

**SMALL WORLD**

NIWA across the globe

**AIR TIME**

Capturing a forest's breath

**MASTER AT WORK**

*Tangaroa's* new man at the helm

**SOUTHERN MISSION**

Six weeks at sea in Antarctica

# Water & Atmosphere

MAY 2025



## UNWANTED GUESTS

Inside the race to control our latest invader

# Water & Atmosphere

May 2025

Maddy Brennan



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*Water & Atmosphere* is published by NIWA. It is available online at [www.niwa.co.nz/pubs/wa](http://www.niwa.co.nz/pubs/wa)

Enquiries to:

The Editor  
*Water & Atmosphere*  
NIWA  
Private Bag 14901  
Kilbirnie  
Wellington 6241  
New Zealand  
Email:  
[enquiries@niwa.co.nz](mailto:enquiries@niwa.co.nz)

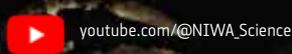
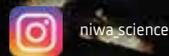
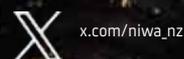
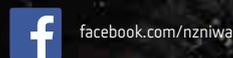
©National Institute of Water & Atmospheric Research Ltd  
ISSN 1172-1014

*Water & Atmosphere* team:

Editor: Susan Pepperell  
Production: NIWA  
Communications and Marketing Team

Editorial Advisory Board:  
Geoff Baird, Sarah Fraser,  
Barb Hayden, Emily Lane,  
Rob Murdoch

Follow us on:



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



Cover: NIWA Freshwater Ecologist, Dr Michele Melchior, sorts through a bucket of invasive clams at Bob's Landing, Waikato River. (Maddy Brennan)

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# ADVANCES IN HAZARD AND FORECASTING SCIENCE

We have a once-in-a-generation opportunity to ensure our science sector leads the world in delivering value, impact and opportunity, says NIWA Chief Executive John Morgan

“Business as usual while establishing a new research and development organisation”

New Zealand science is undergoing the biggest organisational change since Crown Research Institutes were established more than 30 years ago.

For NIWA, this means a merger with GNS Science to create an Earth Sciences-focused Public Research Organisation – at the same time as NIWA acquires MetService.

The combination of the capabilities and resources of the three organisations provides a unique opportunity to create a world-class research organisation – the Earth Sciences Institute (ESI) – to address New Zealand’s environmental and geoscience opportunities and challenges, while driving economic and societal growth.

The benefits of establishing the ESI are compelling. We believe the outcome will be enhanced science, improved operational efficiency and the delivery of greater impact and value to the nation.

The new institute will aim to:

- increase economic growth through sustainable management and innovative research into the use of marine, freshwater, energy and mineral resources,

- enhance resilience by reducing the impacts of natural hazards and climate-related risk and by supporting adaptation and mitigation, and
- enhance the stewardship of ecosystems and biodiversity.

More specifically, ESI will enhance industry and societal relationships to meet challenges such as:

- reducing risk and building resilience to extreme weather, coastal and geological hazards,
- supporting growth of renewable energy,
- supporting resilience to climate change,
- increasing understanding of land and marine geological processes,
- supporting the sustainable use of fisheries, aquaculture and other marine resources,
- improving understanding of coasts, oceans and Antarctica,
- understanding freshwater systems, water quality and management,
- enhancing resilience and risk management through advanced technology, AI, machine learning and data science, and
- supporting economic growth and resilience of Māori and Pacific Island nations.



Rebekah Parsons-King

## A world-class weather and climate forecasting service

Bringing together the weather and climate forecasting capabilities of NIWA and MetService will result in a future-focused organisation designed to enhance the safety, wellbeing and economic benefit of New Zealand and South Pacific nations.

Earth Sciences will do this by delivering tailored and high-resolution information where and when it is needed, using the latest modelling capability, supercomputing technology and the application of AI – integrating meteorological, hydrological, oceanographic and technological forecasting capability, from research through to impacts.

We will continue to provide research and science services to inform key regulatory, policy and investment decisions and give confidence to climate-sensitive industry, local and central government and the public. As a long-standing and core member of the Momentum Partnership we will continue to contribute to the development of the world-leading modelling framework underpinning global weather and climate science.

Our aim is to improve the current warning systems for weather, climate and related hazards through:

- a national flood prediction and warning service, integrated with the severe weather warning service,
- a national coastal hazards warning service,
- and, in collaboration with partner agencies, a forecasting service that extends the warning system to other weather- and climate-related impacts, such as space weather impacts.

The advantages of scale the combination of NIWA and MetService provides will also be realised through investment in technological advances such as supercomputing, data management, data science and AI, sensor systems and satellite remote sensing.

These science sector reforms represent a once-in-a-generation opportunity. While there will inevitably be some changes in the way we operate, the three organisations are committed to meeting our obligations to our current contracted responsibilities. In other words, it's business as usual while establishing a new research and development organisation.

GNS Science, MetService and NIWA all have outstanding reputations for making an important difference to the lives of all New Zealanders. We do not take this responsibility lightly, and we are committed to ensuring the legacy continues.



# NEWS BRIEFS

## PIONEERING SWATHCAM

SwathCam is a new NIWA tool – a nine-metre metal frame fitted with video cameras and lights to provide crystal clear visibility underwater.

Towed on a fibre-optic cable behind NIWA's RV *Kaharoa II*, SwathCam has a variety of applications. It was designed to increase understanding of seafloor habitats, but it can also be used for estimating fish species' abundance and size.

The technology was the brainchild of NIWA marine ecologist Dr Mark Morrison and was built by the Marine Technology Group, led by Will Quinn.

The system was first employed during a survey of underwater habitats in the Hauraki Gulf Marine Park last year with stunning results.



Luke McPake

## DEEP DIVES

NIWA joined two research voyages on the German research vessel *Sonne* in the early part of this year, fostering national and international research collaboration.

The first voyage took NIWA researchers from the Chatham Rise to Fiordland, studying cold-water coral habitats off the coast. A remotely operated vehicle was used to survey and show in real time the communities of creatures living on the seafloor, including corals, anemones, amphipods, sponges and more.

The second voyage saw NIWA and GNS Science working together to better understand the risk of undersea landslides and their potential to cause tsunamis along New Zealand's east coast. Alongside colleagues from German institutions GEOMAR and Kiel University, NIWA scientists looked at different areas off the Wairarapa and Canterbury coasts which have previously experienced huge landslides.



Luke McPake

## MEASURING METHANE FROM THE GROUND, SKY AND SPACE

A successful field campaign in Canterbury saw NIWA researchers measuring atmospheric methane to help validate the MethaneSAT satellite's observations as it passed overhead. The team measured methane from the air with equipment mounted on a Cessna 185, and from the ground using four high-tech instruments called EM27/SUN spectrometers.

The work was part of the MethaneSAT agricultural research programme, led by NIWA with funding administered by the Ministry of Business, Innovation and Employment.

"Tracking methane emissions is a bit like finding a leak," explains Dave Pollard, NIWA atmospheric scientist who led the campaign. "If it's a fire hydrant gushing water, it's easy to spot. But if it's a damp patch in your garden from a slow hose leak, you need more precise tools to track where the water is coming from."

MethaneSAT is designed to detect large-scale emissions from oil and gas operations. It's great at spotting these big 'fire hydrant' leaks, but agricultural emissions are dispersed and harder to pinpoint.

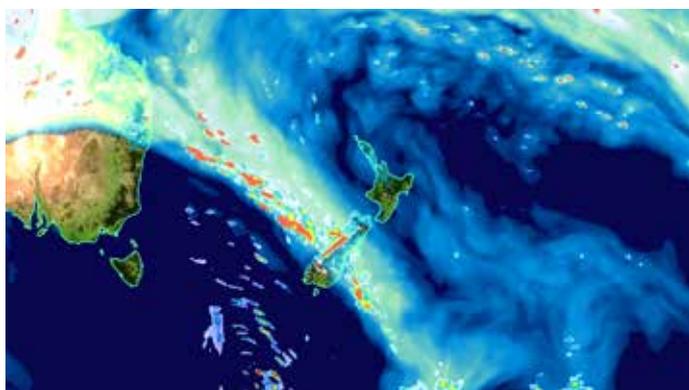
Validating the satellite's accuracy for a country like New Zealand, where we already have excellent information about our methane emissions, means the data can be relied on in countries where emissions profiles are less well known.



In the skies above Canterbury, PhD student Harrison O'Sullivan-Moffat monitors an in situ analyser to measure and validate MethaneSAT data.



Stuart Mackey



## MORE, AND MORE EXTREME

New Zealand could face twice as many of the most extreme atmospheric rivers by the end of the century. In addition, rainfall from these 'rivers in the sky' is likely to make up a much bigger proportion of New Zealand's total annual rainfall.

NIWA's research analysed the latest climate change projections released last year by NIWA and the Ministry for the Environment. NIWA climate scientist Dr Peter Gibson says the study examined the projections for the frequency and intensity of atmospheric rivers under a relatively high greenhouse gas emissions future.

There are two reasons for the likely increase – due to both an overall warmer atmosphere holding more water vapour, and changes in wind patterns.

## KAHAROA II AT WORK

NIWA's new marine research vessel *Kaharoa II* has been in high demand since it arrived in New Zealand last year.

Christened on 19 August by former Science Minister Hon Judith Collins KC, the vessel arrived in Wellington after an 83-day transit from the Astilleros Armon shipyard in northern Spain.

The vessel has already completed three fisheries surveys for Fisheries New Zealand along the West Coast, a habitat study in the Hauraki Gulf Marine Park and a voyage to Chile to deploy Argo floats across the South Pacific.

Designed by Norwegian naval architects Skipsteknisk, *Kaharoa II* is a significantly enhanced, next generation research vessel.



Caroline Beamish

# UNWANTED GUESTS

They're the worst kind of visitors – destroying everything in their path and then refusing to leave. Susan Pepperell goes beyond the surface and reveals how NIWA's experience, ingenuity and continually evolving technology is leading New Zealand's aquatic biosecurity fightback.



