Water & Atmosphere

October 2017

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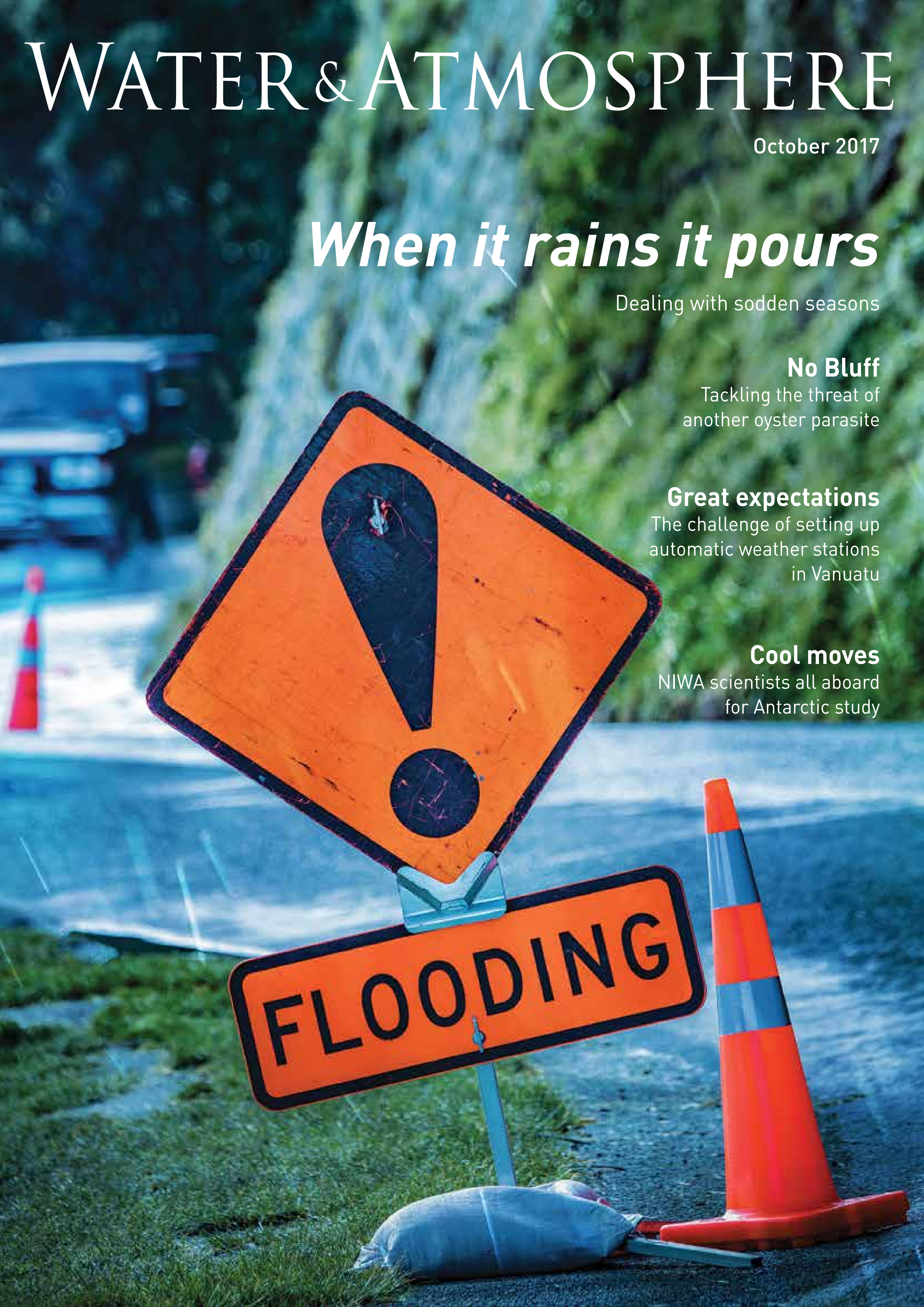

WATER & ATMOSPHERE

October 2017

Cover: Flooding on Shelly Bay Road, Wellington.
(*Dave Allen*)

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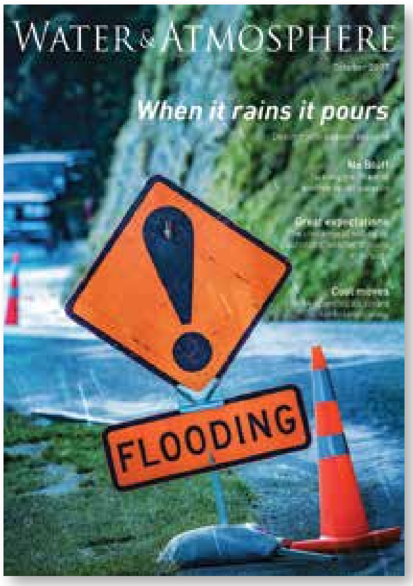


W.R.C.

In brief

Baby snapper, *Pagrus auratus*. (*Alastair Jamieson*)

Baby snapper an unexpected prey

NIWA scientists had to view more than 180 hours of underwater video footage of snapper, but were rewarded with insight on what preys on snapper in their nursery habitat.

The scientists focused on artificial seagrass patches they made from ribbons and mesh and installed in Whangarei Harbour to try to work out how important habitat structure is to juvenile snapper.

They thought that maybe the little fish used the seagrass clumps to shelter from the strong water flow, to feed among the blades of the plants or hide from unknown predators. Fisheries scientist Dr Darren Parsons says the answer – in the form of a large kingfish chasing a school of tiny fish – came as a surprise.

"We know very little about predation of juvenile snapper. So capturing this kingfish chasing the juveniles is a rare event. It makes me think the role of habitat in helping snapper avoid predators is more important than previously thought."

NIWA gears up to crunch big numbers

NIWA is investing in new supercomputers that will significantly enhance scientists' abilities to solve crucial issues facing the country. NIWA is working with Seattle-based global supercomputer leader Cray to purchase the new supercomputers in collaboration with the partners involved in the New Zealand eScience Infrastructure (NeSI).

"NIWA is investing $18 million in the new supercomputer capability which will enable our scientists – including the largest team of weather and climate scientists in the country – to provide better information on hugely important issues such as how climate change will affect New Zealand," says NIWA Chief Executive John Morgan. "The ability of the new supercomputers to process vast amounts of data in very short spaces of time will also enable us to build more precise forecasting tools to help farmers and environmental managers make more informed decisions using the best information available."

Mr Morgan said weather-sensitive industries – such as the energy sector, farming, horticulture and tourism – would benefit directly from NIWA's ability to make more accurate and more specific forecasts. The new supercomputers would also allow NIWA to improve early warnings of the effects of severe events, such as flooding and storm surge.

A common dolphin in the Hauraki Gulf showing a dorsal fin lesion possibly caused by a vessel propeller. (*Krista Hupman*)

Photo ID helping define dolphins

NIWA analysis suggests that photo-identification can be used to examine human impacts on dolphins.

Research recently published in the journal *Aquatic Mammals* assessed photo-identification as a tool to examine potential effects of human activities on gregarious, free-ranging dolphins. Photo-identification of common dolphins was collected for three years in the Hauraki Gulf.

Of the 2083 unique individuals identified via natural markings on their dorsal fins, about 80% exhibited lesions. Possible causes of these lesions included intra- or interspecific interactions, environmental conditions, infectious origins, fisheries and vessel interactions, and/or human-induced environmental stressors.

Pollen from New Zealand pine forests travels more than 1500km through wind and ocean currents. (*Dave Allen*)

Pine pollen travels far and wide

Pollen from New Zealand pine forests may be altering remote deepsea ecosystems, a recent NIWA study shows.

Study findings based on sediment samples from the Kermadec and Tonga trenches showed pollen from New Zealand pine forests travels more than 1500km through wind and ocean currents. Pollen was particularly abundant in the deepest part of the Tonga Trench, some 10,800m deep. There is evidence that pollen may be a food source for some deepsea organisms and could be responsible for altering deepsea food webs. The gradual burial of pine pollen, part of which is highly resistant to decomposition, likely contributes to the sequestration of land-derived carbon. NIWA scientists are now investigating just how much carbon and nutrients are being transported by pine pollen to the deep sea around New Zealand, as well as examining the contribution of pollen to the diet of deepsea organisms.

Review of river and lake monitoring in the Otago region

NIWA has been contracted by the Otago Regional Council (ORC) to undertake a review of river and lake water quality and biological monitoring in the region.

The review is addressing monitoring needs to satisfy general State of the Environment monitoring as well as the requirements of their Regional Water Plan and the National Policy Statement for Freshwater Management. It looks at the monitoring sites, methods, frequency and the parameters measured.

One key priority for ORC is improving the monitoring of Otago's iconic and large alpine lakes – Wakatipu, Wanaka and Hawea – which have been impacted by *Lindavia intermedia* or `lake snow' algae.

The monitoring review work will help inform science resourcing requirements in the ORC's Long Term Plan.

A mako shark is tagged and released by MPI observers in waters off Gisborne. (*Matt Saunders*)

Marking makos for mortality

The first 30 mako sharks of a planned 33 have been tagged and released by MPI observers trained by NIWA scientists.

The tagging programme is part of a wider study focusing on mako and silky sharks in the Pacific Ocean which NIWA has been contracted to carry out on behalf of the Western and Central Pacific Fisheries in New Zealand waters.

The purpose of this tagging programme is to identify the mortality rate of mako and silky sharks caught as bycatch in surface longline fisheries for tuna.

Dr Adam Uytendaal of Otago Regional Council on Lake Wakatipu checking a zooplankton net for 'lake snow'. (*Nathan Manning*)

NEWS

WRIBO's phoning it in

A sophisticated buoy has been deployed in Wellington Harbour to 'phone home' information about currents, waves and water quality in the harbour.

The buoy, named WRIBO (Wellington Region Integrated Buoy Observations), was deployed in early July southeast of Matiu/ Somes Island by NIWA's flagship research vessel *Tangaroa*.

Part of a joint project between NIWA and the Greater Wellington Regional Council (GWRC), WRIBO delivers real-time data on currents, waves, salinity, temperature, oxygen, chlorophyll, ocean acidification and wind.

NIWA coastal physicist Dr Joanne O'Callaghan says WRIBO will greatly enhance understanding of the factors affecting the health of Wellington Harbour. One of its key roles will be to monitor plumes from the Hutt River that wash into the harbour after heavy rain. These plumes carry sediments and nutrients from the Hutt catchment to the harbour. Water quality instruments observed an algal bloom after ex-tropical cyclones Debbie and Cook.

"The interim buoy that has been deployed in the harbour since September last year has shown some big responses in surface salinity and currents. Ocean salinity, measured in practical salinity units (psu), is typically around 35 psu. After the ex-tropical cyclones (Debbie, Cook and Donna) in autumn this year, surface salinity decreased to 10 psu for several days," says Dr O'Callaghan .

"Without the surface instrument these harbour responses to river flows would have been missed completely. From other research, short-lived events from river flows can modify flows in a system for several weeks to a month. So sediment or nutrients that come into the harbour from rivers may impact the harbour health for much longer than previously thought."

Wellington Harbour is a body of water that had not been well studied previously, but WRIBO changes this.

"Long-term observations and associated science in the coastal ocean has tended to focus on one or two regions – Otago and the Hauraki Gulf."

