JUNE 2019

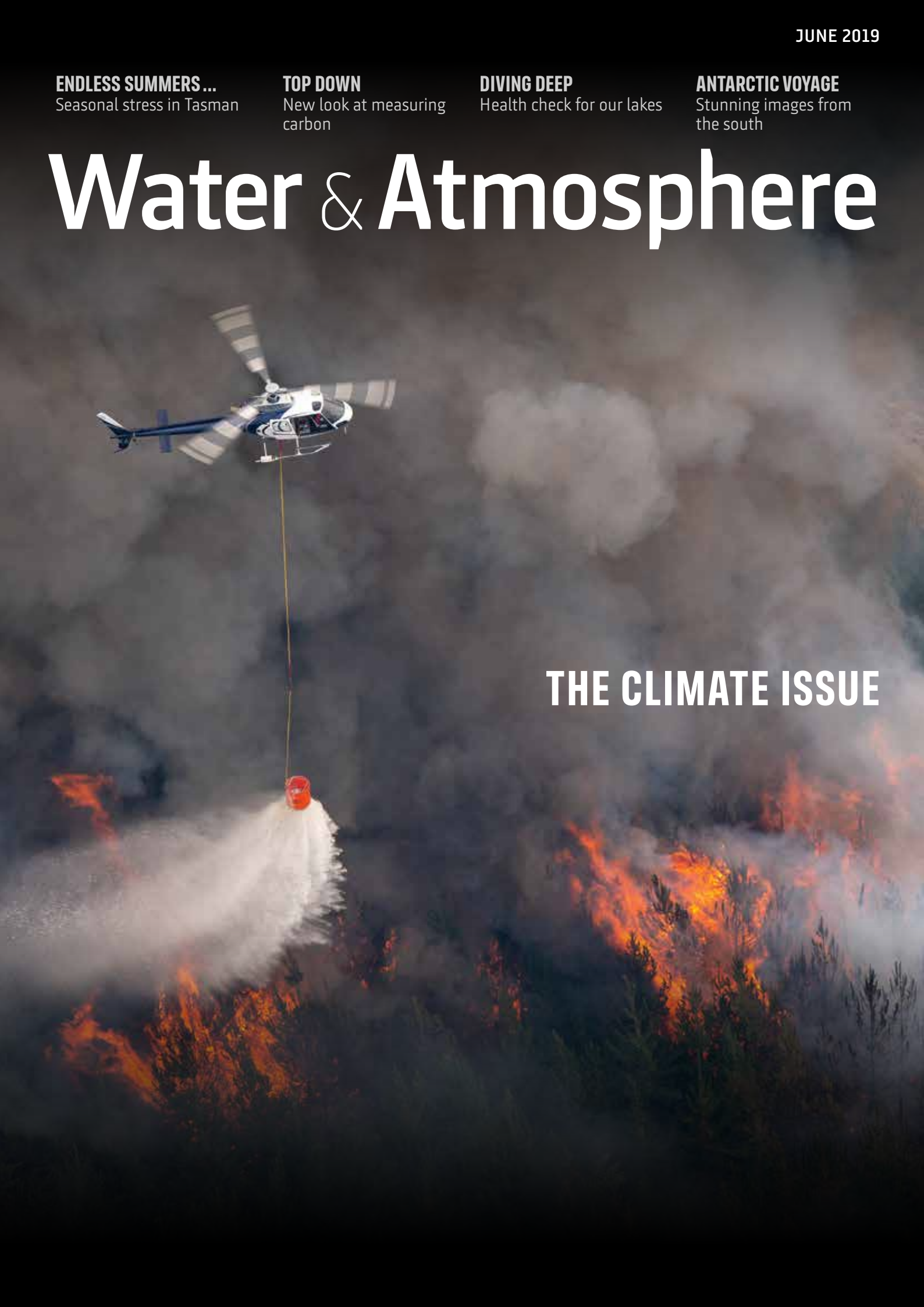
ENDLESS SUMMERS ...
Seasonal stress in Tasman

TOP DOWN
New look at measuring carbon

DIVING DEEP
Health check for our lakes

ANTARCTIC VOYAGE
Stunning images from the south

Water & Atmosphere



THE CLIMATE ISSUE

Water & Atmosphere

June 2019

Water & Atmosphere is published by NIWA.
It is available online at www.niwa.co.nz/pubs/wa

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ISSN 1172-1014

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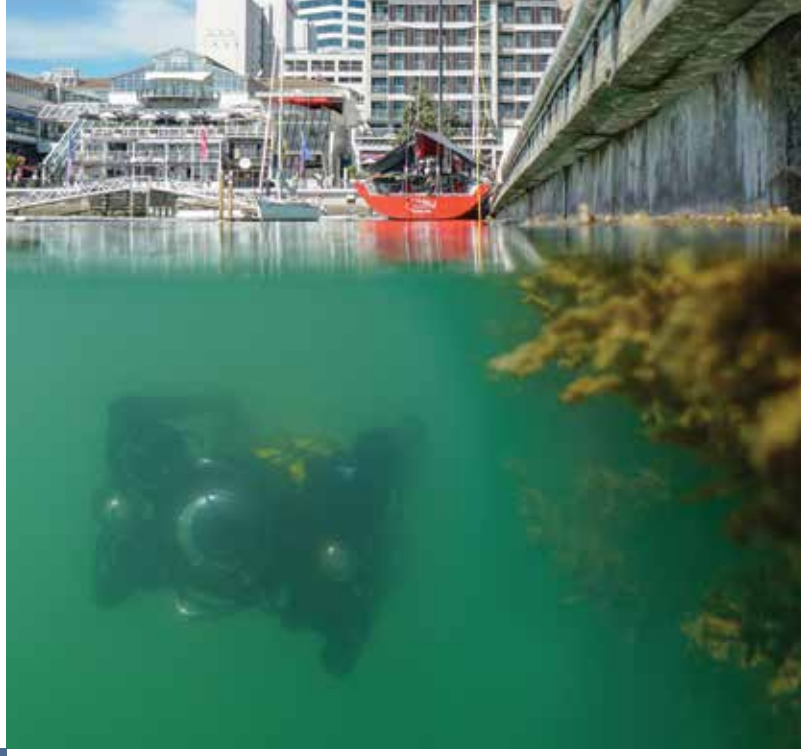
Water & Atmosphere is produced using vegetable-based inks on paper made from FSC certifed mixed-source fibres under the ISO 14001 environmental management system.

NIWA
Taihoro Nukurangi

Cover: One of 23 helicopters battling to control the flames sweeping through tinder-dry forests in Pigeon Valley, near Nelson, in February. The region went 71 days without significant rain. (*Ned Dawson*)

Stuff

CONTENTS



Time for bold actions guided by science

New Zealanders are fast becoming aware that our changing climate matters a great deal. NIWA Chief Executive John Morgan explains.

The Waiho Bridge near Franz Josef – swept away during March's West Coast deluge. (*Stuff*)

The flames fueled by Nelson's summer drought, and the bridges wrecked by March's record-breaking downpour on the West Coast, speak for themselves.

It is also sobering to read the latest report from NIWA's sea-level experts, who are projecting a potential $38 billion bill for commercial and residential building owners from a one metre rise in our coastal waters.

As a nation we are currently grappling with the actions we will need to take to curb the greenhouse gas emissions that are fueling this change in our atmosphere and oceans.

> **"Science has already prompted political action, and science is the pathway to solutions"**

The Zero Carbon Bill has set out clear emissions targets for 2050, but it will take bold and confident decision making by our political leaders to enact the practical measures that will get us there.

Difficult decisions lie ahead, but I am confident that – guided by science – New Zealand can reach those targets. Science has already prompted political action, and science is the pathway to solutions.

NIWA's core purpose embraces climate change research and advice, so we have a pivotal role to play in answering New Zealand's climate challenge.

This month we are gathering together decision makers from across the public and private sectors to help shape the science and the information they will need to meet their own climate challenges.

NIWA is well placed to respond. Our recent $20 million investment in New Zealand's High Performance Computing Facility and our work, in partnership with the Deep South National Science Challenge, on the Earth System Model puts NIWA at the forefront of global climate modeling capability.

Our climate scientists already deliver detailed regional climate projections stretching out into the next century. These, along with services such as the NIWA/GNS Science RiskScape hazard analysis tool, empower local communities and businesses to build resilience to future climate risks such as flooding, fires or sea-level rise.

NIWA researchers are also pioneering the greenhouse gas monitoring research that New Zealand requires to accurately track our carbon balance and deliver on our Zero Carbon goals.

Last year NIWA was awarded $11 million from MBIE's Endeavour Fund to develop CarbonWatchNZ. This internationally significant carbon monitoring collaboration – involving NIWA, GNS Science, Manaaki Whenua, Auckland Council and the University of Waikato – will track New Zealand's progress in cutting greenhouse gases. Equally important, it will provide the data New Zealanders need to make the right decisions on how to curb carbon emissions.

New Zealand needs to act decisively if we are to take effective actions to curb the greenhouse gases driving our changing climate and to adapt to our changing environment.

NIWA is committed to working alongside New Zealand communities and businesses to deliver the innovative and resolute science they need to underpin those decisions.

IN BRIEF

NIWA CEO John Morgan, left, seals the deal with Emirates Team New Zealand head Grant Dalton. (*Stuart Mackay*)

NIWA signs with Team NZ

Emirates Team New Zealand has welcomed NIWA onboard to provide marine dynamics and high resolution forecasting expertise for the 36th defence of the America's Cup in Auckland in 2021.

Under an agreement signed last month, NIWA scientists and forecasters will work closely with the cup defence team over the next two years to provide technical information for the design of the new AC75 racing yacht as well as vital race-day forecasting services.

NIWA's Maui supercomputer – the largest in New Zealand – will help in providing high performance analysis of ocean currents and detailed course forecasts.

Chief Executive John Morgan says he is delighted to see NIWA's scientific expertise joining Emirates Team New Zealand's campaign to defend the Auld Mug.

Leopard seal scat goes global

In February this year, a USB stick was extracted from a leopard seal poo sample – known scientifically as scat.

The scat had been stored in a NIWA freezer for almost a year.

Scat can tell NIWA researchers what these endangered Antarctic predators are eating, how healthy they are and how long they may have been in New Zealand waters.

Remarkably, the USB stick not only worked, but also contained detailed footage of sea lions playing in The Catlins.

NIWA shared the footage online and in the media in a bid to track down the owner of the USB stick and find out more about the leopard seal's movements.

The story went viral, with the video viewed over a million times on Twitter and the unusual discovery covered by media agencies worldwide.

The owner of the USB stick was also quickly tracked down.

Dave Allen

Stuart Mackay

Bring in the robots

NIWA scientists are pioneering new underwater drones to help inspections for introduced species in ports and harbours around New Zealand. Invasive species can easily attach themselves to foreign vessels and enter our waters undetected. NIWA is contracted by the Ministry for Primary Industries to check the country's high-risk ports or harbours for unwanted marine guests.

Murky, cramped conditions make some checks dangerous for divers, so NIWA is testing underwater drone cameras, called remote operated vehicles (ROVs), to bolster marine surveillance operations.

