulation of mud and sand. Megan Oliver says the team can use this scientific evidence "to encourage local authorities to put stricter rules on developers and stormwater discharges".

Warrick Lyon, a NIWA fisheries technician who grew up in the area, says another good indicator of changing ecosystem health is the size of the cockle population in the harbour. Back in 1970s, the then Department of Science and Industrial Research carried out a survey of cockles in both arms and estimated that the intertidal population was well over 500 million. Almost two decades later, the Guardians of Pauatahanui Inlet organised the first recount, and by then the population had more than halved, reflecting a period with significant subdivision development on the inlet's shores. Since then, the cockle population has been on the increase again and surveys are carried out every three years to keep track of changes.

Apart from cockles, NIWA has been working with Ngati Toa to establish baseline data on other intertidal shellfish and fish species. The fish survey identified 21 species that live in the harbour or use it during certain times of the year. This list includes yellow-eyed and grey mullet, spotties, mottled triplefin, but also kawahai, flounders, eagle rays and rig.

"The biggest issue is sedimentation. If we could tackle that, we would reduce pollution and improve success rates for habitat restoration projects" – Megan Oliver, Greater Wellington Regional Council. (*Dave Allen*)



"Flounder, kahawai, rays, rig and shellfish. Large volumes of sediment and pollutants washed into the water place stress on the ability of these animals to feed, grow and reproduce in the harbour."

Warrick Lyon

"Porirua Harbour is an important estuary with habitats that are essential in the life history of many species," the survey found. "It is used in many different ways by many different species. Some species are year-round residents, such as kahawai that use the harbour until they reach maturity; sand flounder of all sizes that leave only to spawn; and mottled triplefins whose entire life is spent in the harbour."

Rig come into Porirua Harbour to mate and to have pups. These small sharks are a commercial species known as lemonfish, and they are often what you eat when you have fish-and-chips.

Warrick Lyon has managed to track rig during one summer, using an especially designed floating GPS tracking system, and he says the two estuaries are an important nursery for their young.

NIWA's work was set up to build capacity and to encourage members of Ngati Toa to continue the surveys and the work to restore habitat. The earlier surveys from the 1970s found a rich diversity, with "huge schools of grey mullet", but during the housing development along the inlet, average sedimentation rates reached between 8.5mm and 15mm per year.

"The pre-European background rate is less than 1mm per year," says Megan Oliver.

However, ongoing surveys, including regular bathymetry and fine-scale monitoring of the seafloor, suggest that Porirua Harbour is improving. One example of what can be achieved lies at the far end of the Pauatahanui Inlet, where a bird-rich saltmarsh has replaced what was once paddocks and a go-kart track.

To complement the strategy, Greater Wellington has established the Te Awarua-o-Porirua Whaitua, which represents the entire catchment area. Warrick Lyon is a Whaitua committee member and describes the process as collaborative and consensual, with the goal of developing regulatory and non-regulatory proposals for land and water management and to set objectives and limits on what can be taken from or discharged into the Porirua Harbour waterways.

NIWA urban aquatic scientist Jonathan Moores and aquatic chemist Dr Jennifer Gadd are also involved in the Te Awarua-o-Porirua Whaitua process with the "Modelling Leadership Group". This multi-disciplinary group of seven researchers from throughout New Zealand is contracted by Greater Wellington to organise modelling to support the Whaitua Committee in its decision making.

Moores' involvement is to provide expertise in modelling the effects of urban development, with Gadd providing expertise in Bayesian Network modelling. A Bayesian Network is being de veloped for this process which will allow an assessment of the effects of different management methods and development scenarios on water quality and ecological attributes. This work will feed into social, economic and cultural assessments, to enable a holistic assessment of the effects of policies that the Whaitua Committee recommends.

A public health warning in Pauatahunui Inlet. (*Dave Allen*)

The Bayesian Network model will build on previous models developed in the MBIE-funded programme "Resilient Urban Futures" to predict the effects of urban development on freshwater quality and ecology.

Running off the road

[Dave Allen]

Running off the road

At a rough count, 700 million litres of rain runs off the nation's roads every year. That's enough water to fill almost 300 Olympic-sized pools.

But it's not necessarily water you'd want to fill a pool with. In places, it is contaminated by toxicants such as fuels, additives, oil, and brake and tyre residues.

The areas that receive this road runoff vary widely. Even where stormwater pipes and ditches are built alongside roads, road runoff sooner or later ends up in streams, rivers, lakes, wetlands, estuaries, harbours and coastline.

Jonathan Moores, an Urban Aquatic Scientist with NIWA, explains that the key threat is where road runoff delivers high levels of contaminants to sensitive water bodies.

"Runoff can be a threat to water bodies because of short-term elevated levels of toxicants in water and their long-term accumulation in sediment."

"So we need to know where road runoff presents the greatest risks of these short- and long-term effects. We can then target those places with improved stormwater management and treatment."

Moores says investigations of the effects of runoff had previously tried to understand the level and type of contaminants produced from roads.

"Until now we've not really had a tool for assessing its effects on receiving environments. We've needed a way of understanding both the local and more far-reaching effects of road runoff."

Regional councils are beginning to move toward risk-based stormwater consenting regimes, in support of the Government's National Policy Statement for Freshwater Management 2014.

Without a way of knowing what impacts runoff has after it is channelled off the road, road-builders may be required by regulatory authorities to over-engineer or even under-engineer solutions.