"Many studies in harbours or coastal ocean have been for specific commercial work with observations of a month or so to address the minimum modelling requirements. Over the past five years I have been progressing a research theme around river plumes in the Hauraki Gulf and Doubtful Sound – as an idealised natural laboratory – and now Wellington Harbour."

Wellington Harbour WRIBO Buoy Deployment. From left - Claire Conwell (GWRC), Joanne O'Callaghan (NIWA), Mike Brewer (NIWA). (*Dave Allen*)

A buoy with the ability to transmit real-time oceanographic and weather data, WRIBO (Wellington Region Integrated Buoy Observations) commences service in Wellington Harbour. (*Stuart Mackay*)

River plumes are only a few metres thick, so there is now an instrument just beneath the surface to measure them. There are also a number of instruments in the water column attached to the buoy to enable scientists to analyse harbour response at various depths. Waves and currents move sediments during storms, so there is an instrument near the seabed and two more through the water to know the size of the impact.

Having access to detailed data over a number of seasons will allow Dr O'Callaghan to drill down on how long events of several days, such as the autumnal ex-tropical cyclones, affect Wellington Harbour.

"By understanding what these timescales are, GWRC can think about how to manage and set limits for the incoming rivers. It is thinking about the system as a whole – a source-to-sea approach. There are a number of water quality parameters being measured, and there will be regular water sampling at the buoy to make sure the data is calibrated and of best quality."

And that quality data will be phoned home immediately by WRIBO.

"The buoy makes a phone call to a computer and sends back data of up-to-date conditions in the harbour. This means we don't have to wait for good weather to collect the data, which is never easy in Wellington."

The buoy stands three metres tall and is powered by solar panels and manufactured by AXYS technologies in Canada. Constructed by NIWA's mooring technician Mike Brewer over several weeks at NIWA's Wellington site, WRIBO is the most complicated of its kind in New Zealand waters.

"One of the mooring challenges is making sure it stays in place during large storms in the windy city," says Dr O'Callaghan. "Three days after deployment, one of the windiest storms in two years occurred. We have lost moorings in Wellington Harbour before in large storms, so it's quite worrying, but it's a wait-and-see approach once all the planning and actual deployment has occurred. WRIBO stayed in place in early July, which was a huge relief."

Dr O'Callaghan says it's not only inclement weather WRIBO has to manage. Wellington Harbour is obviously very busy, with ferries, commercial shipping, commercial and recreational use.

"The buoy is appropriately lit and sends signals directly to vessels entering or leaving the Harbour. The location was chosen to be out of the shipping lanes, not an easy feat in Wellington, but also to be in a useful location.

"I think the wind and wave data will be most used by the various users of the harbour. Having real-time weather data for fishing and sailing will be sought after."

GWRC coastal scientist Dr Claire Conwell says this is the beginning of a dedicated water quality monitoring programme for Wellington Harbour and the region's coastal marine area.

"This information will help us to make links between the freshwater and marine environments, and to assess the impacts on water quality of land-based activities," Dr Conwell says.

"A key focus for us is to also make the data accessible, so we'll be working with the NIWA team to get the data streaming via our respective websites. In the long run, we'd like to see this sit alongside other data from buoys across New Zealand, forming part of a national network."

Joining the flooded dots

The term "joined-up government" was coined in the 1990s to describe the coordination modern governments need to deal with large problems.

Despite the hype and attractive logic of integrated policymaking, it has often proved hard to do. The multi-dimensional nature of problems, society and organisations make it a challenge. In the face of such challenges, it is imperative that science informs policy and planning.

Challenging, but certainly not impossible. Our Government's National Science Challenges are proof. Big issues affecting the nation's environmental, social and economic objectives were identified, and then packaged into research programmes to be undertaken by multi-disciplinary teams across science institutions and the wider community.

There are few bigger challenges for joined-up government than dealing with the growing impact of weather-related hazards – especially floods like those we experienced again this year in New Zealand.

Weather caused 90% of global disasters in the twenty years to 2015. These disasters killed more than 600,000 people and otherwise harmed 4.1 billion people.

Flooding was responsible for just under half these world-wide disasters, and it's getting worse. The US, for example, is experiencing a higher frequency of billion-dollar flood events.

Flooding is responsible for a greater share of the weather disasters in New Zealand than the world average. Sixteen of the 25 weather disasters tracked for insurance purposes since 2015 were floods, and they caused an estimated $200 million in insurance-claimed damage.

There are places that suffer repeated floods, but a look at New Zealand flood records over the past 30 years shows that most parts of the country have been affected. As our climate changes, and where we live and work evolves, the past may not be a good predictor of future flood exposure and impact.

We do know that the number of floods, and their costs, are rising. New Zealand's increase in population, development and wealth means we have more people and assets located where floods could happen, and the assets at risk are more expensive.

Police redirect traffic away from Whanganui's CBD as flood waters rise after record rainfall in June 2015. (*Mark Brimblecombe*)


Edgecumbe has joined a long list of New Zealand towns and cities who know how devastating flood damage can be and what it takes to get back to normal. (*Dave Allen*)

Changes in our climate are also increasing the frequency of the extreme weather that leads to floods. Heavy rainfall events and the ensuing flood risks are increasing because warmer temperatures load the atmosphere with more water vapour.

Crucially though, NIWA now has the scientific capability to predict and provide advanced warning of floods to help mitigate these risks, using a combination of models that predict rainfall, how much and how soon it will get into waterways, and whether they will flood. This service is currently operational for two major catchments, but it needs to be rolled out over the whole country.

A programme called RiskScape, a joint venture between NIWA and GNS Science, can look at what would happen if areas flood. It can estimate possible human casualties and displacement, building damage and replacement costs, and economic losses. This allows city planners to work out how to avoid such problems – such as by limiting habitation and enforcing certain building restrictions.

City planners can use science to help them organise on an even grander and longer-term scale. For example, the Greater Wellington Regional Council recently commissioned NIWA to examine, for the first time, what the region's climate could look like in 2090.

Using NIWA's forecasting and climate modelling expertise, the scientists' findings were sobering. The NIWA report found that, in a world with ongoing high emissions of greenhouse gases, Wellington could become hotter than Northland is now, and end up with a temperature closer to that of Sydney today.

NIWA's modelling showed Wellington City would have warmer autumns, almost a month of days over 25°C and up to 10 per cent more winter rain by 2090. One of the more startling projections was an increase for Wellington City from 6 hot days (over 25°C) a year now, to 26 days by 2090. In the Wairarapa, that figure goes from 24 days now, to 94 – in just over 70 years.

That climate might sound nice, but it would require significant adjustment if Wellingtonians want to avoid consequences more serious than occasional sunburn. There are many possibilities brought about by the prospect of heavier downpours and warmer temperatures – such as the potential for more floods, and for drought during summer – all affecting suburban and rural lives and industries differently.

Councils are responsible for an enormous amount of community and regional infrastructure, and for things like land-use planning. GWRC Chairman Chris Laidlaw said, "We're all in this together" and that the big question was "How do you future-proof the system?"

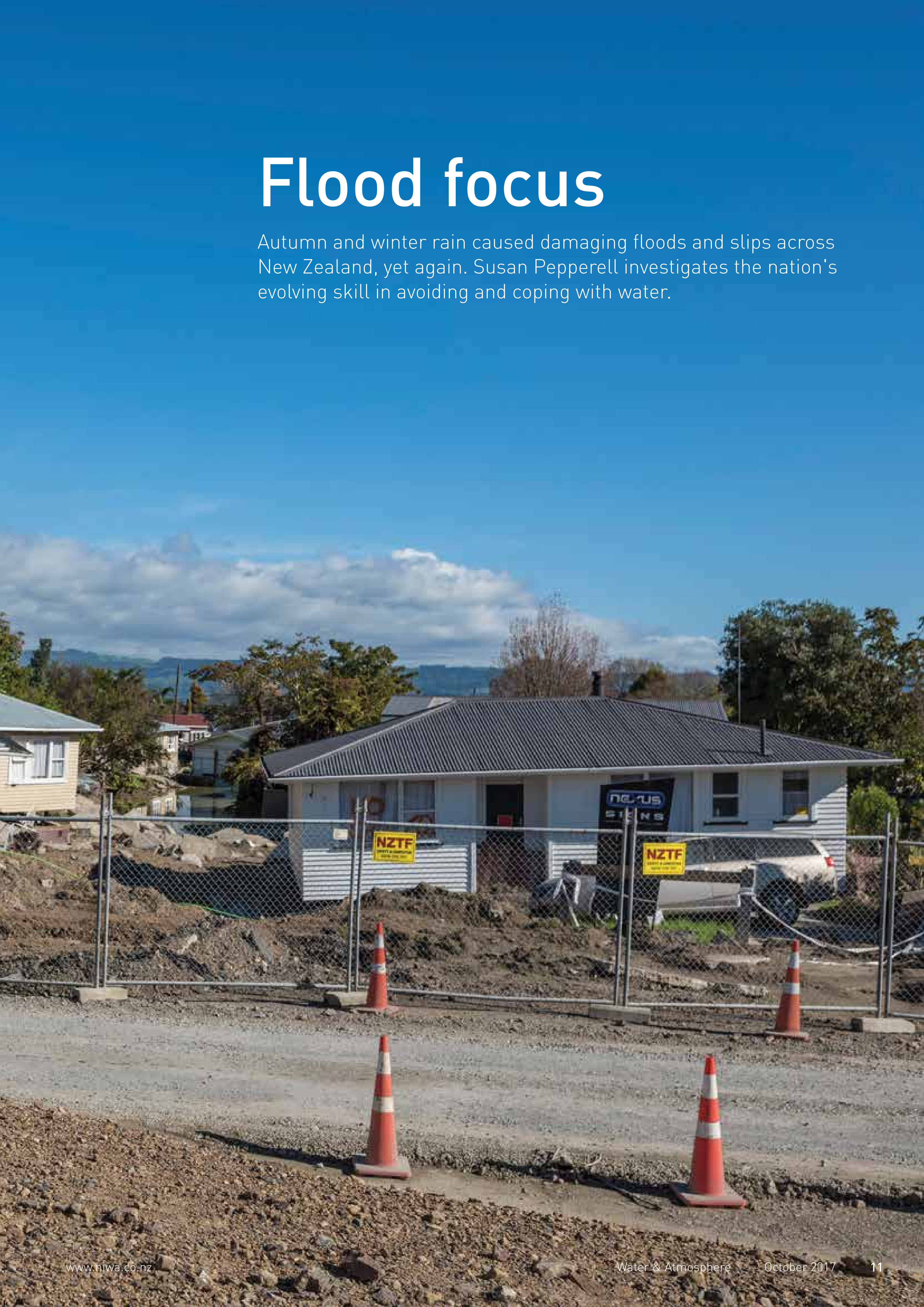
What was most rewarding after the NIWA report was released by GWRC, was the public reception. Community discussion centred on what it would be like to live in that climate. One of the key issues was what extreme storms and sea-level rise would mean for people living on the region's coastline. The public looked at the future, and appreciated that changes and some tough decisions would need to be made.

Science is critical to help join the dots and make our communities resilient to the big weather-related issues. We not only need to provide adequate warning of imminent floods, but also predictions of future climate to enable better planning and risk mitigation.

NIWA Hazard Analysts Shaun Williams (left) and Ryan Paulik survey residential properties after the Edgecumbe flooding event in April 2017. (*Dave Allen*)

Flood focus

Autumn and winter rain caused damaging floods and slips across New Zealand, yet again. Susan Pepperell investigates the nation's evolving skill in avoiding and coping with water.