**PLUS: NIWA'S 30  
YEARS OF AQUATIC  
BIOSECURITY**

# Clammed up: the race to stop NZ's latest invader

Invasive clams have made themselves at home in the Waikato River. Scientists hope to stop them in their tracks.



Measuring invasive clams at Bob's Landing, Waikato River. (Maddy Brennan)

In a Hamilton laboratory Dr Michele Melchior is juggling buckets, nets and waders.

The NIWA freshwater ecologist may look like she's preparing for a field trip, but instead she's spraying everything with a variety of compounds to find out what will kill something the size of a grain of sand without damaging anything else.

The task is urgent. Right now the official advice to ensure the invasive clam, *Corbicula fluminea*, doesn't stray from the Waikato River, is to check and clean boats and gear and then dry everything for 48 hours. That's a lot of time between fishing trips.

The clam, native to Asia, is one of New Zealand's newest invasive freshwater species. First discovered in May 2023 at Bob's Landing, Kārapiro, it has also been found in Lake Maraetai and downstream reaches of the Waikato River, but, touch wood, so far nowhere else.

What makes this invasive species so bad is that it doesn't need a mate to breed. It fertilises itself and is capable of spitting out a staggering 70,000 clams per year. These baby clams are among the tiniest invisible enemy imaginable – approximately 0.2 millimetres wide.

The clam can live quite happily bunched up with 20,000 others in one square metre for up to five years. Such dense populations have clogged pipes and infrastructure overseas and have the potential to do the same here. The Waikato River, the longest in New Zealand, has numerous drinking water intakes and hydroelectric power plants along its 425 kilometre course.

The clam appears to like the same habitat as the kākahi, our native freshwater mussel, and by sheer weight of numbers could reduce the habitat available for kākahi. The clams also release ammonia. In dense populations those ammonia levels can get high and be detrimental to underwater plants.

Vigilance may be the only control option at the moment, but at their Hamilton base, NIWA

freshwater scientists are working quickly to figure out how to get ahead of the clams and stop them establishing further.

Biologist Brian Smith was one of the first people to see the invasive clam – he was called in by Biosecurity New Zealand (Ministry for Primary Industries) when they were first spotted at Bob's Landing on Lake Kārapiro, and asked to conduct a visual search along the river.

"It was so different from anything else I'd seen. I didn't know what it was, but I did know it wasn't supposed to be there."

He checked several other sites downstream – the Moana Reserve, Keeley's Park, the Cambridge boat ramp and Wellington Street Beach, in central Hamilton. There were clams at all of them.

"The thing with invasive species is that they tend to do quite well. Without predators or the biological controls they may face in their native habitat, they can quickly take over."

The next step was a 'delimiting survey' undertaken for Biosecurity New Zealand and starting from Taupō to establish exactly where the clams were, followed by a more comprehensive baseline survey in May last year. By August the clam had been declared an unwanted organism under the Biosecurity Act.

In October the NIWA freshwater science team was notified it had succeeded in securing \$10 million from MBIE's Endeavour Fund to develop "novel control methods, understand the impacts of the clam on taonga species, and predict its further spread".

One of the most important challenges for the scientists is learning how the invasive clams behave in New Zealand and how they interact with native flora and fauna.

Scientists want to establish where the baby clams are likely to go in the water column when they are dispersed, the quality and depth of water they prefer to establish in and what they're happy co-habiting with.

## NIWA'S BIOSECURITY MILESTONES

### 1995

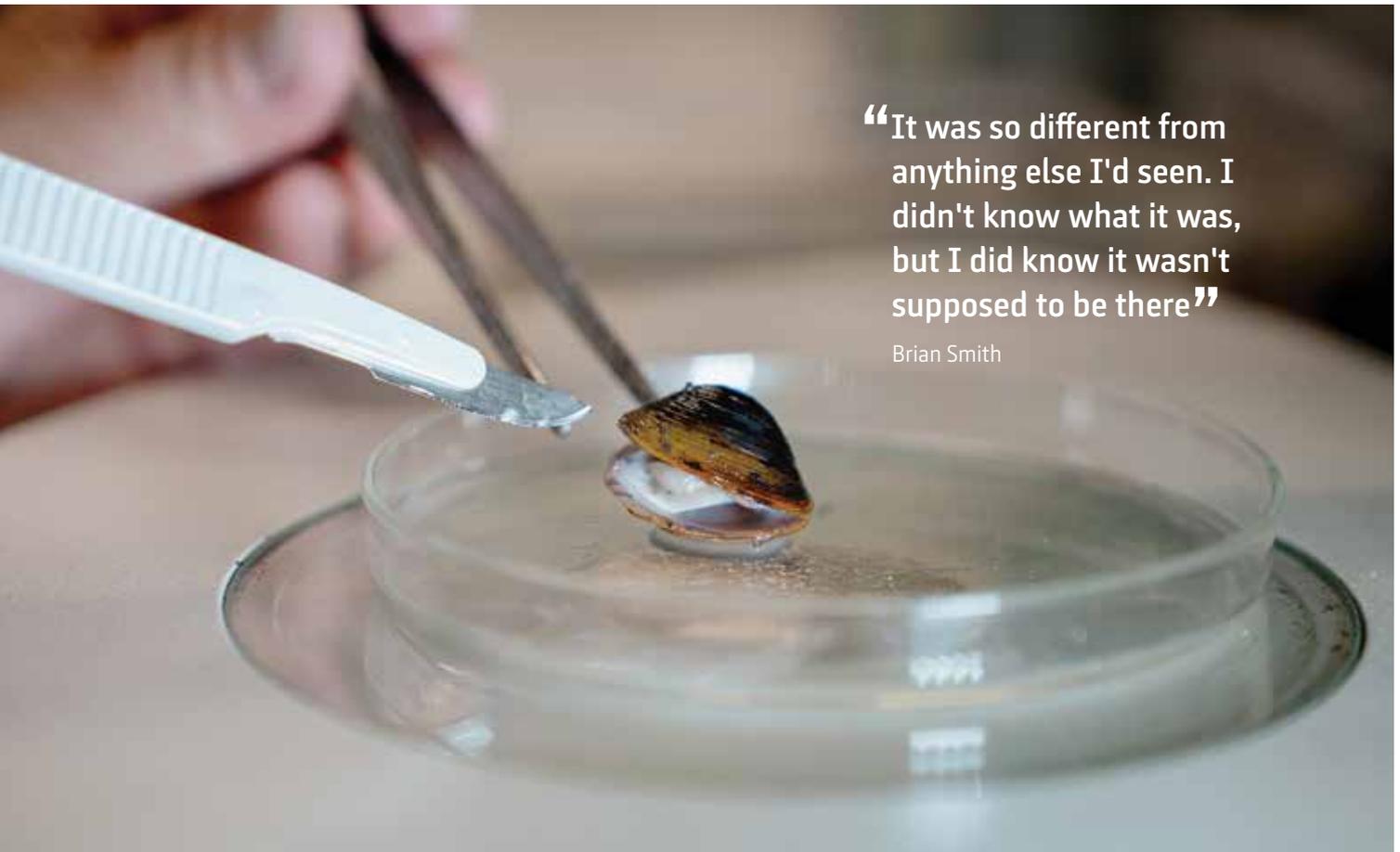
NIWA scientists establish the first NZ Ballast Water Advisory Group to develop strategy on managing risks from ships' ballast water and biofouling.

### 2001

NIWA begins surveying marine plants and animals in ports and marinas to provide baseline monitoring of native and introduced organisms.

### 2002

NIWA implements a national surveillance programme for high-risk exotic marine organisms. It becomes the National High Risk Site Surveillance programme in 2005.



“It was so different from anything else I'd seen. I didn't know what it was, but I did know it wasn't supposed to be there”

Brian Smith

Invasive clam dissection in NIWA's Hamilton laboratory. (Maddy Brennan)

As Dr Deborah Hofstra, NIWA's principal scientist, freshwater ecology says: “At some point we want to know where the clams might be. Are they everywhere or can we say ‘this area is too muddy so put your efforts here’.”

The team is also taking what's already been tried overseas and adapting it to the New Zealand environment while testing other ideas.

This knowledge will assist in testing conventional control methods and developing innovative approaches aimed at targeting the most vulnerable lifestages of the clam to disrupt its development and limit further spread.

Melchior will trial benthic barrier methods – effectively like laying carpet over the clam habitats, something that has proved successful in controlling the invasive weed *Lagarosiphon major* in South Island lakes, and more recently to smother exotic caulerpa. Caulerpa is another invasive species, first discovered in New Zealand marine habitats in 2021.

She's also working with an acoustician based at the University of Waikato to test whether sound could disrupt clam development.

Smith has recently placed passive samplers in the river in different habitats, as part of research to develop a passive sampling method. When he removes them, he'll count the juveniles as a first step to designing methodology that could be more widely used along the river. This data will ultimately be fed into predictive models.

Meanwhile, NIWA environmental economist Zoe Qu is figuring out how to determine the economic and social impact of their spread.

To attempt this, she needs to first understand the potential economic impact of the clams on people, industries and other end users of the river, and what people think about the clam spreading from their own perspectives.

Meanwhile, businesses are keen for information to assess the risks and work out mitigation options. The clams have already been found in other places, or at least knocking at the gates.

Recently Smith dug his hand into the clear bottom of the Waikato River. As he rinsed off the sand he held out his palm. On it sat eight clams.

**For more information on how to stop invasive clams spreading see:**

**[www.biosecurity.govt.nz/clam](http://www.biosecurity.govt.nz/clam)**

## 2002

NIWA uses DNA methods to identify the invasive Japanese paddle crab, *Charybdis japonica* from Waitematā Harbour.

[www.niwa.co.nz](http://www.niwa.co.nz)

## 2004

NIWA undertakes a biofouling risk study on 500+ international vessels to support NZ's Craft Risk Management Standard for vessel biofouling.

## 2005

NIWA undertakes a national delimitation survey at 26 high-risk locations for Unwanted Organism, *Styela clava*, following detection in Auckland and Lyttelton.



# AI seeks out invasive species

Pinpointing new incursions of invasive species in marine and freshwater ecosystems is now quicker, cheaper and more accurate



Freshwater ecologist Dr Daniel Clements tinkers with an autonomous vehicle kitted out to detect the invasive lagarosiphon using AI. (Maddy Brennan).