That's why the New Zealand Transport Agency (NZTA) wants to know more about the conditions in which stormwater runoff from roads could harm the environment. NZTA is responsible for all state highways, as well as providing guidance for road operations by local councils.

Armed with information about the estimated contaminant load of runoff, and local topography and waterways, road designers can decide the best sort of drainage to install.

To estimate the effect of runoff from particular stretches of road, the Agency had previously developed a model called the Vehicle Kilometres Travelled (VKT) screening tool. The tool focused on the 'downstream' effect – how much contaminant would make it to estuaries and coasts – and used VKT as a surrogate measure for contamination.

Motorways can contaminate large volumes of water, polluting New Zealand's aquatic environment. (*Dave Allen*)

"High concentrations of toxins can affect plant and animal life where road runoff doesn't move away quickly"
– Jonathan Moores, Urban Aquatic Scientist. (*Stu Mackay*)

NZTA contracted NIWA and MWH Global, an engineering consultancy, to make the model also applicable to rivers and streams and to use estimates of contaminant levels, rather than VKT, as the basis of the risk assessment.

Carol Bannock, environmental specialist at NZTA, said the project involved a number of significant tasks so that effects on both freshwater and coastal waterbodies could be assessed.

"We need a robust, consistent method for establishing the relative risk of adverse effects from road runoff that can be applied anywhere in New Zealand using existing datasets."

That meant crafting the tool to also calculate contaminant loads from sources other than roads in built-up urban environments.

"It required factoring in the effects of pathway attenuation, traffic congestion and non-road pollution sources."

Moores explains that a significant component of urban runoff is copper and zinc from roofs and building materials, as well as road-related sources such as car brake linings and tyre wear.

"Copper and zinc are important, both in their own right as ecotoxicants, but also as indicators of wider contamination of water bodies from other stormwater-related contaminants."

Copper is about 5 to 10 times more toxic to aquatic life than zinc, but road runoff generally contains something like five times as much as zinc as copper. The zinc to copper ratio can be even higher than this in stormwater from other urban land uses. Previous studies have found sediments in urban Auckland estuaries containing 12 to 35 parts per million of copper and 60 to 220 parts per million of zinc. Marine life begins to be affected at concentrations of 34 and 150 parts per million, for copper and zinc respectively.

Moores says the tool aims to take into account the cumulative effect of contaminants rather than zinc or copper in isolation.

"A key assumption of the method is that elevated concentrations of copper and zinc together can be more harmful than one in the absence of the other."

While NZTA's intention was to improve the screening method for road networks, a secondary objective was to describe ways in which the method could be extended to provide for an absolute risk assessment in relation to established effects thresholds.

The resulting tool is valuable for what Moores describes as its "relative assessment scale".

"We can pinpoint those areas most sensitive to the contaminated water running off nearby roads. This is where the risk is greatest, based on the characteristics of both the runoff from the road and the characteristics of the receiving environment.

"High risk discharges are red-flagged, taking into account the sensitivity of the environment and the levels of contaminants in the discharge from the road."

The model does that by estimating in-stream copper and zinc concentrations relative to guideline safety concentrations. It matches those against the sensitivity of the receiving environment, which is based on existing modelled values of a macroinvertebrate community index.

The model contains a number of linked modules and runs in readily available software platforms (Excel and ArcGIS). Input data includes river flow estimates, assessments of estuary deposition rates, land use information, road traffic data and road drainage design details.

The tool can produce hotspot maps, showing the relative risk across sub-catchments. Users of the tool can then drill in to look at the road network within a given sub-catchment to look for the roads which generate the highest contaminant loads.

Where the tool signals that road runoff presents a risk to receiving water bodies, Bannock says road drainage can be designed, or retrofitted, with stormwater treatment systems.

"Stormwater treatment devices include engineered ponds and wetlands that allow the contaminants to settle out and systems such as raingardens, swales and media filters that remove contaminants by filtration," she says.

Bannock says the study has been very successful, and is likely to play an increasing part in road management.

"It will be used to inform road operation and maintenance contracts, efficient application of stormwater management and treatment on road improvement projects, and development of regional plans and resource consent conditions.

"Other applications include a 'drill down' facility to screen the road network for contaminated load 'hot spots' and apportioning contaminant loads between local roads and state highways. Even better, it can analyse catchments to identify which roads and urban areas are most troublesome."

Porirua testbed

The new model was tested around Porirua Harbour, on the west coast of Wellington. According to Bannock, the diverse road and land mix of the area made it a good testing ground, being similar to many other New Zealand catchments.

"The Te Awarua-o-Porirua Harbour and its catchment comprises a 178 square kilometres mix of local roads and state highways that discharge to streams of varying dilution potential."

Critically, it also includes the coastal waterbodies of Pauatahanui Inlet and Onepoto Arm.