When it rained in March, it really rained. In some places more rain fell in 24 hours than is usual for the whole month. Records tumbled, and then it happened again. And in early April, again.

That's when the stopbank of the Rangitaiki River breached and flooded the Bay of Plenty town of Edgecumbe.

NIWA hazards analyst Ryan Paulik was one of a team of researchers who went to Edgecumbe three weeks after the flood occurred and where about 450 buildings were damaged.

"It felt quite strange. There weren't many residents around; it was pretty deserted – although there were plenty of tradespeople."

Demolition was in full swing; buildings were being stripped back to the frame. Even partitions were being dismantled, requiring ceiling frames to be propped up.

"A lot of homes had particle board floors which are very absorbent and very brittle, so entire floors were having to be removed and replaced. Floods are pretty nasty things," Mr Paulik said.

The team recorded high water marks on buildings, and details about what each building was made from, how it was constructed and how it was damaged.

From that information a 'damage ratio' is established – a percentage derived from dividing the cost of repairs by the cost to replace. All the information is fed into scientific models that can be used to calculate the damage to similar buildings if they flood in other parts of New Zealand.

Several months on, the next stage for the team is to survey the indirect damage – that's how much it costs people to be out of their homes while they're being repaired. The information is a crucial part of assessing the true cost of severe flooding.

As the rebuild progresses, Edgecumbe has joined a long list of New Zealand towns and cities who know how devastating flood damage can be and what it takes to get back to normal.

Whanganui, Northland, Kāpiti Coast, the West Coast, Thames, Lower Hutt ... the list is extensive, the damage adding up to billions of dollars.

Whanganui worries

In Manawatu-Whanganui, authorities are only too aware that it's a matter of time until there's another major flood.

Edgecumbe resident John McNeill says it's heart-breaking to see the enormous impact that the flood has had on the town, but he's glad that no one was hurt. (*Dave Allen*)

20 June 2015, the Whanganui River burst its banks and water flowed through the city's CBD before easing into the sea. (*Mark Brimblecombe*)

The catchment has been at the epicentre of several significant flood events, notably in June 2015, when a month's worth of rain fell across the Whanganui region in 24 hours.

The Whanganui River reached its highest ever level, 9.1 metres at Town Bridge, at 3am with a flow rate of 5,150 cubic metres a second. Water spilled into the central business district, and into low-lying residential areas adjoining the river. The city was cut in half by the closure of bridges, and by the end of the weekend, all roads in and out of Whanganui were closed.

In April this year, the city was again on high alert when heavy rain pushed the river level to 7.4 metres. Hundreds were evacuated as residents feared a repeat of the 2015 floods that destroyed homes in the flood zone. Crisis was averted as stopbanks held and rainfall eased, but the Horizons Regional Council knows it is only a matter of time until another major flood event plays out again.

Ramon Strong, Horizons Regional Council Group Manager for River Management, said the Edgecumbe floods had brought into sharp relief the need to understand and address flood risks at a local level.

Community engagement around Whanganui's flood risk – particularly in the high-risk area along Anzac Parade – has been promising. However, the issue is whether higher

When the rain didn't stop

In July, risk of flooding became reality in parts of the South Island. Oamaru recorded its wettest day in history since records began in 1950 when more than four times the normal July rainfall came down in just 24 hours. By the end of July it had already experienced its wettest winter on record with a month of the season to come.

Then parts of Dunedin flooded, closely followed by the area next to the Heathcote River as it overflowed.

By the end of July, Wellington had recorded 228mm of rain for the month – or 166 per cent of normal. Slips blocked roads and threatened homes all over the city. Last year the total rainfall for July in Wellington was 68mm.

For Greater Wellington, Otago, parts of Canterbury, Nelson and large parts of the North Island, July rainfall was well above normal. Several extreme weather events drove the record figures, especially for coastal areas from Christchurch south to Balclutha.

stopbanks provided the best long-term solution for those affected and for the wider community.

Horizons is now looking in more detail at retreat options in flood-prone areas of Anzac Parade. Rather than wholesale acquisition of affected properties, Horizons is looking at a combination of voluntary acquisition and raising some houses in the area, following the model adopted in the 1980s for flood-affected properties along the Heathcote River in Christchurch.

"It's a local issue that needs a local solution and funding, but what helps is having understanding from the community, central government and the insurance industry," said Mr Strong. "There is a long-term gain here."

NIWA modelling of rainfall patterns and flood risk in the Whanganui catchment has shown that flood frequency will change over time.

"Risk is still the underlying challenge to address," Mr Strong said.

Warming in Wellington

Wellington city will have warmer autumns, almost a month of days over 25°C and up to 10 per cent more winter rain by 2090.

It's the climate change scenario that looks like good news at first glance if you're a Wellingtonian, but NIWA's Climate Change Report for Wellington Region includes some startling projections.

The report was commissioned by the Greater Wellington Regional Council and shows significant warming that means more droughts, pressure on water supply, fewer frosts and more heat waves.

The report takes into account inherent uncertainty in climate projections due to likely fluctuations in future greenhouse gas emissions. Findings for the Wellington region:

- Autumn is the season likely to warm the most.
- Annual temperatures will increase by 1°C by 2040 and up to 3°C by 2090.
- Frosts in the high elevations of the Tararua Ranges are likely to disappear.
- Spring rainfall will reduce by up to 15% in eastern areas by 2090.
- There will be up to 15% more winter rainfall along the west coast by 2090.
- The risk of drought will increase in the Wairarapa.
- There will be more extreme rainfall events.

Data from the regional council showed parts of Wellington recording the heaviest hourly rainfall in more than 50 years on 14 May 2015. Drainage systems struggled to cope, causing disruption to major transport routes around the city and the Kapiti Coast. (*Dave Allen*)

Dr Graeme Smart captures the impact of flood damage via the mirrored glass of a property in Edgecumbe. (*Graeme Smart*)

Water everywhere

The frequency of flooding in New Zealand, and predictions that it may happen more often as the climate changes, is why NIWA views development of accurate flood forecast tools as a priority. The development of tools involves several complex steps.

The first is to use atmospheric models to predict where and how much it's going to rain. The second is to use hydrological models – NIWA uses a system called TopNet – to translate that information into river and stream flows. This plots how much rain will make its way into the waterways and at what speed it will travel.

From there, it's the turn of the hydrodynamic model. This is a sophisticated computational process that predicts flood plain inundation and the damage that will be caused from the amount and speed of the water.

Another programme, a joint venture between NIWA and GNS Science called RiskScape, is a tool for analysing potential economic and human impacts and losses from natural hazards. It can predict building damage and replacement costs following a flood, as well as human casualties, economic losses, business disruption and the number of people who could be displaced.

Flood modelling is complex and incredibly sensitive to the topography of an area. Weather forecasters seeking to predict the likely path of a tropical cyclone, for instance, face trying to pinpoint where rainfall will occur across what is essentially a very narrow strip of land in the midst of a vast ocean. Small differences make a significant impact.

For flood inundation models, a road or embankment that isn't included can mean the difference between a full-scale flood and a narrow miss.

Accurate topography mapping is crucial and the best way to get that is by LiDAR which stands for Light Detection and Ranging, and is a remote sensing method that uses light in the form of a pulsed laser.

And while most councils have some form of flood prediction system in place, reducing the risk further will require considerable investment.

Graeme Smart, NIWA Principal Scientist of Natural Hazards, says long-term losses from flooding are greater than that of earthquakes, but with earthquakes the threat may be more dramatic.

"Flooding is not seen as such a severe threat, but it is far more debilitating.

"With enough investment we will get better at reducing our exposure to future floods. Practical steps are possible to reduce community vulnerability, but the bottom line is that there needs to be a collective willingness to invest."

Double trouble from oyster parasites

The public meeting was standing-room only. It was a gloomy evening in the small port community of Bluff. The mood was sombre.

The public were there to meet with local authorities, a Ministry for Primary Industries (MPI) representative and NIWA fisheries scientist and oyster expert Keith Michael. The topic for discussion was the spread of *Bonamia ostreae* from Marlborough Sounds to oyster farms in Big Glory Bay (Stewart Island). The 2015 discovery of *B. ostreae* in oysters farmed in the Marlborough Sounds was the first time this parasite had been found in the southern hemisphere. The intense interest arose because this parasite has been disastrous for oyster farmers and fisheries in the northern hemisphere.

While there was no risk to people from eating infected oysters, the parasite could kill the oysters in the farms, and the infection could spread to the valuable wild oyster population – where it was likely to have a devastating effect. Devastating because oysters have been fished from Foveaux Strait for more than 150 years, and the fishery is one of our oldest and most iconic.

Bluff Community Board Chairman Ray Fife said many attendees had worked with oysters all their lives. "We've depended on oysters for the wellbeing of Bluff."

He said these long-term interests meant stopping the spread of the infection was the priority. "We still want to have generations of fishermen that go out there and catch their oysters, for the next 100 years."

Keith Michael explained why the parasite poses a substantial biosecurity risk to the nationally important Bluff oyster fishery and to the Southland environment. It can cause 90% mortality in oyster populations that haven't been exposed to the disease before.

"It is a particularly destructive parasite of flat oysters. It is a waterborne disease. It enters the oyster's blood through the gills, mantle and gut, and multiplies rapidly. Intense infections cause blood cells and tissues to break down or rupture."

Molecular biologist Dr Judy Sutherland and oyster specialist Keith Michael prepare samples for testing. NIWA is making use of advances in molecular technology to develop a better understanding of shellfish diseases. In the near future NIWA's new droplet digital PCR (ddPCR) system will offer even more sensitive detection, and better quantification than current methods. (*Dave Allen*)

After prying the oyster's shell open, fisheries researcher Jeff Forman delicately extracts the oyster's heart, which, at barely 1–2mm in diameter, contains the richest source of red blood cells necessary for bonamia testing. (*Dave Allen*)

Microbial ecologist Debbie Hulston runs a SYBRgreen assay on the qPCR machine. The test analyses the melting points of amplified DNA to detect the bonamia parasites. The green peaks on the graph indicate positive results for the presence of both *Bonamia ostreae* and oyster DNA. (*Dave Allen*)

Since 2000, NIWA, the Bluff Oyster Management Company and MPI have carried out research on a closely related, endemic parasite (*Bonamia exitiosa*). Over the years, this parasite has caused substantial mortality in the Foveaux Strait oyster population and economic losses to the fishery – oyster mortality from this disease is between 10 and 50 times larger than the commercial catch.

NIWA has developed considerable capability and experience in *B. exitiosa* research, and NIWA and MPI science have worked closely to inform the MPI response to the Marlborough Sounds *B. ostreae* infection, and to carry out surveillance programmes to monitor any spread. It was an MPI-designed surveillance programme, carried out by NIWA, that detected the spread of *B. ostreae* to Stewart Island. Sampling in Big Glory Bay as part of this surveillance programme detected the presence of *B. ostreae*. This early detection – before any oyster mortality had been reported to MPI – at least provided an opportunity to contain the disease.

This appearance of *B. ostreae*, however, came just when things were looking up for the Foveaux Strait oyster fishery. The 2017 NIWA and Bluff Oyster Management Company stock assessment and bonamia surveys found that another disease cycle – during which wild oyster numbers halved – had ended. Disease mortality had declined to low levels over the last two years and recruitment had increased.

