Vol. 15 No. 1
March 2007

NIWA
Taihoro Nukurangi

Water & Atmosphere

Latest ozone assessments and what they mean for New Zealand

Also in this issue:

NIWA, the National Institute of Water & Atmospheric Research Ltd, is a New Zealand Crown Research Institute. Our work contributes to the sustainable management and development of New Zealand's atmospheric, marine, and freshwater systems and associated resources.

NIWA's Māori name Taihoro Nukurangi – where the waters meet the sky – describes our work studying the waterways and the interface between the earth and the sky. Our rainbow logo also reflects the intersection of air and water.

For more information about NIWA, visit our website:
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Please direct all correspondence and circulation enquiries to:

The Editor
Water & Atmosphere
NIWA
PO Box 11115, Hamilton
New Zealand
Telephone: +64-7 856 7026
Fax: +64-7 856 0151
email: wa-editor@niwa.co.nz

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Water & Atmosphere team:

Editor: Janice Meadows
Subeditor: Harriet Palmer

Circulation: Donna McArthur

Curriculum advice provided by Shirley Dudli, NZMST Teacher Fellow.

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Teacher feature

Profile

Cover

Though ozone declines have slowed globally (and in some cases have ceased), here in New Zealand we're still subject to very high levels of UV radiation and must take care when we go out in the sun. Read about the latest WMO/UNEP ozone assessments on page 12.

Photo: Janice Meadows

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News from NIWA

Climate scientists making a difference

It was an impressive line-up at a recent climate change seminar in Wellington – and not just because the speakers 'walked the walk' by travelling to the event by bike and train.

The seminar, hosted by Victoria University and the Royal Society, was an opportunity for an influential audience to hear the headline results of the latest report from Working Group 1 of the UN Intergovernmental Panel on Climate Change (IPCC). This is an authoritative summary of the science of climate change.

'It's taken four years to get to this point,' said David Wratt. David leads NIWA's National Climate Centre and is the only New Zealander on the bureau (or steering committee) of the IPCC. The previous report was in 2001. After a brief respite, the bureau began drawing up the scope of this new report and selecting 130 of the world's top climate scientists to be 'lead authors'. NIWA principal scientists Dave Lowe and Jim Renwick are among them.

The report concludes that there is unequivocal evidence of global warming and most of the warming since the mid-20th century is very likely to be the result of human activity.

'Atmospheric carbon dioxide levels now far exceed their natural range over the last 650 000 years. The carbon isotopic footprint is exactly what you'd expect from increased burning of fossil fuels like coal and oil, with some contribution from burning forests,' Dave Lowe told the seminar.

'It's a richer, more compelling story this time', said Jim Renwick, pointing particularly to evidence that the oceans have warmed down to at least 3000 metres.

Even if we hold greenhouse gas concentrations at today's level, the report says we would expect about another 0.6 degrees warming by 2100. The important thing, said David Wratt, is 'what we do is going to make a difference. If we go for lower emissions, we get much less extra warming.'

For further information, contact:
Dr David Wratt, 0-4-386 0588, d.wratt@niwa.co.nz

Jim Renwick (left) and David Wratt listen as Dave Lowe explains the IPCC's findings on greenhouse gases to more than 200 people at a lunchtime seminar in Wellington.

Photo: Alan Blacklock

New Year Honours

Two key players at NIWA have been named in the 2007 New Zealand Honours list: former CEO Paul Hargreaves and Dr Clive Howard-Williams.

Paul has become an Officer of the Order of Merit, in recognition of his services to business. He was involved with NIWA from its foundation, beginning with an appointment to the Establishment Board in 1991 followed by various positions on the NIWA Board of Directors, including Deputy Chair and Acting Chair. After a period as acting Chief Executive, Paul became CEO in 1995, working closely with Research Director Rick Pridmore and Operations Director Rod East to transform NIWA's management structure. Together they created 'One NIWA', the project-based system that underpins NIWA's success in environmental research and consultancy. Paul retired as NIWA Chief Executive in 2002.

Clive Howard-Williams, General Manager (Freshwater, Coasts & Education), has received the New Zealand Antarctic Medal for services to Antarctic science. The medal, which has been instituted to replace the (British) Polar Medal, recognises Clive's outstanding contribution to scientific research; this is the first year the medal has been awarded and he is one of the first two recipients.

Clive's experience in polar research, spanning more than 20 years, has focused on microbial ecosystems in inland waters, on glacial streams and lakes in the Dry Valleys, and on the McMurdo Ice Shelf. In recent years he has been involved in strategic science activity in national and international forums, including the International Polar Year, Antarctica New Zealand's Latitudinal Gradient Programme, and the Scientific Committee on Antarctic Research (SCAR).

Photos: Alan Blacklock

NIWA's former CEO Paul Hargreaves (left) and GM Clive Howard-Williams.

For further information, contact:
Geoff Baird, 0-4-386 0574, g.baird@niwa.co.n

Photo: Paul Hargreaves

Clive of Antarctica in Scott's hut at Cape Evans, Ross Island.

New atmospheric science laboratory in Antarctica

As part of the celebrations of the 50th anniversary of Scott Base, Prime Minister Helen Clark formally opened the new laboratory building at Arrival Heights on 20 January (see *Water & Atmosphere 14(2)*: 8).

NIWA has a range of atmospheric science programmes at Arrival Heights to monitor and understand changing atmospheric composition, using ground-based remote sensing and taking air samples for analysis back in New Zealand. Part of this is monitoring the annual ozone hole and the stratospheric chemistry that leads to it, and part is looking at the concentration and isotopic composition of greenhouse gases (see *Water & Atmosphere 11(3)*: 20–22).

Staff from NIWA began shifting NIWA experiments into the new building in November last year, starting with several spectrometer systems used for ground-based remote sensing of atmospheric composition. These instruments included the venerable Dobson spectrophotometer that measures ozone and the more modern Bruker Fourier transform interferometer that measures several stratospheric trace gases.

During subsequent visits we relocated air-sampling equipment and meteorological instruments and set up and installed a lot of 'new' equipment, from roof hatch fittings with windows or domes for the instruments to see through, to a new tower for the meteorology instruments and air-sampling lines.

In the midst of all this activity, NIWA also operated one of its high-precision UV spectro-radiometers for two months to validate UV measurements made at Arrival Heights by US scientists.

'It's great to have all our gear housed in a better, more spacious facility. We've already seen that the temperature stability of the new building is far better than the old one', said Stephen Wood, who coordinated much of the move.

The old building was dismantled and packed up just before the Prime Minister's visit. The Canterbury Museum plans to use a part of it in a reconstruction of an Antarctic research hut.

For further information, contact:
Dr Stephen Wood, 0-3-440 0426, s.wood@niwa.co.nz


Photo: © G Powell, Antarctica NZ Pictorial Collection: K250 06/07

PM Helen Clark unveils the plaque.


Photo: Stephen Wood

The new laboratory (at right) replaced the small green building at left (now removed).

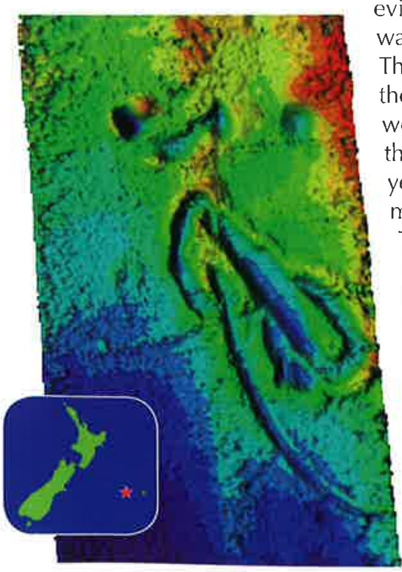

Photo: Stephen Wood

Calibrating the Dobson spectrophotometer in the new building.

Icebergs ahoy!

Bergs were the buzz last November, when several from Antarctica approached the east coast of the South Island. NIWA oceanographer Mike Williams deduced that the icebergs originated at the Ronne Ice Shelf, and isotope analysis done at Otago University has since confirmed this as the most likely source.

During the inaugural voyage of Ocean Survey 20/20 in August, NIWA's multibeam acoustic survey equipment recorded evidence of icebergs in our waters in the more distant past. The scour marks detected on the seabed on the Chatham Rise were probably made during the last ice age, about 20 000 years ago, according to NIWA marine geologist Scott Nodder. The marks suggest an iceberg measuring between 2 and 5 km long – similar or slightly larger than the biggest berg sighted last year.


High-resolution seafloor image of iceberg scours on Chatham Rise. The image is made from multibeam acoustic data collected by NIWA's deepwater research vessel, *Tangaroa*.

For further information, see our iceberg fact sheet:
www.niwascience.co.nz/pubs/mr/archive/2006-11-28-1-/iceburg_fact_sheet.pdf

Customary Coastal Management Workshop

21–22 June, Te Papa, Wellington

Increasingly, the regulatory responsibilities for customary management of kaimoana resources and the coastal environment fall upon iwi and managers of taiapure and mātaitai (traditional fishing grounds). In June, NIWA's National Centres for Coasts & Oceans and Fisheries & Aquaculture will host a two-day workshop at Te Papa in Wellington to highlight how increased scientific knowledge can help.

On the first day, the workshop will identify the key issues and management regimes, and on the second day it will focus on scientific advances that can assist in customary coastal and kaimoana management. Topics will include habitat mapping, resource assessment, fisheries enhancement, and integrated environmental management.

The workshop will be of particular interest to iwi coastal managers, taiapure and mātaitai managers, fisheries managers, resource and environmental planners, and local, regional, and central government policy managers.