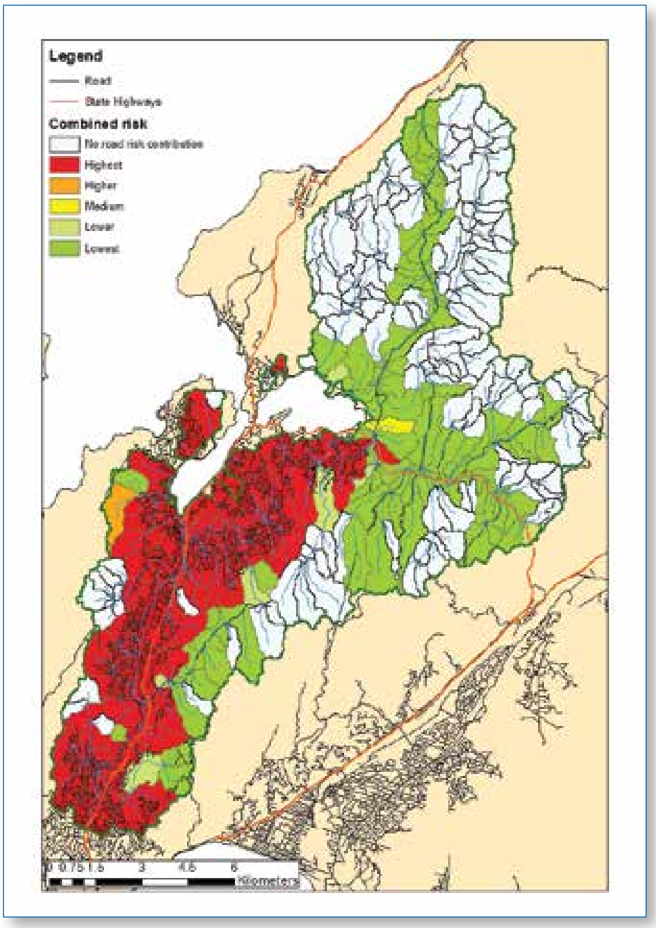
"The sub-catchments of these two waterbodies contain markedly different urban/rural land use (with Onepoto more urbanised), allowing for model evaluation under widely different catchment conditions."

The Porirua test revealed that the model could be used to analyse whole catchments for road contaminant contributions.

The NIWA and MWH team worked to extract, collate and quality check input data from a range of sources. These included GIS and Asset Management files on the water bodies, roads and land use of the case study area.

The model projected contaminant levels across the region's waterways, which were then compared with the results of council monitoring. The research team found that the actual contaminant levels corresponded closely to the levels predicted by the model.

The tool produced maps showing the risk assessment of zinc and copper in streams within reach of runoff from the road and urban contaminant sources [see graphic below]. It also produced risk assessment maps for discharge points to the harbour.



The study produced maps showing the combined risk posed to sub-catchments in Porirua by runoff from roads and urban areas. (*NIWA*)

Stormwater treatment devices include engineered ponds and wetlands that allow the contaminants to settle out. (*Peter Mitchell, NZTA*)

The model showed that 36 stream reaches were 'highest risk' based on consideration of road runoff alone; 103 stream reaches were 'highest risk' based on consideration of urban (non-road) runoff alone; and 107 stream reaches were 'highest risk' based on consideration of road and urban runoff combined.

Flow-on effects

NZTA's next step is to make the model user-friendly and then encourage its use by local authorities, road builders and others interested in waterway health.

"We'll test the model on a number of actual road improvement projects, and tweak it following feedback and lessons learned from end users," Bannock says.

"Once we've worked through these steps, the aim is to promote its widespread use as a screening tool in road projects."

Working on water

The New Zealand Transport Agency has produced a more accurate tool to help design the best sort of stormwater treatment based on measures of how runoff could harm the environment.

The new tool adapts the previous estuaries and coast risk model so it is applicable to rivers and streams. This new estimate of contaminant levels is now the basis of the road runoff risk assessment.

Where the tool signals that road runoff presents a risk to receiving water bodies, road drainage can be designed, or retrofitted, with treatment systems such as engineered ponds and wetlands and systems such as swales and media filters.

The new tool will also inform road operation and maintenance contracts, road improvement projects, and regional plans and resource consent conditions.

The long and short of it

New research tests the air to estimate the carbon sink potential of forests and landscapes. It reveals that the ability of New Zealand's land biosphere to absorb carbon could be 50 per cent more than currently estimated.

[Dave Allen]

The long and the short of it

About half of all the carbon dioxide that has been emitted to the atmosphere from human activities over the last few decades has been absorbed by Earth's oceans and land biosphere. These carbon sinks have dramatically slowed climate change compared to what we would have experienced without them.

Despite the importance of carbon sinks in slowing climate change and meeting our international treaty obligations, we don't yet have a solid sense of how much carbon dioxide is absorbed by forests, soils, pasture and other land areas.

The amount of carbon absorbed by our forests is currently determined by measurements of live trees and dead wood made at a national network of forest plots, which are scaled up to the national level using modelling techniques. This approach is powerful in that it allows a clean separation between different types of land use. Yet there is considerable uncertainty associated with upscaling measurements at sample plots to the national level, and many processes that are not explicitly measured may be missed.

Forests planted since 1990 are counted as carbon credits in international climate treaties. Forest carbon uptake is particularly vital to New Zealand's emissions targets, offsetting just over 30 per cent of our emissions in 2014 according to estimates from the Ministry for the Environment.

Scientists and policymakers are keen to improve the data and models on which the estimates are based. Atmospheric observations could be the key to validating and improving these estimates.

Sniffing the air

An alternate 'inverse' approach is being applied for the first time in New Zealand to refine estimates of carbon uptake. As air passes over our landscape, the amount of carbon dioxide in the air goes up or down due to carbon exchange with the underlying land.

It is possible to estimate the total amount of carbon that has been absorbed or emitted by combining atmospheric carbon dioxide measurements from a network of sites around New Zealand with atmospheric models that describe the pathway of air arriving at the sites.