However, Keith Michael says that a combination of the two bonamia species (*B. ostreae* and *B. exitiosa*) was likely to pose an even greater risk to the Bluff oyster fishery.

The two *Bonamia* species look very similar in size and structure, so it has been a major challenge to distinguish between them. The most reliable way of telling them apart is by using molecular methods targeting species-specific DNA.

NIWA biotechnologists have designed a new method for the detection of bonamia in oysters from raw extracts.

This cost-effective approach can detect low-level infections, and identify this specific pathogen from other, closely related species.

"We use a variation of this method to test for the presence of *B. ostreae* for MPI-run surveillance programmes," Michael says.

"We screen large numbers of samples quickly, and provide the samples that test positive for *B. ostreae* to MPI for confirmatory testing."

NIWA's capability here goes well beyond detection. Seafood Innovations Limited, who provide Ministry of Business, Innovation & Employment research funding to the fishing industry, funded the development of a new method to quantify bonamia infections. As a result, NIWA is making use of advances in molecular technology to open new research areas to develop a better understanding of shellfish diseases. The new method will measure the intensity of infection to track the disease progress through oyster populations, and distinguish between non-fatal and fatal infections.

The community meeting in Bluff was followed by an MPI decision to remove all the farmed oysters from Stewart Island and the Marlborough Sounds. At the time of writing, farmed oysters and cages have been removed from Big Glory Bay, and the removal of lines growing oysters and mussels together is progressing well. The removal of farmed oysters from Marlborough Sounds is also progressing well.

Everyone is hopeful that removing the farmed oysters will help prevent the spread of the parasite. MPI has decided to move to three-monthly surveillance for the presence of *B. ostreae* in Southland and remain as biennial for other areas. NIWA is working with the MPI biosecurity team to undertake these surveys.

Cool moves

The Antarctic continues to fascinate the public and scientists alike. At the end of this year, NIWA scientists will head there again. We look at some of their fascinating work.

Dave Allen

From sea ice to seabed

NIWA scientists who pioneered techniques to investigate the influence of climate change on algae living on the underside of Antarctic sea ice are returning to the cold continent in October, this time to focus on the seabed.

Drs Drew Lohrer and Vonda Cummings are leading an international team of researchers that will follow the fate of under-ice algae after it settles to the seafloor. The algae are an important part of the food chain, with many seafloor organisms sustained by the algae that fall down from the under-surface of the ice.

Their earlier research discovered that the productivity of the under-ice algae increased when seawater pH falls ('acidifies') to levels associated with higher atmospheric CO_2 concentrations.

They measured productivity using purpose-built chambers that were installed on the underside of sea ice, and manipulated seawater pH and temperature inside the chambers to assess future climate scenarios.

The new research will turn things upside-down, with similar chambers deployed on the seafloor instead of on the underside of sea ice. The quantity of algae reaching the seafloor is predicted to change with climate warming, and this could alter the communities of microbes and fauna living on the seabed.

"We want to understand what could happen right across this sensitive ecosystem in response to climate change.

"The first block of research showed that climate-related changes are likely to increase algal production.

"So the next question is: what happens if the supply of food to the seabed is increased?" Drew says.

The plan for the upcoming season is to collect large quantities of algae from the under-surface of the ice and to add it to the chambers on the seafloor every day for two to three weeks.

A series of measurements will be made throughout the experiment to track the responses of animals such as scallops and brittle stars, and to monitor the seafloor community's oxygen consumption and nutrient regeneration rates.

The communities of organisms living under sea ice and on the seafloor cannot be recreated in a laboratory setting. "We had to take our lab to them. The chambers allow us to change one or two parameters at a time in a controlled manner. Everything else about their lives remains the same."

The team is expanding the testing sites beyond those used in the original sea-ice experiment.

"We're including one particularly food-poor location where the ice is thicker and very little light gets through. The addition of food at this site may make quite a difference."

Drew says the chambers will allow the researchers to add food evenly to specific patches of sediment.

"If the added algae enrich the sediment enough, the seafloor communities may change as animals migrate toward the patches," he says.

The seabed research is part of a larger NIWA-led multi-organisation project called Resilience of Antarctic Biota and Ecosystems, funded by the New Zealand Antarctic Research Institute (NZARI). The aim is to determine the relative vulnerabilities of Antarctic marine, lake and terrestrial ecosystems to climate-related changes.

Spawning sea urchins. (*Peter Marriott*)

Revealing toothfish secrets

NIWA fisheries scientist Dr Steve Parker says the 1.55 million square kilometre Ross Sea Marine Protected Area (MPA) in the Southern Ocean will help further research into the ecology of Antarctic toothfish.

Dr Stu Hanchet wrangles an Antarctic toothfish at the surface for tagging. (*Laura Ghigliotti*)

Toothfish are found throughout the Ross Sea, and may be important prey items for top predators such as Weddell seals and killer whales.

Dr Parker has been travelling to the sea ice of McMurdo Sound since 2014 to develop survey methods to understand the ecological role of toothfish and their interactions with top predators in the area.

"The MPA creates the framework and scientific rationale for understanding how this polar marine ecosystem functions and, by doing that, understanding how to best conserve it."

Counting corals

A master's student from the Université de Brest, France (Anne Boulet) is working with NIWA in Nelson on a six-month internship to analyse benthic invertebrate data from the Ross Sea.

Habitat-forming benthic invertebrates are caught in the process of catching toothfish in the Ross Sea. The project examines more than 8,000 observations of benthic organisms such as corals, sponges, or anemones to create distribution maps. These will be used to plan studies into the effects of fishing on the Ross Sea benthic ecosystem as part of the new Ross Sea Marine Protected Area.

More toothfish

The sixth annual Ross Sea Shelf Survey of sub-adult Antarctic toothfish was completed in January 2017. The results showed a new relatively strong year class moving onto the shelf region, to be used to index year-class strength in the stock assessment.

Parker is rising to the challenge of working in the extreme Antarctic environment, cutting through 2m of sea ice to then study a species that lives in the dark more than 500m below the surface in water near minus 2°C.

"We have already shown that the fish living under the ice in coastal regions are large, slow-growing, old fish, and that they likely live there to eat the abundant Antarctic silverfish, but do so at the peril of being eaten by seals and killer whales.

"We are now trying to understand if Weddell seals and killer whales eat toothfish occasionally, or if they rely on them during certain times of the year when the melting sea ice gives them access to these areas."

The work will require a NIWA team to spend several seasons on the sea ice to develop ecosystem indicators and a monitoring plan to detect any changes due to climate change or the effects of fishing in areas outside the MPA.

Breaking the ice

The *Deep South* National Science Challenge is one of New Zealand's most audacious collaborative projects in recent times.

The NIWA-led project aims to create a new numerical Earth System Model that more accurately predicts future changes in New Zealand's climate, and to deliver the information to New Zealanders to create real-world, real-time solutions.

It is doing that by combining science, mathematics, social science, community development, politics, business, infrastructure, and communication.

The multi-faceted project has seen scientists meet with different industries and groups that will be impacted by the research. Engagement has varied from an elaborate art exhibition at Auckland Museum ('Antarctica – while you were sleeping'), a partnership with New Zealand Geographic, and collaboration with industry groups and education institutions.

The future of insurance

The Insurance Council of New Zealand is one of the project's leading partners, reflecting the need for New Zealanders to start long-term thinking about safeguarding against climate-change impacts.

"Most of us are concerned with immediate and tangible risks such as burglary or a car crash, but climate change is an increasingly significant issue – for the public, and for insurers and re-insurers," said Insurance Council of New Zealand Chief Executive Tim Grafton.

"The industry insures a lot of assets globally that will be impacted by climate change, and we are a significant investor in assets that may be vulnerable, including carbon-based equities. Liability insurance will be impacted, particularly for local councils that may find themselves accountable for infrastructures that are unable to cope with rising sea levels or king tides.

"We are keen advocates of the adaptation model: reducing risk, building resilience. NIWA's work will allow us to scope the size of the risk in different areas to a very precise level, which will inform our response for policies for how we can transfer the risks."

Antarctic trip

The RV *Tangaroa* is scheduled to travel to the deep south again:

Sub-Antarctic Trawl Survey – 2017
24 Nov to 22 Dec (29 days)

Antarctic Voyage – 2018
5 Feb to 21 Mar (45 days)

A catalyst for change

Despite the doomsday dialogue that traditionally dominates climate-change discussion, *Deep South* researchers and designers have given Māori farmers a beacon of hope.

Led by Principal Investigator Dr Huhana Smith, the Adaptation Strategies to Address Climate Change Impacts on Coastal Māori Communities project researchers ran hui and wānanga with iwi farmers, shareholders and whanau trust boards within the Kāpiti and Horowhenua districts to map what climate change could mean for their areas within different time periods.

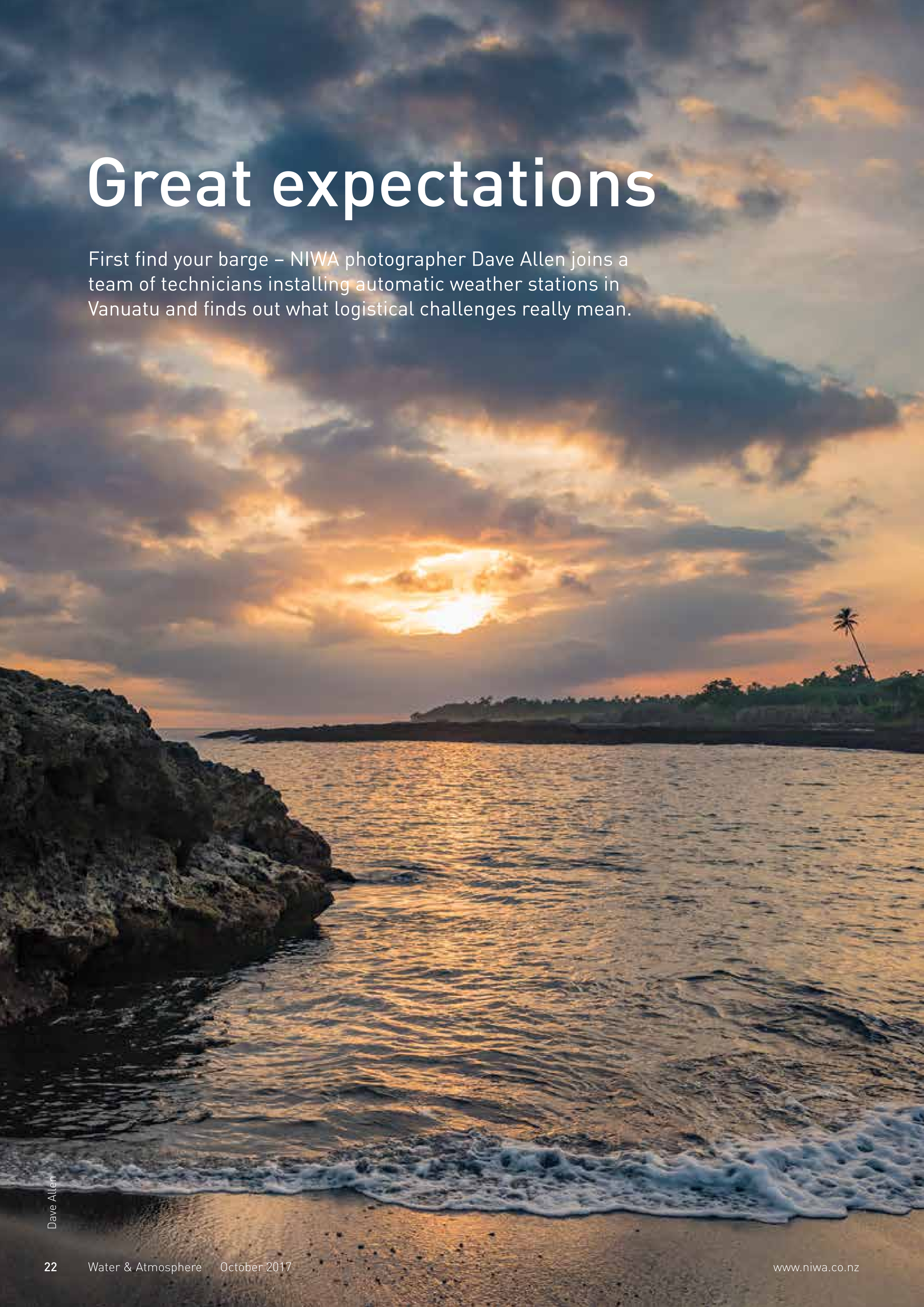
The farmers were then presented with an exhibition (in a disused dairy shed in Kuku, Horowhenua) of different visual solutions incorporating diversified farming practices, and new building designs created by Victoria University of Wellington Architecture and Design students. They exemplified how iwi-led farming could be adapted to be more resilient and profitable in the future.