**“It is far more cost effective to conduct management at the early stages of an invasion”**

Dr Daniel Clements

NIWA is leading the way in developing new detection tools that are likely to revolutionise how New Zealand carries out its biosecurity programmes.

Top of the list is using AI in conjunction with underwater drones or autonomous unmanned surface vessels. The work is multi-disciplinary and has involved NIWA aquatic scientists, AI data science specialists and the instrument systems team building the hardware.

That combined expertise has led to a new approach to the detection of three invasive species: Caulerpa and Mediterranean fan worm in the marine environment and *Lagarosiphon major* in freshwater. Each species is capable of rapid growth and developing dense stands with the ability to displace native biota.

But detecting and managing invasive species in our oceans and freshwater environments is time-consuming and laborious work.

NIWA is contracted by Biosecurity New Zealand, part of the Ministry of Primary Industries (MPI), and Land Information New Zealand (LINZ), to carry out marine and freshwater surveillance surveys using visual surveys by divers or with underwater video cameras filming the seafloor or lakebeds, wharves and other

infrastructure. In the past, the video was processed and analysed on shore before decisions were made on how to manage or eradicate the species.

However, in recent months marine ecologist Dr Leigh Tait has been mapping Caulerpa incursions around Waiheke Island and the Bay of Islands using an underwater remote operated vehicle (ROV) in conjunction with an AI detector system. The AI algorithm is trained to recognise Caulerpa and records its position via GPS as cameras pass over it.

This detection in real time is the game changer, according to Tait.

“For a regulatory agency like MPI, we could feed a product like this into a web interface where there are people back in Wellington who are able to see it.

“If, for example, we discover something that isn’t where we expected it to be, we could be given real time instructions on whether to continue to find the edges of the population. It makes things a lot more flexible, more efficient and also reduces the costs of processing.”

The other advantage of this technology is the ability for it to go where divers can’t.

By necessity, underwater surveillance surveys have to be planned to fit within a diver’s safe limits and availability.

“I really believe that is going to be the standard operating style for these types of surveys in the future. These methods are highly accurate, sensitive and provide an immediate geographic location,” says Tait.

“And the thing about the AI detector is that development here and now will be of benefit when the next invasive species arrives and the next one after that.”

Meanwhile, NIWA freshwater ecologist Dr Daniel Clements has been leading the freshwater AI detection project and is excited by its potential to limit the spread of other freshwater invasive species.

“It is far more cost effective to conduct management at the early stages of an invasion.”

## NIWA'S BIOSECURITY MILESTONES

### 2005

NIWA expertise sought for possible foot-and-mouth outbreak on Waiheke Island to predict wind and atmospheric conditions.

### 2006

NIWA provides expertise to help mitigate spread of invasive algae didymo, discovered by a NIWA scientist in the Waiau River.

### 2007

NIWA advises on containment of lagarosiphon, a weed threatening hydro-generation. Meanwhile, NIWA identifies the best formula to kill didymo.

Suction dredging – like vacuum cleaning the seafloor but bigger – is one of the methods divers have used to help control incursions of the invasive *Caulerpa*. (Leigh Tait)



The lagarosiphon AI prototype has been trialed in several rivers and lakes around New Zealand, and when combined with remotely operated surface vessels will be able to be deployed more frequently and extensively than current surveillance methods. The addition of hydroacoustic sensors into the detection work will further enhance capability.

Dr Graeme Inglis, manager of NIWA's biosecurity services programme which includes a marine invasives taxonomic service and operational management of biosecurity responses, says the development of practical and efficient techniques for surveillance and management of aquatic pests is one reason New Zealand is a world leader in biosecurity.

"We are one of a few countries to have an active national surveillance programme. Many countries don't have a government equivalent to Biosecurity New Zealand, that is, an agency with a mandate to manage risks from invasive species."

He points to New Zealand also being one of the first countries to implement mandatory ballast water control on ships and the first to introduce regulations on ships governing biofouling.

"New Zealanders have a general awareness of the importance of biosecurity to our economy, natural environments and taonga – more so than most other

nations. We understand what's at stake if new pests are not detected and managed effectively."

But he is concerned that further challenges lie ahead. He is wary of emerging diseases and 'sleeping pests' that may already be present in New Zealand and may become problematic with a warming climate.

In the meantime, work on managing the spread of *Caulerpa* continues. NIWA's field teams have been working solidly for the last few years undertaking delimiting surveys throughout north-eastern New Zealand to determine the size of new incursions, and trial control methods with partner organisations, including large-scale application of salt or chlorine, hand removal, benthic matting to smother the plant, and industrial-scale suction dredging.

There have been some successes, and further evaluation is needed to find the right management tool for different locations.

As Tait and Clements continue to refine their AI detection methods, NIWA is focusing on developing the computing infrastructure to allow data scientists to quickly develop algorithms for new species.

That's because when it comes to biosecurity the only certainty is that pests that are already here won't stop reproducing without intervention, and the next invasive species is knocking on the door.

## 2008

NIWA detects the Unwanted Organism Mediterranean fanworm in Lyttelton Harbour and leads a local elimination programme.

## 2013

NIWA works with Zespri and Plant & Food Research to develop a model to forecast risks from the kiwifruit disease *Psa-V* ahead of weather-related outbreaks.

## 2015

NIWA awarded \$3 million from MBIE's Environmental Research Fund to develop methods to forecast and quantify the impacts of invasive marine species.



# SOS: save our shellfish

Dr Henry Lane loves eating oysters – preferably cold, raw and with a dash of lemon.

He also likes them in the lab, where he trades his shucking knife for a microscope to understand hidden threats to our shellfish in a changing climate. Peering into a hidden microbial world, he is investigating the bacteria *Vibrio*, a pathogen emerging as an issue as water temperatures rise.

Lane, a marine biosecurity scientist, leads NIWA's aquatic animal health work, a rapidly growing area due to its importance for commercial, recreational, and customary fisheries as well as aquaculture.

mass numbers of shellfish die in summer and no one quite understands why.”

A lack of baseline data is now starting to be filled, but Lane says there remains “large unknowns we’re just trying to understand”.

“Once you identify a potential issue, then you can begin to understand it and start to develop some management approaches. Unfortunately, there’s no silver bullet, but the science will provide options to be able to do something about it.”

It’s also biosecurity science that may ultimately see the flat oyster farming industry reinvigorated.

After decimating flat oyster populations in Europe, the parasite *Bonamia ostreae* turned up in the Marlborough Sounds in 2015. When it was subsequently discovered near Stewart Island, the Ministry for Primary Industries ordered the removal of all flat oyster stocks from marine farms in New Zealand to protect the iconic Bluff oyster fishery.

Lane says the idea was that by reducing the number of hosts of the parasite, you could reduce the opportunities for transmission – similar to how lockdown aimed to prevent the spread of COVID-19.

NIWA has been carrying out surveillance of bonamia in wild oysters for a number of years.

“It’s a wily little parasite. It hasn’t gone away and the wild fishers are incredibly worried about it turning up in their stocks, while at the same time there are people wanting to start farming oysters again.”

Lane believes the research is a chance to show that New Zealand can have its cake and eat it.

“I do see this as an opportunity to demonstrate that we can have a productive wild fishery that is safe and secure as well as an aquaculture industry.”

The key to that is minimising the risk of transmission between farmed populations and the wild.

“The research needs to be data driven and that’s one of the things I’m trying to do right now.

“Because if we’re realistic, things are going to continue to turn up in New Zealand and we can’t just keep destroying our aquaculture industry.”



A thin slice of a New Zealand oyster cut for laboratory research into the *Bonamia ostreae* parasite. (Stuart Mackay)

Eating raw or undercooked shellfish contaminated with *Vibrio* can make you sick. But it can also kill shellfish and in a changing climate could become more prevalent in New Zealand waters.

Lane’s project looks at predicting the risk of *Vibrio* in wild and production shellfish like pipi and mussels, under a range of climate change scenarios. The work draws on field observations and NIWA’s extensive climate modelling and environmental data science capabilities to deploy machine learning tools to predict where the risk is highest.

There are increased anecdotal observations that shellfish die-offs are now happening more frequently.

While Lane says there are primary drivers contributing to large shellfish die-offs such as temperature, salinity, or nutrient inputs, we need to understand their relationship to *Vibrio* and other pathogens in New Zealand’s waters before we can begin predicting them with any accuracy.

“There has been this emergence of a syndrome known as summer mortality, which happens when

## NIWA'S BIOSECURITY MILESTONES

### 2016

NIWA leads a project to enhance collaboration in marine biosecurity with Australia, Canada and the US, involving scientists from more than 50 institutions.

### 2017

NIWA provides crucial expertise after discovery of the lethal parasite *Bonamia ostreae* at two Stewart Island oyster farms.

### 2017

NIWA conducts critical modelling to assess the potential sources and timing of risk for aerial transport of Myrtle Rust spores from Australia.

Marine biosecurity scientist Dr Henry Lane is researching how to predict outbreaks of shellfish disease under climate change. (Stuart Mackay)



**“I do see this as an opportunity to demonstrate we can have a productive wild fishery that is safe and secure, as well as an aquaculture industry”**

Dr Henry Lane

## 2021

NIWA responds to the discovery of two new species of the fast-growing invasive seaweed *Caulerpa* by conducting surveillance and research.

[www.niwa.co.nz](http://www.niwa.co.nz)

## 2023

The invasive freshwater clam *Corbicula fluminea* discovered in the Waikato River. NIWA begins surveys along the river.

## 2024

NIWA is awarded \$10 million from MBIE's Endeavour Fund to develop clam control methods.

# SCIENTISTS AND THE ART OF COLLABORATION

Researchers will go to the ends of the earth for answers. Here's some who have done just that.

Science, said US physicist and two-time Nobel prize winner John Bardeen, is a collaborative effort.

“Further, it is truly international in scope ... the combined result of several people working together is often much more effective than could be that of an individual scientist working alone.”