IN BRIEF

NIWA dives deep with James Cameron

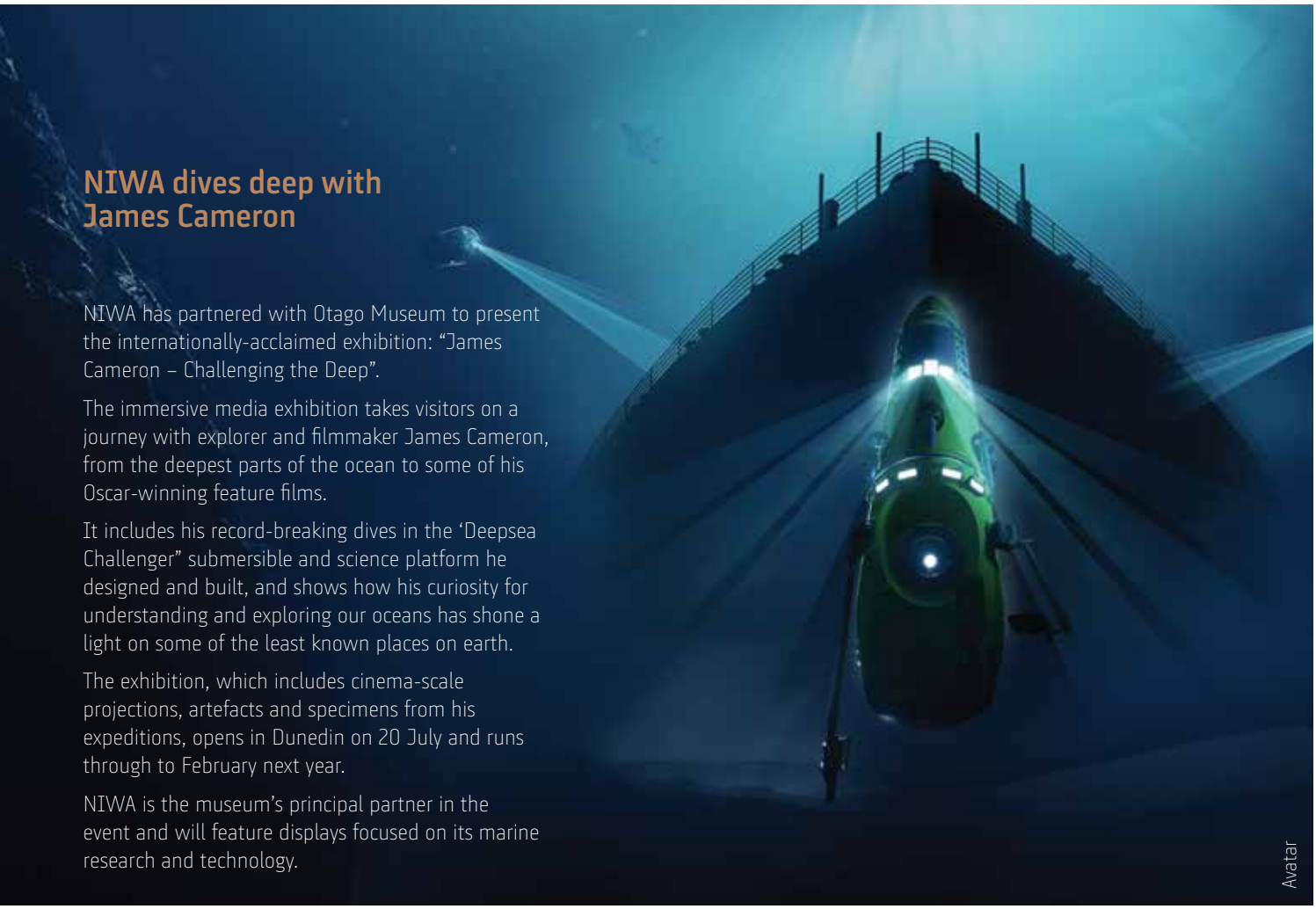
NIWA has partnered with Otago Museum to present the internationally-acclaimed exhibition: "James Cameron – Challenging the Deep".

The immersive media exhibition takes visitors on a journey with explorer and filmmaker James Cameron, from the deepest parts of the ocean to some of his Oscar-winning feature films.

It includes his record-breaking dives in the 'Deepsea Challenger" submersible and science platform he designed and built, and shows how his curiosity for understanding and exploring our oceans has shone a light on some of the least known places on earth.

The exhibition, which includes cinema-scale projections, artefacts and specimens from his expeditions, opens in Dunedin on 20 July and runs through to February next year.

NIWA is the museum's principal partner in the event and will feature displays focused on its marine research and technology.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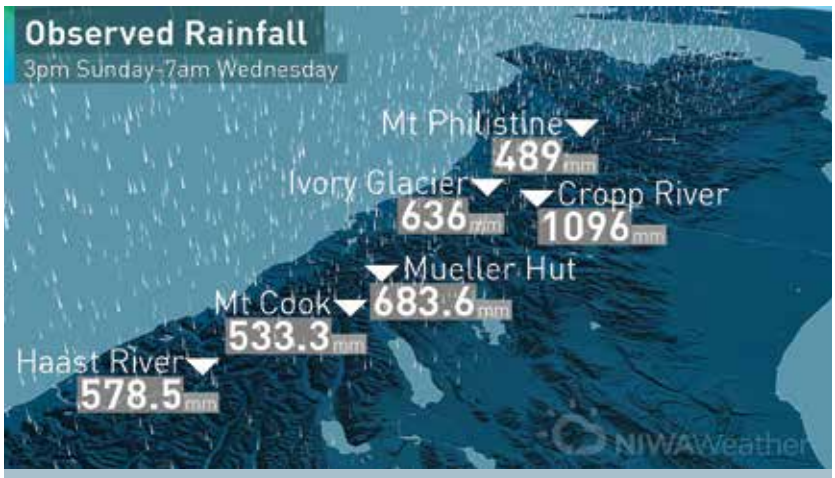


Coast rains supreme

On 26 March, a state of emergency was declared in Westland as torrential rainfall and strong winds battered the region.

NIWA recorded 1086mm of rain in 48 hours at the Cropp Waterfall weather station, near Hokitika – a new national record for rainfall measured over a two-day period. The deluge that hit the Coast over that 48-hour period delivered just under the total rain Auckland averages over a full year.

Forecasters say the intense downpour was caused by a potent mix of an atmospheric river streaming south west from Australian cyclones, fuelled by extra energy from the Tasman Sea marine heatwave.

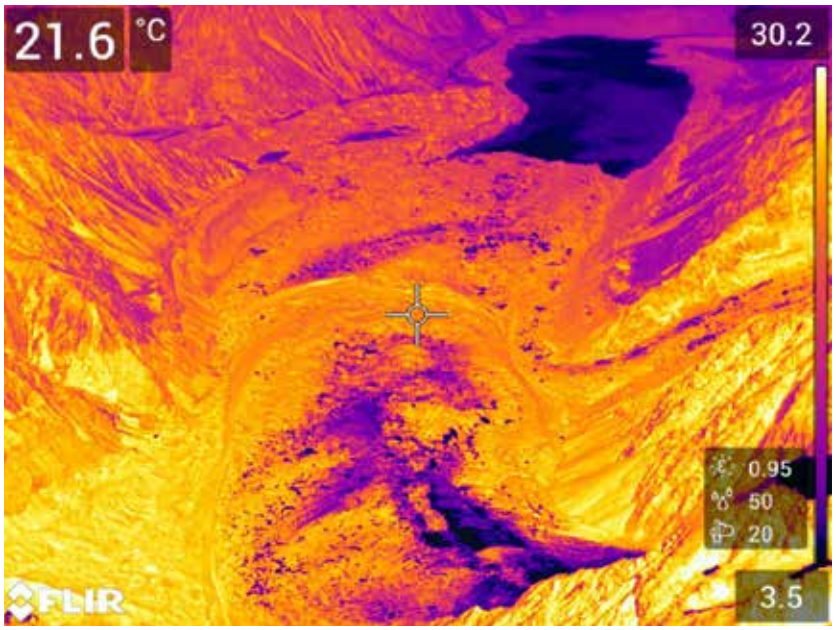

Bob McDowell

Whitebait swim for science

A NIWA lab in Hamilton is hosting a freshwater fish Olympics of sorts – and the name of the game is endurance. Freshwater specialists want to know how long different whitebait species can swim at certain speeds and how much variation there is among the same species.

There are five species of whitebait that travel up-river from the sea. Manmade obstacles, such as dams and weirs, disrupt their breeding journey and pose one of their biggest threats.

NIWA scientists want to design better tunnel structures to help the small fish make it to their breeding sites.



Looking down the Tasman Glacier's debris-covered terminus to Tasman Lake. Bright colours show warmer temperatures while dark areas are cool – the surface temperature of debris on the glacier registered 21.6°C. (*Andrew Lorrey*)

Thermal images pinpoint glacier hot spots

Thermal images taken during this summer's South Island glacier aerial survey graphically reveal how heat in the surrounding landscape affects the ice. Every year, NIWA's aerial survey records the snowline altitude of up to 50 glaciers across the South Island, photographing the summer melt to record changes over the previous 12 months.

A thermal imaging camera used this year clearly reveals hot layers of rock and debris covering some glacier surfaces and near-by mountainsides. NIWA climate scientist Dr Andrew Lorrey says the effect is much like the glacier being surrounded by an electric blanket. "These debris layers can be really warm and the surrounding rocks and cliffs can be up in the high 20°Cs to about 30°Cs." This unique survey now spans 41 years and this year's results confirm the glaciers' ongoing retreat.

Jewel squid (*Stigmatoteuthis hoylei*). (*Rob Stewart*)

Coming up from the deep

A number of new squid and octopus species have been identified after a voyage to the Kermadec Islands by scientists aboard NIWA's research vessel *Tangaroa*. One hundred and fifty specimens were collected from deep waters near the islands and later analysed by researchers from Auckland University of Technology. Thirteen specimens have never been found in New Zealand waters, and at least three appear new to science. The discoveries broaden knowledge of marine biodiversity around the Kermadecs, which include a chain of seamounts and the second deepest ocean trench in the world.

A blue ring around the eye indicates this longfin eel is ready to migrate. (*Stuart Mackay*)

Tagging along with tuna

Freshwater ecologists have turned to sophisticated new satellite tags in a bid to find out exactly where New Zealand's tuna (longfin eel) go to breed.

At up to 2 metres long, and with a life span of well over 50 years, tuna are the largest and longest-lived of the world's freshwater eels. Early tracking attempts show mature females swim hundreds of kilometres northwest into the Pacific to breed.

But precisely where they migrate to, along with many other details about their spawning, remains a mystery.

Last month NIWA researchers, working alongside iwi and Danish tagging specialists, attached satellite pop-up tags to 10 tuna, releasing them back into the Waikato rivermouth.

The tags are programmed to detach and return to the surface after five to seven months, transmitting back vital information about the eels' journey, including details about ocean depth, light and temperature.

Climate Matters – shaping our climate solutions

NIWA is bringing together decision makers and influencers from across New Zealand this month to shape the science we need to respond to our changing climate.

Houses damaged in the 2017 Edgecumbe floods after Cyclone Debbie swept through the Bay of Plenty. (*Dave Allen*)

NIWA's national climate conversation, Climate Matters, gets under way at Te Papa in Wellington on 26 June. It is firmly focused on the science required for effective decision making about climate mitigation and adaptation strategies.

Mitigation refers to steps we can take to slow climate change, such as changing our transport choices to reduce greenhouse gas emissions.

Adaptation describes actions we can take to respond to climate changes. This can range from moves such as retreating from threatened coastlines in response to sea-level rise to planting new crops to take advantage of new climate opportunities.

Both mitigation and adaptation are urgently required if New Zealand is to reach its zero carbon emissions targets and also prepare communities and businesses for climate-related challenges.

NIWA's science already plays a pivotal role in guiding effective mitigation actions and ensuring we build resilience into the ways we adapt and respond. Climate Matters provides a national forum for public and private decision makers to share the research and information they need to accelerate this work.

Central and local government, the energy, water, transport and insurance sectors, primary industries, academia and New Zealand's National Science Challenges are all involved. Climate change has a disproportionate effect on future generations and a group of young ambassadors from Blake (the Sir Peter Blake Trust) will bring their viewpoint to the table.