For further information, contact:
Dr Ian Wright, 0-4-386 0322, i.wright@niwa.co.nz
or see: www.niwascience.co.nz/ncco/workshops/

Tagging sea cucumbers

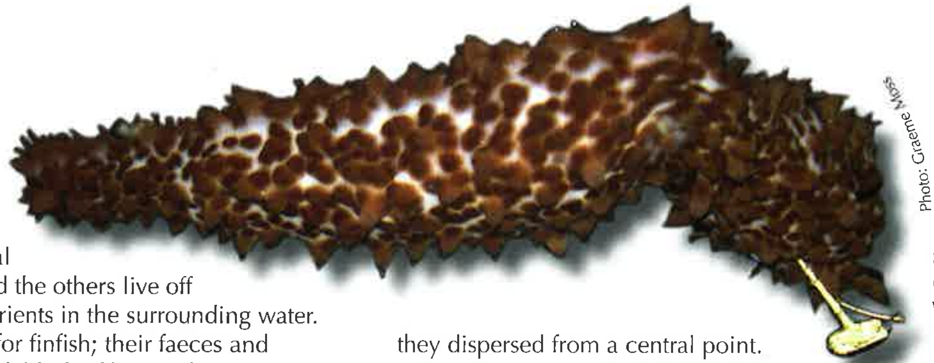


Photo: Graeme Moss

Sea cucumber (*Stichopus mollis*) with a T-tag.

NIWA is working with the mussel farming industry to trial 'multi-trophic co-culture', a system where several species are raised together in ecological balance. One species is fed and the others live off the dissolved or particulate nutrients in the surrounding water.

In our design, feed is added for finfish; their faeces and any food that they miss are available for filtration by mussels; dissolved nutrients are soaked up by cultured seaweed, which in turn is food for sea urchins for roe enhancement. Faeces that settle on the seabed from finfish, mussels, and sea urchins are consumed by ranched sea cucumbers.

But how do we assess whether it is ecologically feasible to ranch sea cucumbers? If juvenile sea cucumbers are placed under finfish/mussel farms, will they stay put, or will they move off to 'greener pastures'?

To answer this question, we had to find a way to tag sea cucumbers for release and recapture under farms. Graeme Moss from NIWA's Mahanga Bay aquaculture facility investigated six different methods, including freeze branding, micro-sand blasting, pit-tagging, T-bar tags, and Visible Implant Fluorescent Elastomer, or VIFE for short. VIFE (developed by Northwest Marine Technology Inc., Washington) involves injecting a viscous, stretchy liquid (elastomer) into the paler underside of a sea cucumber where the elastomer forms a marker that glows under blue light. After 4 weeks in the laboratory, the best results (tag retained without mortality) were obtained with the T-bars (87%) and the VIFE technique (93%). After 3 months, tag retention had dropped to 40% for the T-bars and 87% with VIFE.

We used the VIFE technique – backed up with T-tags – and released 100 tagged sea cucumbers in Mahanga Bay to see how they dispersed from a central point. Scuba divers were able to retrieve half of the tagged sea cucumbers in two 15-m radial searches, one after 24 hours and the other after 9 days. Our next step is to release VIFE-tagged individuals under marine farms and experiment with different search patterns to optimise retrieval. Then we can statistically evaluate the feasibility of ranching sea cucumbers.

This project is funded by the FRST International Investment Opportunity Fund and we are working in collaboration with the Yellow Sea Fisheries Research Institute in China.

Read more about culturing multiple species in 'Land-based polyculture for coastal Māori', pp. 22–23.

For further information, contact:
Dr Jeanie Stenton-Dozey, 0-3-343 8030, j.stenton-dozey@niwa.co.nz

VIFE implant (circled) appears bright orange under blue light.

Photo: Graeme Moss

What the ...?

Looking like a small hedgehog, this peculiar object was caught in a beam trawl when NIWA staff were sampling flatfish in Te Waihora (Lake Ellesmere). Closer examination revealed not a drowned introduced mammal, but rather a very old ball of seeds from a native aquatic plant.

Before the *Wahine* storm of 1968, Waihora was fringed by an extensive community of aquatic plants. While there is some evidence that the community was already slowly deteriorating, the storm certainly accelerated the cycle by uprooting the weed beds. These were primarily comprised of two species of *Ruppia* (lakeweed) and some *Potamageton pectinalis* (fennel-leaved pondweed). Since that time, the lake has been too turbid for the plants to repopulate. Where there is sufficient light in the shallows, wave action and grazing by swans rapidly removes any regenerating weed.

Photo: Don Jellyman

So, the trawled-up specimen is in fact a ball of *Ruppia* seed that must have gradually accumulated during the 38 years since the weed beds were destroyed by the storm. We incubated the seed ball in the laboratory and many of the seeds germinated, indicating they were still viable. Small quantities of *Ruppia* are occasionally seen in sheltered embayments, although it appears the plants are grazed down by waterfowl before significant communities can establish.

Currently, there is considerable interest in exploring opportunities to re-establish aquatic plants within the lake, as they provide habitat diversity and are useful for food production, trapping suspended sediments, reducing wave impacts, and assisting in nutrient uptake.

For further information, contact:
Dr Don Jellyman, 0-3-343 7846, d.jellyman@niwa.co.nz

Photo: Alan Blacklock

Megan Oliver (left), Nathaniel Manning (right), his sister, and a friend examine a deep-sea crab specimen during their visit to NIWA.

New scientist

Meet budding marine scientist Nathaniel Manning. This keen 12-year-old won the junior prize in the QTV online science quiz. The prize? Five days in the Bay of Islands studying bottlenose dolphins with Auckland University scientist Kirsty Russell. On this research trip, sponsored by the Ellerslie Rotary Club, Nathanial and Kirsty observed, photographed, and tracked populations of bottlenose dolphin around the Russell area.

In September 2006, Nathaniel and his family were given a guided tour of NIWA's Wellington campus at Greta Point. Nathaniel's favourite part of the visit was learning about the rock lobsters and their extraordinary ability to regenerate broken limbs, antennae, and damaged eyes. In the museum, Nathaniel was impressed by the deep-sea crabs and gigantic isopod. His interest in isopods has extended to a school project on the beasties. This is a young scientist in the making. Well done Nathaniel and keep up the good work.

QTV is the 13-part science series for kids that screened on TV1 early in 2006 and was partially funded by NIWA and the other crown research institutes. You can buy a DVD of the series and read more about Nathaniel's trip on the QTV website. Plus, there are excellent science games, including 'Decomposer', 'Pooface', and 'Deep-sea Explorer'.

For further information, contact:
Megan Oliver, 0-4-386 0392, m.oliver@niwa.co.nz
QTV website: www.qteam.co.nz

Training at NIWA

Remaining courses for 2006/07:

Managing coastal hazards
20–21 March, Hamilton

Electric fishing machine operators
17–18 April, Christchurch

Identification of wetland sedges and rushes
2 days in May, Hamilton (see website for dates)

For further information, see:
www.niwa.co.nz/edu/training
or contact Donna McArthur, 0-7-859 1842, training@niwa.co.nz

Back to school for NIWA

In May 2006, Wellington's Miramar Central School joined NIWA scientists aboard *Tangaroa* as they sailed to New Zealand's Graveyard, a group of seamounts (undersea mountains) on the Chatham Rise. The name was apparently inspired by the horror film the first visitors were watching when they found this group of seamounts. However, to visit seamounts including Zombie and Gothic, the children did not even have to leave their classroom – instead taking a virtual voyage over the internet via daily ship-to-shore logs.

During the voyage, the website generated over 33 000 hits, with visitors following along almost in real time, able to join in the excitement as new species were discovered and deep-sea animals were observed in their natural environment.

In October, NIWA scientist Mireille Consalvey and Michelle Carter, a NIWA/Victoria University PhD student, visited Miramar Central School to tell the children more about the trip and life at sea. They began the afternoon by exploring New Zealand's undersea environment, moving from shallow beaches down to the abyss, and travelling around our highly variable undersea terrain before stopping to look at seamounts in more detail.

The group of 9 and 10-year-olds watched as NIWA's deep-towed camera was lowered to water depths of 1 km, and were able to see rare footage of the seafloor. They learned that corals are found not just in the tropics, but also in the deep sea, and about some of the many creatures that live on and around seamounts – ranging from orange roughy to giant squid.

Teacher Caragh Briggs says, 'It was great to have real-life scientists at school as it gave the children an authentic learning experience. Hearing about what is being done by those people who are actually carrying out the research made it a real-life situation and not just something in a book or documentary.' The visit stimulated a lot of discussion and artwork and provided the children with the opportunity to ask the scientists questions first hand. But they still couldn't answer one question: 'Is the Loch Ness Monster real?'

The voyage was funded by the Ministry of Fisheries and the Foundation for Research, Science and Technology; additional support came from the Census of Marine Life programme CenSeam, a global census of marine life on seamounts.

Read more about the trip at:
censeam.niwa.co.nz/outreach/censeam_graveyard

For further information, contact:
Dr Mireille Consalvey, 0-4-386 0853, m.consalvey@niwa.co.nz

'Orange roughy' by Georgia Bellve.

Water Quality

Environmental forensics: cracking the case of the contaminated streams

Why are some urban streams more highly contaminated than others? ***Michael Ahrens, Craig Depree,*** *and* ***Greg Olsen*** *have drilled to the core of the problem.*

Sleuthing out suspect stream sediments

- PAHs are widespread urban contaminants, commonly produced by burning fossil fuels.
- Sediments in some urban streams have a PAH 'fingerprint' that suggests an overlooked, historic source of pollution.
- Environmental forensics can help resource managers identify unknown sources of contamination.

By global standards, most of our country's streams are still relatively unpolluted. However, near centres of human activity, stormwater runoff and other inputs have lead to elevated levels of metals and organic contaminants. In order to reduce these inputs, environmental scientists and resource managers want to know where contaminants come from and how they get into our waterways. Environmental forensics is the process of collecting evidence to relate environmental problems to their likely causes.

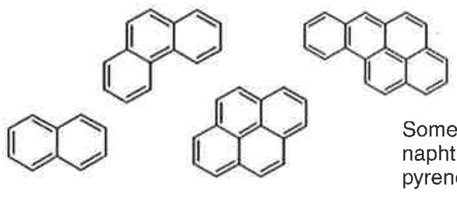
PAHs – ubiquitous, toxic, and persistent

One prominent group of organic contaminants found in urban environments worldwide are the polycyclic aromatic hydrocarbons (PAHs), a class of ring-shaped compounds produced during the incomplete burning of fossil fuel or other types of organic matter. Most PAHs are thought to originate from motor vehicle emissions, domestic heating, or power plants, although forest fires and unprocessed fossil fuels, such as coal and oil, can be important sources as well. PAHs readily attach to sediment particles, leading to elevated concentrations in sediments.