NIWA researcher Dr Sara Mikaloff-Fletcher is using this approach to estimate our national carbon sinks. A core-funded project analysed data collected by NIWA's three national atmospheric carbon dioxide monitoring stations, looking for telltale changes in atmospheric carbon dioxide.

"The inverse modelling technique is like smelling an amazing BBQ somewhere in your neighbourhood. If you sniff the air in a few different places, and notice the direction the wind is blowing from at each spot, you'll probably be able to work out where the BBQ is."

"A network of atmospheric monitoring sites 'sniff' for changes in atmospheric carbon dioxide and atmospheric models to work out which direction the wind was blowing when each measurement was taken. These pieces of information can be combined to work out the carbon uptake from different regions around New Zealand needed to match the data."

An atmospheric model is run backwards in time to understand what parts of New Zealand the air passed over before it arrived at the station.

Mikaloff-Fletcher explains: "For each measurement being used in the inverse model, we release 1,000 particles at the site and run the model backwards in time for four days. This tells us all of the different ways air might have travelled to the observing site at that particular measurement time."

This research also integrates land model simulations produced by GNS Science, and observations of sea surface carbon dioxide, to provide a 'first guess' about what the air-land and air-sea exchange.

"The inverse approach integrates information about carbon dioxide sources and sinks from atmospheric data, ocean data and models."

The results are reported in a research paper submitted to *Atmospheric Chemistry and Physics,* "Atmospheric CO_2 observations and models suggest strong carbon uptake by forests in New Zealand".

Bigger than it looks

The most stunning discovery is that the carbon carrying capacity of New Zealand's landscape could be much greater than expected from the national inventory report or the land model used in the study.

On the annual scale, the terrestrial biosphere in New Zealand is estimated to be a net CO_2 sink, removing 98 (±37) teragrams (Tg) CO_2 per year (a teragram is one million metric tons) from the atmosphere on average during 2011–13. This sink is much larger than the reported 27 Tg CO_2 per year from the national inventory for the same time period.

Mikaloff-Fletcher says the team can partially reconcile the difference by factoring in forest and agricultural management and exports, fossil fuel emission estimates, hydrologic fluxes and soil carbon change.

"But there are still a lot of processes that may not be captured by the national inventory report."

"The results suggest that indigenous forests on the South Island may be a much more vigorous carbon sink than previously thought. Uptake by grasslands, hill country, and soils may also play a key role."

"The research suggests surprisingly high photosynthetic and respiratory activity in western regions of the South Island that are covered by indigenous forest." – Sara Mikaloff-Fletcher. (*Dave Allen*)

"The inverse model reveals strong terrestrial land fluxes from the South Island of New Zealand, especially in western regions covered by indigenous forest, suggesting a surprisingly high carbon uptake there."

"There might be some unique terrestrial processes happening inside the Fiordland forest that we don't yet know about," she says.

What next?

The Intergovernmental Panel on Climate Change recommends using inverse methods to refine and compliment carbon sink calculations from the national inventory reporting done by the Ministry for the Environment. New Zealand has a natural advantage for the application of these techniques.

"By the time air reaches New Zealand it is well mixed and contains very little influence from other countries," Mikaloff-Fletcher says.

Now the proof of concept has been piloted, Mikaloff-Fletcher is planning a range of sophisticated improvements.

"We need two things to give New Zealanders policy-relevant information about our carbon sinks; better information about where and why our forests and land areas are absorbing so much carbon dioxide, and less uncertainty in the inverse estimates.

"The former is particularly important, since that's where we might be able to give real advice about how land management decisions could impact on climate and treaty obligations."

The initial study was based on only two observing sites; Baring Head, near Wellington, and Lauder in Cental Otago.

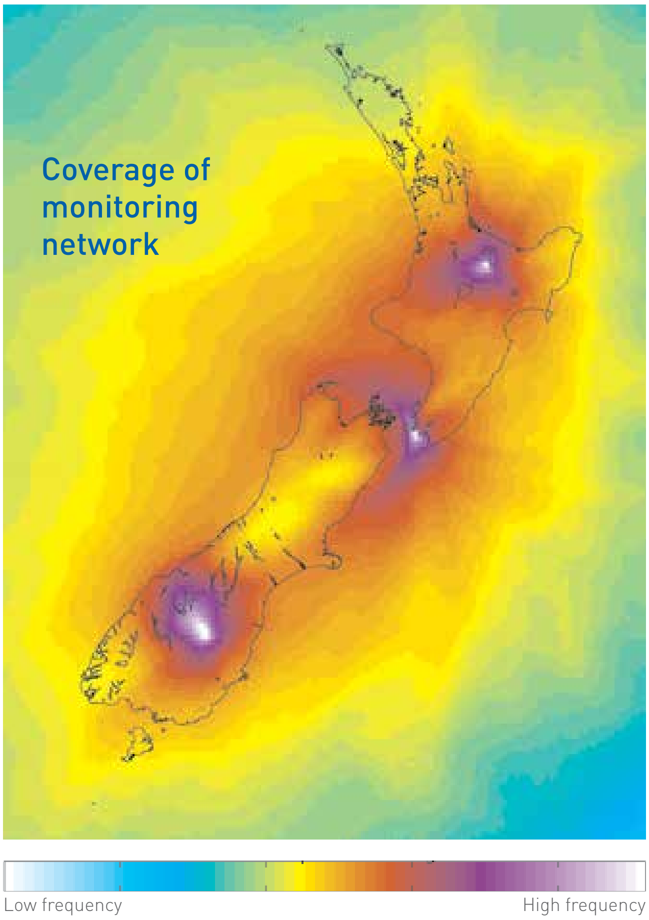
"Even from these two sites, it is possible to observe much of New Zealand, because we have measured carbon dioxide there continuously for years and because the winds are always changing. This afternoon, our Lauder station might be seeing signals from Fiordland, but tomorrow it could be telling us something about the Canterbury Plains."