Jeff Privette, Deputy Director of the the Center for Weather and Climate at the USA's National Oceanic and Atmospheric Administration (NOAA) leads the plenary session. Senior NIWA scientists will brief participants on the latest projections for our future climate, the impact of climate change on our oceans and NIWA's science on mitigation and adaptation.

The main focus is on targeted workshops to enable community, sector and government decision makers engage with NIWA about the research and tools they need to respond to our climate challenges.

CLIMATE MATTERS

Our climate is changing and New Zealanders are already counting the costs.

- Insurance companies have paid out more than $500 million in severe storm and flood claims since 2016.
- Treasury estimates droughts have cost more than $700 million over the past 10 years.
- Residential and commercial buildings worth up to $38 billion may be at risk from rising sesa levels.

Super-model for a worldwide stage

Demands for new weather and climate predictions are unprecedented as nations struggle to understand their exposure to risk from severe climatic events.

NIWA is a key player in one of the world's most successful forecasting and climate prediction systems – the global Unified Model Partnership. It's a system that draws on a wide range of science and high performance computing capacity to predict the world's weather and model future climate scenarios.

Originally developed by the UK Met office, the Unified Model can predict weather at a global level in timescales of hours to weeks, as well as modelling climate for decades to come.

NIWA was a founding member of the international partnership and continues to play a pivotal role in its development.

The partners recently gathered in Wellington for a NIWA-hosted conference to celebrate the first five years of the partnership and to commit to a further five years of international collaboration.

The gathering drew meteorologists and technical experts from the UK, Australia, Korea, India, USA, Singapore, Poland and South Africa and reinforced the need for accurate forecasting to cope with a changing global climate.

NIWA climate scientist Dr Sam Dean describes the model as an example of the power of international collaboration.

"It has already proved invaluable in forecasting tropical cyclones, floods, sea-level storm surges and fire risks across the world," he says.

"A growing number of countries and organisations are using the model as the climate and weather predictor of choice."

Dean says the strength of the UM is underpinned by the science that informs it, and the range of international collaborators working to improve the modelling systems.

Forecasting visionary

Dr Michael Uddstrom was the first scientist from outside the United Kingdom to adopt the Unified Model.

The recently retired NIWA environmental forecaster and High Performance Computing manager was a founding member of the Unified Model Partnership and has worked tirelessly to position NIWA at the heart of the global climate collaboration.

Uddstrom introduced supercomputing to New Zealand and was instrumental in NIWA's purchases of supercomputers in 1999, 2010 and 2018.

These high performance computing facilities have revolutionised NIWA's climate forecasting and supercharged New Zealand's ability to model future scenarios.

Dr Michael Uddstrom addressing the Unified Model conference. (*Dave Allen*)

Endless summers ...

Susan Pepperell reports on a region trying to cope with a changing climate

Jim Tannock

The summer rain came early to Tasman. It fell as light showers at the beginning of December, stopped for a while, and then came back steady and heavy for about a week before Christmas.

So much rain so soon in the season made Richard and Jan Fenton a happy pair. The water tanks on their Upper Moutere farm were full, the sheep were munching on lush paddocks and there was virtually no wind.

"That is very appealing when you come from Canterbury," says Richard.

Then it all changed. It rained on Christmas Day, but that was it. There would be no more rainfall of any significance for 71 long days.

NEW ZEALAND SUMMER OF 2018/19

3rd

Warmest on record

38.4°C

Highest temperature recorded at Hanmer Forest, Canterbury, 31 January

105mm

Heaviest daily rainfall at Maungatautari, Waikato, 24 December

>30,000

Lightening strikes recorded across the country on 14 December

On the first day Richard and Jan watched the sky glowing orange above the ridge of flames until well past midnight

Without the rain, soil moisture levels dropped rapidly across Tasman and the wind picked up. By the end of January, NIWA soil moisture probes were reading below wilting point, the level at which it is difficult for plants to survive.

Water restrictions were enforced with ever-increasing severity, but the Fentons were coping after taking prudent storage measures. Jan was also capturing water from the sink and shower in a vain attempt to keep her vege garden going.

Richard drove to Christchurch and brought back lucerne for the sheep. Some farmers were starting to use their winter feed.

As the constant hot wind killed the grass and left hectare after hectare of hillside forests tinder dry, the fire danger risk got stuck on extreme.

Then, in the middle of the afternoon of 5 February, in Pigeon Valley 30km from Nelson, there were flames.

They spread, multiplied and jumped. Entire hillsides were engulfed, homes evacuated, stock threatened, and the fight to fully extinguish the fire lasted three weeks.

NIWA's forecasters were pulled into the vortex, providing Fire and Emergency New Zealand's (FENZ) incident management team with urgently needed high resolution weather and wind data. (see Fighting fires – one forecast at a time, page 38)

By the time the fire was over 2434 hectares were burnt and it ranked as New Zealand's largest forest fire in 60 years.

On the first day Richard and Jan watched the sky glowing orange above the ridge of flames until well past midnight. It was close enough to be terrifying, but not close enough to have to evacuate.

The Fentons had also witnessed the Port Hills fire of 2017, so when they shifted north they took some precautionary measures. They store 1000 litres of water in a pump on wheels for emergencies and harvest rain water stored in three tanks, adding up to another 75,000 litres. And in May they put in another two tanks that hold a further 30,000 litres.

A pond on their property is part way to completion – when full it will hold enough water for helicopters to dip their monsoon buckets into if it's ever needed.

Richard and Jan are firm believers in being prepared. They have watched their corner of the world change in

the last few years, and this year's exceptionally harsh summer has focused their minds on how they can position themselves better for what's coming.

Winds of change

Scientists say it is not possible to ascribe one scorching summer to climate change, but they do know that extreme weather events are likely to become more frequent.

More wildfires are another possible consequence, although scientifically it is difficult to determine whether that is already happening here.

Fire & Emergency New Zealand run predictive models that help determine where a fire may occur over a certain period of time based on the conditions, and it expects fire danger seasons to be longer in the future. This year in Nelson the danger season doubled.

NIWA climate scientists have compiled several reports on regional climate predictions for councils around the country. These reports help communities adapt to the effects of a changing climate, which is likely to include temperature increases, more floods, storms, cyclones, droughts and landslips.

For Tasman, NIWA predicts a 5 percent increase in the frequency of droughts by 2050 and 10 percent by 2090. The risk of forest fires is also increasing, with scientists predicting a 71 percent increase in the fire danger season by the 2040s, under a mid-range warming scenario.

Above: The Tasman district received under one-third of it's normal rainfall over summer. Civil Defence and drought emergencies, with severe water restrictions, were declared. (*Jim Tannock*)

2018 – A YEAR OF GLOBAL WEATHER EXTREMES

- **JANUARY–MARCH – Argentina's worst drought in 30 years.**
- **FEBRUARY/MARCH – blizzards sweep across Europe bringing unusually low temperatures.**
- **JUNE/JULY – European heatwave. UK records its hottest three month period. Heatwave in Japan – 22,000 hospitalised.**
- **AUGUST – record floods in India affect 5.4 million people.**
- **SEPTEMBER – Super typhoon Mangkhut sweeps through Guam, the Philippines and parts of south China. Wind speeds of up to 281km/h recorded.**
- **OCTOBER – Hurricanes Florence and Michael devastate parts of North Carolina and Florida.**
- **NOVEMBER – largest wildfires in California's history burn 186,000 hectares.**

Weather systems travelling over the sea pick up more water vapour when sea surface temperatures are warmer

Fever in the ocean

Driving from Upper Moutere to Nelson is a scenic delight and from vantage points in the hills you can stop and look across the picturesque landscape to the Tasman Sea.

It's useful to think about the ocean when putting the pieces of climate change together. Most of the heat generated by global warming – caused by pumping carbon dioxide and other greenhouse gas emissions into the atmosphere ends up in the ocean.

For the past two years parts of the Tasman Sea have experienced a marine heatwave, sometimes described as an ocean fever. Marine heatwaves occur when sea surface temperatures are extremely warm for a prolonged period of time. They can extend for thousands of kilometres (see Our changing oceans, page 22).

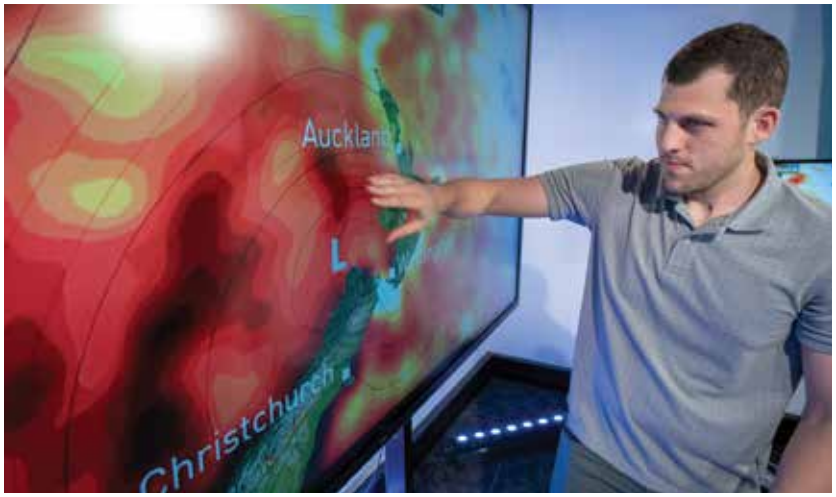
Marine heatwaves influence air temperatures and rainfall patterns. NIWA meteorologist Ben Noll says weather systems travelling over the sea pick up more water vapour when the sea surface temperatures are warmer. That means that ex-tropical cyclones heading towards New Zealand may not weaken as much as they normally would and retain their tropical integrity for longer.

Ex-tropical cyclones Gita and Fehi, which wreaked havoc on the West Coast and Nelson region last year, are good examples – they still had some tropical characteristics when they hit land.

New Zealand experienced its hottest summer on record over 2017/18, as well as a record marine heatwave, which spread the width of the Tasman.

Noll says the Tasman's "ocean fever" was a striking feature on a regional and global climate scale.

This summer, while not the record breaker of the previous year, was also dominated by a marine heatwave.



Above: NIWA meteorologist Ben Noll. (*Stuart Mackay*)
Below: Nelson residents struggle through Cyclone Fehi's destructive tidal surge last summer. (*Stuff*)

Death by a thousand cuts

Agriculture Minister Damien O'Connor declared a medium-scale adverse event in Tasman on 8 February, unlocking funding for Rural Support Trusts to help in the recovery of farming and horticultural businesses.

Nelson MP Nick Smith said he thought the drought in 2001 was as bad as it could get ... until this one.

That was a sentiment echoed by Tasman District Council hydrologist Joseph Thomas, a council veteran.

"Droughts are very insidious, it's death by a thousand cuts. You can see the grass shrivelling, the stock struggling, the plants wilting. It's not like a storm or a flood which is gone in a day or two and then you get back on your feet.

"I have never seen some of the streams go dry in 30 years of being here but this year I did. We had to make some big calls. It is never easy recommending extreme water restrictions. People would come to a drought meeting and be in tears; their voices breaking. You could see how stressed they were."