Due to their hexagonal ring-structure, PAHs are very stable compounds that can persist in the environment for many years. This wouldn't be much of a concern, were it not for an inconvenient fact: many PAHs are toxic. Furthermore, some PAHs can cause cancer (for example, the 5-ring PAH benzo(a)pyrene is one of the known carcinogens in cigarette smoke). As a rule, the greater the number of rings, the less water-soluble, more stable, and more toxic the PAH is. Eventually, PAHs in the environment are broken down by the action of bacteria, oxygen, and sunlight to form carbon dioxide and water.

The PAH source mystery

For many years, aquatic chemists monitoring urban contaminants in New Zealand noted exceptionally high sediment PAH levels in a number of inner city streams in Christchurch and Auckland – more than 100 times the typical mean. Such large differences could hardly be attributed to variations in traffic volume. To further the puzzle, the highest PAH concentrations in the stream sediments were not found downstream of the most heavily trafficked roads, but rather in streams in quiet, long-established residential neighbourhoods, on the coarsest grains, rather than on the fine grains characteristic of combustion soot. These observations suggested a mysterious, previously overlooked PAH source.



Some PAHs (left to right): naphthalene, phenanthrene, pyrene, and benzo(a)pyrene.

Environmental forensics – getting to the core

To expose the elusive source of the high PAH levels in city streams, we analysed the PAH compositional pattern (or 'fingerprint') of stream sediments. PAHs commonly occur in the environment as a mixture of 15–30 different compounds, which vary in their relative abundance. By comparing the PAH fingerprint of a sediment sample with a variety of potential source materials, we hoped to identify likely suspects and eliminate unlikely ones. We collected sediments from several streams in Auckland and Christchurch and also obtained samples of possible source materials: petrol and diesel fuel, car tyres, motor oil, soot from vehicle tailpipes, chimney soot (from domestic and municipal furnaces), as well as road pavements. We extracted the PAHs from the different materials and carefully determined the abundance of the individual compounds, using a sensitive analytical instrument called a gas chromatograph mass spectrometer.

From fingerprint to exposé

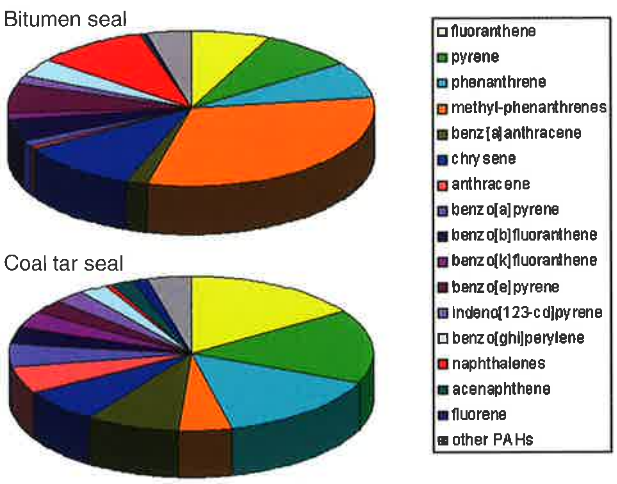
The source material that most closely resembled the PAH composition of sediments in contaminated streams in Christchurch and Auckland turned out to be … coal tar. This came as a big surprise since virtually no coal tar has been produced in New Zealand since the 1980s. However, during the last century coal tar was produced in large quantities as a by-product of coal gasification, a process by which coal is converted to coke and town gas (for cooking and heating) in a very hot furnace under oxygen-starved conditions. Coal tar was the sticky residue at the end of the gasification process. Coal tar has extremely high PAH content – up to 75% by weight. With over 50 gasworks operating in every major New Zealand town between the 1880s and 1980s, millions of litres of coal tar were produced.

What happened to all this coal tar? As it turns out, most of it ended up on our roads – as tar seal. Mixed with gravel, coal-tar produced an excellent, rugged, water-resistant paving material, well-suited for our rapidly growing fleet of motor vehicles. Best of all, coal tar was cheap and easy to come by. The downside: the high PAH levels. As a consequence of coal tar's widespread use in road-building, substantial amounts of PAHs would have washed into roadside streams as stormwater runoff. This is confirmed by deep sediment cores from Auckland Harbour that show PAH levels were higher in past decades than they are now. With the rise of oil as the dominant fuel source (the Marsden oil refinery in Whangarei opened in 1964), coal tar was replaced by petroleum-based bitumen binders (also called asphalt) as the road seal of preference. This was a welcome change, not only for the environment, but also for road workers, since it was realised early on that coal tar had the potential to cause severe rashes and even skin cancers.

The legacy of tar seal

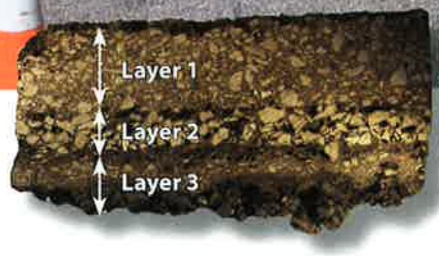
If coal tar is no longer used in road building, why is it still showing up in streams? To understand this, it helps to know that roads are typically re-sealed several times over the course of their lifetime before being rebuilt from their base. Thus, while all current roads in New Zealand are paved with asphalt, roads constructed before the 1960s may still contain coal tar in their base layers, especially in areas with low traffic volume.

To confirm this, we cored several roads and footpaths in pre-1960 residential neighbourhoods in Christchurch and Auckland and analysed the PAH composition in different pavement layers. Coal tar has roughly 4000 times higher PAH levels than bitumen and the PAH fingerprints of the two types of binders are very different. The road-coring study confirmed very high PAH levels in the deeper, older pavement layers, with a composition unmistakably resembling coal tar. Even more tellingly, the PAH composition of coal tar pavements closely matched that of adjacent stream sediments. In contrast, modern bitumen pavements had relatively low PAH levels, with a different PAH fingerprint, as did most of the other potential PAH sources analysed.



Unique fingerprints: comparison of the PAHs in a bitumen layer and a tar seal layer shows distinctive differences in the relative amounts of individual PAH compounds. Samples from two Auckland roads were analysed using a gas chromatograph mass spectrometer.

Coring a sample from a Christchurch road. Back in the lab, the different layers of seal are clearly visible in a section of the core.



This answered the question of the source of very high PAH levels in some urban streams. However, if older, deeper coal tar road layers are capped by bitumen, how does the coal tar get into the streams? The answer: probably very slowly – by gradual erosion of pavements and roadside soils that have accumulated coal tar fragments over years of wear and tear. This is confirmed by analyses of roadside soils and gutter debris from 'coal-tar-era' Christchurch roads: these also showed exceptionally high levels and had the same conspicuous PAH fingerprint as coal tar and adjacent stream sediments. Because PAH levels in coal-tar binder are so high, it only takes a few tar speckles to elevate sediment PAH concentrations beyond normal urban levels. Even though use of coal tar for road-building ceased many years ago, we see its legacy decades later.

The solution: leave it, lock it in, or remove it?

Having solved the PAH source mystery, we are faced with the question: what to do about the high PAH levels in urban streams? This is the focus of ongoing research looking at toxicity and treatment options. If it can be shown that current sediment PAH levels are causing adverse effects in stream life, it will be necessary to find solutions to reducing PAH inputs. Based on what we have learned, the most effective starting place would be to minimise inputs of coal tar. This could mean rebuilding or re-sealing older roads that have a coal tar base. Alternatively, removing and capping PAH-rich roadside soils with clean soil might prove effective. While these remedies would not remove PAHs already present in stream sediments, over time clean sediments from the land would gradually dilute the high-PAH stream sediments. W&A

Dr Michael Ahrens, Dr Craig Depree, and Greg Olsen are organic chemists working at NIWA in Hamilton. *This study is part of the FRST-funded 'Restoring Aquatic Ecosystems' programme.*

Air Quality

Tracing the sources of air pollution in New Zealand

NIWA scientists are developing methods to trace the sources of air pollution and determine their relative contribution to air quality problems. ***Perry Davy*** *and* ***Tom Clarkson*** *work closely with regional councils to solve air pollution puzzles.*

Clearing the air

- Air pollution is a problem for some New Zealand towns and cities, especially in winter.
- Solving the problem first requires identifying the sources of pollution.
- Two methods have been used for 'source apportionment' so local authorities can determine where improvements are needed.

Air pollution has a direct effect on human health, from subtle interactions with the respiratory system (asthma, shortness of breath) to the risk of hospitalisation or even death. Long-term exposure to high levels of fine particles increases the risk of heart and lung disease. In New Zealand, despite our minimal heavy industry and our small population base, we don't escape the problem of air pollution and its consequent health effects. A number of urban areas, including rural towns like Taumaranui and Alexandra, have air pollution problems, particularly during the winter.

Setting national standards

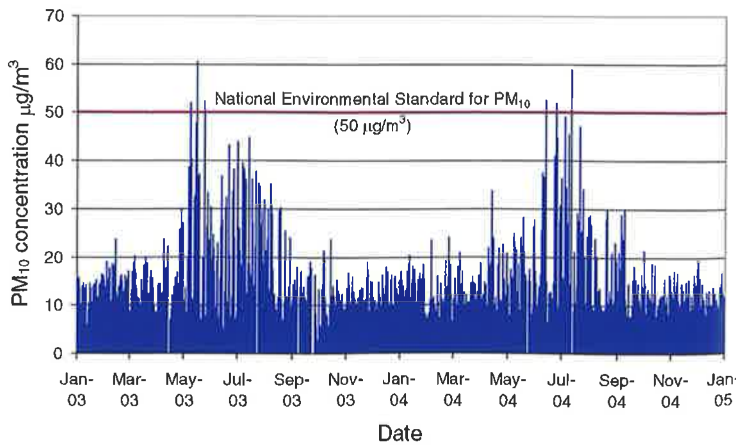
The air pollution issue prompted the New Zealand Government to introduce mandatory air quality standards: the National Environmental Standards for Air Quality (NES). There are five standards for ambient (outdoor) air quality to keep the air outdoors clean and safe for people to breathe. These standards deal with pollutants like sulphur dioxide, carbon monoxide, nitrogen dioxide, ozone, and smoke and dusts. These last two are collectively referred to as fine particles, and denoted as PM_{10}, which indicates particles less than 10 micrometres (or microns) in diameter. Since September 2005, regional councils have been required to monitor air quality and publicly report if the air pollution in their region exceeds the ambient standards. In areas where air pollution exceeds the NES, councils must make improvements to achieve compliance by 2013.