How much is green?

It's estimated that natural and planted forest covers about 37 per cent of New Zealand's land area.

Indigenous forests cover approximately 6.2 million hectares. Scrublands cover 2.7 million hectares.

The combined area of indigenous forest and scrub covers more than five times the area that is under plantation forest, and contains a significant stock of carbon locked up in trees, understory, forest floor and soil.



This map shows how well CO_2 emitted or absorbed by different parts of New Zealand can be detected by our three observing stations. Colours indicate frequency with which CO_2 from the originating location is observed by one or more of the three stations. (*NIWA*)

Vegetation survey

The National Vegetation Survey Databank (NVS) records over 94,000 vegetation survey plots. This provides a 50-year record of indigenous and exotic plants across New Zealand habitats, particularly native forest and grasslands.

The data has been used to meet reporting requirements for the Convention on Biological Diversity, Framework Convention on Climate Change, and Resource Management Act. It has also been used to assess the impacts of climate change on indigenous ecosystems, the storage of carbon in indigenous ecosystems, and setting restoration goals in degraded areas.

The New Zealand Forest Service, Department of Lands & Survey, and the DSIR Botany Division conducted the original surveys. On-going surveys and research by the Department of Conservation, regional councils, universities, private consultants and Landcare Research are continually providing new data to NVS.

However, with just two sites, Mikaloff Fletcher says they can only reliably estimate the total carbon uptake from relatively large spatial regions.

"We have already established a new carbon dioxide observing site at Rainbow Mountain, near Rotorua, and the measurement record there is long enough that we can begin using it in the inversion later this year.

"Our first analysis of the Rainbow Mountain data suggests that it has an exciting story to tell us about forest carbon uptake in the central North Island."

Mikaloff-Fletcher hopes to deploy at least two more atmospheric sensing sites. The white space in the graphic on the left indicates the regions not currently being 'sensed' by the three existing stations. The expanded national carbon dioxide observing network will improve ability to pinpoint sink locations and reduce uncertainty in estimates.

"The next step will be to improve the resolution of the meteorology we use to drive the model, which will dramatically reduce the uncertainty of our estimates. This is particularly important for New Zealand, because of the way the winds interact with our complex topography.

"All this doesn't amount to much without building close links to New Zealand's land carbon uptake community. The inverse method's strength is also its weakness. The atmosphere records total carbon exchange, so all processes are captured.

"It is very difficult to isolate processes using this technique, which you need in order to understand what the results mean for land and carbon management decisions and treaty obligations. We work with land modellers and the carbon accounting community, and these collaborations need to strengthen if we are to understand why New Zealand is absorbing so much carbon."

What a difference research makes

News that our carbon sink could be bigger than estimated is significant information for those discussing climate change policy and negotiating international agreements.

Mikaloff-Fletcher's long-term work will provide more accurate assessments of the importance of non-Kyoto factors in determining our contribution to climate change, and perhaps to our targets.

She warns that the first study produced a carbon-carrying capacity bigger than expected.

"It's produced results that are bigger than we expected, and with less certainty than we need. While that suggests the current models could be improved, our techniques need improving as well."

"The research report has stirred a lot of interest among scientists and policymakers. Everyone has an interest in being more accurate about the role of landscape in the carbon cycle."

It's estimated that natural and planted forest covers about 37 per cent of New Zealand's land area. Indigenous forests cover approximately 6.2 million hectares. Scrublands cover 2.7 million hectares. (*Dave Allen*)

Counting trees

To determine carbon stocks in forestland and change in those stocks over time, the Ministry for the Environment uses inventory-based methods, and conversion equations and models.

About one hundred standard-sized sampling areas (forest plots) are located on a sampling grid set across forestland. The plots are permanent and monitored over time.

Measurements are taken of both living trees and dead wood, along with other plot specific data. Allometric equations and modelling techniques are used in the calculations for the amount of carbon held in natural and planted forests respectively.

New Zealand has estimated the carbon carrying capacity of forests with the help of an airborne remote sensing technology called LiDAR. The tool measures distance and surface properties of targets by illuminating them with a laser and recording the reflections. Analysis of the data allows researchers to estimate the forest structure and ground elevation.

Forests are complex three-dimensional structures containing large variations in the amount, orientation, distribution and clumping of vegetative tissues and non-vegetative elements. That means the complex interaction of LiDAR's electromagnetic radiation with vegetation canopies needs to be unscrambled with the assistance of other statistical techniques.

New Zealand's LiDAR data is made up of 70m-wide sweeps across forests established before and after the crucial Kyoto 1989/1990 creation dates. The measurements were taken in 2008 and 2010. Ground-based sampling updates growth rates.


EXPEDITION

Antarctic wintering over

Science runs in the family for NIWA hydrologist Roddy Henderson. Scott Base was just two years old in 1958 when Roddy's father Bob Henderson wintered over, working as a technician for the Department of Scientific and Industrial Research (DSIR).