Above: Marine heatwave conditions in Tasman Bay and beyond intensify tropical weather systems. Last summer cyclones Fehi and Gita caused widespread damage in Nelson and the West Coast. (*Jim Tannock*)

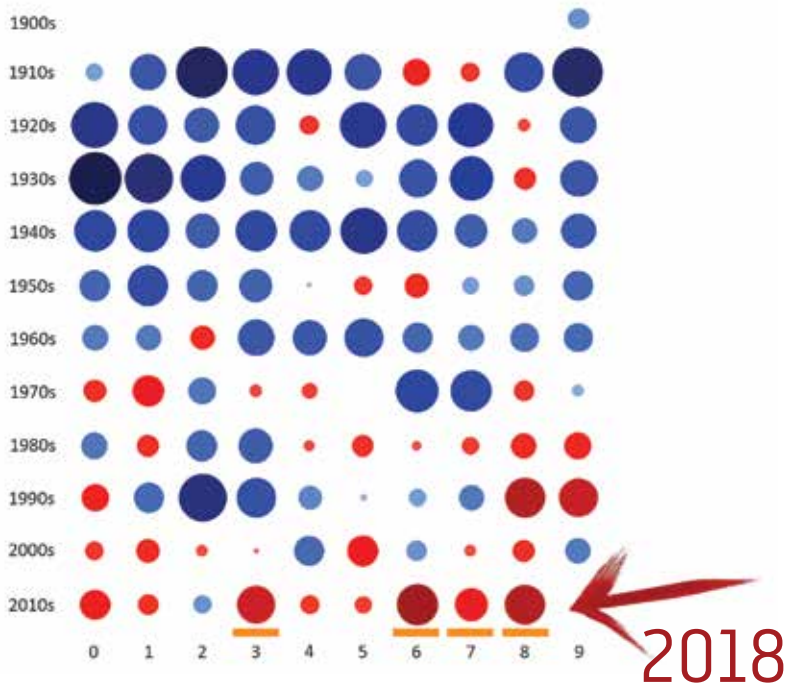
Growers were forced to choose which crops to save, farmers destocked, and cows were dried off early, but Thomas says there were a lot of people who were totally unprepared. "Many didn't have a plan and would ask 'What do I tell my workers?'. I had to say I don't know."

The final cost of the Tasman drought is still unclear, but some estimates go as high as $100 million. It's not just one bad season, it's the length of time it takes to recover what was there before it stopped raining. As well as lost crops and unproductive pasture to account for, there are job losses such as those caused after the fires shut down forestry operations.

Then there's the impending changes to water plans needed in some of the Tasman catchments.

"It's not just about everything that's happening in the environment though," says Thomas. "It's also about community resilience and how much people can withstand."

Four of the last six years have been amongst New Zealand's warmest on record



Dot size and colour are based on temperature anomalies from NIWA's 7 station series and are relative to the 1981–2010 average. (*Nava Fedaeff, NIWA*)

What next?

The first solid rain for Tasman came on 7 March – it was a relief of course, but not enough to reverse the damage across the district.

Jan Fenton kept a list of the things that changed over summer. It includes the tui that lived in a tree beside the house and then disappeared. Also on the list are missing kererū, a falcon, bees and dead trees – natives, redwoods, a silver birch and an old man pine more than 100 years old.

In early April the grass on the Fentons' paddocks seems, if not lush, then plentiful. It's an optical illusion. The ground is scarred with deep cracks every few metres and the grass is really tufts of spindly tendrils and little substance.

It's winter now, and Jan has stopped looking at the weather forecast "50 times a day". Soil moisture levels are mostly back to normal, and water restrictions have eased.

But the sea surface temperature is still warmer than normal, temperatures are above average and the amount of carbon dioxide in the atmosphere continues to rise.

GLOBAL

"The physical signs and socio-economic impacts of climate change are accelerating as record greenhouse gas concentrations drive global temperatures towards increasingly dangerous levels."

State of the Climate in 2018 – World Meteorological Organization

Key points

- nine of the world's 10 warmest years have occurred since 2005
- 62 million people affected by extreme weather and climate related events in 2018
- More than two million people directly displaced due to weather and climate events
- Record low Arctic sea ice cover registered for January and February
- Warming seas set new heat records for upper 700m and upper 2000m ocean zones

NEW ZEALAND

"We can be sure nearly all aspects of life in New Zealand will be affected by climate change."

Environment Aotearoa 2019 – Ministry for the Environment

Key points

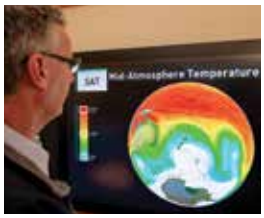
- four of the past six years have been among NZ's warmest on record
- Southern Alps glaciers lost 25% of their volume between 1997 and 2018
- localised sea surface temperatures up to 3°C or more above normal recorded over the past two summers
- sea levels rose by 14–22cm between 1916 and 2016
- ocean acidity has increased 7% between 1998 and 2016

> "Climate change is already impacting on New Zealand, and the effects will intensify with time"
>
> Ministry for the Environment

Jim Tanmock

From Gore to NIWA via NASA

A science-fiction fan, amateur actor, and eternal optimist, is now NIWA's Chief Scientist for Climate, Atmosphere and Hazards. Susan Pepperell finds out more.



Computer models help Dr Andrew Tait track the complex interactions shaping our climate. (*Hamish McCormick*)

Within the space of a couple of months Andrew Tait has achieved two major milestones: turning 50 and getting a new job. For one his family gave him a fancy barbecue, and for the other, he received a new office with a glimpse of the sea.

If things go in threes, the third will be Tait's 20th anniversary at NIWA, which will pass on 1 May next year. It's been an eventful year for NIWA's newest chief scientist as he takes on a more high-profile role advocating for NIWA's climate science capabilities and the need for evidence-based decision making.

Tait's scientific career probably had its origins in high school. The Gore-born, Invercargill-raised boy had a bent for chemistry, but in his first year at the University of Otago it was the climatology component of his geography paper that captivated him.

"Everybody has a way of connecting with the climate. I became interested in looking at climatic patterns and variations across a landscape. Things like where frost forms, and where it doesn't and how it's influenced by local airflows and topoclimatic temperature and radiation differences."

That interest, and a particularly engaging professor Blair Fitzharris, saw him complete not only his bachelor's degree, but also his masters. Fitzharris also helped smooth the way into a doctorate programme at the University of Colorado in Boulder, where Tait spent four memorable years.

"Boulder is special. I had a fantastic time, and it was there it became obvious what I wanted to do for the rest of my life."

A year doing post-doctoral research in Bristol, England followed, and then a research scholarship at NASA's Goddard Space Flight Centre just outside Washington DC. Three years later a friend emailed a job advert for a climate scientist at NIWA and he jumped at it.

Tait is most comfortable describing himself as an applied climate scientist whose interest predominantly lies in answering questions about how businesses, communities or individuals are likely to be impacted by a variable and changing climate.

As chief scientist he has followed in the footsteps of his mentors Drs David Wratt and Murray Poulter and his immediate predecessor Dr Sam Dean, seeing his primary role as working with key stakeholders and end users to provide the expertise they need.

"I need to ensure NIWA is doing the right science to benefit New Zealanders. I also need to support our science teams to build their capability and capacity, and work with them to ensure they have adequate funding for the science to be done."

He is also keen to ensure that climate science is better understood, so the issues it raises are well grounded in fact. "I am more than happy to be an advocate for the pursuit of scientific evidence and contribute in some small way to a better understanding of what climate change means for all of us."

However, he also recognises that climate change doesn't lend itself to optimism.

"I hate being pessimistic about anything. But it really worries me that as a global community we're nowhere near on track to doing what's required to keep the impacts of climate change within our coping range."

That said, he is heartened that the importance of adapting to our changing climate is now much more widely recognised.

"In the past we tended to focus a lot on mitigation, which was needed, but it was unfortunate it came at the cost of thinking about adaptation – these days they're more on a par and people are coming to the realisation that you can't do one without the other."

Unusually for a Crown Research Institute scientist, he has been at the forefront of two government organisations grappling with how to adapt to climate

change. Secondments to the Ministry for Primary Industries and the Department of Conservation (DOC) have convinced him of the value of these placements, personally and for the organisations involved.

"One of the big pieces of work I was involved with at DOC was trying to better model climate conditions in beech forests, where warm summers produce much more seed, which increases food supply and results in a pest population explosion."

These huge seed production events are called masts – Tait's job was to help work out when climatic conditions would produce a mast and where.

"Masting depends very much on air temperature, so the ultimate aim is to determine which temperature variables are useful to predict masting conditions, and then automate that so it can be used for better management."

He also worked on a report looking at DOC's exposure to coastal flooding risk, identifying assets like campgrounds, huts, tracks and archaeological sites that are particularly vulnerable.

"Adaptation is about embedding the right information at the right place. Really, it's quite simple. You can adapt a lot by just being clever about the way you include climate information into existing processes. If you are thinking long-term, then small changes over time build up to significant benefits, with the ultimate goal of being less vulnerable."

This month Tait has another new role to perform. A keen amateur actor, he will be playing Gordon Ramsbottom in a play called *Little Grimley Presents Strictly Sex Factor* (*on Ice*). The character, Tait says, is a cross between Basil Fawlty and Yes Minister's Jim Hacker.

He's also a superfan of science fiction writer Peter F. Hamilton – "I've read everything he's written twice" – and is a keen advocate for Upper Hutt, where he has lived since returning to New Zealand.

"The commute is a bit of a haul, but I'm paying my wife back for her years of commuting around the Beltway when we lived outside Washington DC and my work was across the road while hers was miles away. Mind you after 19 years, I think I might have paid that debt by now."

A bird's-eye view of our carbon balance

By Stacy Mohan

> "This project will give us a clearer idea of what we can do to meet our long-term goal of being carbon neutral"
>
> Dr Sara Mikaloff-Fletcher

Baring Head Clean Air Station overlooking Cook Strait. (*Dave Allen*)

Our current best estimate is that 30 percent of New Zealand's greenhouse gas emissions are offset by forests and land use.

Dr Sara Mikaloff-Fletcher is looking to turn the internationally accepted science of monitoring greenhouse gas emissions upside down – and the rest of the world is watching closely.

Last year the NIWA atmosphere-ocean scientist was awarded $11.4 million from MBIE's prestigious Endeavour Fund to develop CarbonWatchNZ.

This ambitious programme aims to build the world's first complete national-scale picture of a country's carbon balance based on measurements of greenhouse gases in the atmosphere.

This is precisely the sort of detailed information policy makers urgently require if New Zealand is to meet its goal of being carbon neutral by 2050.

The programme has already prompted the United Nations World Meteorological Organization to highlight New Zealand as an "exemplar" country, providing a template for other nations to follow for their own carbon reporting.

Looking down from above

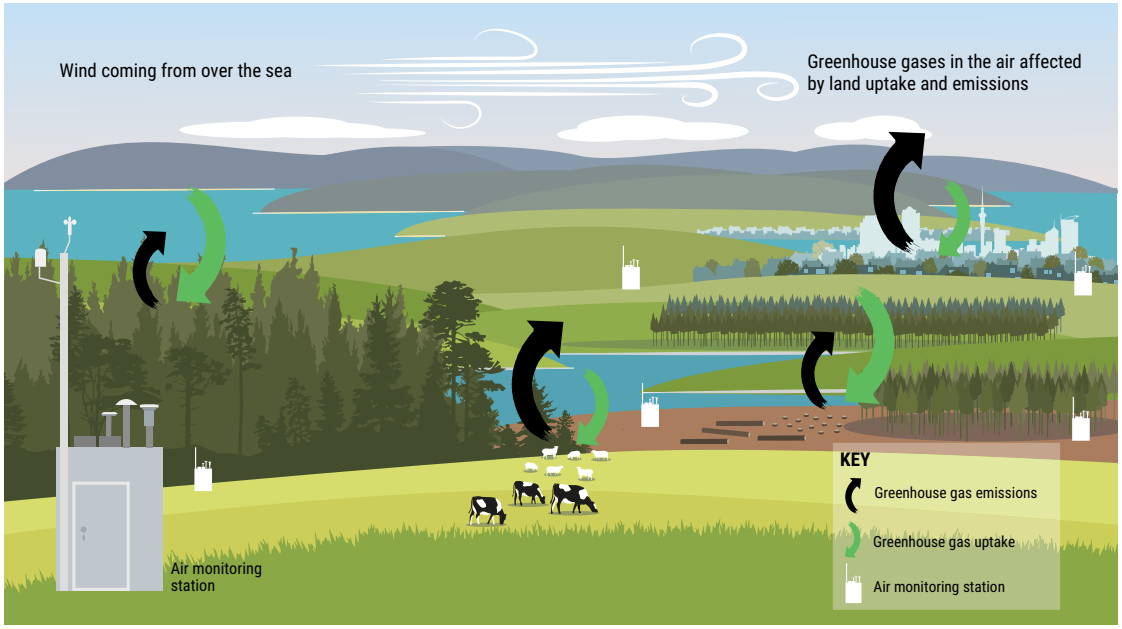
"Traditionally, greenhouse gas emissions and uptake have been estimated using methods we think of as bottom-up," Mikaloff-Fletcher explains.