Cause and effect

Air pollution is the result of a complex interaction between local weather and the quantity of pollutants emitted to the atmosphere from various sources. The more pollution that is emitted in an area, the higher the local ambient air pollution concentrations are likely to be. If the area is also windy, however, then the air pollution will be well dispersed (blown away). The worst air pollution occurs when large quantities of pollutants are emitted into a calm atmosphere. In New Zealand, this is most likely to occur during cold and frosty conditions in winter. At some locations, PM_{10} concentrations can be many times higher than the NES throughout the winter period.

Sussing out sources

Routine air pollution monitoring only provides information about the local concentrations of pollutants such as PM_{10} but does not tell us anything about the sources of that pollution. Of course, before we can do anything about it, we need to know what the sources are and how much they contribute to air pollution; this is called source apportionment. Working closely with Greater Wellington Regional Council, NIWA has been researching two source apportionment methods in order to understand PM_{10} pollution at Masterton, where the NES for PM_{10} is exceeded every winter.



PM_{10} concentrations at Masterton for 2003 and 2004.

Early morning air pollution in Masterton, July 2004.

Photo: Greater Wellington Regional Council

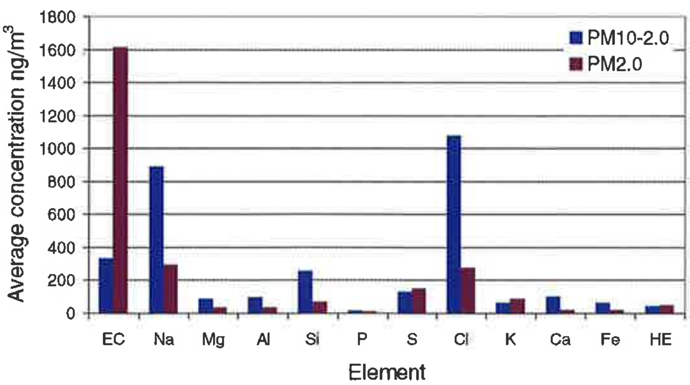
Method 1: emissions inventory and airshed modelling

An emissions inventory estimates the quantity of pollutants emitted from different sources, such as motor vehicles, industries, or domestic solid fuel fires used for home heating. For example, a recent survey by the Ministry for the Environment found that a total of 112 tonnes of wood are burnt per day during a typical July by households in the Masterton urban area. We combine these estimated emissions with local meteorology using a sophisticated three-dimensional dispersion model, called an airshed model. We can then predict how all these emissions of PM_{10} mix in the atmosphere to produce the total concentration of PM_{10} measured at a particular point, such as the Masterton air quality monitoring site operated by Greater Wellington. If the modelled (predicted) and measured (actual) concentrations agree, then we are on the right track.

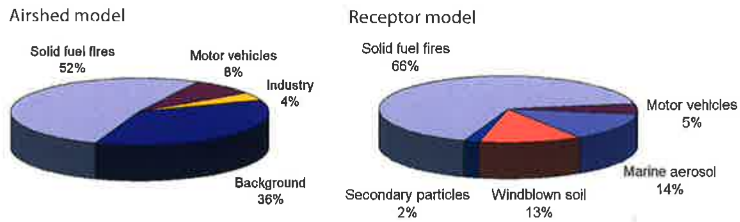
Method 2: receptor modelling

Each source of pollution has a different combination of chemical elements. From this elemental 'fingerprint', or source profile, we can infer the contributions of different sources to PM_{10} concentrations. In practice, we collect and analyse two subsets of PM_{10}: particles with a diameter less than two microns ($PM_{2.0}$) and particles with diameters between two and ten microns ($PM_{10-2.0}$). This detail reveals much more information on the various contributors to air pollution.

The advantage of the receptor modelling method is that it can tell us about the contributions of pollutants from natural sources, the 'background' PM_{10}. The background in Masterton is composed of particles from marine aerosol, wind-blown dust, secondary particles formed in the atmosphere from gas-to-particle conversion processes, and some pollen and other biological detritus. We're interested in background concentrations of fine particles because there's not much that can be done about controlling those sources and this fraction has to be removed from the equation when regional councils are formulating strategies to reduce air pollution.



Average elemental concentrations measured in the two different size fractions of airborne particles collected at Masterton. EC = elemental carbon (soot); HE = total weight of heavier elements (titanium to lead).



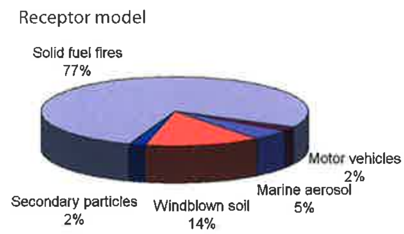
Source contributions to particle air pollution in Masterton (May–August).

What's the best method for Masterton?

By comparing the results of the two source apportionment methods, we can test the validity of both. The pie charts present the average winter results for 2003 and 2004 and show us several things, for example:

- Domestic fires are by far the greatest contributor to PM_{10} air pollution in Masterton.
- About a third of the particle concentrations are from background sources (marine aerosol, wind-blown soil, etc.).

The two different approaches provided similar results, which gives us (and the regional council) confidence that the proportions are about right. These results are an average over the entire winter period, but what about an individual pollution event when the NES has been exceeded? The third pie chart shows us the source contributions for a single day when measured PM_{10} in Masterton was 59 µg/m^3 (compared to the NES of 50 µg/m^3). Now we see domestic fire sources dominating PM_{10} concentrations on an individual pollution day (77% or 45 µg/m^3).



Sources contributing to ambient PM_{10} at Masterton on 12 July 2004.

Have we solved the problem?

From our research we now know that the peaks in air pollution concentrations during the winter are mainly due to smoke from domestic fires, with a minor component from motor vehicle exhaust emissions. The background PM_{10} contribution (approximately 6–8 µg/m^3) was found to be relatively constant at Masterton. We have also determined that the two source apportionment approaches are valid.

Greater Wellington now needs to decide how to reduce emissions during the winter in Masterton in order to meet the NES by 2013, and this could be a major headache in itself. We can still help with deciding on the most effective measures to curb air pollution in Masterton – before any make it off the drawing board – by using the emissions inventory and airshed model method to predict PM_{10} concentrations from future emissions scenarios.

NIWA scientists are currently collaborating with the Hawke's Bay and Auckland regional councils to determine the sources of air pollution in those regions, too. W&A

Perry Davy and Dr Tom Clarkson are air quality scientists based at NIWA in Wellington. *They thank Greater Wellington Regional Council for use of data and images, and also acknowledge their collaborator Dr Shanju Xie, formerly of NIWA in Auckland.*

Atmospheric Research

The 2006 WMO/UNEP Ozone Assessments: what they mean for New Zealand

Our close proximity to the Antarctic ozone hole and our high rate of skin cancer justify New Zealanders' concern about ozone depletion and its effects on UV radiation. ***Richard McKenzie*** *and* ***Greg Bodeker*** *report on the most recent assessments of the science of ozone depletion and its environmental effects.*

Under the terms of the Montreal Protocol for the protection of the ozone layer, assessments of our state of knowledge on the subject are required by the signatory parties every four years. NIWA scientists based at Lauder, Central Otago, have been heavily involved with both the WMO Science Panel assessment, and the UNEP Effects Panel assessment, which are part of this process. The Science Panel reports on changes in our understanding of the atmospheric physics and chemistry relating to ozone depletion and UV increases, and the Effects Panel reports on the expected environmental effects of the changes in UV radiation. In each case, the panels review the published literature to provide an assessment of the current state of knowledge and how it differs from previous assessments, and updates predictions of ozone and UV levels. Here we summarise the major results of the most recent of these assessments, and how they affect New Zealand.

Ozone changes

Interactions between ozone depletion and climate change are a source of uncertainty in predictions of future changes in ozone, and have been a major focus of research in recent years. Although the issues are quite separate, there are important linkages. Previously, it was thought that these interactions could significantly delay the recovery of ozone. New results from more sophisticated models suggest that this is unlikely and we now expect that ozone at southern mid-latitudes will recover from the effects of manmade ozone-depleting chemicals around the middle of the century. It will take the polar regions a decade or two longer to recover to 1980 ozone levels because of the slower turn-over time of air in those areas.

Ozone depletion vs global warming

Ozone depletion	Global warming
• Global problem	• Global problem
• Manmade (especially by the developed world)	• Manmade (especially by the developed world)
• Developing world is key	• Developing world is key
• Multi-decadal	• Multi-decadal
• Some culprit gases in common (such as O_3, H_2O,CFCs)	• Some culprit gases in common (such as O_3, H_2O,CFCs)
• Caused by CFCs	• Caused by CO_2, CH_4, N_2O
• Initial scepticism by big business	• Initial scepticism by big business
• Replacements available	• No replacements available
• International agreement (eventually)	• Some countries not yet cooperating (USA, Australia)
• Clouds influence	• Clouds influence
• Aerosols influence	• Aerosols influence
• Surface albedo influence	• Surface albedo influence
• Solar cycle influence	• Solar cycle influence
• Dynamical influence	• Dynamical influence
• International response: Montreal Protocol + amendments	• International response: Kyoto Convention + ?
• May be past the worst	• Worst is still to come