With camera in hand Bob witnessed the triumphant arrival of Sir Edmund Hillary and Dr Vivian Fuchs' Trans-Antarctic Expedition, the significant US presence in the area, and spectacular Antarctic wildlife, at a time when getting about by dog sled was the most common form of transport on the ice.

Bob Henderson on a sledge, exercising the dogs.

The Commonwealth-sponsored Trans-Antarctic Expedition arrives at Scott Base marking the first overland crossing of Antarctica, via the South Pole, on 2 March 1958.

Antarctic wintering over

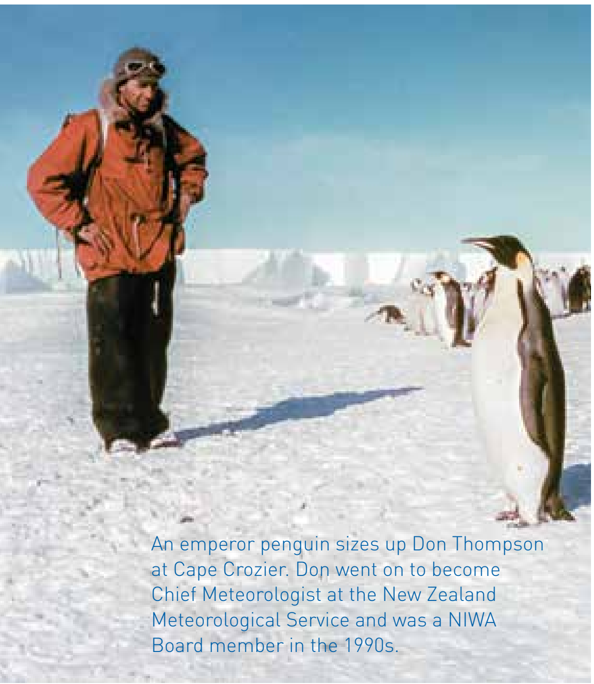
Scott Base with various buildings painted yellow as it was in 1958. In 1965 a decision was made to repaint the base to be "more in keeping with the image of the New Zealand landscape" – green, specifically British Standard BS670.

The 1958 wintering over party including Buzz Burrows (technician), Les Duff (mechanic), Franco Faggioni (Italian scientist), Mike Gibson (radio technician), Bob Henderson (technician), Lin Martin (team leader), Graeme Midwinter (scientist), Murray Robb (diesel engineer), Maurice Speary (cook), Don Thompson (senior scientist), and Peter Yeates (radio officer). (*Photographer unknown*)

During the Antarctic summer US Air Force Globemasters ferry supplies and people to and from McMurdo Station.

Antarctic wintering over

Once a familiar site on Antarctic ice, by 1994 all huskies were removed from the continent and replaced by motor vehicles.



An emperor penguin sizes up Don Thompson at Cape Crozier. Don went on to become Chief Meteorologist at the New Zealand Meteorological Service and was a NIWA Board member in the 1990s.

Built mainly of wood, but strengthened for work in sea ice, HMNZS *Endeavour* was used as a support vessel for the Trans-Antarctic Expedition and scientific operations at Scott Base.

Two killer whales pop up for air, capturing the attention of a photographer.

Roddy Henderson, wearing a 60-year-old fur-lined oilskin jacket, holds a photo of his Dad relaxing at the newly constructed Scott Base. (*Dave Allen*)

Q&A

You don't know jack about frost

Beautiful, bracing and occasionally bothersome – it's the time of year when Jack Frost pays New Zealand a visit. NIWA climate scientist Gregor Macara gives us the cold, hard facts about frost.

What causes frosts?

Frost occurs when the ground surface and air temperature falls below freezing (0°C). Water vapour in the air deposits on to the ground surface and freezes, covering the ground surface in feathery ice crystals we associate with frosts.

Are there different types of frost and do they vary?

There are two types of frost recorded. Air frosts occur when the air temperature measured by a thermometer in a screen 1.3 metres above the ground falls below 0°C. Ground frosts are recorded when the air temperature 2.5 cm above a closely cut grass surface falls to -1.0°C or lower. Both types of frosts are common in many areas of New Zealand.

Are there optimal conditions for frost?

A combination of cloudless skies and light winds provides the ideal conditions for frost to occur. We typically observe these conditions in conjunction when an anticyclone (high pressure system) is situated over the country. Clear skies enhance the rate of radiative cooling that occurs. Or, thought of another way, clouds act like a blanket, trapping heat near the earth surface at night. The second key factor is light winds, which reduce the amount of turbulent mixing of the air. Cold air is relatively dense, so when there is a lack of turbulent mixing it tends to sink towards the earth surface. As a result, areas most likely to experience frost are flat areas, where cold air is unable to drain away on calm nights, and in inland valleys and basins, where cold air pools after descending from mountainous areas nearby.

What time of the year is frost most likely to occur?

Frosts occur most frequently in winter, and the "frostiest" month of the year is typically July. This is primarily due to two reasons. Firstly, air temperatures are lowest at this time of year. Secondly, the nights are longest at this time of year, which lengthens the period of time that radiative cooling can occur.

Gregor Macara, NIWA climate scientist. (*Dave Allen*)

In New Zealand, what places are most affected by frost?

Central Otago and the Mackenzie Basin observe the most frosts. Frosts can occur throughout New Zealand. However, as a general rule of thumb, frosts occur with increasing frequency as you move south and further from the coast.