Carbon dioxide (CO_2) emissions from transport, for example, are currently calculated from estimates based on the amount of fuel burnt by New Zealand vehicles.

Forest carbon uptake is estimated by measuring changes in the circumference of trees in a number of set locations. This is combined with forest height and land cover information and scaled up across the country.

"In comparison, CarbonWatchNZ will give us a bird's-eye view of our carbon emissions and uptake," says Mikaloff-Fletcher.

The project involves measuring CO_2 and methane (CH_4) in the air above New Zealand at a network of sites around the country.



CarbonWatchNZ measures greenhouse gas emissions and uptake across New Zealand's cities, forests and farmlands.

By combining these atmospheric measurements with information about winds and air movement over our cities, forests and farmlands, CarbonWatchNZ will measure the greenhouse gases we are emitting and how much carbon our landscapes absorb.

When these "top down" atmospheric observations are added to existing estimates from the ground up, New Zealand will be able to build the world's first complete picture of a country's carbon profile.

The lucky country

Mikaloff-Fletcher says New Zealand has "three unfair advantages" that make it the ideal place to perfect this approach.

Firstly, the air travelling across the oceans to New Zealand has not been in contact with land for days. Unlike most countries, changes in the amount of CO_2 or CH_4 as the air passes over New Zealand can be clearly identified and sourced.

Secondly, NIWA already has an internationally renowned network of atmospheric monitoring stations: Baring Head at the bottom of the North Island, Lauder in Central Otago and Maunga Kakaramea near Rotorua. The datasets from these include some of the longest running greenhouse gas measurements in the southern hemisphere.

Thirdly, NIWA's high resolution weather forecasting capabilities mean researchers can accurately model wind flow and clearly track the path of greenhouse gases across the country.

Guiding decision making

CarbonWatchNZ is looking at the four landscapes that are most important to New Zealand's carbon balance – our indigenous and exotic forests, our farmland and our cities.

By adding new monitoring stations at key sites such as Fiordland, the central North Island, Canterbury and across Auckland, CarbonWatchNZ will be able to track greenhouse gas emissions and uptake across these four target landscapes.

The results will give us a detailed understanding of the carbon uptake rates of native compared with exotic forests in key locations. This information can then be used in decisions about land management and tree planting to offset our greenhouse gas emissions.

Equally, atmospheric measurements across Auckland will help decision makers monitor the effectiveness of steps taken to reduce urban emissions. Changes in CO_2 concentrations above the city will directly reflect the impact of tree planting programmes or steps to cut vehicle numbers on city motorways.

Methane is a highly significant greenhouse gas in New Zealand due to our reliance on agriculture.

"Our government has invested heavily in reducing methane emissions from agriculture by food additives, vaccines and other interventions. It's easy to see how well these things may work in a lab, but it's much more complicated to know whether they work in real life. Our atmospheric measurements will help answer this question."

Mikaloff-Fletcher is clear about the value of CarbonWatchNZ.

"The current best estimate is that 30 percent of all of the greenhouse gases we emit in New Zealand are offset by forests and other land use.

"The aim of this project is to get a better handle on our true carbon emissions and uptake. It will give us a clearer idea of what we can do to meet our long-term goal of being carbon neutral."

CarbonWatchNZ
GUIDING CARBON MITIGATION STRATEGIES

Dr Sara Mikaloff-Fletcher at Baring Head Monitoring Station talking to media as atmospheric CO_2 levels there passed the 400 parts per million (ppm) level in 2016. (*Dave Allen*)

CarbonWatchNZ is a collaboration between NIWA, GNS Science, Manaaki Whenua Landcare Research, Auckland Council and the University of Waikato.

Our changing oceans

By Lesley Patston

About 40 percent of the CO_2 produced by humans in the past 50 years has ended up in our seas

The on-going rise of atmospheric carbon dioxide (CO_2) that is fuelling climate change is also driving significant changes in the waters off our coasts.

Rising seas are the most obvious sign of this greenhouse gas-powered transformation. But equally dramatic – if somewhat less visible – are the changes occurring in the ocean itself.

More than 90 percent of the excess heat generated as a result of global warming has been absorbed by the oceans, and about 40 percent of the CO_2 produced by humans in the past 50 years has ended up in our seas.

NIWA research confirms that our oceans are getting both warmer and more acidic, and scientists are now focusing on how these changes threaten the delicate balance of life beneath the waves.

It's getting hot out there

Research released earlier this year by NIWA oceanographer Dr Phil Sutton reveals the surface waters in the New Zealand region are significantly warmer than they were 30 years ago.

Our marine environment has seen a warming of about 0.1°C to 0.3°C per decade. This seemingly small rise has already contributed to record sea surface temperatures recorded in the Tasman Sea in the past two years.

NIWA Principal Scientist Dr Craig Stevens says this ocean warming is undoubtedly damaging for marine ecosystems.

"Species that normally live in tropical waters are extending their ranges and displacing other species. Mobile marine life can escape the warmer temperatures, but sedentary plants and animals will be hardest hit. The impacts are there for aquaculture as well, with warmer waters making it more difficult to grow some finfish or shellfish."

Increasing marine heatwaves are an indication that the earth's climate system is starting to change.

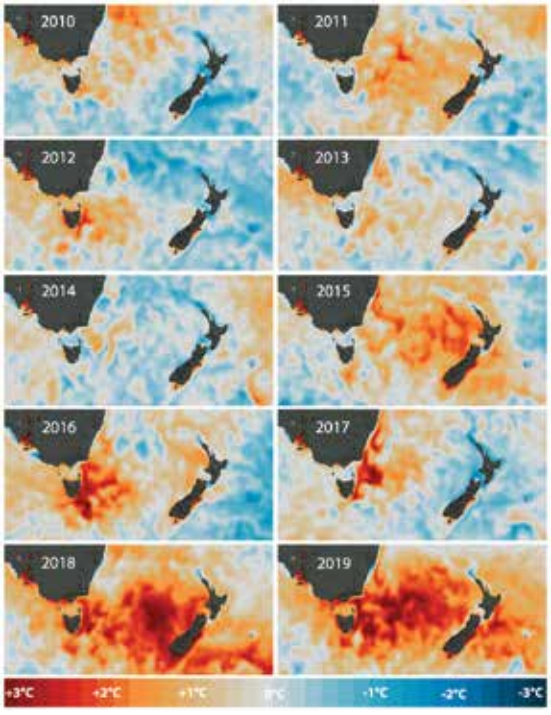
"Individual warm seasons have always occurred, but in future there will be more of them and they will keep getting warmer," Stevens says.

"And a sobering thought is that even if we somehow managed to turn global warming off right now, the atmosphere would keep warming for some years to come because of the heat that's stored in the ocean."

Marine heatwaves are upon us

Warm weather and seas have seen Kiwis flocking to the beaches in the past two summers. Both years featured marine heatwaves - periods of five or more days where water temperatures exceed 90% of those measured over the past 30 years.

Last summer, measurements of sea temperatures from a fleet of sophisticated buoys found surface waters off our west coast almost four degrees above normal, with this warmer water extending down to 80m in the south of the country. Looking at the trend over the past decade suggests more warm years are on the way.



Bad acid trip

The on-going rise in greenhouse gases is also acidifying the waters around New Zealand. As the oceans absorb more CO_2, the pH of the water changes, becoming more acidic through a process known as ocean acidification.

NIWA's Dr Kim Currie, in partnership with the University of Otago's Department of Chemistry, has been tracking this gradual acidification of waters off the coast of Otago for almost 20 years. The study, the Munida Transect Time Series, is the Southern Hemisphere's longest-running record of pH measurements.

"Through this work, we've established a clear decline in pH that corresponds directly with the increase in atmospheric CO_2 recorded at NIWA's atmospheric research station near Wellington," says Currie.

Shellfish, cold-water corals and some algae and plankton struggle to produce shells as the pH decreases, and the NIWA-led CARIM (Coastal Acidification: Rate, Impacts and Management) project is looking at how marine organisms will cope with this changing pH.

CARIM is a partnership between central and local government, the fishing industry, science organisations, iwi and other community groups. It is examining the effects of acidification on primary production, food quality and habitat availability in New Zealand coastal waters.

CARIM has a particular focus on the sensitivity of the different life stages of iconic New Zealand species including pāua, greenshell mussels and snapper larvae.

Project lead and NIWA Principal Scientist Dr Cliff Law says a key part of the programme is finding out whether coastal areas are resilient or will be vulnerable as ocean acidification intensifies.

"We know coastal waters are the most variable in their natural pH levels. They are where we gain the most benefits in terms of food, recreation and other amenities, yet it's also where we impact the ocean most.

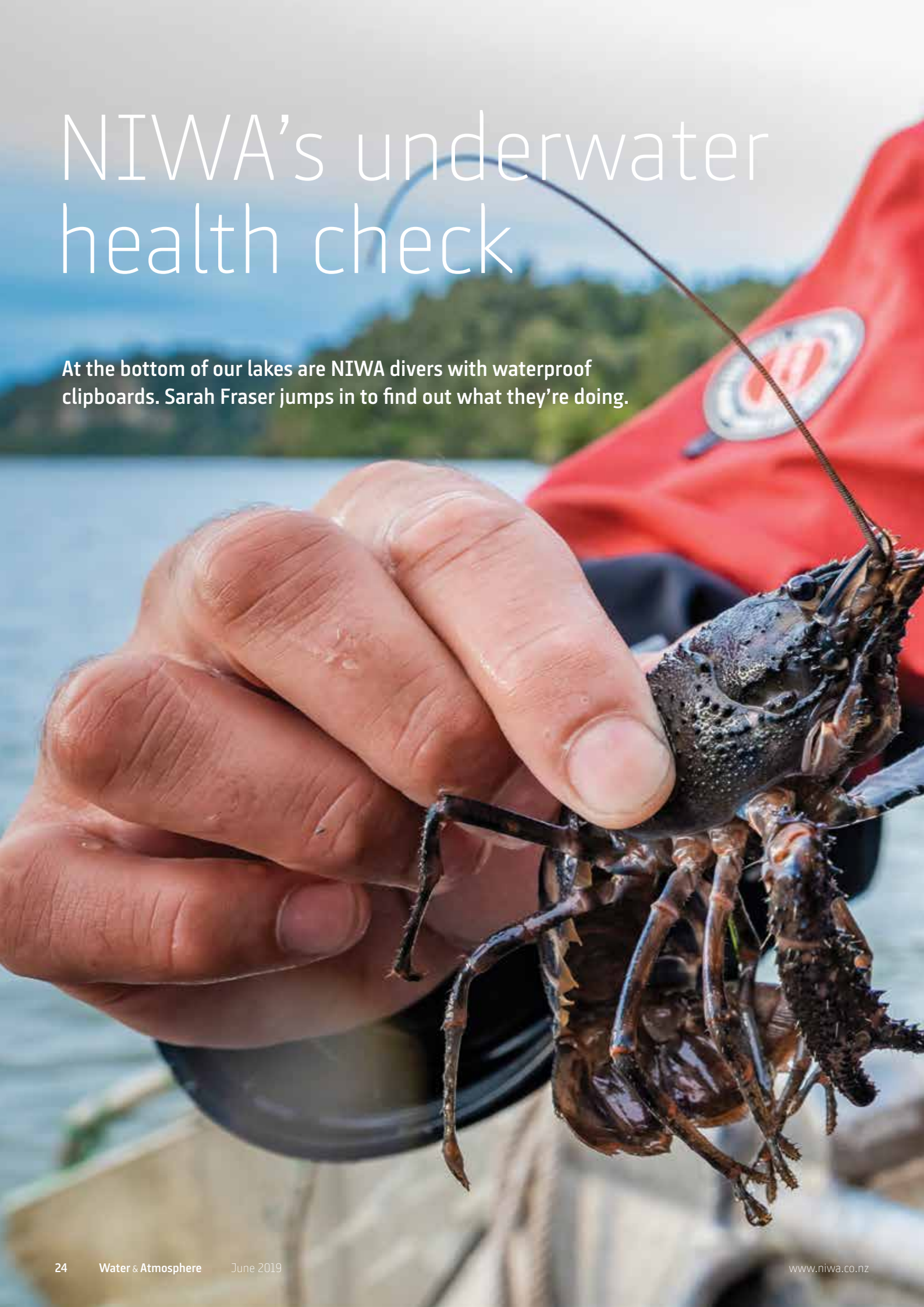
"We are building our knowledge of ecosystem interactions, which is critical for developing models and projections. These tools and solutions will help us mitigate and adapt to ocean acidification.