NIWA, like scientific institutions worldwide, has international collaboration in its DNA. It works with most of the leading scientific institutions in its fields

Sperlich is now the manager of NIWA's Tropospheric Chemistry Group which maintains a long-standing time series of greenhouse gas concentrations. The team develops new methods to make extremely challenging measurements of tiny atmospheric changes.

“Measuring these microscopic changes takes place within a global network which helps define greenhouse gas emissions. It's a very exciting field to work in and one where I feel our team can make a difference.”

Sperlich and his team collaborate on method development, air sampling, analysis and interpretation of results among other areas.

“We also calibrate many of our instruments using standard gases that are only available from one specific international institute. We exchange air samples to assess our global measurements and to ensure our measurements and those of every other lab are as robust as can be.”

Sperlich says one of his favourite collaborative ventures was camping on the Greenland ice sheet with 25 researchers from 11 countries “all coming together to retrieve a bit of ancient ice for analysis”.

Right now, he is developing a new system for measuring methane from waste and agricultural sources – a project he says he was able to get going a lot faster with the help of international colleagues, requiring less funding to achieve the goal.

“Our international collaborations grow because we have a desire to improve and help each other. These partnerships constantly provide vital building blocks to our work. With no funding to waste and no time to lose, working together internationally has proven many times over to be a successful way to maximise the impact of our research and the benefit for New Zealand.”

Any scientist at NIWA can easily rattle off a list of names and institutions around the world that they talk to on a regular basis. But it's the variety of these collaborations which provides an insight into just how international science really is.

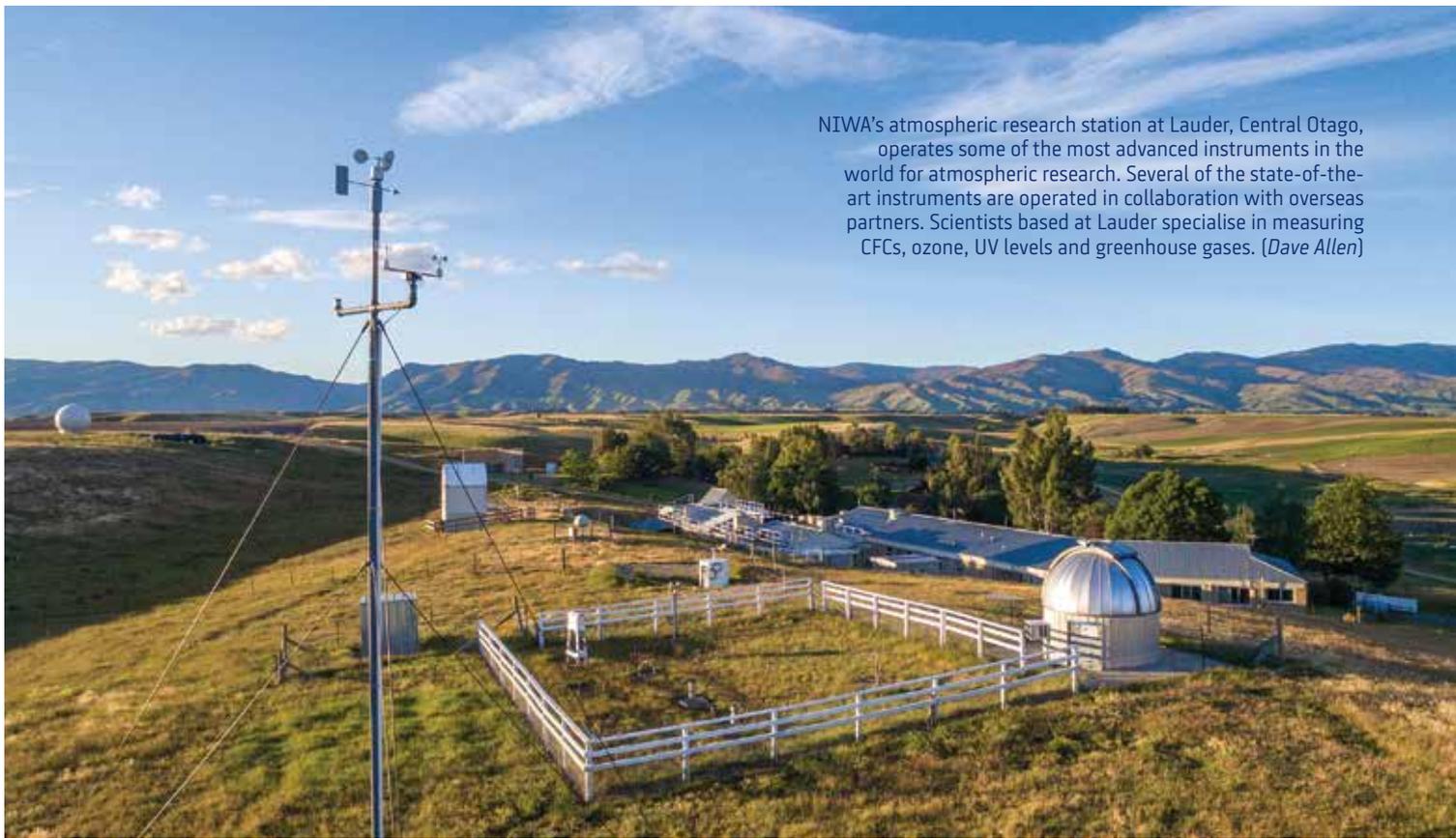


Atmospheric Scientist Dr Peter Sperlich. (Dave Allen)

– more of that overleaf – and the networks of its scientists reach into the far flung corners of the globe.

**Atmospheric scientist Peter Sperlich** is the perfect embodiment of that practice. Born in Cologne, his university studies took him from Goettingen and Bremen in Germany to Copenhagen in Denmark when he completed his PhD in geophysics. But not before coming to New Zealand.

“The Danish PhD system recognises the importance of overseas experience and relationships for a science career so funds a visit to an overseas lab. I was developing a method to measure methane isotopes in ancient ice core samples and the NIWA gas lab is the birthplace of such measurements so it was a privilege to come here.”



NIWA's atmospheric research station at Lauder, Central Otago, operates some of the most advanced instruments in the world for atmospheric research. Several of the state-of-the-art instruments are operated in collaboration with overseas partners. Scientists based at Lauder specialise in measuring CFCs, ozone, UV levels and greenhouse gases. (Dave Allen)



Coastal scientist  
Rafa Costa Santana



Data scientist  
Dr Gemma Mason



Marine ecologist  
Niki Davey



Climate scientist  
Dr Suzanne Rosier

**Rafa Costa Santana** met US scientist Chris Horvat on a staff outing to Wellington nature reserve Zealandia. Horvat stayed in touch when he returned to the US and then introduced Santana to colleagues in Norway. They simulated fractures in Antarctic sea ice for the first time with the results suggesting a need to change how sea ice is simulated in climate models.

It's important information for the planet, but for Santana it's also resulted in some firm friendships.

"We're all still in touch and are participating in a workshop together in July."

**Data scientist Gemma Mason** has been working with the UK Met Office and Bureau of Meteorology in Australia creating a software package for data management of AI and machine learning in weather, climate and other earth sciences.

What started as a reading group to keep up with dramatic advances in AI, has led to a joint funding proposal. "We've now got the beginnings of a great software package."

And a mysterious sea cucumber was the catalyst for **marine ecologist Niki Davey** travelling to Poland, France and the US sharing her taxonomic expertise.

Her first collaboration with a researcher at the Museum of Victoria in Australia came when she was struggling to identify the sea cucumber she was studying in Fiordland.

That association led to another, and she has recently been involved in a joint report on sea cucumbers in the Indian Ocean territories.

"It is so hard to get funding for this type of work so really, the collaborative support is one of the greatest achievements."

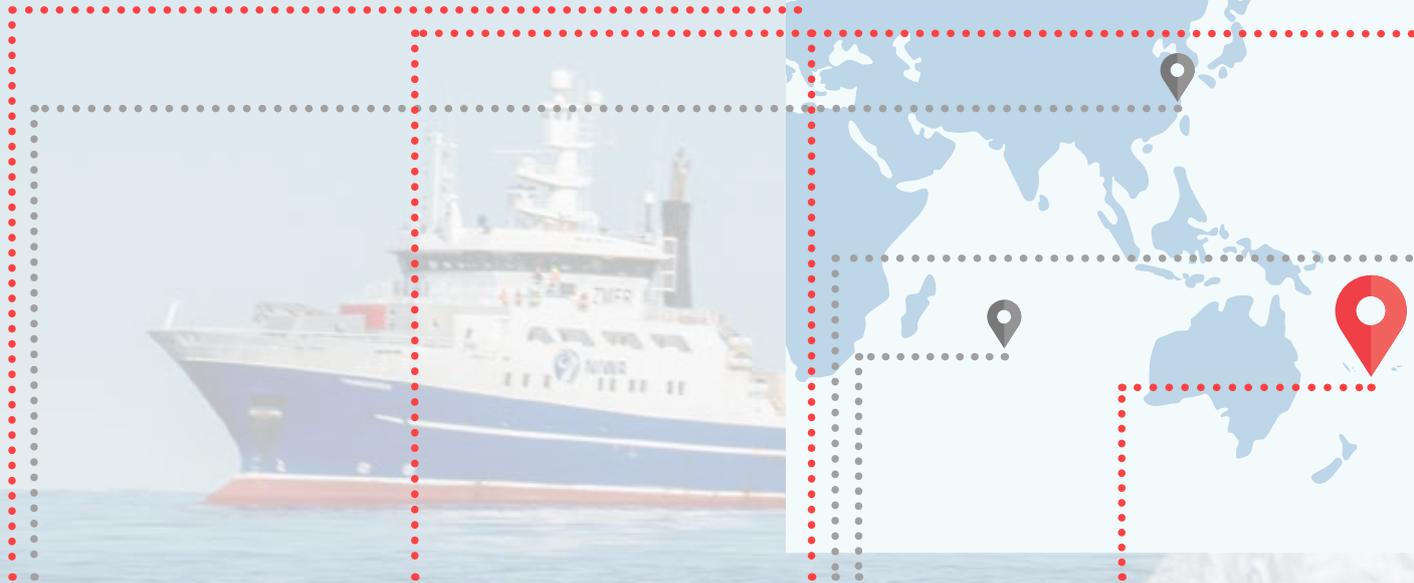
Meanwhile, **climate scientist Suzanne Rosier's** connections with Oxford University have enabled her to create New Zealand's only multi-member regional climate model simulations using Oxford's platform for distributing 3D numerical climate models to the public, harnessing their spare computer power.