Has NIWA detected any trends or variances in frost in New Zealand?

From 1972 to 2008 frost frequency across New Zealand as a whole was found to have decreased, which is consistent with increasing global temperatures that have been observed during that time. However, there was some interesting regional variability, with an increase in frost observed in parts of the Wairarapa, and the eastern South Island from the southern Canterbury Plains down to South Otago. Over the coming century, we can expect frost frequency to decrease in all areas of the country due to the further increase in temperatures that are predicted. The decrease will be most notable in inland areas of the South Island, where the current frost frequency is relatively high. In contrast, this change won't be particularly notable in Northland and Auckland, which already receive very few frosts.

Frost can impact on the primary sector – what specific crops and operations in New Zealand are most at risk from frost?

Orchards and vineyards can be susceptible to frost, particularly early in the growing season.

What can be done to combat the effects of frost?

Given that frost forms when winds are light, reducing turbulent mixing and enabling cold, dense air to "pool" at the ground surface, this can be combatted by introducing turbulent mixing of the air. This can achieved using wind turbines, or even bringing in helicopters to fly overhead (the rotor-wash breaks up the cold air pool). Another method is spraying trees or vines with water, which coats the surface of the vegetation in ice. This may seem counter-intuitive, but when water turns to ice it releases latent heat, and additionally the ice coating provides insulation from the colder surrounding air temperatures.

Does NIWA have any tools or services available to help in the management of frost?

Our *EcoConnect* desktop client can be used to access temperature observations and forecasts, and it has an alerting facility where a user-defined temperature threshold can be established. For example, an alert is sent when the temperature at a chosen location is forecast to fall below 0°C. In addition, NIWA is developing a decision support tool aimed at enhancing operational and environmental decision making in the viticulture sector.

Profile

Considered in collaboration

Marino Tahi is a man who speaks volumes between sentences.

If he knows the commanding effect of the long pauses he takes before answering a question, he shows little sign. Direct a question at him and he will look at you, flex his facial muscles, shift in his chair and think.

You are best to wait, and to watch. What seems to be going on is a furious internal debate about what, and how much to say that will result in the most meaningful response.

The reward for his consideration is to be let in on a carefully constructed and thought-provoking conversation with someone who is spearheading something of a revolution at NIWA.

Those who know him well remark on the huge advances he has made since he first arrived at his Hamilton base a little over 12 months ago.

He is the head of Te Kūwaha, NIWA's Māori environmental research team, a role he says is not the easiest to explain.

"On the one hand it's about developing sustainable relationships and growing capability, on the other it's about crystallising research opportunities, I suppose. Then at an organisational level it's about developing an approach to position NIWA to be the trusted partner for Māori in the Māori development space."

Te Kūwaha is unique as a team dedicated to helping Māori communities by providing the latest scientific knowledge and tools so they can manage their natural resources.

Fundamental to Te Kūwaha is partnership and collaboration with Māori – and a determination to ensure that the skills needed within NIWA to achieve this grow alongside an awareness of tikanga and te reo.

"The way I see it, there are two types of projects at NIWA. We've got a mainstream research project that looks for a Māori add-on, an end user – and Māori don't have any sort of role in that research other than to be someone who might be interested in the results alongside every other end user out there."

"At the other end of the spectrum we have research that has been co-developed, that is Māori-centric and has a strong element of them driving, contributing and participating in the research. That's the space Te Kūwaha is in."

It is fair to say that Te Kūwaha has made huge strides in the past year. Tahi is making things happen, say his colleagues – a clear Māori strategy has been established, core funding has increased, staff with extensive experience working with Māori organisations have come on board, cultural-development programmes rejuvenated, and in the large, complex organisation that NIWA undoubtedly is, there is a sense among Te Kūwaha staff that they are becoming a lot more visible.

Tahi, predictably, has a different take.

"Collaboration is key. If you enable and empower your people to succeed, then the team will succeed, and if the team succeeds then the organisation succeeds."

This is a principle embodied in the broader Māori value of whanuangatanga that includes family connections and a sense of belonging. It was whanaungatanga that surrounded Tahi as he grew up. Family, and in particular his grandparents who adopted him as a baby, remain the greatest influence on his life.

Tahi is 43 and Tuhoe, affiliated to hapu Te Urerewa, Tamakimoana, Te Paenga, Ngati Rongo, and Ngati Kuri. The small town of Ruatahuna in the heart of Te Urerewa is his home. Ruatahuna is two hours' drive to Rotorua, twice that to Gisborne and best known for its association with influential Māori spiritual leaders Te Kooti and Rua Kenana. And as the hometown of the great Māori singer Prince Tui Teka.

"It's a small community, everyone knows everyone. It's very strong on whanau-based and hapu-based values, and back when I was young, we didn't have technology so basically we made our own fun – eeling, hunting, staying out in the bush, horse riding, all that."

Tahi, like most children from Ruatahuna, went to boarding school for his secondary education and from there to university.

"This is the dream job – developing opportunities for Māori" – Marino Tahi. (*Dave Allen*)

"My grandparents expected I would go. To be fair they wanted me to get out of the bush, so as to speak, get an education and see the wider world. They saw that as important because there was no employment future for young people in Ruatahuna at the time."

So Tahi enrolled at Victoria University in Wellington and studied commerce and Māori. After graduating he moved to Rotorua, working for Skills NZ as a contract manager and from there back to Wellington to work for Te Puni Kōkiri as a policy analyst. He discovered a passion for Māori business development in a stint at New Zealand Trade and Enterprise, using that experience to set up his own consulting business working with iwi, government and the private sector to engage and deliver services in the Māori development space.