In a video summarising the project, student Ally Jackson said: "Climate change can be a positive influence, a catalyst for change."

More information: www.deepsouthchallenge.co.nz

Great expectations

First find your barge – NIWA photographer Dave Allen joins a team of technicians installing automatic weather stations in Vanuatu and finds out what logistical challenges really mean.



Dave Allen

"Nothing goes quite to plan, but usually goes as expected." With over 15 years working as a NIWA climate technician in the Pacific, Andrew Harper knows what to expect when working in the region.

He says plans might state 17 bags of cement, 42m of PVC conduit, 80m of heavy duty fencing materials and tools will be delivered in time for construction. "But the plan goes out the window when the barge carrying the supplies hasn't left port due to a passing cyclone.

"There's often limited local transport available, so if you can find a vehicle to rent, then that's a bonus. On Vanuatu's smaller islands, cash is required for accommodation, flights and food, which is fine until you learn that there is literally no place for foreigners to get cash without going back to the mainland."

Throw language difficulties into the mix, and logistical operations that you might take for granted in New Zealand can seem like an insurmountable challenge in the Pacific.

All these challenges were faced earlier this year when NIWA started installing automatic weather stations (AWS) across Vanuatu. The challenges meant the work would not have been possible without the local knowledge of project partner, the Vanuatu Meteorology and Geohazards Department (VMGD).

Andrew Harper and colleague Marty Flanagan worked with six VMGD technicians and a small group of local men who provided manual labour. Andrew and Marty oversee the technical details, and train and coach VMGD staff, with the intention that they will be able to work autonomously on future projects.

With the link up and running, Andrew Harper and Tanna's local meteorological observer Bradley Bani monitor data relayed from the island's station for the very first time. (*Dave Allen*)

Six of the stations are now installed, and three more have been shipped and will be installed in September. Another six are planned, probably for next year.

NIWA technicians are available for ongoing support if required, but the fundamental idea behind this work in Vanuatu, and so much of NIWA's work in the Pacific, is to

VMGD Technician Jeremy Bani (Left) and local Observation Officer Bradley Bani install cables on the weather station mast. (*Dave Allen*) enable local organisations in each country to maintain the equipment and sustain their own operations independently.

The AWS network is to be spread across almost 1000km from Aneityum in the south to Vanua Lava in the north.

Each AWS houses precision instruments that measure wind speed and direction, air and ground temperature, barometric pressure, humidity, rainfall and solar radiation. All of the instruments are installed in a highly specified manner in accordance with World Meteorological Organization standards and procedures, to ensure consistent reporting.

Data from these instruments are sent to a centralised data archive via the internet. This seems simple enough on the surface, but the key is ensuring all instruments are installed so that they work correctly and durably for many years, with minimal maintenance requirements. Is the temperature sensor 1.2m above ground? Is the soil moisture sensor exactly 0.2m deep? Is the wind vane aligned true north? NIWA's experience in this area is invaluable – it's all specified, and it all needs to be done accurately.

Vanuatu, like most Pacific nations, is highly vulnerable to natural disasters such as cyclones and droughts.

Mixing concrete – island style. The concrete foundations for the weather station will help the instruments hold up to extreme winds that are likely in future cyclones. (*Dave Allen*)

VMGD Technicians Jeremy Bani (left) and Loic Jimmy work on a colour-coded patchwork of cabling to the Stevenson Screen – a standardised housing for instruments to measure air temperature, humidity and atmospheric pressure. (*Dave Allen*)

Project Coordinator Sam Tapo (centre) prepares the concrete – mixed 'island style' on a tarpaulin. (*Dave Allen*)

With Tanna's only bank not able to dispense cash, and credit card payments impossible, Marty Flanagan and Andrew Harper wait for money to be transferred from Auckland via Western Union. (*Dave Allen*)

Improved climate data will help Vanuatu's government departments better plan for climate related events. For example, Government Ministries of Fisheries and Agriculture will be able to plan water storage requirements with better seasonal forecasts for temperature and rainfall. (*Dave Allen*)

High quality weather and climate information will help the country better prepare for these events.

However, VMGD Project Coordinator Sam Tapo says the data will do so much more than this. "It will improve the livelihood of people living here in so many ways."

Sam says the information will help Vanuatu's government departments better plan for climate-related events. For example, the Fisheries Department and the Ministry of Agriculture will be able to plan water storage requirements with better seasonal forecasts for temperature and rainfall. The tourism industry will benefit from a better understanding of weather patterns and how El Niño / La Niña affect the area.

Much improved rainfall and temperature data will enable the Department of Health to provide better advice on mosquito-borne diseases. And the Department of Energy will be able to gain new insights on the potential for solar energy to replace some islands' reliance on diesel power generation.

The work is funded by the Global Environment Facility, and implemented by the Vanuatu Ministry of Climate Change and the United Nations Development Programme (UNDP), as part of a programme to build resilience through improved infrastructure. It's a relatively small cost, but has potential to return much more.

NIWA's Instagram gallery: work in progress

If you like NIWA's photography, then you should take a look at NIWA's Instagram account @niwa_science. New content is posted almost every day by staff photographers Dave Allen, Hamish McCormick and Stuart Mackay. It's a sometimes serious, sometimes fun, look at the science NIWA does and the beautiful parts of the country we get to work in.

niwa_science
Raoul Island

82 likes

Raoul Island continues to deliver for the team on board *Tangaroa*. While the whale team was out sampling on a smaller boat, a mother humpback and calf paid a visit to *Tangaroa*, giving those still on board a sight of a lifetime.

niwa_science
Antarctica

24 likes

NIWA's Dr Hinrich Schaefer and PhD student Eleanor Rainsley stand at the terminus of the Taylor Glacier in Antarctica. The image was captured by Katje Riedel.

niwa_science
Lauder, Central Otago

44 likes

Astrophotographer Petr Horálek captured this incredible image of the Aurora Australis while visiting NIWA's facility at Lauder in central Otago.

niwa_science
Wellington

26 likes

Juvenile paua aged about 6 months.

niwa_science
Antarctica

47 likes

Caption this photo! Please provide a caption for this photo in the comments and we will repost our favourite caption.

niwa_science
Underwater angel

65 likes

A very, very rare in-water picture of a juvenile flying fish. These amazing fish look like underwater angels. This shot was captured by NIWA's Crispin Middleton. We are not aware of any other good underwater images of flying fish in New Zealand.

niwa_science
Poor Knights Marine Reserve

27 likes

Scientific diver, Crispin Middleton is surrounded by panicked starry toado pufferfish. This rarely seen pelagic pufferfish usually lives in deep, blue, open water. On very rare occasions, the fish stray too close to land and immediately get attacked by hungry kingfish and snapper. The panicked fish seek shelter around anything in the water.

niwa_science
Granity, West Coast

24 likes

Is your wood burner polluting the atmosphere? Well, yes, quite a lot actually. During winter, wood burning is the leading cause of air pollution in the country – it's just not supposed to look this pretty.

niwa_science
Psychedelic sea slug

65 likes

The people's choice winner in the 2014 NIWA Staff Photo Competition, Rachel Boschen.

niwa_science
Doubtful Sound/Patea

46 likes

Not a 'bad day at the office'. NIWA's Evan Baddock and Eric Stevens doing an assessment on Monowai River in Doubtful Sound/Patea.

niwa_science
Doubtful Sound, Fiordland

114 likes

To do science, NIWA needs data – the more the better. So we have thousands of sensors, loggers and transmitters located all over the country and out at sea. Some are located on the top of NIWA buildings and others are found in the middle of dense Fiordland bush. Environmental researcher Evan Baddock downloads river gauge data at a remote station near Doubtful Sound. You wouldn't know the Lyvia River flows just a few metres away.

niwa_science
Macquarie Island

51 likes

Hundreds of king penguins huddle together at Lusitania Bay, along the east coast of Macquarie Island, Southern Ocean.

Fire – call NIWA!

When a fire breaks out, the first call you make is to 111. Fire and Emergency New Zealand, meanwhile, calls NIWA.

For the past year, NIWA's meteorologists have been on call to provide real-time, comprehensive information about weather patterns that may accelerate a fire … and boy, have they been kept busy.

Over the 2016/17 summer, NIWA's on-call forecast team received more than 100 requests from Fire and Emergency New Zealand for up-to-date forecasts.

"One night I got three calls – one around 1am, another at 3am, and another at 6am. It was a fairly sleepless night all round. January through to March was a very active period for fires, and requests for forecasts," recalled NIWA meteorologist Seth Carrier, who is one of Fire and Emergency New Zealand's 'go to guys' for fire weather information alongside Chris Brandolino and Ben Noll.

Fighting fires together

NIWA's on-call forecasting service was introduced officially on 1 February 2017 following an extensive pilot. The contract formalises more than a decade of support and partnership between NIWA and Fire and Emergency New Zealand that has included developing improved forecasting methods.

Four years ago, NIWA replaced the New Zealand Fire Service's outdated Fire Weather System with its purpose-built EcoConnect-Fire, a unique system that combines data, including wind direction, wind speed, rainfall, temperatures, and humidity, to provide a comprehensive, tailored, multi-hazard forecast.

In addition to EcoConnect, which is accessible via mobile, email and online, NIWA provides nationwide weather forecasts for Fire and Emergency New Zealand on request.

Port Hills put the system to the test

Most of the fires NIWA provides forecasts for are thankfully contained or extinguished within hours. When the conditions are just right, however, fires can rage on for weeks, which is exactly what happened in Canterbury in February. On a quiet Monday afternoon on 13 February, two separate fires started on different sites in the Port Hills of Christchurch. Within 36 hours the fires had combined, causing mass evacuations of nearby residents, power outages to more than 89,000 homes, destruction of 11 homes, and an eventual declaration of a civil defence emergency.