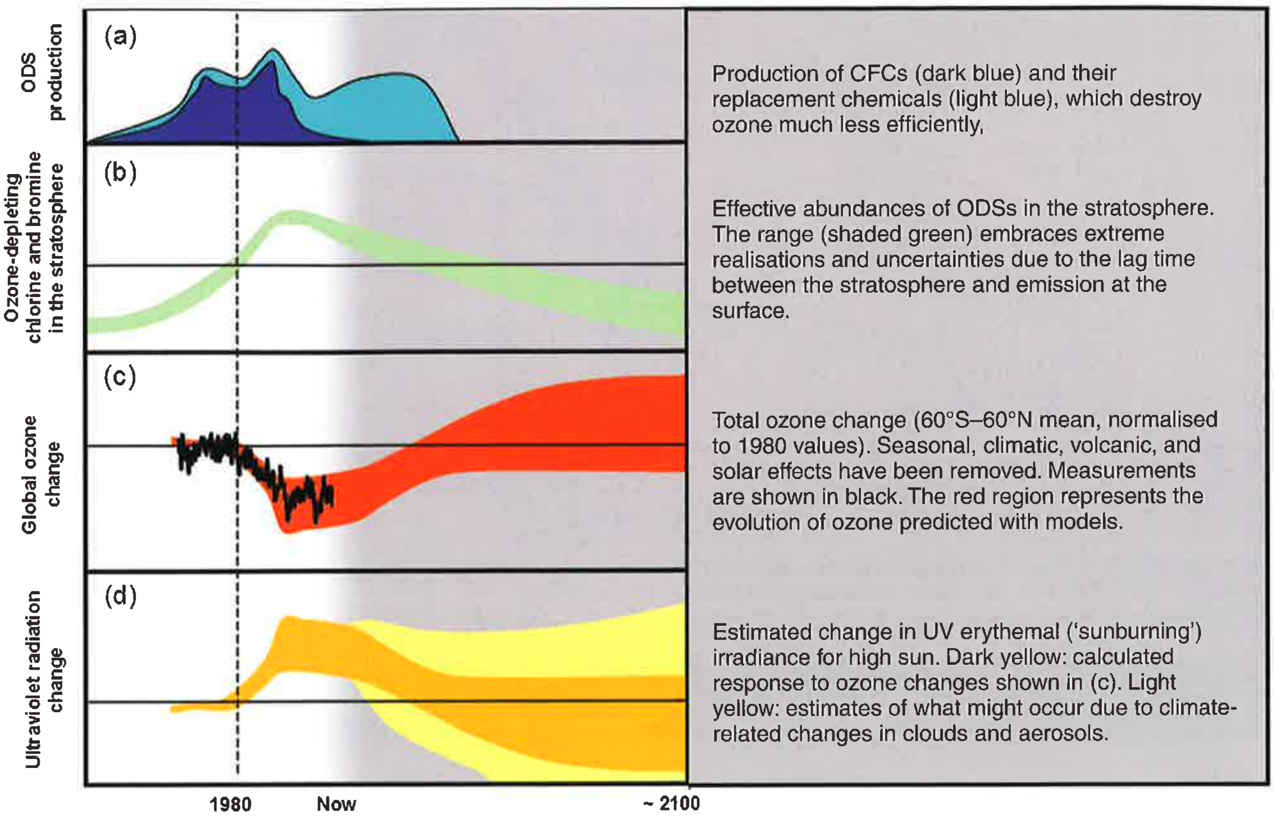
The Montreal Protocol is working

- The concentrations of ozone-depleting chemicals are now decreasing.
- The decline in ozone in the 1980s and 1990s has not continued in recent years.
- Ozone is expected to recover slowly over the decades ahead.
- UV intensities in NZ will remain high in summer (and low in winter).

The first signs of recovery are already evident at mid-latitudes, including New Zealand, where ozone in the upper stratosphere has levelled off, or even been slightly higher in recent years than around the turn of the century. These early signs of recovery are expected because the concentrations of ozone-depleting chemicals reached a maximum in the late 1990s, and have been declining since then. This is the most tangible evidence that the Montreal Protocol is working. These findings, and the outlook for the future, are summarised qualitatively in the illustration on the next page, which was published in the executive summary of the Science Panel's assessment.

However, there is no room for complacency, for a number of reasons:

1. Our understanding of atmospheric chemistry and dynamics is incomplete. Models have been unable to reproduce all of the observed variability in ozone, especially in the southern hemisphere.
2. A large, explosive volcanic eruption in the next few years – while atmospheric chlorine and bromine remains elevated – could result in severe ozone depletion.
3. We rely on continued political and economic will to ensure continued adherence to the terms of the Montreal Protocol (see 'Methyl bromide and the Protocol').



Estimated global development of ozone-depleting substances (ODSs), their impact on global mean ozone and UV radiation.

A significant part of the apparent recovery in ozone in recent years, especially at northern mid-latitudes, can be attributed to changes in atmospheric wind patterns rather than being solely due to changes in ozone-depleting chemicals. In the future, further changes in circulation patterns may be expected in response to climate change. Thus, while there is consensus that ozone will continue to increase, we cannot be certain on the details of how ozone will evolve in the years ahead.

Furthermore, there is uncertainty regarding whether ozone will revert to levels similar to those prior to the onset of ozone depletion in 1980, or whether interactions with climate change will result in stabilisation at higher or lower levels. The most recent evidence suggests that, because of interactions with climate change, there will be a super-recovery in ozone by the end of the century (that is, higher values of ozone than in 1980). Past experience tells us that ozone has variability on a wide range of time scales, and its global 'equilibrium' will always be dynamic.

In New Zealand we have reason to be concerned about the situation in Antarctica, since our summertime ozone is strongly correlated with springtime ozone depletion there.

Methyl bromide and the Protocol

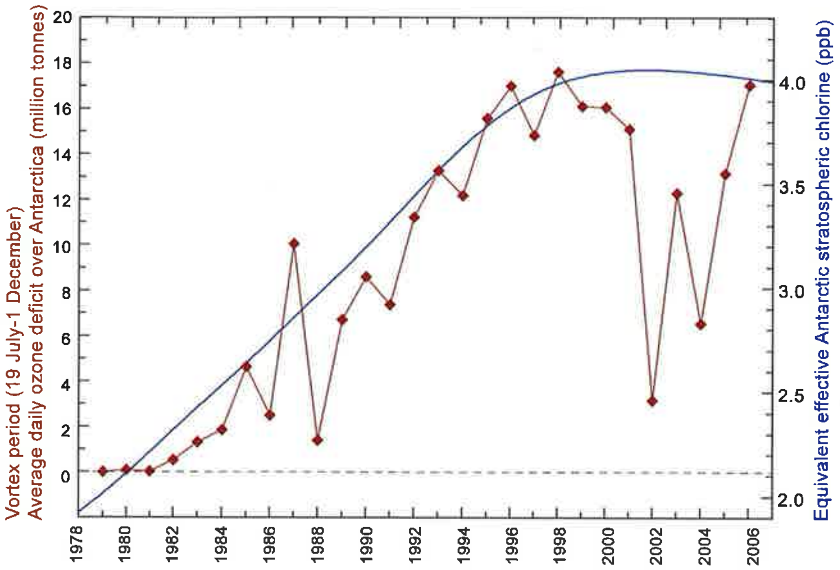
The continued success of the Montreal Protocol requires that the global community continues to honour its terms. Significant reductions in the risk can also be achieved through policy decisions which lead to accelerations in the phase-out rate of chemicals that are harmful to ozone. One example in this category is methyl bromide.

Tropospheric methyl bromide concentrations decreased globally by 14% from 1997 to 2004. However, over the same period, methyl bromide use in New Zealand increased from 160 tonnes/year to 243 tonnes/year. It is used as a fumigant to treat imported and exported fruit, vegetables, and timber.

Photo: Janice Meadows

Under the Montreal Protocol, New Zealand must apply annually for a critical-use exemption for methyl bromide (in addition to the use allowed for quarantine and pre-shipment). Current critical-use exemptions are all for strawberry growers.

The New Zealand government has determined that 2007 will be the last year that an application will be made for the critical use of methyl bromide by the strawberry industry.

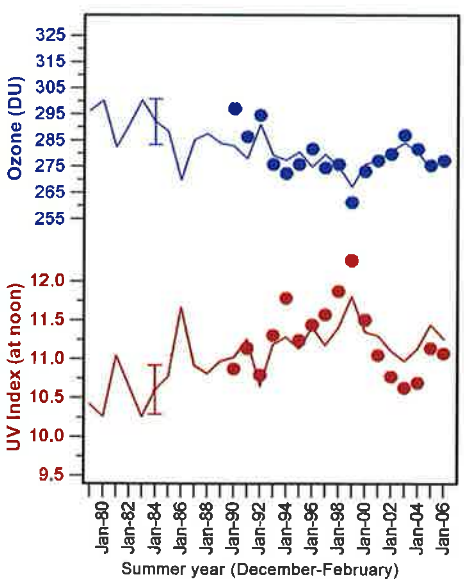


The size of the Antarctic ozone hole in terms of the averaged loss (mass deficit) of ozone (red line), and the corresponding concentrations of ozone-depleting chemicals in the Antarctic atmosphere (blue line).

Approximately half of the summer-time ozone decreases that have occurred in New Zealand since the late 1970s can be attributed to the export of ozone-poor air from the Antarctic ozone hole after its break-up in November or December. Although the ozone hole has been smaller in recent years, it reached near record proportions in the spring of 2006.

Ultraviolet radiation

Our concern about ozone depletion arose because of the protective shield it provides against solar UV radiation transmitted to the Earth's surface. As ozone decreases, the intensity of UV increases, and vice versa. The graph below shows the changes in peak UV intensities that have occurred in New Zealand in recent years in response to changes in ozone. The highest UV intensities to date occurred in the summer of 1998–99, when ozone was at a minimum. Since then, the peak UV intensities have tended to be lower. Although not all of the observed decreases in UV can be attributed to ozone increases, similar recoveries in UV have also been seen at other unpolluted sites. There is greater uncertainty about future UV than ozone because it is influenced by several factors other than ozone, which will in turn be influenced by climate change. These include changes in cloud cover, water vapour, and atmospheric pollution (such as aerosols and tropospheric ozone, and other trace gases, such as NO_2, SO_2). The effects of the ozone hole are expected to continue to exert a significant but variable influence on summer ozone and UV radiation in New Zealand for several decades.