"At the time the treaty settlement process was in full swing, assets were being returned to tribes and there was a big focus on managing those assets for the benefit of their people. There were some big players coming through and the Māori economy was starting to take off."

Before working at NIWA, Tahi spent a decade at Landcare Research in Palmerston North as its Māori partnerships manager, getting more involved in Māori economic development and the research needed to drive it forward.

Then he decided he needed a change – NIWA provided him the opportunity to help shape the company's future while helping iwi build their capabilities and achieve.

"Science enabling Māori development is an exciting area to be in and essentially this is the dream job – developing opportunities for Māori and getting paid to do it."

Tahi is at his most passionate explaining the satisfaction he derives from his work in helping others, and at his most reticent when asked what he does outside work.

But with a hint of a smile he replies: "In my time off I like to go back to Ruatahuna, catch up with whanau, go hunting and tramping up the Whakatane River to one of my marae in the bush. Otherwise I spend my weekends here in Hamilton kicking back on the couch. I know a lot of people do a lot of active stuff like biking and things like that, and good on them."

Solutions

SHMAK packs a wallop for stream health

With freshwater quality an issue of public environmental concern in New Zealand, NIWA continues to spearhead the citizen science movement with a kit that helps communities take a leading role in looking after the country's streams.

NIWA's Stream Health Monitoring Assessment Kit (SHMAK) gives land owners, iwi, school and community groups simple, scientifically-sound tools and resources required to monitor the ecological health of New Zealand's streams.

SHMAK enables community volunteers to assess ecological condition based on benthic (stream-bed dwelling) algae and macro-invertebrate animal life. It provides guidance on assessing the condition of channels, riparian zones and catchments as a whole, as well as measuring a range of important water-quality indicators.

While SHMAK does not replace more formal methods of stream health monitoring, it encourages participation and awareness in stream management.

NIWA Freshwater Ecology Technician Aslan Wright-Stow says SHMAK was developed to provide methods for monitoring that enabled community and farm groups to collect data on stream health and water quality.

"The development recognised an increasing public awareness of environmental impacts and desire to know the condition of their local waterways, and what could be done to help restore them."

Originally released in 1998, NIWA has continued to develop and upgrade SHMAK's functionality and ease-of-use.

"The kit was designed to enable the public to collect scientifically robust data using the same or similar methods to those used by professionals," says Mr Wright-Stow.

"It's been designed to simplify these techniques without losing too much information or relying on expensive gear – that is, remain affordable for community groups. In contrast to some other community monitoring tools, the kit has been designed for use without direct supervision by people with a broad range of backgrounds, and works in streams from the top to the bottom of the country.

"Interestingly, innovative methods developed for measuring visual water clarity in SHMAK have now been adopted by professional monitors for more accurately measuring very dirty water, and in a much safer way – a reverse of the technology transfer we usually expect."

Mawaihakona Stream, Silver Stream Restoration Group, Lower Hutt, Wellington. (*Allan Sheppard*)

Being able to demonstrate that restoration work is having a positive effect on a stream has a variety of ecological, social and financial benefits.

"Community groups are encouraged to keep working, new members join, friends are made and environmental knowledge is shared, and funders are more likely to continue to contribute if they can see investments have been worthwhile. Also, monitoring enables readjustment or retrofitting of restoration methods if there are some aspects of the stream that are not improving."

NIWA has also upgraded SHMAK to include a strong focus on the principles of Māori scientific research and to recognise the pivotal role of iwi in manawhenua, manamoana and kaitiakitanga.

SHMAK has helped foster partnerships, understanding and action across stakeholder groups that are ultimately beneficial to all, says Mr Wright-Stow.

"One example is from the Waitao Valley, near Tauranga, where the findings of SHMAK monitoring, and the threat of a landfill within the catchment, brought residents together to protect their stream from contaminants and led to the formation of the Waitao-Kaiate Environmental Group. The group successfully stopped the landfill and continued the fencing and planting started at the bottom of the valley by local hapu.

"Using SHMAK, local kaitiaki were able to show the high quality of water at the top of the catchment, and have been able to show the improvements that stock exclusion and planting has had further down in the catchment, and thus help convince other landowners of the importance of protecting their waterways.

"Similarly, locals near Kaikohe in Northland used SHMAK to monitor the condition of the Utakura River that flows from Lake Omapere following concerns of deteriorating water quality in the lake. The monitoring has been used by Te Roopū Taiao o Utakura marae to help inform a restoration strategy to improve conditions of both the river and lake above."

While SHMAK is already driving positive results at a community level and proving an invaluable tool for monitoring stream health, NIWA is continuing to improve it in line with growing public interest in the water quality of New Zealand's streams.

"Advances in technology, particularly with respect to water quality testing, and a better knowledge of what user groups want and need from the kit, means we'll be upgrading SHMAK again starting early in 2017," says Mr Wright-Stow.

"The upgraded kit will include better data entry and management tools, improved identification guides, more accurate assessment of visual water clarity and a brand new technique for measuring faecal bacteria indicators – the latter two giving community groups the ability to accurately assess swimmability."

For more information about SHMAK go to:
www.niwa.co.nz/freshwater/tools/shmak

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Back cover:

Lake Pukaki. (*Dave Allen*)

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