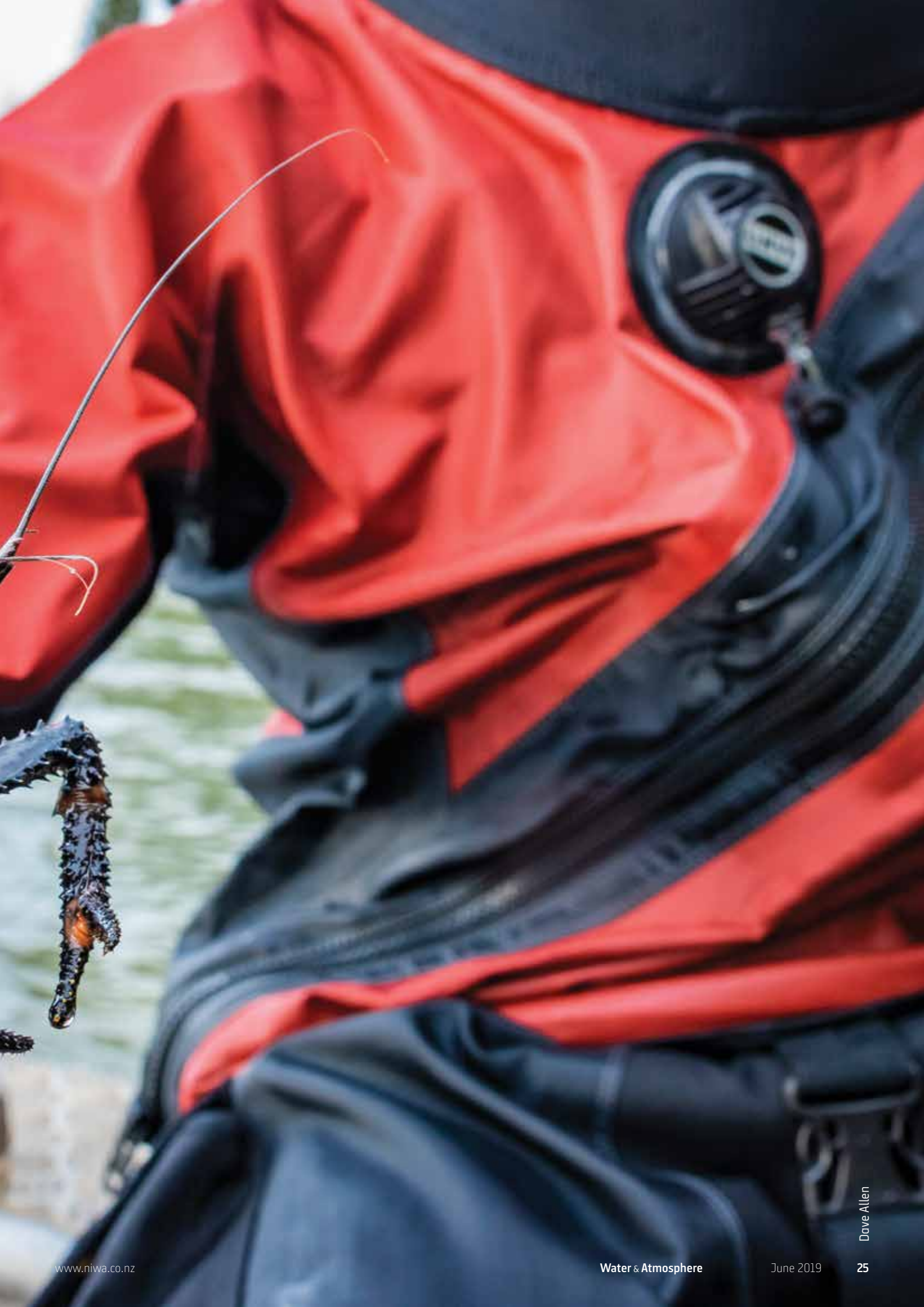
"The outcome of CARIM will be better models, allowing more accurate predictions of the impacts of acidification in coastal waters, as well as potential management options."

Dr Kim Currie's research has tracked ocean pH levels off the coast of Otago for almost 20 years. (*Dave Allen*)

NIWA's underwater health check

At the bottom of our lakes are NIWA divers with waterproof clipboards. Sarah Fraser jumps in to find out what they're doing.





Dave Allen

Above: NIWA researchers Tracey Burton and Rod Budd recording observations after one of their five dives for the biannual survey of Lake Rotomā. (*Dave Allen*)

Opposite: Te Arawa scientific advisor Joe Butterworth with a kōura (which was returned to the lake after it had finished its modelling duties). (*Dave Allen*)

For Joe Butterworth and his Te Arawa iwi, lake restoration goals are encapsulated in the footsteps of the kōura, our native freshwater crayfish.

"The kōura migrate to the shallows to feed, and that's when they're easiest to catch. With the water quality degrading in some lakes, you're unable to see them even in the shallows. If the water quality improves, we'll be able to see those kōura again."

Butterworth, a scientific advisor for the Te Arawa Lakes Trust, says it's not just about the clarity of the water – it's about the whole lake ecosystem. "Kōura are scavengers and live on the lake bed. They need oxygen and rely on other species to feed. If the ecosystem is healthy, you'll get lots of kōura. But for them to feed in the shallows, they need to be able to get there. In some lakes invasive plants form almost a solid wall preventing them migrating to the edges.

"The Rotorua Te Arawa lakes are used widely, not only by the local community, but also by lots of people from other regions for recreational activity. They're pretty important to Te Arawa for cultural reasons. These lakes are the food basket, and so we want to keep that going for the future."

Lake health

Butterworth says being able to contribute to his iwi and the whole community in trying to restore the Rotorua Te Arawa lakes is what gets him up in the morning. Making a difference and contributing to the health of New Zealand's lakes is also what inspires NIWA freshwater ecologist and scientific diver Tracey Burton. Both Burton and Butterworth, along with other NIWA colleagues, have been working underwater over autumn to assess the health of the Rotorua Te Arawa lakes using the LakeSPI (Submerged Plant Indicators) survey method.

LakeSPI was developed by NIWA scientists 18 years ago, and uses the underwater plants growing in a lake as indicators of its ecological health. The divers don cold water drysuits, dive masks, fins and scuba gear before heading beneath the surface with waterproof field sheets to assess the state of the vegetation on the lake bed at pre-defined locations. Their observations feed into the national LakeSPI

LAKE MEASUREMENT – THE FACTS

NZ has 3,820 lakes that are 1 hectare or more and just over 50% of those lakes are partially or completely in conservation areas. "We monitor the lakes with the greatest problems, which are primarily large lowland lakes and are more impacted by human activity," says NIWA Emeritus Scientist Dr Clive Howard-Williams. "More than half of our lakes are on DOC land, so much less affected by pollutants and weed invasions."

"If the water quality improves, we'll be able to see those kōura again."

Joe Butterworth

> **"A piece of weed the size of your thumbnail would be all that it takes for hornwort to be transferred to Rotomā"**
>
> Dr Tracey Burton

Of the 300+ lakes monitored using LakeSPI

34%
are rated as excellent/high
(close to pristine or with minor impacts from invasive species)

30%
moderate

14%
poor
(extensive invasions)

and

22%
non-vegetated
(degraded – not suitable for plant growth)

database and build a picture of lake condition and change over the years. The submerged plant indicators help measure two major influences on lake ecology: increased sediments and nutrients and the impact of invasive weeds on the lake's native vegetation.

Lake owners and managers such as the Te Arawa Lakes Trust, the Bay of Plenty Regional Council (BOPRC) and Rotorua District Council can use LakeSPI to assess the status of the lakes and monitor changes within them.

NIWA has been conducting regular LakeSPI surveys on 12 Rotorua Te Arawa lakes (Ōkāreka, Ōkaro, Ōkataina, Rerewhakaaitu, Rotoehu, Rotokākahi, Rotomā, Rotomāhana, Rotoiti, Rotorua, Tarawera, and Tikitapu) since 2005 – work funded by BOPRC.

Alien invaders

Burton has been diving in the lakes for 20 years and says she has seen both positive and negative changes in the lakes.

"Many of the negative changes are attributable to the spread of alien invasive weed species such as hornwort, egeria and lagarosiphon which have had a devastating impact on some of the lakes. But increased awareness of lake issues and new management initiatives have seen some lakes improve."

Targeted interventions by BOPRC, such as the efforts to eradicate hornwort in Lake Ōkāreka have met with success. LakeSPI results show improvements in lake condition over the last six years. But this lake and others are still at high risk of new invasions. Only two of the 12 Rotorua Te Arawa lakes remain free of major weeds and constant vigilance is needed to prevent the spread of weeds throughout New Zealand's waterways. This is especially relevant for Lake Rotomā, currently one of the highest ranked lakes in the region. LakeSPI shows Rotomā has remained stable, with little change for more than 20 years. However, Lake Rotoehu is just one kilometre to the east and it is classified in poor condition, with a heavy infestation of hornwort and water quality issues.

"A piece of weed the size of your thumbnail would be all that it takes for hornwort to be transferred to Rotomā. Once in, it would displace the native vegetation in the lake – we've already seen this happen in Lake Tarawera and areas of Lake Taupo," says Burton. "That's why the 'check, clean, dry' message is so important."

As well as blocking the passage of kōura, and smothering the native vegetation, NIWA divers have noticed other less well-known impacts from invasive weeds. For example, where there are large dense weed beds, there are fewer kākahi (native freshwater mussels). Kākahi are highly valued both as mahinga kai for Māori communities and for the role they play in maintaining ecosystem health as biofilters. (See Protecting freshwater taonga, page 36).