"In this way the models can be run many more times than are usually possible, even with a supercomputer. These have enabled us to document many aspects of New Zealand's extreme weather, and how it is changing as a result of human interference in the climate system."

Better together. It's how we roll.

**See overleaf for more of NIWA's international collaborations**

# Working with the world



## Marine research

For more than 30 years NIWA has contributed to global marine research. NIWA's relationship with German organisations, the GEOMAR Helmholtz Centre for Ocean Research and Kiel University has enabled its scientists to take part in voyages aboard the deep ocean research vessel *Sonne*. This year NIWA scientists have been on board twice, surveying coral reefs and sea mounts and studying the risk of undersea landslides. NIWA scientists were also on board the Chinese vessel *RV Tan Suo Yi Hao* to explore the Puysegur Trench.



Kareen Schriabel



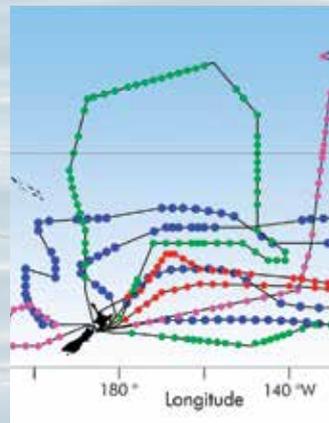
Dave Allen

## Atmospheric data

Every few weeks NIWA collects two flasks of air from Baring Head, near Wellington, and sends them to the US where The National Oceanic and Atmospheric Administration measures them, recording the amounts of methane, carbon dioxide, and a range of other gases. The information, along with other data supplied from across the globe, is fed into a co-operative air sampling network, forming one of the world's most valuable atmospheric measuring programmes.

## Argo floats

For more than two decades, NIWA has been part of the international Argo programme, deploying floats to measure temperature and salinity throughout the world's oceans. This collaboration with the Scripps Institution of Oceanography, the University of Washington and CSIRO improves understanding of the oceans' role in climate, weather and climate prediction. NIWA has deployed about 20 per cent of the 4000-strong float network. Most floats measure the oceans' top 2,000 m but Deep Argo floats go down to 6,000 m.



Hamish Biggs

## Pacific partnerships

Since 2016 NIWA scientists have worked with six Pacific countries on the Pacific Risk Tool for Resilience project to build resilience to climate-related hazards. The upcoming work includes the Cook Islands, Republic of Marshall Islands, Samoa, Tonga, Vanuatu and Tuvalu. It addresses a critical gap in the availability and use of low-cost tools to support people making decisions based on the risk of extreme weather events.



“Almost everything we do involves international collaboration”

Dr Peter Sperlich

## Antarctica research

NIWA is a major contributor to stewardship and science in the Antarctic region. Scientists conduct Antarctic field work for a range of research projects, mostly related to climate change. NIWA also maintains an atmospheric measuring station at Arrival Heights and has led a multi-year programme to monitor the marine protected area of the Ross Sea. The state of Antarctic fisheries is also a key research area for NIWA scientists having significant input into CCAMLR, the international convention to conserve Antarctic marine life.



Stuart Mackay



Stuart Mackay

## Antarctic voyages

About every two years NIWA's flagship research vessel *Tangaroa* heads to the Ross Sea, carrying scientists from around the globe. Each mission contributes to our growing understanding of the region. *Tangaroa* has now been to Antarctica 16 times, supported by a range of institutions within New Zealand and overseas.

## Methane measuring

One of NIWA's most high-profile international projects is MethaneSAT, the first NZ government-funded satellite mission. The MethaneSAT satellite measures methane with pinpoint precision. This allows scientists to determine the sources of this potent greenhouse gas. Designed to detect emissions from oil and gas infrastructure, MethaneSAT can also be used to measure agriculture emissions. This year NIWA conducted a trial using ground-based remote sensing and atmospheric profiles from aircraft to validate satellite measurements.



Supplied

## Better forecasting

The Momentum Partnership comprises five countries developing world-leading weather and climate forecasting technology. Members include NZ (NIWA), UK, Australia, India and Singapore plus four associates. The partnership is a world-leading modelling framework at the core of weather and climate prediction. It is invaluable in forecasting tropical cyclones, fire weather risks, flooding and storm surges. The partnership focuses on global and regional predictions and projections, and AI applications.



Rebekah Parsons-King

# Master at work

*RV Tangaroa's new master is a Samoan family man with the sea in his blood. Ryan Willoughby meets the man who set his sights on the top.*

Mapu Jr Tapuai remembers sitting with his father in Samoa, sheltering under a coconut tree and sipping kava. It was his 21st birthday and the pair spoke about the future and their shared passion for the sea.

"My father is the boss," says Tapuai. "He is somebody that I look up to. I remember when I was six or seven, he would take me on the inter-island services he captained. I wanted to be like him."

While Tapuai's father supported his son's aspirations to be like him, he wanted more for him. He wanted

Along the way, he married, settled in New Zealand, and had children of his own, further cementing his drive to achieve his father's hope.

"When you have kids, you want to better yourself," Tapuai says. "You want to provide a good life for them, a better life for them because you won't always be there for them one day."

After accumulating enough seafaring experience, Tapuai had everything he needed to become a Master Mariner. But one exam stood in his way. Under the weight of expectation, he took the rigorous maritime licensing exam, which probed his mastery of navigation, ship operations and his ability to take overall command of a vessel. He passed.

"When I got my masters ... I was so proud. Not only for me, but for my father. I promised my old man that I would. Taking my first command as captain ... it was very special. It's a big achievement."

For the majority of his career Tapuai worked on vessels based in Australia where the work was plentiful. But after reading an article about NIWA, he set his sights on a new goal and a new ship – NIWA's flagship research vessel, *RV Tangaroa*.

"At the time I was working offshore in Australia. I was earning a lot of money, but I was talking to my wife about it and she knew how much I wanted this role, so she encouraged me to go for it."

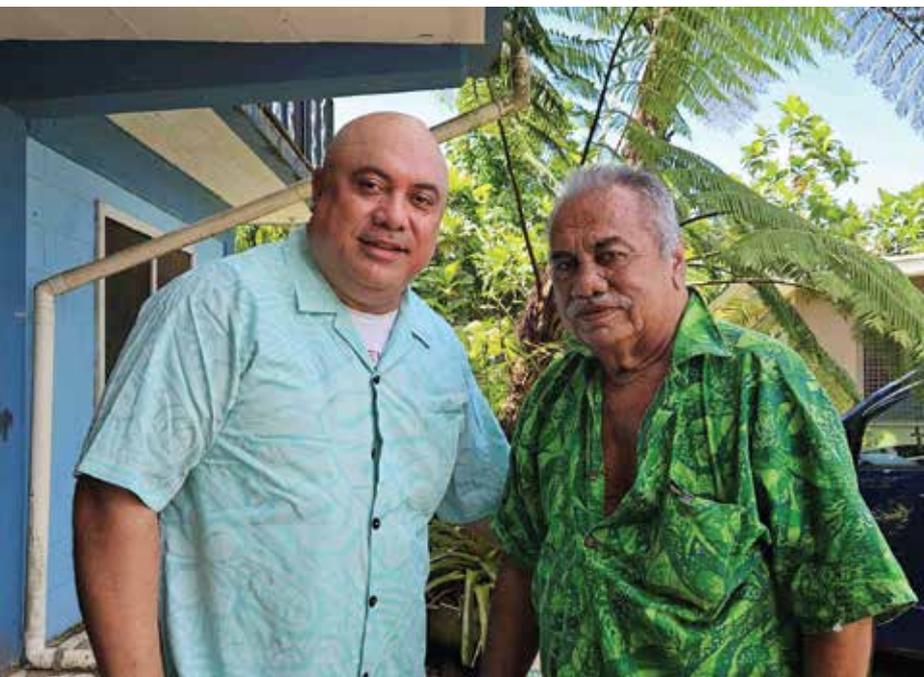
Late last year Tapuai took the helm of New Zealand's only deepsea research vessel. In doing so, he became the first person from the wider Pacific to take the helm.

Stepping aboard was a special moment for Tapuai. "I still feel goosebumps every time I go back to join the ship. I still can't believe it. I pinch myself every time."

Since taking on the leadership role, Tapuai has taken the ship as far as the Kermadec Islands. But when he was given the opportunity to take it further south, as far as south goes, he took it.

Over the summer, Tapuai led 38 crew and scientists to Antarctic waters to research the impacts of climate change on Antarctica's Ross Sea, and the impacts of a changing Ross Sea on the rest of the globe.

"Operating in Antarctica is extreme. It comes with challenges with equipment, navigation and in terms of decision making as well. But we had a good team with experience in the area."



Like father, like son – Mapu Jr Tapuai, left, with his father Mapu, in Samoa share a passion for the sea. (Supplied)

his son to be at the helm of ships that could cross the world's oceans. To achieve this, Tapuai would need to become a Master Mariner, the highest level of certification a mariner can obtain.

Tapuai knew the end goal, but there was work to do. To give him opportunities, Tapuai's family sent him to New Zealand to attend high school at 14. This set him up for marine school in Samoa, where he would begin his training in earnest.

From there he worked on local ferries in Samoa, which soon led to jobs on container ships and opportunities as an able seaman. Tapuai also gained experience in Samoa and New Zealand in warehouse logistics, customer service and administration.



“I still get goosebumps every time I go back to join the ship”

Mapu Jr Tapuai

This year Mapu Jr Tapuai, RV *Tangaroa*'s new master, captained the ship on a six-week voyage to Antarctica, an experience he says he will cherish. (Luke McPake)

“To see the continent of Antarctica, it was such an amazing experience. Words and photos do not do it justice. It was an unreal experience and one that I will cherish as a mariner.”