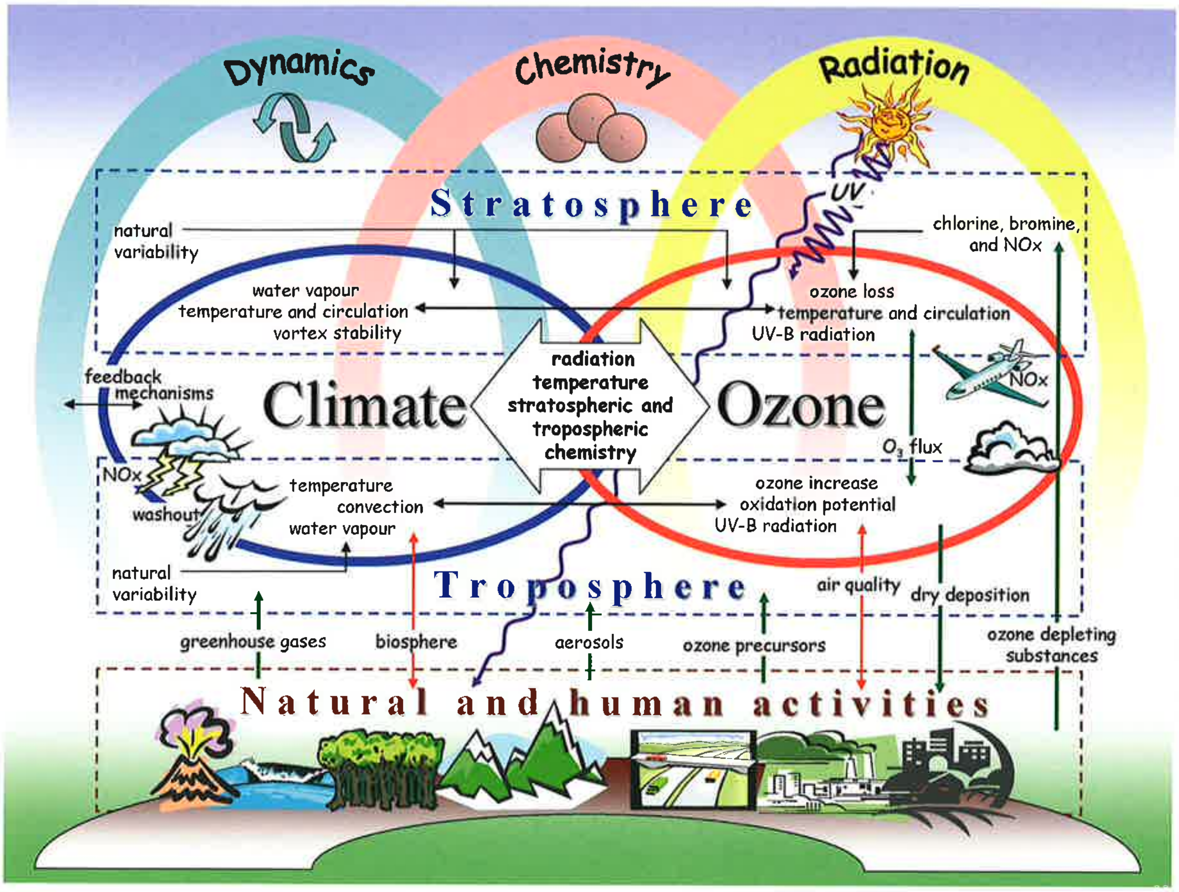
Long-term changes in summertime ozone (blue) and in peak summertime UVI (red) at Lauder, Central Otago. The dots show the average ozone and corresponding noontime UV Index for the five highest UVI days in December, January, and February of each summer, based on UV measurements. The lines represent the average summertime ozone from satellite measurements of ozone, and the corresponding UVI calculated from those ozone values.

Even in the event of a full recovery of ozone, UV intensities in New Zealand will remain much higher than at corresponding latitudes in the northern hemisphere. Ground-based measurements have shown that the peak intensity of sunburning UV radiation is about 40% greater in New Zealand than at corresponding latitudes in the northern hemisphere (although it is still much lower than the peak global UV intensities at high altitudes near the equator). Global estimates of UV from satellite-based instruments show much smaller contrasts between the northern and southern hemispheres because the sensors do not adequately probe the lowermost regions of the atmosphere, where UV is most severely affected by pollutants.

Because of the success of the Montreal Protocol, decreases in ozone and the attendant environmental effects of increases in UV have been much smaller than anticipated. Outside regions directly influenced by the Antarctic ozone hole, increases in UV irradiances have been modest. At mid southern latitudes, such as New Zealand's, ozone is currently about 6% lower than in the 1970s, and the corresponding increases in UV radiation over the intervening period have been of comparable magnitude.

Interactions with climate change

Models show that we should expect to see interactions between ozone depletion and climate change. These interactions can be in both senses: climate changes can influence ozone depletion, and ozone depletion can affect climate. For example, the accumulation of greenhouse gases that increase temperatures at the Earth's surface lead to decreased temperatures in the stratosphere where most of the ozone is found. These in turn lead to slower ozone depletion rates at mid-latitudes, but more efficient ozone depletion on ice crystals that form at cold temperatures in the polar stratosphere.



Graphic: Courtesy I.S.A. Isaksen, Editor, *EC Air Pollution Report No. 81: Ozone-Climate Interactions*, 2003.

Feedback linkages between climate and ozone.

Some of these linkages are illustrated in the graphic above. In some cases, these interactions exacerbate the environmental impacts. For example, studies have shown that there is increased susceptibility of plastic building materials to UV damage, and increased skin sensitivity to UV radiation under warmer conditions. In other cases, there is reduced sensitivity. For example, in plants, increases in UV can alter plants in ways which reduce their susceptibility to heat and drought stress. Changes at the ecosystem level can be complex and can act in both directions through changes in radiation shielding (for example, by forest canopies, water, ice, snow, or clouds) and surface reflectivity (from ice and snow). Complex interactions between UV and air quality may also be influenced by climate change, through changes in temperature and humidity.

Special New Zealand perspectives

A new development in the ozone/UV story has emerged with a large body of literature on the beneficial effects of UV radiation. This is important for New Zealand: although we are subjected to extreme skin-damaging UV in the summer, our wintertime UV, which is essential for vitamin D production, is low. Consequently, a significant fraction of our population is deficient in vitamin D, especially in the winter months. The health costs of these deficiencies are potentially far greater than the costs of skin damage attributable to high levels of UV.

These assessments show that a battle against CFCs has been successful, but the war against ozone depletion and UV has yet to be won. We are still in the period when UV risks are close to their maximum, so we must continue to be vigilant to minimise our summertime UV exposure. In the years ahead, we will be monitoring the situation carefully and we'll use observations in conjunction with models to improve our ability to understand and predict future changes. W&A

Further reading and useful links

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Wright, C.; Bodeker, G.; Reeder, T. (2005). How much UV are New Zealand schoolchildren getting? *Water & Atmosphere 13(2)*: 10–11.

UV Radiation and its Effects: an update, Papers and posters from the NIWA UV Workshop, Dunedin, 2006 www.niwa.co.nz/rc/atmos/uvconference/2006/papers

Dr Richard McKenzie and Dr Greg Bodeker study atmospheric processes at NIWA in Lauder, Central Otago. Much of their work focuses on atmospheric chemistry, ozone depletion, ultraviolet radiation, and health effects of UV exposure.

Marine Ecology

Comparing seagrass meadows across New Zealand

Photo: Glen Carbines

NIWA scientists are on a mission to discover the role and importance of seagrass in New Zealand marine ecosystems. ***Mark Morrison, Meredith Lowe, Keren Spong, and Nicola Rush*** *outline what they've found so far.*

Seagrass **meadows** are known to play a number of important **ecological** roles in estuarine and shallow-water coastal **ecosystems**: they enhance primary production and nutrient cycling, stabilise sediments, elevate biodiversity, and provide nursery and feeding grounds for a range of invertebrates and fish. New Zealand has primarily one species of seagrass, *Zostera capricorni*, which grows mainly in the intertidal zone; there are also limited populations growing at sheltered subtidal areas with very clear water (the maximum depth recorded is 7 m). Seagrass grows throughout New Zealand, from Parengarenga Harbour in the very far north, down to Cooks Inlet at the bottom of Stewart Island. It is found at many types of coast, from sheltered estuaries and coastal beaches, to intertidal coastal reef platforms, to subtidal bays around coastal islands.

As in many other regions around the world, New Zealand's seagrass meadows are at risk from human activities, especially from increased sedimentation and reduced water clarity associated with runoff from land-use. Over the last 100 years, extensive areas of seagrass have been lost from many locations, including the Whangarei, Manukau, Waitemata, Tauranga, and Avon-Heathcote estuaries. Subtidal seagrass has been most affected; for instance, 90% of the subtidal seagrass in Tauranga Harbour disappeared in the years from 1959 to 1996, with an overall decline of 34% of seagrass cover; and almost all of Whangarei Harbour's 12 km^2 of seagrass was lost in the 1960s, including subtidal areas.

Encouragingly, there has recently been some resurgence of seagrass in the Auckland region, with seagrass expanding or re-establishing in parts of the lower Kaipara Harbour, and at Snells Beach and St Heliers Beach in the greater Hauraki Gulf.

Is the (sea)grass always greener?

- Seagrass meadows are found in coastal areas throughout New Zealand.
- Scientists are are using a sampling survey to assess the importance of seagrass for biodiversity, shelter, and food for fish and invertebrates.
- Results will be shared with coastal resource managers through a workshop and a comprehensive report.

There are still extensive seagrass meadows in a number of New Zealand harbours; these include Parengarenga, Rangaunu, Kaipara, Kahwia, Tairua, and Tauranga in the North Island, Wanganui Inlet, Farewell Spit, and Bluff Harbour in the South Island, and Paterson Inlet in Stewart Island.

A search for values

NIWA scientists are conducting a three-year research programme to quantify the relative 'values' of seagrass at regional and national levels. Our goals are to better understand the role that seagrass meadows play in New Zealand's nearshore ecosystems, and to provide resource managers with improved habitat-management tools. We're trying to answer several questions.

- With respect to biodiversity and providing nursery grounds, how does the role of seagrass meadows vary with latitude, region, and coastal setting?
- How are different seagrass meadows genetically linked?
- To what extent does seagrass biomass support other marine life, such as shellfish and juvenile finfish?

Sampling the New Zealand regions

In the summer and autumn of 2006, we sampled seagrass meadows in four biogeographical regions: west Northland, northeastern New Zealand, Nelson/Marlborough, and Southland, as well as on the intertidal reef platforms at Gisborne and Kaikoura. Where possible, within each region we sampled a seagrass meadow from a small and a large estuary, a coastal intertidal reef platform, and a coastal island. At each location, we collected small fishes with a fine-mesh beach seine (except on the reef platforms), small invertebrates with cores, and larger invertebrates and plants with strip transects. We also counted birds. This sampling was repeated for an adjacent area of bare sediments. Data from this extensive sampling will help us assess the relative ecological values of the different meadows.