Invaluable tool

LakeSPI has been used to assess the condition of 305 of New Zealand's 3,820 lakes, with many of them, such as the Rotorua Te Arawa lakes, being surveyed multiple times. The Ministry for the Environment uses the data to help describe the state of our freshwater, and it links directly to the Land And Water Aotearoa database, which also uses StatsNZ data collected by NIWA and regional councils (www.stats.govt.nz/indicators/lake-water-quality).

Bay of Plenty Regional Council's senior biosecurity officer Hamish Lass says LakeSPI has proved invaluable. "It gives us trends over time which show where we've got issues in some lakes, and where other lakes are getting better through good management. It also lets us know what plant species we have in the lakes and what impact invasive species are having on overall lake condition."

He says LakeSPI also illustrates the impact of people. "The lakes that have the most human contact have got most of the invasive weeds. For example, Lake Rotorua, with six boat ramps, has all four of the worst invasive weeds, whereas Lake Rotokakahi, which is a private lake with no public access has only one weed in it."

"One of the most valuable things about LakeSPI is that we can use it as a tool to aid in decisions as to what our lakes should look like compared to how they once were, and what we would find acceptable in the future," says Burton. "We can use this information to set limits and define targets for our lakes, and these kinds of discussions are already underway in the Bay of Plenty."

Joe Butterworth says the Trust wants to be able to use a combination of matauranga Māori and western science to achieve its goal, to improve the lakes.

"At the end of the day, both have the same goal, don't they? When the lakes were taken, they were in good health, but since Te Arawa's taken back ownership of the lake beds, they're not in good health. So we want to put that right using matauranga alongside western science.

"We may not be able to restore some of them back to the way they once were – we've got to be realistic about that, but we've got to do something."

LakeSPI results for the Rotorua Te Arawa lakes and others at www.lakespi.niwa.co.nz

Tracey Burton standing on the lake bed to measure the height of lagarosiphon in Lake Rotomā. (*Rod Budd*)

THE WORST WEEDS

HORNWORT
(*Ceratophyllum demersum*)

New Zealand's worst submerged weed. Can grow up to 8m tall (taller than a two story building). Spread throughout North Island. Eradicated from South Island – not seen there since 2008.

EGERIA
(*Egeria densa*)

Can grow up to 6m tall. Thrives in turbid, enriched waters. Widespread throughout North Island and in some parts of Marlborough.

LAGAROSIPHON
(*Lagarosiphon major*)

Major impacts on native plant biodiversity. Grows up to 4m tall. Found throughout much of New Zealand.

CANADIAN PONDWEED
(*Elodea canadensis*)

Most widely distributed of weed species found in New Zealand. Only invasive species in Lake Rotokakahi, and only invasive oxygen weed allowed to be sold in the aquarium trade.

Setting new baselines in the southern seas

While most New Zealanders were settling into their summer break, some scientists were double-checking their survival gear before heading to work deep in the Southern Ocean.

NIWA's deepwater research vessel *Tangaroa*, set off early in January for a six-week trip to Antarctica, sailing as far south as 76° 30' – just 30km short of *Tangaroa*'s southernmost voyage.

Working amongst ice floes, strong winds and heavy swells, the 21 New Zealand and international scientists and 19 crew faced a daunting research schedule.

Their primary focus was setting up long-term monitoring programmes for the newly-created Ross Sea Marine Protected Area (MPA).

Data collected by *Tangaroa*'s scientists covered whale, fish and plankton abundance, seabed samples and oceanographic and atmospheric conditions. It will provide the crucial baselines needed to assess the MPA's future impact.

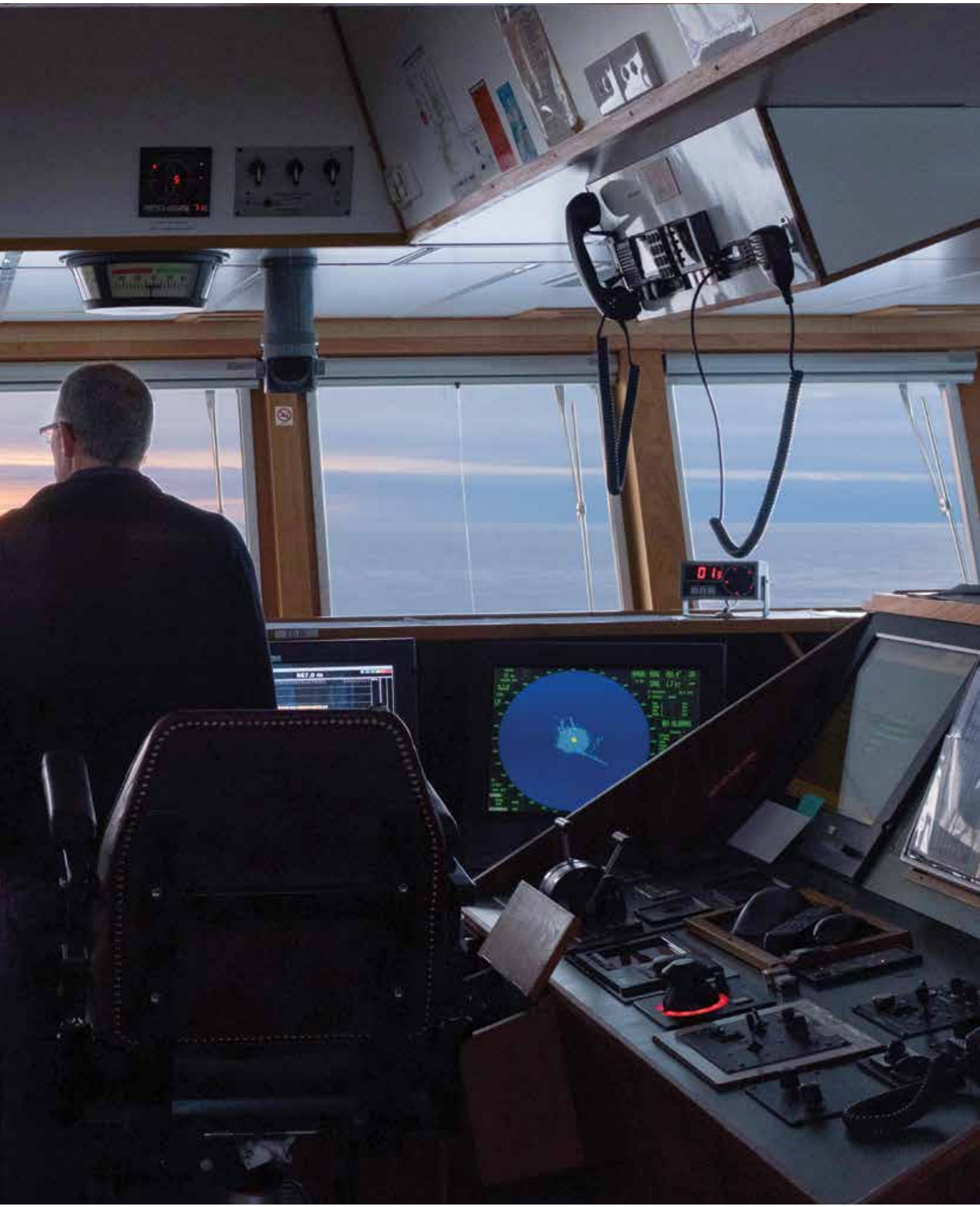
"New Zealand has a commitment to playing a leading role in monitoring the MPA, and this voyage is a key contribution," says voyage leader and NIWA Principal Scientist Dr Richard O'Driscoll.

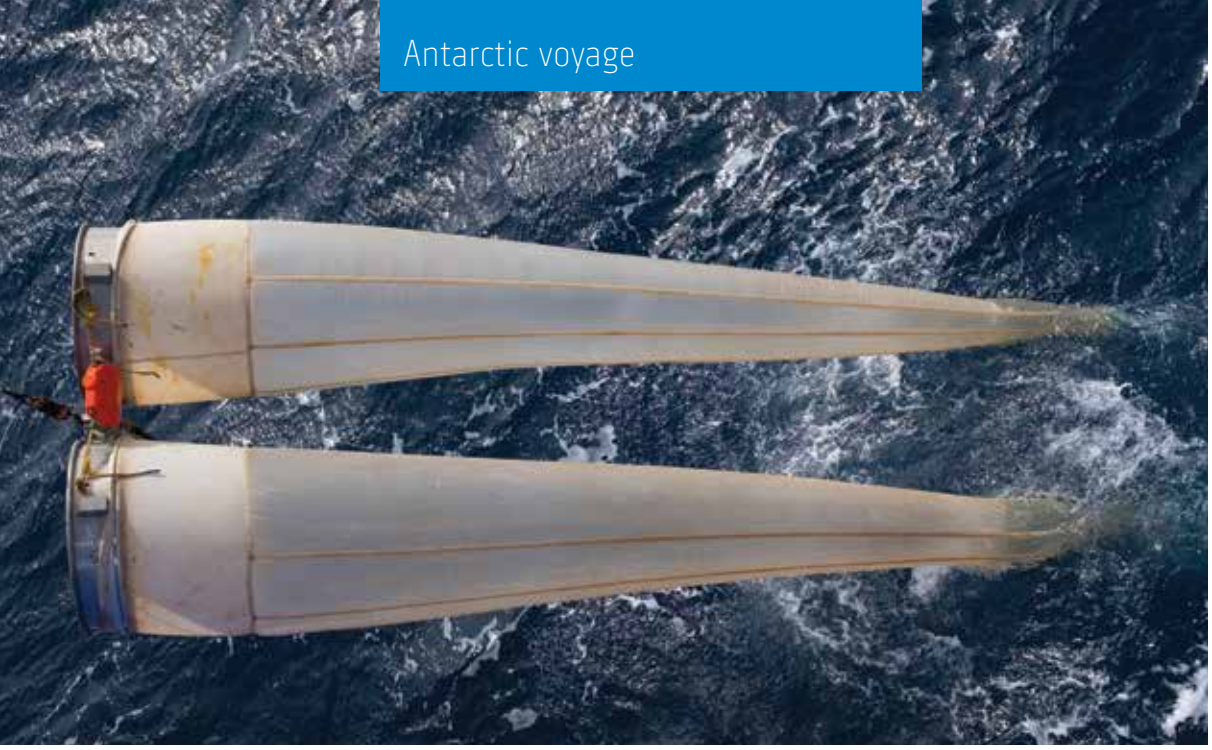
"Data collected on the voyage will also build New Zealand's reputation for research into atmosphere and ocean circulation processes."

Break out the short sleeves. The 40-strong team of researchers and crew mark another successful scientific expedition which netted more than 4700 samples, 33 hours of video and in excess of 8000 images of life on the southern seabed. (*Dave Bowden*)

Ice floes feature on the left of this 360° view of calm Antarctic waters taken from 'monkey island' – the platform high above *Tangaroa*'s deck, carrying vital navigation, communication and metrological equipment. (*Mark Gall*)

First Mate Ian Popenhagen keeps a watchful eye for ice as *Tangaroa* sails deep into a deceptively benign Ross Sea. The 11,800km voyage took *Tangaroa* just 30km shy of the furthest south it has ever been. (*Dave Bowden*)





Top: 'Bongo' nets can be deployed as deep as 1000m, enabling researchers to build a detailed picture of the rich range of plankton found in Antarctic waters. (*Dave Bowden*)

Middle: Fisheries scientists Peter McMillan and Pablo Escobar-Flores examining lantern fish in the wetlab. The deepsea species is named for the underwater glow produced by organs along their body. (*Dave Bowden*)

Bottom: A sea spider or pycnogonid. Carnivorous marine predators and scavengers, Antarctic sea spiders are amongst the largest found world-wide, with a leg span of more than 20cm. (*Rob Stewart*)

Right: Light shines cobalt blue through the fractures of a Ross Sea iceberg. Despite voyaging so far south, the crew reported a relative lack of sea ice and icebergs compared with earlier expeditions. (*Olivia Price*)

Protecting freshwater taonga

Taonga species such as tuna (freshwater eels), kōura (freshwater crayfish) and kākahi (freshwater mussels) are central to the identity and wellbeing of many Māori.