Tapuai says the experience transformed his appreciation of the ocean as more than a way to make a living and provide for his family.

“Seeing the dedication of the scientists and the work they were doing, I was just in awe and could not be any prouder to be a part of it. I look at the ocean with so much respect and gratitude knowing the data we collected from Antarctic waters will help in making good decisions for future generations.”

The team were able to complete all their objectives, but a late reversal of their voyage track to avoid sea ice in the north, tested the agility of Tapuai and his crew.

“The best moment for me is when we reached the furthest point south after adjusting the plan,” says Tapuai. “To be able to collect those samples and recover the moorings was an overwhelming experience for me. I was all in and wanted to make sure that it was a successful voyage.”

# VENTURING SOUTH



The scenery is spectacular, the work demanding, the experience incredible.

For six weeks over summer 38 scientists and crew of NIWA's flagship research vessel RV *Tangaroa* travelled 9000km to Antarctica and back undertaking an ambitious research programme right to the boundary of the Ross Ice Shelf.

This was the vessel's 16th trip to Antarctica, with each mission contributing to our growing understanding of the region. NIWA research voyages to the Ross Sea are undertaken every two years.

Key projects this year included the identification of different water masses, population changes of benthic communities, eDNA of benthic and mid-water species, biogenic sampling of underwater seeps and near surface biogeochemistry.

The work is made possible by funding through the Ministry of Business, Innovation and Employment, the Antarctic Science Platform, NIWA's Marine Environment Platform Strategic Science Investment Funds, Waipapa Taumata Rau University of Auckland, University of Otago – Ōtākou Whakaihu Waka, University of Canterbury, and overseas funding agencies including India's Centre for Marine and Living Resources and Ecology and the University of Southampton.

These images, taken by those onboard, provide a glimpse into an area that is rarely seen.



RV *Tangaroa* played a cat-and-mouse game with the sea ice to complete the science programme without becoming trapped.  
*(Hugh Carter)*

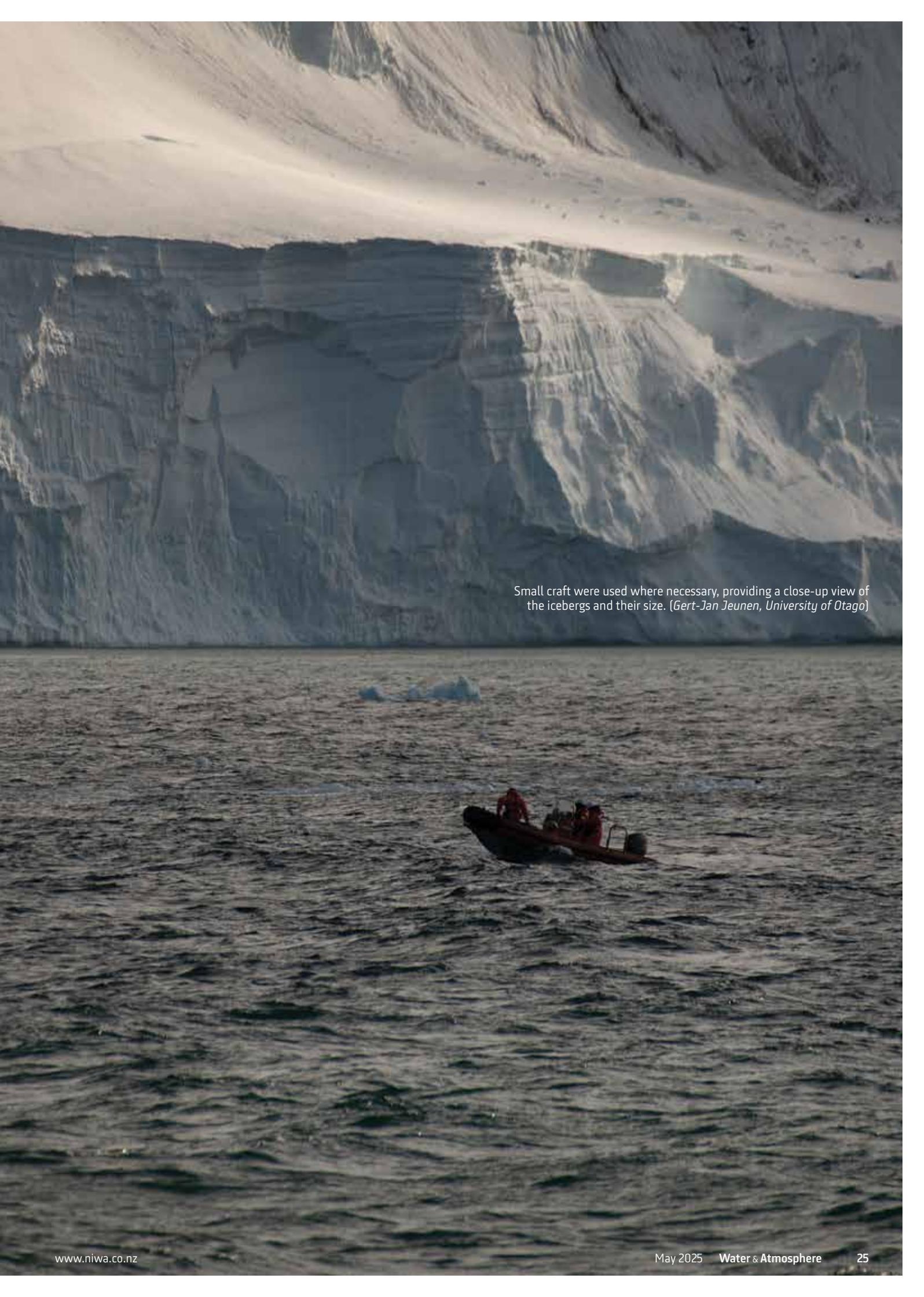
## Venturing south



While sea ice cover continued to hit record lows, distribution in key sampling areas, plus some tricky weather, forced the voyage to reverse their planned track around the Ross Sea in the hope it would clear. (Nicole Hill, IMAS/UTAS)

NIWA's research vessel *Tangaroa* surveying north of Ross Island in the shadow of Mount Erebus. (Rob King)





Small craft were used where necessary, providing a close-up view of the icebergs and their size. (*Gert-Jan Jeunen, University of Otago*)

## Venturing south

NIWA's remote ocean glider *Manaia* off on another mission to probe water and current conditions along the Ross Ice Shelf. *(Svenja Halfter)*



Seafloor imagery guided the collection of physical samples using equipment like the van Veen grab. *(Gert-Jan Jeunen, University of Otago)*

Deployment and retrieval of instruments allow scientists to monitor changes in ocean heat, salt and oxygen in the area, including a critical heat and salt corridor for the Ross Ice Shelf. *(Craig Stevens)*



More than 2,500 biological specimens were gathered throughout the voyage, contributing to the assessment of marine life in the Ross Sea Marine Protected Area. (Pamela Olmedo-Rojas)



The voyage included participants from Australia, Europe, India and the United Kingdom, reflecting the international cooperation needed to study this vital area. (Svenja Halfter)



# Capturing the forest's breath

Deep in the Raukūmara forest, a scientist learns how air and soil interact, what that means for the trees – and New Zealand. Mia Blyth reports.



Fine tuning in Raukūmara forest. (Mia Blyth)

A ute cruises along the windy, rugged coastline of State Highway 35.

On one side of this East Cape route is the Pacific, a vivid white and blue swirl, on the other, the dense Raukūmara forest.

Pōhutukawa tilt their branches across the highway, pointing the way to a narrow entrance. The ute makes a sharp turn up a gravel driveway overshadowed by massive tōtara. It stops, and all that can be heard is the occasional swoop of a kererū and the relentless shrill of cicadas.

Kararaina Te Puni gets out, hoists a sturdy, well-worn black box from the boot and trudges off into the forest. She's been here before and knows exactly where she's headed. Tucked in the scrub, Kararaina spots the glint of the instruments she placed here more than a year ago.

Over the past three years, Kararaina, an atmospheric scientist and PhD student, has been to the East Cape of New Zealand's North Island more than a dozen times. At carefully chosen sites – just inside the forest, out around the coast, and inland near the base of Mt Hikurangi – she has collected air samples

each time. Each sample contains a snapshot of the forest's breath. Her goal is to collect air upwind and downwind of the forest to understand how much carbon dioxide (CO<sub>2</sub>) it absorbs.

Specifically, Kararaina is investigating the ability of New Zealand's native forests to sequester carbon. Her work is part of CarbonWatch NZ, a five-year, NIWA-led research project to better understand the carbon processes across New Zealand (see panel page 25).

She is looking at the vast Raukūmara Forest, 200,000 hectares of steeply dissected hillsides with many areas more than 1,300m above sea level – the largest mountain-to-sea forest landscape in the North Island.

Forests primarily act as carbon sinks, sucking up carbon dioxide from the air and using this through photosynthesis to form the building blocks they need for growth.

Indigenous forests cover about 6.2 million hectares in New Zealand, yet these mature, old growth forests are often overshadowed by exotic pine, their faster-growing, rapid carbon sequestering counterparts.



Kararaina Te Puni prepares her equipment. (Mia Blyth)



**“Our native forests are dynamic ecosystems”**

Kararaina Te Puni

Kararaina collecting soil/air samples in Raukūmara forest. (Mia Blyth)

“People have always assumed our native forests are acting at equilibrium where the decay and release into the atmosphere is similar to the amount of carbon they take up,” Kararaina says.

Preliminary research using a limited number of atmospheric measurements suggested that this was not the case, and that native forests were likely taking up more carbon than previously thought. Yet, that study did not include data from forests in the North Island, so it was not clear whether this effect was replicated across the country. This earlier work provided the impetus for the CarbonWatch NZ project, and subsequently, for Kararaina’s PhD.

“Our native forests are dynamic ecosystems, ranging from low-lying shrubs to the massive tōtara, which are sustainable for a long time, far longer than the quick-fix solution we see with pine,” she says.

“If a mature indigenous forest down in Fiordland is taking up more carbon than we thought, what is happening up here in the Raukūmara forest?”