NIWA meteorologist Seth Carrier and Thomas Harre from Fire and Emergency New Zealand. (*Stuart Mackay*)

Helicopters with monsoon buckets dump water on fires on Christchurch's Port Hills. Better information on weather conditions significantly improved the firefighters' ability to dowse the flames. (*Christchurch City Council Newsline*)

NIWA's meteorological team was on hand releasing forecasts twice daily to allow the firefighters to get a jump on potential hot spots.

"It was a very intense period for all involved. The Port Hills fire was much larger and went on for a lot longer than most fires that are fought over the summer period. We provided forecasts at 8am every day and again at 4pm and were on-call over night to provide updates as required," Mr Carrier said.

"Fire and Emergency New Zealand brought in portable weather stations to obtain real-time data on the weather conditions in the Hills that we could feed into EcoConnect and provide even more precise forecasts. Feedback from Fire and Emergency New Zealand was very positive, particularly about the accuracy of the forecasts. With NIWA's forecasts, Fire and Emergency New Zealand could assess weather conditions and determine how many personnel they would need in a certain spot."

NIWA staff personally impacted

Several NIWA staff whose homes were in the firing line personally benefitted from their colleagues' forecasts. Chief Scientist, Coasts and Oceans, Barb Hayden had to escape her 20ha farm situated on the lower slopes of the Port Hills, just 700m away from where the first fire started. The helicopters commandeered to help douse the fires used water from her pool to stop the fire spreading to houses and nearby pine plantations.

"[By the time] the state of civil emergency was declared, hundreds of people had been evacuated from their homes in areas near the fire, including a bunch of NIWA folk. About 75 per cent of our land burned. Our focus now is on repairing about 2km of fences, dropping about 100 burnt pine trees that are now a hazard and getting rid of the gazillions of gorse seedlings that germinated after the fire. Chris Brandolino kept us updated with weather forecasts to inform us on the best days to reseed (the land)."

Vagaries of variability

There's good news and bad news on the weather front – tropical cyclones forming in the southwest Pacific are becoming less frequent, but those that do form are likely to be more severe.

Chris Brandolino, NIWA Principal Scientist – Forecasting, says research suggests that tropical cyclone frequency globally appears likely to decrease with climate change, but the intensity of these cyclones will likely increase, along with the number of intense cyclones.

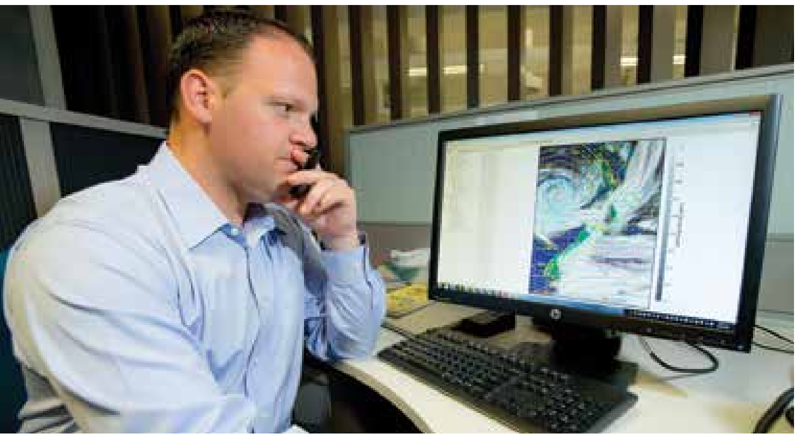
New Zealand copped the brunt of some severe cyclonic activity recently, with ex-tropical cyclones Debbie, Cook and Donna hitting the North Island in April and May. Dubbed the Tasman Tempest, the three ex-tropical cyclones brought heavy rain to parts of the country.

"What's happened this year is likely due to natural variability," Brandolino says. "Some years are busy and some are not. Perhaps more important was how cyclones were distributed. The first two-thirds of the season was very quiet. In fact, it was a record low start to the season.

"Then we had an uptick in tropical cyclones towards the very end of the season – I think the season as a whole got up to near or below average in terms of the number of cyclones for the Pacific southwest basin."

Dr Brett Mullan, Principal Scientist – Climate, confirmed tropical cyclone activity across the southwest Pacific had, on the whole, been below normal this year.

"However, the situation was reversed as far as ex-tropical cyclones influencing New Zealand were concerned. The season has been very active, with three named ex-tropical cyclones influencing the North Island – Debbie on 4–5 April, Cook on 14–16 April and Donna on 11 May.



"Tropical cyclone frequency globally appears likely to decrease with climate change, but the intensity of these cyclones will likely increase." – Chris Brandolino. (*Geoff Osborne*)

"The drivers of cyclone activity are sporadic in the tropics, and that was the case again this season," said Dr Mullan.

"It can make a big difference to have a slow-moving mid-latitude cyclone in the 'right place at the right time' to help 'drag' the tropical cyclone south over the country, and we have had those this past autumn. These weather systems have been slow-moving, held up in the Tasman due to blocking highs further south and east.

"The other factor that could have played a role is anomalously warm sea surface temperatures over the autumn season, which have been experienced from east of Queensland down to around the North Island. Sea temperatures of 1°C or more warmer than normal could have played a role in maintaining the strength of the tropical cyclones as they came south."

Natural variability played a major role in the generation of tropical cyclones, and the resulting impact on New Zealand. While the Tasman Tempest had raised the spectre of climate change as responsible for driving more intense systems onto the country, Dr Mullan said climate change was more likely another variable adding to natural variability.

"For the globe, as a whole, there is scientific evidence for an increase in the number of tropical cyclones reaching the higher intensity levels (3, 4 or 5), and this is probably true for the southwest Pacific region as well.

"However, when we look at just those ex-tropical cyclones that impact on New Zealand, the sample is much too small

"For the globe, as a whole, there is scientific evidence for an increase in the number of tropical cyclones reaching the higher intensity levels" – Dr Brett Mullan. (*Dave Allen*)

to infer anything about trends. The last very active season from a New Zealand perspective was 1997, when three ex-tropical cyclones affected the country – Fergus and Dreena in January 1997, and Cyclone Gavin in March the same year."

While the North Island had taken a battering from the Tasman Tempest, the East Coast had borne the brunt.

"Differences in vulnerability of western versus eastern parts of the North Island depend very much on the state of the El Niño-Southern Oscillation (ENSO)," said Dr Mullan.

"In El Niño periods, the cyclones are more likely to be west of Auckland as they approach New Zealand, whereas in ENSO-neutral or La Niña periods they tend to be to the east, affecting the Bay of Plenty and Gisborne/Napier regions. The latter situation prevailed this year."

NIWA is learning much more about tropical cyclone seasons and the potential impacts on New Zealand, with forecasting models continuing to improve.

"NIWA has access to one of the best global forecasting models in the world in the UK MetOffice Unified Model," said Dr Mullan.

"At the seasonal time-scale, for assessing likely activity over a coming tropical cyclone season, we continue monitoring El Niño developments, and are pursuing further research into ENSO influences on tropical convection."

Q&A

Going to sea for fresh water

Since the end of June, a barge has been stationed just off Wellington's Miramar Peninsula drilling into the seabed to find an alternative water source for the city.

Wellington needs it in case there's a large earthquake and existing water supply routes are damaged. But why go to sea to find fresh water? NIWA marine geologist Dr Scott Nodder explains.

What's out there?

Aquifers are common sources of water around New Zealand and typically comprise buried layers of gravels deposited originally by rivers that are capable of holding and storing groundwater. These gravel layers are 'confined' by overlying fine-grained sediments that are often predominantly muddy deposits deposited in marine or land environments.

There are two aquifers beneath Wellington Harbour: the Waiwhetu Aquifer and the Moera Aquifer. Along the Petone foreshore, the Waiwhetu Gravels are 20–30m below ground level and the Moera Gravels are 100–160m down. Last year, NIWA surveyed the Wellington Harbour/Te Whanganui a Tara for Wellington Water Ltd to image the geological layers that mark the top and bottom of the Waiwhetu Aquifer and found it extends across the Harbour to Miramar Peninsula/Te Motu Kairangi. Beneath the harbour the aquifer is buried under a 30–40m-thick layer of mud of marine origin, which acts to 'confine' the aquifer and pressurise the water contained in the gravels.

The Waiwhetu Aquifer provides more than 40 per cent of the freshwater demands of Wellington City and environs, including Porirua and Lower Hutt cities. This extraction from the aquifer can rise to as much as 70 per cent of the demand in summer when river levels are low.

What's an aquifer and how does it work?

An aquifer is a saturated underground layer of permeable rock, gravel, sand or silt through which water can move easily – they store huge amounts of freshwater that can be accessed via a bore.

Water in aquifers is derived from rivers and to a lesser extent rainfall. Groundwater levels are influenced by factors such as river stage, rainfall recharge and extraction rates. Tidal and barometric pressure variations also affect groundwater levels in confined aquifers. Discharge from the Waiwhetu Aquifer occurs beneath the harbour and has formed large depressions in the seafloor off Point Howard (Seaview), the Hutt River/Te Awa Kairangi mouth and Somes Island/Matiu.

How do you know where the best place to drill is?

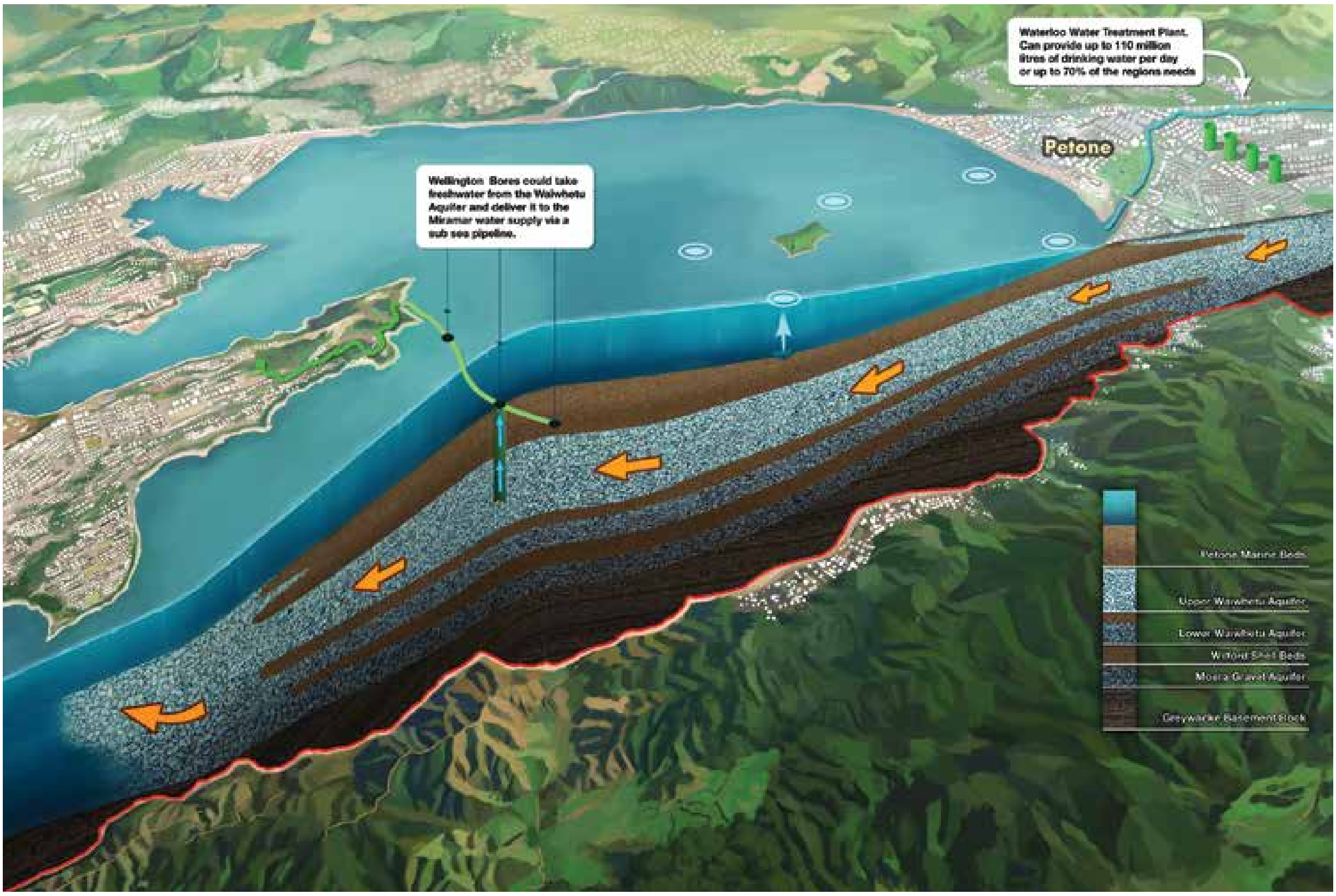
NIWA has mapped the extent of the upper part of the Waiwhetu Aquifer gravels across the harbour from where it is known to intersect the borehole off Somes Island/Matiu. We have used shallow geophysical techniques, involving sound sources and hydrophones, towed behind survey vessels, to generate an image of the aquifer beneath the seafloor. However, the only way to be absolutely sure the aquifer is where we have mapped it is to drill to retrieve and test the freshwater within the aquifer.