One kākahi can filter about a litre of freshwater an hour. (*Stuart Mackay*)

For generations these species have sustained communities and helped transfer customary practices and knowledge from one generation to the next.

However, many communities are reporting that both the abundance and size of these freshwater taonga are declining.

Te Kūwaha, NIWA' s national centre for Māori environmental research, has been working with whanau, hapū and iwi for more than a decade to co-develop methods for the protection, restoration and economic development of these species.

This work continues through the MBIE-funded Cultural Keystone Species programme.

Nicole Hanrahan's research will help develop new techniques to restore kākahi populations. (*Stuart Mackay*)

Hitchhiking biofilters

Kākahi (freshwater mussels) are valued not only as an important mahinga kai species, but also for their role in maintaining water quality as biofilters in our lakes and streams.

It is estimated that one kākahi can filter about a litre of freshwater an hour. If present in large enough numbers, kākahi can filter the entire volume of a small lake within days.

But numbers are in decline. Researchers need to better understand their lifecycle to protect them – particularly during their distinctive parasitic stage, when kākahi are most vulnerable.

Kākahi reproduce by releasing clouds of larvae into the water. The larvae attach themselves to passing fish, transform into a juvenile and hitchhike upstream with their hosts to a new habitat, where they fall off, settle and grow.

As part of the Cultural Keystone Species programme, postgraduate student Nicole Hanrahan is investigating this host-parasite relationship between kākahi and native fish in Waikato streams.

She is also working in the laboratory to find out whether host fish develop an immunity to repeated kākahi infestation.

Hanrahan has found kākahi attached to nine different freshwater fish species, including some fish that they have never been found on before.

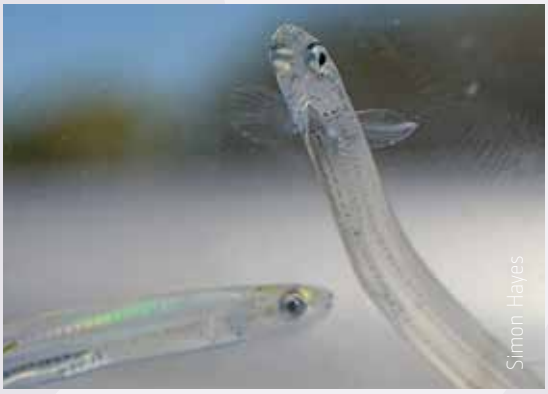
She has also artificially infested common bully with kākahi to see if the fish develop an immunity to the parasitic stage of the mussel. Preliminary results suggest they do not.

Hanrahan's work is significantly building knowledge about kākahi lifecycle and habitat preferences and will help tailor more effective restoration techniques for this treasured species.

Ask a scientist

Each week NIWA receives queries about a host of different topics. Our experts are tasked with delivering the answers. Here's a taste of our inbox.

Q. Where do whitebait come from, and what is happening to their overall numbers?



A. Whitebait is the term we give to the juveniles of five different species of migratory native fish called galaxiids. The name galaxiid comes from the patterns on the skin of the adult fish that look like a galaxy of stars. The larvae of these fish develop at sea before returning to freshwater as juveniles. Those that escape the nets will grow to adults in our rivers and streams. Presently, four of the five species are in decline or threatened. There are a number of reasons for this, but the primary factors are thought to be the loss and degradation of the freshwater habitats that the whitebait need to complete their lifecycle.

Dr Cindy Baker, Principal Scientist – Freshwater Fish, Hamilton

Q. Where was New Zealand's longest recorded dry spell, and will climate change mean we are likely to see this record broken?

A. The longest spell without any rainfall recorded in New Zealand is 71 days. This was measured at the Wai-iti weather station near Seddon in Marlborough, starting from 8 February, 1939. Much of New Zealand, particularly in the east and north of both main islands, is projected to become more drought-prone with climate change, and the lengths of dry spells will increase. New Zealand's climate is also expected to become more variable, so it is likely that this record dry spell length will be broken in the years to come.

Petra Pearce, Climate Scientist, Auckland

Q. Kingfish have been caught as far south as Otago Harbour this year. Why is this and can anglers expect more of the same in the future?

A. Yes. Some fish species that are normally found in the warmer waters around the North Island occasionally straggle south as far as Otago and Foveaux Strait. Good examples are snapper and kingfish, which have been reported from the Otago region for at least a century, usually turning up during autumn when water temperatures are at their warmest. Now, with ocean temperatures increasing around New Zealand, these species are being seen in larger numbers and are probably staying for longer in southern waters. Kingfish and snapper may one day be common in Otago Harbour.

Dr Malcolm Francis, Principal Scientist – Fisheries, Wellington

Fighting fires – one forecast at a time

When fire came to Pigeon Valley, Fire and Emergency came to NIWA.

> "We create a forecast and then walk the incident management team and any of the key decision makers through it"
>
> Chris Brandolino

Chris Brandolino took the first fire call at 3.40 pm on 5 February walking back to his Auckland desk after a meeting. Flames were starting to rage across Pigeon Valley near Nelson and Fire Emergency New Zealand (FENZ) were in urgent need of some highly detailed weather information.

NIWA's principal forecaster had been half expecting it – soil moisture levels were extremely dry in Tasman, there hadn't been any significant rain since Christmas and there was plenty of fuel to feed a huge blaze.

From then on, as the fire spread – along with the understanding that it was going to take enormous resources to bring it under control – Brandolino and his team became an integral part of the firefighting strategy.

Since 2017 NIWA has been providing an on-call forecasting service to FENZ, but last year it introduced several new forecasting products that had their debut during the Nelson fires.

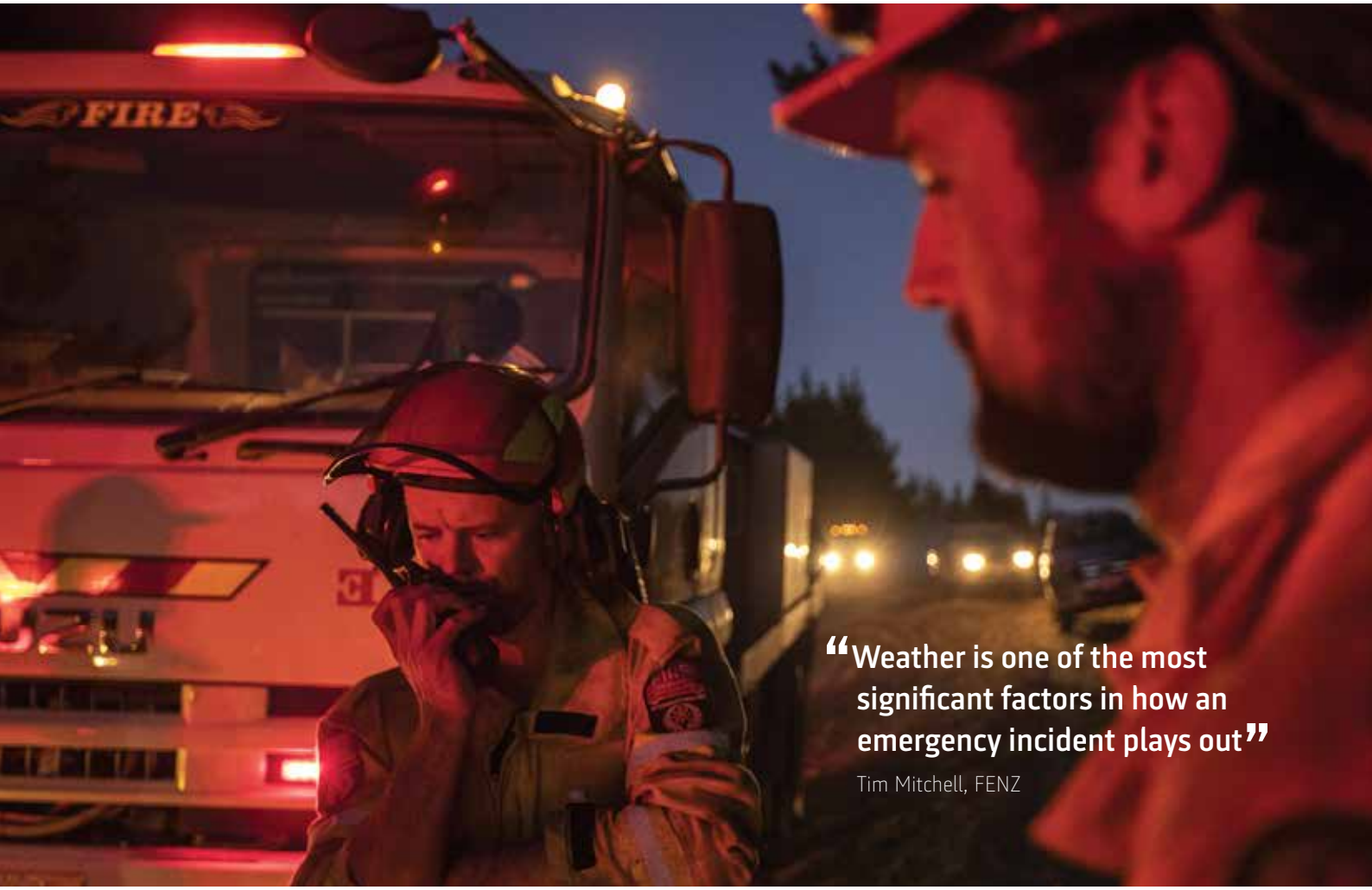
"Over the first weekend things were quite touch and go, so we initiated our new Incident Response Service," says Brandolino.

"It is designed for significant situations like Nelson – we create a forecast and then walk the incident management team and any of the key decision makers through it. We use maps and computerised graphics of wind speeds and directions and provide a very detailed understanding of the weather."

The NIWA weather team delivered three of these comprehensive briefings over the duration of the fires and these were supplemented by four targeted forecasts a day – some short term, some extremely localised and some a weekly outlook that enabled FENZ to strategically plan its attack.

Weather, says Tim Mitchell, one of FENZ's rural fire managers, is one of the most significant factors in how an emergency incident plays out.

NIWA's principal forecaster Chris Brandolino. (*Dave Allen*)



"If it's a hazardous spill, we need to know which way the wind is blowing and whether rain will wash it into the drainage system faster. If there's a fire risk, a weather forecast can help us decide whether to introduce restrictions or prohibit certain activities outdoors."

With something the scale of the Nelson fires, the first priority is to understand what's going on at the micro scale. That's where NIWA's high resolution forecasting system comes into its own. It can predict weather changes in very small areas, taking account of terrain and landscape, and how the air interacts with mountains and the sea, to provide a more accurate wind forecast.

Mitchell says the accuracy and quality of weather forecasts is critical.

"We take that knowledge and work out what to do with it, deciding which areas to prioritise, where to position our resources and plan our tactics for the next few days."

NIWA provided 95 forecasts to FENZ during February. Brandolino believes that NIWA's success is the quality of the model that underpins the service, and he says working directly with the customer provides clarity and removes doubt.

He says it's a service that can also be applied to a wide range of different businesses where weather is an important factor.

"We got to know the Nelson weather patterns particularly well – especially the conditions that produce strong wind gusts. We were also reminded of how hard it is to actually get rain in Nelson."

Above: NIWA's high resolution weather updates helped shape frontline decisions for crews battling the Pigeon Valley blaze. (*FENZ*)

Graphic by FENZ

Back cover photo: Nelson fires rage. (*Stuff*)