Kararaina works closely with the iwi-led Raukūmara Pae Maunga restoration project (see panel page 25) which manages the forest. Like Kararaina, they are driven by a strong passion for seeing the forest flourish and thrive.

Kararaina’s PhD has involved developing a new method and instrumentation to measure the air samples she collects, including to measure the uptake of carbonyl sulphide (COS) in the soil.

Similar in structure to carbon dioxide, COS enters plants and trees in the same way, but is not released. By measuring COS, Kararaina can get a better understanding of how the forest is storing carbon.

When she collects air samples in the forest, she uses metal cylinders embedded in the ground to collect flasks of air that has interacted directly with the soil.

“Just like the trees, the soil breathes gases in and out. I look at how the soils are breathing and what they are breathing in and out, and how that affects the composition of gases the trees breathe.”

## From a single forest to an entire country

While Kararaina spends time in the field collecting atmospheric data, others in the team work on high resolution models that show how the air moved before arriving at Kararaina’s observing sites. That is where Daemon Kennett comes in.

Like Kararaina, he is in the final stage of his multi-year research looking at New Zealand’s native forests and the role they play in carbon sequestration. His research uses an atmospheric inverse modelling approach to estimate carbon uptake in forests and grasslands.

What started as a pilot project using data from just two stations, has expanded to five in situ sites across New Zealand and more than 10 years of atmospheric observations.

## “This is just the first step in the journey to understanding our native forests and their impact on our atmosphere”

Kararaina Te Puni

This is no easy feat, starting with an initial theory; a hypothesis of what the uptake and release of carbon may be and then running the model through a statistical analysis with atmospheric observations; “adding information into the system” to make an accurate estimate for what the carbon uptake is in forests and across New Zealand.

Daemon has also developed capability to include measurements from two of NASA's CO<sub>2</sub> observing satellites, making observations from places even if no in situ station is there.

As Kararaina describes it, their differing research adds to the tools used to look at carbon uptake across New Zealand.

### Looking ahead

The Ministry for the Environment (MfE) reports annually on the country's carbon emissions and uptake through New Zealand's Greenhouse Gas Inventory. However, the research of the CarbonWatch NZ team confirms that we may be underestimating the role of native forests in this inventory.

Another modeller on the project, Dr Beata Bukosa – and Daemon's PhD supervisor – has spent the past five years compiling a decade of the team's atmospheric data – from 2011 to 2020 – into a crucial research paper.

The team's findings could have implications for New Zealand's greenhouse gas reporting, carbon credit costs, and climate and land-use policies.

They used an inverse modelling technique combining atmospheric greenhouse gases with a model showing how air is transported through the atmosphere to identify the CO<sub>2</sub> sources and sinks.

They compared their results against New Zealand's Greenhouse Gas Inventory as well as 'bottom-up' models. While the Inventory applies a combination of field inventory, modelling, and remote sensing to quantify forest carbon stocks and stock changes, the 'bottom-up' models use calculations based on ecosystem processes, land use and climate across the country. The NIWA-led inverse model showed greater CO<sub>2</sub> uptake than both of these other methods, particularly across Fiordland native forests and extending up the West Coast.

Meanwhile, with CarbonWatch NZ having reached its end, Kararaina and Daemon are also wrapping up their PhDs.

For Kararaina, it's her last time (for now) working in the Raukūmara Forest and time to head home. After three years of travel between the labs in Wellington and the East Cape, she has completed all her fieldwork and is almost at the end of her PhD.

But, she says: “This is just the first step in a long journey of understanding our native forests and their impact on our atmosphere.”



NIWA's Daemon Kennett measures carbon emissions using inverse modelling. (Luke McPake)

## Sharing research and knowledge

Once silent, pest-invaded, eroding, and facing ecological collapse, Raukūmara was on the brink of collapse. With restoration urgent, the Raukūmara Pae Maunga Trust was born.

An iwi-led group of Ngāti Porou and Te Whānau-ā-Apanui in partnership with the Department of Conservation, it's the largest iwi-led pest eradication project in New Zealand.

For both Kararaina, and the wider CarbonWatch NZ team this partnership has presented a unique opportunity to work alongside the restoration project and investigate how carbon uptake changes as the pests are knocked back and the forest regenerates.

"Kararaina has created a space that brings together a western science approach and a mātauranga Māori approach. By doing this I believe the research is enabling the forest to thrive," says Raukūmara Pae Maunga's Michaela Insley.

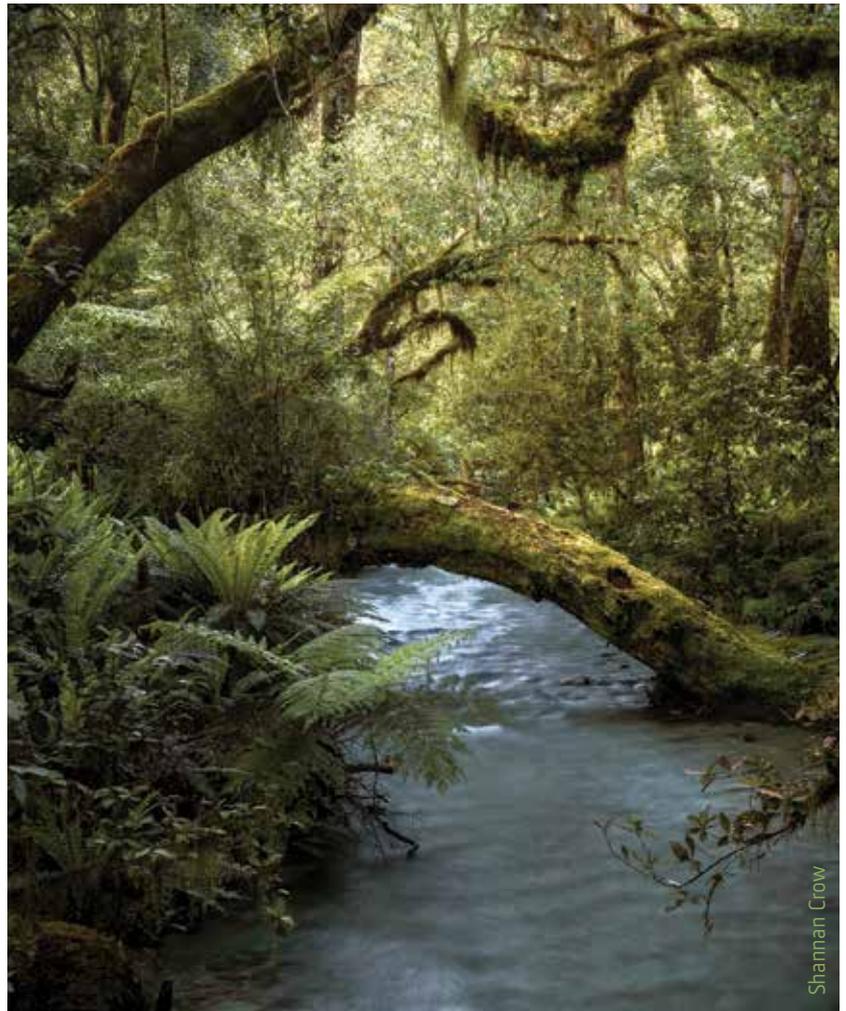
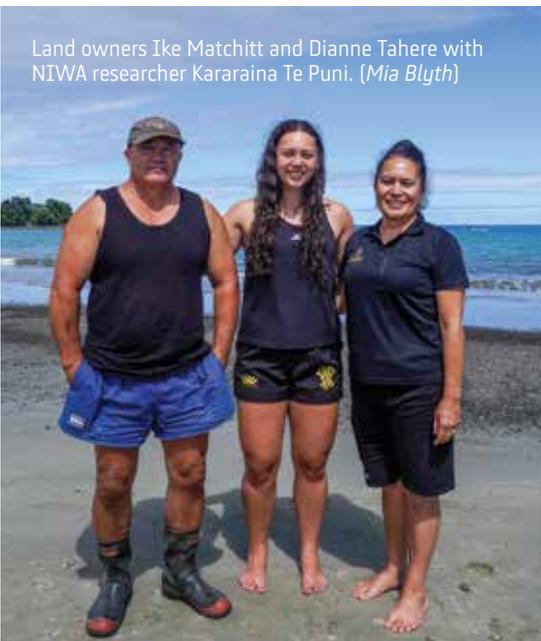
Kararaina agrees and says the biggest highlight has been the relationships she has built in her work. "We have come together to support one another, share research, and educate rangitahi."

Meanwhile, the forest is healing. The birds have returned. The trees have fruit.

Raukūmara Pae Maunga's Rangitahi Wharepapa says Kararaina is no longer a visitor to the East Cape.

"She is part of this place, she has done all this mahi in the Raukūmara, for the Raukūmara, she is part of the Raukūmara."

Land owners Ike Matchitt and Dianne Tahere with NIWA researcher Kararaina Te Puni. (Mia Blyth)



Shannan Crow

## CarbonWatch NZ: A bird's eye view of our carbon balance

*CarbonWatch NZ* was a five year \$11.5 million Endeavour research programme funded by the Ministry for Business, Innovation and Employment that finished earlier this year. The research combined measurements of greenhouse gases in the air above New Zealand with high-resolution weather models that show where those gases came from, giving a bird's eye view of the country's carbon balance.

The project looks specifically at carbon emitted from fossil fuels and agriculture and reabsorbed by four important environments: forests, grasslands, pasture and urban.

By weaving together decades of atmospheric data with an expanding network of in situ atmospheric monitoring stations, the project has built a more complete picture of New Zealand's carbon profile.

For *CarbonWatch NZ* programme leader Dr Sara Mikaloff-Fletcher this is crucial for building on previous findings.

In 2017 the team found a large carbon sink in the Fiordland Forest. Since then, they have discovered that this carbon sink is actually distributed across a large range of indigenous forests throughout New Zealand.

"With current carbon strategies primarily focused on planting exotic pine, this new research offers fresh insights into how we can make more informed decisions about planting and land management to better support climate mitigation with significant biodiversity co-benefits," says Dr Mikaloff-Fletcher.