If there was a significant earthquake that disrupted the existing water supply, wouldn't the aquifer be affected as well?

Yes, there is potential for this to occur, as was the case in Christchurch after the recent earthquakes there. The borehole drilling, however, will provide additional resilience to the infrastructure required for getting water to areas of Wellington City that may be potentially disrupted or damaged by a local earthquake.

You will be examining the core samples of the seabed brought up by the drilling rig – what will they tell you?

The geological samples from the cores will be described and collected by geologists from Stantec MWH and GNS Science. This will provide new information about the geological history of Wellington Harbour/Te Whanganui a Tara and the conditions of the aquifer and its confining layers, which will improve our understanding about the physical and hydraulic characteristics of the Waiwhetu Aquifer (i.e., size and density of sediment grains and water pressures in the aquifer). The information will find use in studies investigating the climatic, sea-level and tectonic evolution of the area. The water from the aquifer will also be chemically tested and monitored to determine if it is suitable as a drinking water source. NIWA is providing technical skills in this monitoring.



The Waiwhetu Aquifer. (*Wellington Regional Council, Wellington Water*)

A tugboat gently manoeuvers the barge and drilling rig out into Wellington Harbour. (*Nick Gee*)

Small town, huge horizons

If it wasn't for a damaged shoulder, Wills Dobson wouldn't be launching weather balloons. Or fixing high-precision atmospheric measuring instruments. Or living in a small town where sometimes it feels like everyone is more than 20 years older than you.

The shoulder changed everything. He was well on his way to becoming a pilot in the Air Force, but just before the final physical test at the end of his officer's training he damaged his rotator cuff.

"I couldn't take the test. It was brutal, but that's the way things go."

An enforced period of reflection, and some work in his original career choice as an outdoors instructor, led him to realise he wanted to learn more about what made the world tick. University seemed the next obvious step.

Wills chose Canterbury because it offered him the opportunity to combine physics, astronomy and Antarctic studies – and the chance to head to Scott Base during some postgraduate study. It got under his skin and he's been back to the ice every year since. This September will see him there again, taking on the responsibility of training two new science technicians to operate the atmospheric instruments NIWA has installed at Arrival Heights, Antarctica.

At just 29, Wills Dobson's forging a scientific career of international importance. He is now an atmospheric technician at NIWA's Lauder atmospheric research station. If not the most bustling or glamorous of work places, it is stunningly beautiful. Nestled under the Dunstan Range 35km from Alexandra in Central Otago, the station comprises a single storey office block which is overlooked by several purpose-built buildings dotted across a ridge line, each housing a world-class scientific instrument.

These instruments measure trace gases and chemical compounds in the atmosphere. Wills' favourite coincidentally bears his name. It is the Dobson spectrophotometer and it measures ozone in the stratosphere. Wills' job is to record the measurements it makes and make sure it keeps on making them.

He takes measurements from the Dobson twice a day and performs calibrations on several instruments either weekly or monthly to ensure they are operating correctly.

"The idea is that you run a known value through your instrument that will give you known readings you can compare to what is being measured. If the readings are different to what you expect, something's wrong."

Any slight human alteration to these high precision instruments is recorded in case it affects the measurements.

"You can't just go out there and do anything you like because we've got a really long-term data series, and if that affects the measurements or puts a step in our data, then that's not good. We pride ourselves on having really good-quality long-term data series. They're world renowned."

Occasionally things don't go to plan and they break. Then it's up to Wills to fix them.

"Sometimes it might just mean a piece of tape in the right place to get it going.

"Sometimes it means figuring out what you did when you were tired or what the last operator did by mistake, and just changing one or two settings.

"But sometimes things really go wrong and then it's a process of elimination."

Figuring out what the problem is, is about 95 per cent of fixing it.

"You go through your instrument, you work out what has failed and why, and do a whole bunch of different tests you often have to make up on the spot to isolate the problem, and then figure out how to fix it."

Despite Lauder's isolation, there is help close at hand. There is a lot of on-site experience and, beyond that, people doing similar work at similar stations around the world.

"I ask if they've ever had this problem before and sometimes they can tell you straight away what to do to fix it. Other times they haven't had the problem, but are keen to know the outcome because they don't want it to happen to them."

The weather balloons take Wills away from the machines. They are launched weekly and carry an ozone sonde to measure ozone as it goes up through the atmosphere, transmitting the data back as it goes. The sondes start being prepared two weeks ahead of launch date, and while they are ideally released on a clear, sunny day, it is a rare week when the weather doesn't cooperate.

Wills Dobson on a recent tramping expedition to Mavora Lakes, Central Otago. (*Rebecca Nadge*)

"It can get difficult in spring because the wind tends to pick up about 9.30am or 10am. Then it's all hands on deck first thing in the morning to get one away."

Wills lives in Alexandra. He says small town life has taken some adjusting, but he has it well worked out now.

"Most people here tend to be 50-plus, and a large part of that 65-plus. They're a good bunch of people, but not who I'd normally go out on the town with.

"For a while I had a fairly transient group of friends. I knew a lot of backpackers, and of course they'd be here for a few months and then go on somewhere else. The plus side is I have lots of places I can stay in Germany."

But gradually a core of younger people has shifted to town and there are dinner nights, pub quizzes, skiing and tramping to be getting on with outside work.

"Alex is a pretty chilled place to live. It was pretty hard to acclimatise at first, but I'm under no illusion about how lucky I was to get this job."

The team atmosphere at Lauder is definitely a selling point and his workmates appreciate his organisational skills and improvements he's made to their systems. He's also their number one Lauder tour guide.

Wills says with only eight full-time staff, a couple of emeritus researchers and the odd student on site, you can spend large amounts of time not seeing anyone else.

Except for the legendary Lauder morning and afternoon teas. "If it wasn't for them, we'd hardly ever see each other because everyone does their own thing. All group discussions happen then – sometimes they can get pretty heated and passionate, but they are always constructive.

"We're all a little bit crazy out here in one way or another."

A wave of hazard research

It is well known that earthquakes can trigger tsunami. We've all seen the warning signs: "If an earthquake is long or strong, get gone". What few New Zealanders know, however, is that tsunami can also be caused by landslides – with devastating effects.

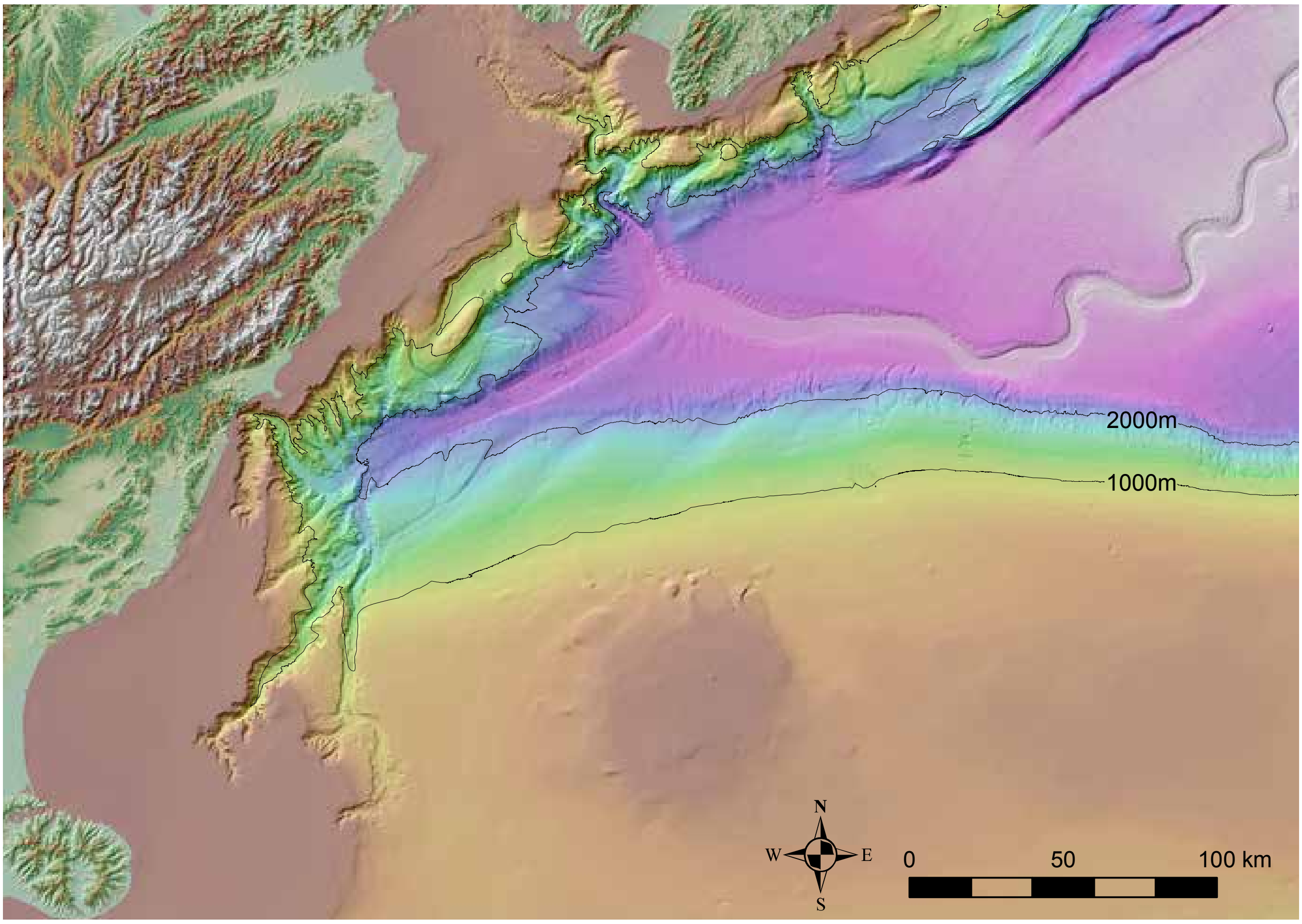
In fact, right now New Zealand's eastern coastline is at risk of landslide-induced tsunami, courtesy of the large submarine canyons that surround our coastline, and a dynamic tectonically active seafloor landscape.