Fishy findings

In northern New Zealand, estuaries with seagrass (especially subtidal) had high densities of juveniles of at least six fish species, in comparison to adjacent bare sediments. On the west coast of Northland, small snapper, trevally, and garfish dominated the fish found in subtidal meadows, while juvenile grey mullet were associated with intertidal meadows. On the east coast, subtidal meadows supported higher numbers of juvenile snapper, along with parore, spotties, garfish, and triplefins, while intertidal meadows had much lower numbers of these species (but still higher than surrounding bare sediments). Conversely, subtidal seagrass meadows at offshore islands, such as Urapukapuka Island (Bay of Islands) and Slipper Island (Bay of Plenty), had very low densities of juvenile fish, although Slipper Island supported high densities of a pipefish species not found in adjacent mainland estuaries.

Photo: Paul Buisson, DOC

Catch of the day: juvenile snapper from the seagrass meadows at Rangaunu Harbour.

South of Cook Strait, snapper, trevally, grey mullet, and parore approach the southern limit for their adult distribution, and this was reflected in the scarcity of juveniles in this region's seagrass meadows.

We found relatively high densities of spotties in many meadows, such as those of Wanganui Inlet and the inner Marlborough Sounds, but not at Farewell Spit. Such patterns extended into Southland, with the addition of juvenile leatherjackets and a pipefish species.

Challenging the paradigm

These preliminary findings demonstrate that the accepted paradigm that seagrass meadows provide important juvenile finfish nurseries does not hold across all locations, but needs to be carefully evaluated with respect to factors such as whether the meadow is intertidal or subtidal, its coastal setting, and its regional context. We're still compiling our invertebrate data. Other work at NIWA discusses the small invertebrates in the following article: 'Does seagrass contribute to marine biodiversity?' (pp. 18–19).

Once all of our samples have been processed, we'll use the data to construct relative value rankings for the different seagrass combinations: latitude, region, coastal setting, and depth. These will be assessed from a number of different perspectives, such as their relative value as nursery grounds, whether they support economically valuable species, and their contribution to biodiversity.

Early next year, we'll hold a workshop as part of this process, so that resource managers and other interested groups will have the opportunity to tell us what would be most valuable to them, from a management perspective. A final report will appear in the Ministry of Fisheries' *Marine Biodiversity Biosecurity Report* series, which is publicly available. W&A

Dr Mark Morrison works with fisheries ecology and habitats, Meredith Lowe is completing a PhD at Auckland University, Keren Spong and Nicola Rush are marine technicians. They are all based at NIWA in Auckland.

They thank those who have contributed to this programme, including Dane Buckthought, Glen Carbines, Ashmita Gosai, Jacquie Reed, and Matthew Smith (NIWA) and Andrew Baxter, Paul Buisson, Beverley Freen, and Don Neale (Department of Conservation). This work is funded by the Ministry of Fisheries Biodiversity Fund project 'Seagrass Meadows as Biodiversity and Connectivity Hotspots'.

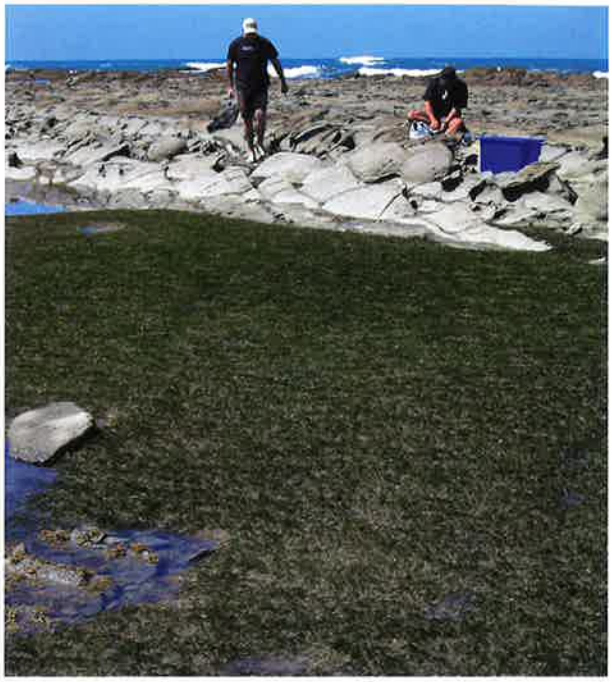

Photo: Jacquie Reed

Sampling intertidal seagrass on the rocky reef at Gisborne.

Further reading

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Photo: Glen Carbines

Marine Ecology

Does seagrass contribute to marine biodiversity?

In looking at biodiversity, marine ecologists at NIWA have compared seagrass meadows and patches with nearby unvegetated areas. ***Judi Hewitt*** *answers some of the questions that have guided the research.*

At many places in our country, people are grappling with the multiple ways that New Zealanders use coastal areas. They are trying to balance uses with protection, and, in some cases, restoration. Seagrass meadows are often singled out as a habitat that should be protected, with the idea that a more diverse and different array of animals live within them than on surrounding non-vegetated areas. But much of the basis to this thinking is derived from overseas research, and there are some significant differences between seagrass here and overseas. In New Zealand, more of our seagrass is intertidal than subtidal, it is shorter in length, and it is primarily one species, *Zostera capricorni*. To examine the contribution of seagrass meadows in New Zealand, our recent research has posed a series of questions.

Are seagrass communities more diverse than those of surrounding bare sediments?

We've collected samples of **benthic macrofauna** (see below for definitions) within and outside of seagrass meadows and patches in a number of places in the North Island. We've sampled **intertidally** at Manukau, Whangapoua, Wharekawa, Whangamata, Kaipara, and Snells Beach, and **subtidally** in Kaipara, Slipper Island, and the Mercury Islands. This research has shown that there is no definite answer: in some areas seagrass habitats have higher numbers of species than surrounding sediments, in some areas they don't. Also the answer varies within a location (for example, within Whangapoua Harbour) and with years and seasons. So, seagrass **communities** are not necessarily more diverse.

Does seagrass provide a unique habitat?

In other words, are the communities of a seagrass meadow or patch the same, regardless of which harbour they are located in? Again, research shows that the answer is 'no'. While the communities of seagrass habitats can be different from the surrounding communities, they are usually more similar to the surrounding communities than they are to the community from seagrass in another place – even a different arm of the same harbour.

Terminology

Benthic macrofauna – animals (fauna) that live in or on the seabed or shore; 'macro' (large) refers to animals 0.5 mm to 100 mm across.
Communities – similar to human communities, benthic communities are comprised of the animals that live together in a certain location or habitat.
Intertidal – the region on the shore that's exposed at low tide and covered at high tide.
Subtidal – the region at the shore that's always underwater.

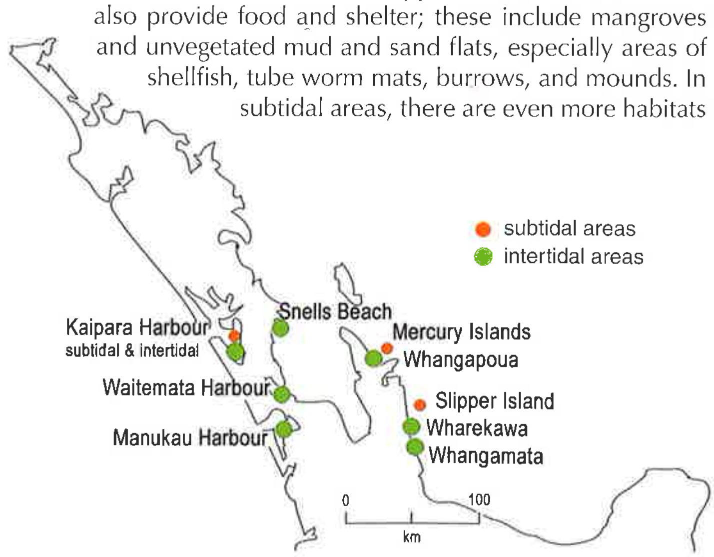
Doing its bit for biodiversity

- Benthic communities in seagrass are not necessarily more diverse than surrounding non-vegetated areas.
- Seagrass is still important because it contributes to habitat diversity.
- A range of habitats provides the necessary variety of 'services' – such as food, shelter, and nursery grounds.

However, if the seagrass is growing in a sandy area, several varieties of crabs are more likely to be found inside than in surrounding bare sediments. Conversely, the New Zealand cockle is often found in higher densities outside seagrass beds.

Are seagrass beds uniquely important for birds and fish?

Birds use intertidal areas – seagrass as well as unvegetated areas of mud and sand flats – for foraging while the tide is out. Intertidal seagrass provides hiding places and food for juvenile fish while the tide is in (see previous article: 'Comparing seagrass meadows across New Zealand', pp. 16–17). But other areas also provide food and shelter; these include mangroves and unvegetated mud and sand flats, especially areas of shellfish, tube worm mats, burrows, and mounds. In subtidal areas, there are even more habitats



Seagrass sampling sites in the upper North Island.

that fish can use, including shellfish beds, rubble patches, and sponge gardens.

Does this mean that seagrass beds are not important in coastal areas?

No. Marine systems support biodiversity by providing a variety of habitats and communities for different plants, animals, and birds to live in and use.

A healthy system is a diverse system

A single estuary can contain a range of habitats: wetlands, nonvegetated and vegetated (mangroves and seagrass) intertidal flats, subtidal areas, and areas of differing sediment types. Even within a habitat type, bare sandflats, for example, a number of different benthic macrofaunal communities will be found – in a healthy system.

As a system becomes more and more dominated by one habitat type, and especially one community type, it will generally become less able to provide the variety of services – food, shelter, nursery grounds – needed by other organisms (including humans). Our research continues, focusing on the services provided by different habitats and how these services are put at risk by destruction of habitats within an estuary, harbour, or coastal area. W&A

Dr Judi Hewitt is a marine benthic ecologist based at NIWA in Hamilton. This article summarises work by a number of people and organisations, including Kristel van Houte-Howes at NIWA and Dr Conrad Pilditch at the University of Waikato.

Some examples of different habitats found in New Zealand nearshore coastal areas.
top to bottom:
A flock of swan foraging in seagrass as the tide retreats.
Cockles in the intertidal flat.
Worm mounds and tubes create areas for animals to feed and hide out.
left: Seagrass meadow at low tide.