# Dining out on the very versatile Haku kingfish

Three chefs, one restaurant and a banquet. Ryan Willoughby reports.

Select markets have been getting a taste of our premium Haku kingfish as production ramps up from NIWA's Northland Aquaculture Centre.

The facility was officially opened in August last year by Whangārei MP and now Science, Innovation and Technology Minister Dr Shane Reti. The experimental farm is designed to establish the commercial viability of on-land aquaculture and is a joint venture with Northland Regional Council.

The farm features eight 350,000 litre tanks as part of its experimental Recirculating Aquaculture System (RAS), which offers superior environmental and economic performance, and full control over all aspects of production. The current market focus for Haku kingfish is food suppliers and high-end restaurants.

Product development manager Jeremy Singleton says NIWA has built a very loyal customer base excited for the future.

"Haku is a premium product produced at smaller volumes than a lot of the competition, so we've been testing the market within New Zealand, Australia and most recently in the US. We've proven what we can do with our initial supply, and we are building on that as we build the brand, and explore new markets and approaches."

Singleton recently asked three of New Zealand's top chefs, Neil Sapitula, Cory Campbell and Makoto Tokuyama, to create some Haku kingfish dishes at Rothko Restaurant in Matakana.

"We asked them to create dishes that used the whole fish, but

also showcased its versatility. Their creations were superb, from a Japanese style whole fish sashimi to a salt bake with a banquet style presentation. And we even brought an aged-fish component in there to really show what you can do with it."

As demand increases, the aim is to supply sufficient product from the RAS to build interest and encourage further development.

The farm at Ruakākā is on track to produce 400 tonnes of kingfish a year, building up to 600 tonnes annually over the coming years.

RAS Manager Amanda Cleary says production could ramp up much higher in the hands of an independent operator, conducting business from part of NIWA's current site and reaching upwards of 3,000 tonnes.

"We are amassing the technical knowledge, learning how to use things at scale, so we can pass it on to commercial players using RAS to produce kingfish themselves. We would still maintain supply of broodstock, hatchery and juveniles to support these ventures."

The development opportunities also extend far beyond Northland.

"RAS is adaptable to new locations and species," Cleary says. "We would like to see farms popping up around the country, boosting the regions who recognise the lucrative yet environmentally sustainable farming methods demonstrated. Applied science helps New Zealand grow, particularly in the regions, and we have a focus on bringing people along as we grow, especially young people."



Haku Kingfish being prepared by chefs Makoto Tokuyama, Cory Campbell and Neil Sapitula at Matakana's Rothko Restaurant. (Stuart Mackay)

# New supercomputer boosts AI capabilities

NIWA's science and forecasting operations are so demanding that they literally wear out our supercomputer every six to seven years.

About a quarter of NIWA's business relies on our supercomputers, including climate model updates, flood modelling, space science and remote sensing. That means the sheer volume of calculations and data generated by our third generation supercomputing systems have physically worn out, exhausted or overwhelmed the hardware.

Planning for a successor has been three years in the making and NIWA's fourth-generation supercomputer is now up-and-running at its new home in Auckland.

Divided into two parts, Cascade (our supercomputer) and Rapids (our scientific data archive) offer the latest in supercomputer technology. They are being housed at two different CDC data centres – in Hobsonville and Silverdale – for disaster recovery purposes and so each can act as backup for the other.

For greater connectivity, a high-speed network between the two data centres lets the two computers talk to each other, and allows access if the public network is disrupted.

Cascade comprises 61,440 CPU cores, 7 petabytes of storage and 240 terabytes of RAM, across 320 servers connected by 7.5 kilometres of data cable. The result is 2.4 petaflops (floating point operations per second) of compute power – a human would take roughly 32 million years to do a similar number of calculations.

The advance in technology means three times more generational power than our previous supercomputer which, for something like climate research allows for higher resolution and more frequent processing plus the use of additional AI workloads.

Now that Cascade is built, testing has shown significant advances in our most powerful models, like the New Zealand Convective Scale model (NZCSM – our flagship high-resolution forecast). Cascade produces 43 hours of NZCSM forecasting for each hour of compute time compared with 22 hours per compute hour on our previous supercomputer.

However, NIWA's supercomputing teams have also worked hard to ensure Cascade is as climate-friendly as possible. The electricity supplied to CDC's datacentres is 100 per cent generated from renewable sources, and the advanced liquid cooling



system used is a fully closed loop, minimising the amount of water required. This helps to ensure that the footprint of our models and AI is as light as possible.

Testing of Cascade's peak performance has shown greater energy efficiency than expected. The reduction in energy use is likely to save about \$1.5 million over Cascade's lifespan compared with design plans.

Rapids is also specially designed to cope with the exponential demand for access to large environmental datasets. Starting with 22 petabytes and scaling to 100 petabytes in the next decade, Rapids will be a safe storage location for NIWA and New Zealand's valuable science data, while ensuring new research can continue to add value to it.

"Climate research in atmospheric rivers alone requires petabytes of data," says Chief Scientist – Advanced Technology Jess Robertson.

"The growth in the use of AI is the reason we invested heavily in the supercomputer's ability to consume large datasets for this generation of machine."

REANNZ (the Research and Education Advanced Network New Zealand) and NIWA have agreed to provide Crown-funded access to Cascade and Rapids, not just for NIWA researchers, but New Zealand's entire science sector. This will help enable ongoing collaboration across the science community.

**“NIWA's new supercomputer can do in one second, what would take a human 32 million years”**

Jess Robertson

# Forget the red carpet, roll out the biodegradable matting



Native plants of milfoil and pondweed on a muka mat after approximately six weeks. Lead weights were used to hold the mat in place on plastic trays during this small-scale tank trial.

## A project to grow aquatic plants on mats and shift them to degraded lakes has shown promising results.

A NIWA research project has come up with an ingenious method to make restoring degraded freshwater lakes easier and more likely to succeed by using biodegradable mats.

The solution has been dubbed RotoTurf, and comprises a mat made from natural fibres on which aquatic plants can be grown and nurtured, and then the whole lot rolled out on to the bottom of a lake or waterway.

The RotoTurf project addresses one of the issues facing many of New Zealand's shallow lakes – permanently turbid water leaving plants with insufficient light to grow. And without plants, wave action creates a feedback loop trapping a lake in a degraded state.

Action is required on several fronts to reverse the process, including reducing sediment and nutrient inputs, but RotoTurf project lead and NIWA Principal Scientist, Dr Deborah Hofstra says even when that is addressed, it can be difficult for plants to re-establish themselves.

“That’s where our research with mats can help.”

The team trialled a range of biodegradable mats, including hessian, coconut fibre, muka (flax) and wool, using different plants and densities. The matting needed to support large-scale plant cultivation and be able to be easily relocated to a lakebed. Over time the mat breaks down naturally while the plants anchor themselves into the lakebed.

Wool and muka were the longest-lasting mats in outdoor culture tanks and were both subsequently trialled in a lake. Plant selection is also crucial for success, with the research having looked at a range of natives, including milfoils, pondweeds, charophytes and isoetes.



From left, NIWA freshwater ecologist Inigo Zabarte-Maeztu, University of Lille, France Juliette Coadic and NIWA biogeochemist Ben Woodward, research creating turfs of aquatic plants in Lake Ohinewai. (Stuart Mackay)



Dr Deborah Hofstra and Ben Woodward at the freshwater aquatic plant trials. (Stuart Mackay)

RotoTurf is a NIWA-led Smart Ideas project funded by the Ministry of Business, Innovation and Employment. The project infused scientific research with mātauranga Māori to ensure the best outcomes.

From the research two tools were developed that can be used to help decide whether RotoTurf can help with a restoration project:

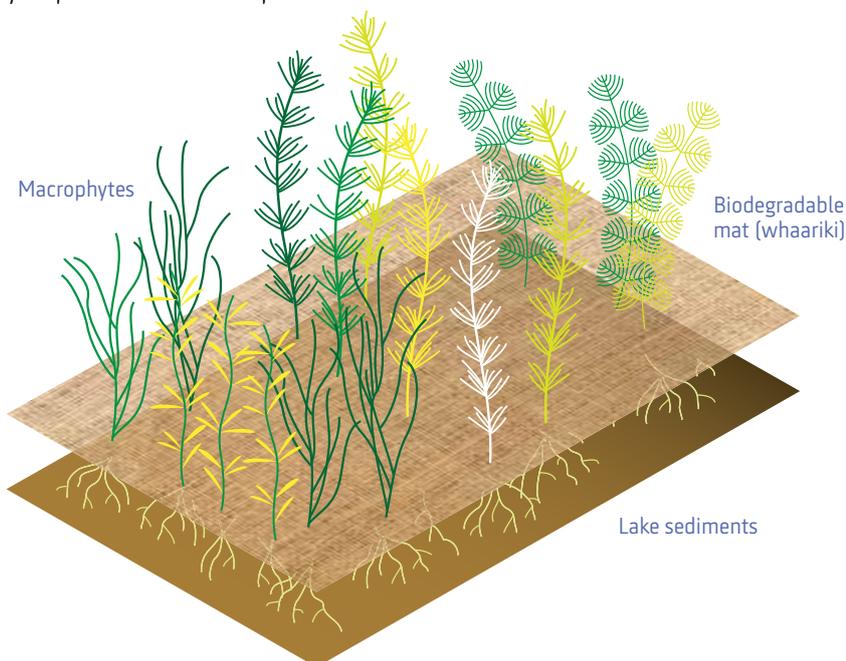
- The RotoTurf suitability decision tool – guides the decision-making process and identifies areas that may be improved before using RotoTurf,
- The RotoTurf Macrophyte Species Selector – helps

select species of aquatic plants that will thrive in different conditions.

Both are available on the NIWA website along with a guide on growing and translocating aquatic plant mats for freshwater restoration.

“The goal is to be able to grow enough plants and have a mass planting event that reaches a threshold where the plants are self-perpetuating, the water becomes clearer and the ecosystem is in much better health,” Hofstra says.

Stylised diagram of the RotoTurf concept. (NIWA)



Back cover:  
Close up of the siphon of an invasive freshwater clam. (Maddy Brennan)