Learning what lies beneath both the waves and ocean floor is fundamental to assessing hazards to underpin hazard management plans. For NIWA's Dr Joshu Mountjoy, the Kaikoura earthquake provided a huge learning opportunity for landslide and tsunami hazard science.

"The tsunami following the 2016 Kaikoura earthquake was relatively small, but it was still the most significant event in around 50 years. Being onsite at the time and in the following months, we were able to document changes to the seabed, and it has revealed some exciting science," Dr Mountjoy said.

"Being onsite at the time of the earthquake and in the following months, we were able to document changes to the seabed and it has revealed some exciting science." Dr Joshu Mountjoy. (*Dave Allen*)

The *JOIDES* (Joint Oceanographic Institutions for Deep Earth Sampling) *Resolution* is a specialist research vessel capable of drilling deep into the ocean floor to collect and study core samples. (*National Science Foundation*)



Seafloor bathymetry of the southern Hikurangi Canyon-channel system. Clockwise from left the three major canyons are Pegasus Canyon, Kaikoura Canyon and the Cook Strait Canyon System. Both the Kaikoura and Cook Strait Canyons bring steep and deep seafloor right up close to land, meaning the potential for large tsunami-generating landslides near to shore is greater than anywhere else. (*NIWA*)

"In January 2017, we surveyed down to 2000m and discovered that large areas of the Kaikoura Canyon have drastically changed. Sediment has been transported from the Kaikoura canyon at least 300km north to the deep ocean floor offshore Wairarapa. The earthquake shook loose a huge amount of mud from the canyon rim that then flowed down into the canyon channel. As it accelerated downslope, this material appears to have eroded deeply into the canyon floor and ignited into a critical condition we call 'autosuspension'. Amazingly, in this condition, sediment can flow indefinitely across the ocean floor. We know the deepsea Hikurangi Channel is 1500km long, and this flow may have travelled the full length of it. No one has ever directly observed this process before – it is an amazing opportunity."

Previous NIWA research revealed that the canyon had the potential to generate large landslide tsunami. The NIWA team is now in the process of pulling together data from its January expedition to see if the canyon has been further destabilised and if the tsunami potential has increased or decreased.

Further up the coast, Dr Mountjoy is studying the slow-moving Tuaheni submarine landslide complex, off the coast of Gisborne – one of the few active submarine landslides in the world. Slow landslides like this might actually reduce the potential tsunami hazard, so understanding the underlying controls is very important for accurate hazard assessments.

Together with Dr Gareth Crutchley from GNS Science, Dr Mountjoy received a Marsden Fund grant this year to assess whether pockets of gas-trapped landslides can control active landsliding on the seafloor. The duo is assessing 3D seismic data and core samples collected from last year's RV *Sonne* expedition for evidence of pressurised gas and liquefaction in the landslide.

The research dovetails NIWA and GNS Science's slow-slip earthquake investigations, which, as Dr Mountjoy pointed out, are the "major discovery of this century" when it comes to earthquake hazard. He will join the International Ocean Discovery Programme's drillship *JOIDES Resolution* expedition in November 2017 to sample the sub-seafloor of the Tuaheni landslide.

"The Tuaheni landslide covers an area roughly the size of Auckland and is slowly moving downslope like a glacier. This is the first example of an active landslide globally and has changed our understanding of seafloor landslides," Dr Mountjoy said.

"Large landslides on the seafloor can move mountain-scale size pieces of rock and mud and have caused some of the largest tsunami in human history. To calculate the potential for causing large tsunami we need to understand how fast landslides move and what causes them to collapse. This scientific drilling project using *JOIDES Resolution* will give us the information we need to understand the tsunami hazard and help plan for the appropriate civil defence response."

Solutions

Abstraction art

Increasing demands on New Zealand's freshwater resources has led NIWA to develop a smart addition to its suite of tools assisting in the planning, regulation and evaluation of water use.

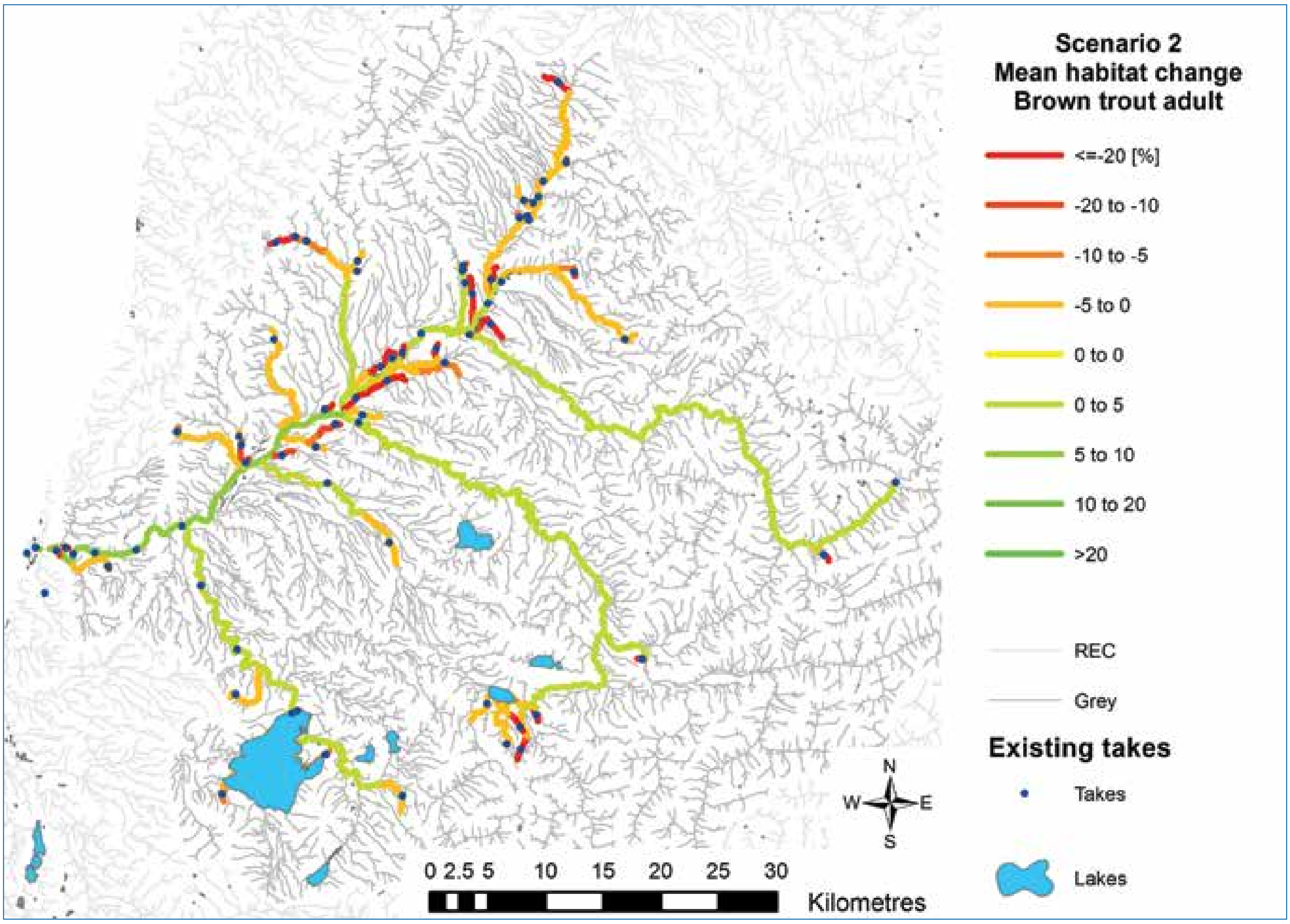
NIWA's CHES (Cumulative Hydrological Effects Simulator) software tool predicts how water-flows in a catchment will change with multiple water uses, such as direct abstractions or storage reservoirs, and what the consequences will be to in-stream ecosystems and reliability of water-take.

New Zealand's rivers are coming under increasing pressure to supply water for irrigation, hydro schemes, and domestic and industry uses, says NIWA software developer Dr Jan Diettrich. Understanding and managing these pressures are important for resource managers and end users, including regional councils, irrigation companies and communities.

"Users need to know the availability of water from a river channel and reliability of supply of water out of a reservoir. This needs to be done under the constraints of what water's actually in the river, what's allocated to other users in the catchment and limits set by regional councils around minimum flow and maximum take.

"They also need to consider the effects of water-take on in-stream environments, such as fish habitat."

CHES maps flows everywhere across a catchment on a daily basis. Starting with natural flows, it is able to adjust and



The image depicts the mean habitat change for adult brown trout, when comparing the natural flows (no abstractions) with the current state consented abstractions. Abstractions (takes) are depicted as "." in the figure, and for each river segment (NZReach) the physical habitat change for brown trout was simulated, using simulated mean daily flows. Hence river segments that are coloured in green indicate that brown trout has better habitat due to abstractions, whereas river segments that are coloured red indicate that abstractions are causing a reduction in habitat for brown trout.

So, abstractions (taking water from the river) can lead to an improvement in physical habitat, as the river might have been too high or too fast without any abstractions, and taking water 'shifts' the flow environment closer to the optimum conditions for brown trout. (*Dave Allen*)

Jan Diettrich points to a graph representing how Bluegill Bully, a small native fish, would be affected under various water abstraction scenarios. Green river segments indicate better habitat due to abstractions, and river segments that are coloured red indicate that abstractions are causing a reduction in habitat. The CHES software predicts how river and stream flows change after water is abstracted or directed to storage reservoirs, and what the consequences will be to in-stream ecosystems. (*Greg Kelly*)

estimate flows everywhere throughout the catchment to take into account existing water-takes and changes to flows such as proposed new abstractions.

It also quantifies the consequences for both the overall availability and reliability of the water resource, and the residual flows that determine in-stream environmental effects.

CHES incorporates modelled river-flow time series for New Zealand's half-million reaches, and includes user-specified abstraction and storage options. It calculates the effects of water use by combining numerical water routing with operating rules.

Embedded into ArcMap as an add-in, CHES enables analysis of the simulated or measured time series of residual river flows, and water-takes, for user-specified scenarios.

CHES works on user-specified scenarios:

- Natural – without any abstraction, i.e., 'untouched' river flows
- Current – flow time series calculated with existing takes, input from a consent database
- Proposed – see the impact of potential abstractions on river flow, existing abstractions, and compounded environmental effects

It also allows for mapping of scenario variations.

To access the CHES software tool or for more information, contact Dr Jan Diettrich at jan.diettrich@niwa.co.nz.

NIWA
enhancing the benefits of New Zealand's natural resources

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

NIWA's expertise is in:

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

NIWA employs more than 670 scientists, technicians and support staff.

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

Back cover:

Flooding in Matakana, the Bay of Plenty, 2008. (*Allen Blacklock*)

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