Marine Ecology

Finding the role of Antarctic toothfish in the Ross Sea ecosystem

***Matt Pinkerton, Stuart Hanchet,** and **Janet Bradford-Grieve** have been piecing together the puzzle of Antarctic ecology to understand the potential effects of fishing for Antarctic toothfish.*

The icy waters of Antarctica support unique and complex marine ecosystems. Visitors to the white continent have long been spurred by the twin passions of profit and science; in the 19th and 20th centuries, sealing and whaling had huge impacts on the Antarctic and Ross Sea ecosystems. Until recently, the Ross Sea was one of the last productive continental shelf and slope areas in the world not targeted by commercial fishing, apart from some exploratory fishing by the Soviet trawler fleet during the 1970s. Over the last few years, however, the Ross Sea has become a long-line fishing ground for Antarctic toothfish (*Dissostichus mawsoni*).

Antarctic finfish resources are managed by CCAMLR, the Convention for the Conservation of Antarctic Marine Living Resources, which strongly recognises the need to balance exploitation with conservation. Maintaining this balance in the Ross Sea is difficult, and requires a better understanding of the ecosystem effects of fishing there.

A precautionary model predicts that fishing to date may have reduced the toothfish stock to about 85% of its unfished level. The current CCAMLR rules allow for a long-term reduction of up to 50% over the next 35 years.

Research at NIWA aims to use available information to understand the potential effects on the Ross Sea ecosystem of fishing Antarctic toothfish. In collaboration with international colleagues, we have been pulling together pieces of the Ross Sea ecosystem puzzle from diverse sources of information. We've perused the wealth of international literature on the Antarctic, and from work we are increasing our understanding of how this ecosystem fits together. We're developing a trophic model for the Ross Sea to determine the role of the Antarctic toothfish in this ecosystem. A preliminary version of this 'mass balance' model shows the huge variation in productivity of organisms in the system.

Brushing up on toothfish

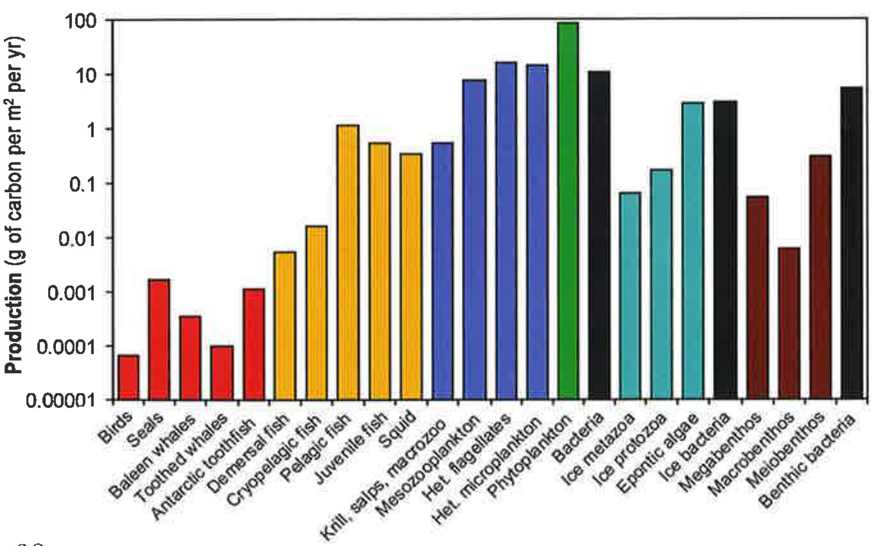
- Although CCAMLR sanctions fishing for toothfish in the Antarctic, how this affects the Ross Sea ecosystem is not known.
- Toothfish are both prey and predator, and reducing their numbers could affect the food chain in both directions.
- NIWA scientists are modelling food and feeding relationships in the Ross Sea based on previous research and ongoing sampling.

How does fishing change an ecosystem?

Species within an ecosystem are interconnected in many ways, and one of the most significant is by one species feeding on another – the trophic relationship. Reducing the abundance of one species by fishing can have immediate effects on the system through these trophic connections. At the simplest level, removing Antarctic toothfish from the Ross Sea reduces food available to its predators. This is known as a first-order effect: the fishing affects species one trophic connection away from the target species.

Effects on predators

The main natural predators of Antarctic toothfish in the Ross Sea (depending on the size of the toothfish) are sperm whales, type-C killer whales, Weddell seals, and, possibly, large squid. New Zealand, US, Italian, and other international scientists, working primarily from shore bases, have provided insights into the biology and ecology of shore-based predators along the western edge of the Ross Sea. However, there has been very limited offshore work, so there are large gaps in



Preliminary results from a 'mass balance' model which is being used to bring together information on food and feeding relationship in the Ross Sea. 'Production' is the average amount of organic carbon incorporated per square metre of the Ross Sea into biomass every year. Note the huge variation in the magnitude of production by various groups – over six orders of magnitude, or a factor of more than a million.

Colours show the different groups of organisms:
red = top predators
yellow = fish (except toothfish) and squid
purple = krill and zooplankton
green = phytoplankton
black = bacteria
blue = sea ice community
brown = benthos

our knowledge of all species in the mid Ross Sea shelf, and particularly on the slope where large toothfish are found and the fishery is focused. We don't know, for example, if killer whales stay in the Ross Sea year round, or leave in winter, and whether they breed in the region.

From our modelling and from international work using chemical markers, analysis of seal scats, and seal-mounted video cameras, it appears that Antarctic toothfish are unlikely to make up a large part of the diets of their predators on an annual basis. At an ecosystem level, there are not enough toothfish to keep any of the predator populations supplied with food. However, potentially important localised effects remain to be investigated. For example, the consumption of toothfish in particular locations, at particular times of the year, or by particular parts of the predator populations, may still be important.

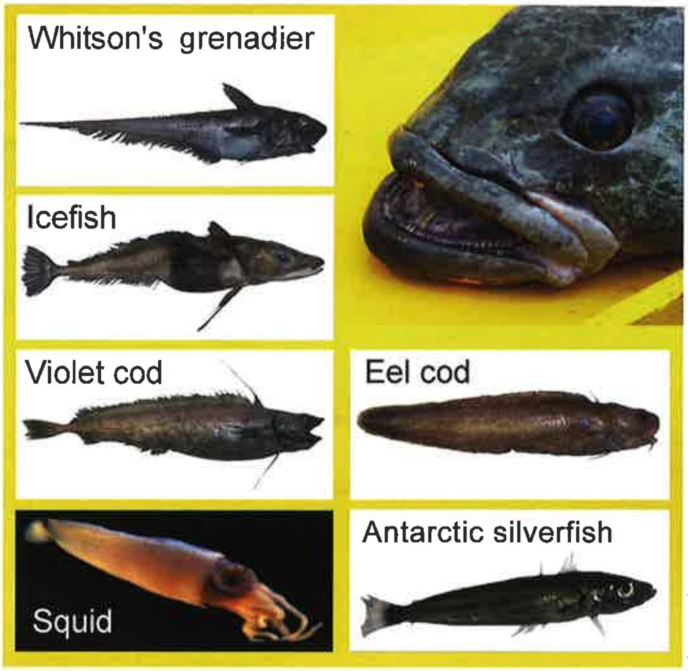
Effects on prey

Removing a predator from a system can also significantly affect the animals lower down the food chain. Antarctic toothfish feed on a wide range of prey but are primarily piscivorous (fish-eating). In coastal waters around McMurdo Sound, where smaller, younger toothfish tend to live, adults feed principally on the ubiquitous Antarctic silverfish (*Pleuragramma antarcticum*). As the toothfish get older, they tend to move north and offshore, where they feed on deepwater demersal (bottom-dwelling) fish such as Whitson's grenadier (*Macrourus whitsoni*), icefish (*Chionobathyscus dewitti*), eel cods (*Muraenolepis* spp.), violet cod (*Antimora rostrata*), and squid.

Changes to the predation of toothfish on these fish prey species may have wide-ranging effects on other species through 'second-order effects', including trophic cascades, and the keystone predator effect. A trophic cascade happens when a reduction in predator numbers leads to increased abundance of its prey, putting pressure, in turn, on their food sources. In other systems, keystone predators maintain biodiversity by preferentially consuming competitively dominant prey species. If predation by keystone predators is reduced, abundance of some prey species can increase to levels where they start to exclude subordinate competitors.

Research shows that these second-order effects are difficult to predict. In addition, the numbers of these demersal fish in the Ross Sea are very poorly known. Any impact on organisms in the middle trophic levels – especially Antarctic silverfish – could damage the whole ecosystem because Antarctic silverfish are key links between primary producers and higher predators in the Ross Sea: they figure in the diets of almost all Ross Sea predators, including penguins, seals, whales, Antarctic toothfish, and other demersal fish.

Dr Matt Pinkerton is a specialist in remote sensing and trophic modelling, and Dr Janet Bradford-Grieve is a marine biologist and ecologist. They are based at NIWA in Wellington. Dr Stuart Hanchet is a fisheries scientist based at NIWA in Nelson.



Photos: Whitson's grenadier, violet cod, eel cod: Peter McMillan; icefish: Peter Marriott; Antarctic toothfish: Stuart Hanchet; squid: Steve O'Shea (Auckland University of Technology); Antarctic silverfish: Antonello Sala (Institute of Marine Sciences, Ancona, Italy)

Antarctic toothfish (top right) and its main prey in the Ross Sea.

Fitting more pieces of the puzzle

The literature review and preliminary work on the trophic model have allowed us to identify major information gaps. We plan to fill some of these gaps through fieldwork in the Ross Sea and work with international colleagues. We're getting acoustic data and biological specimens from fishing vessels now and in future years.

Determining potential ecosystem effects hinges on understanding the distribution and abundance of demersal fish and Antarctic silverfish in the Ross Sea shelf and slope. This will be a priority for future fieldwork, for example, during the proposed multidisciplinary research voyage by RV *Tangaroa* during the International Polar Year in 2007/08. We are well placed to learn more about the biomass and distribution of the main Ross Sea middle trophic species: *Tangaroa* is fitted out to survey these species acoustically and to sample using a variety of gear, including plankton nets, young-fish trawls, midwater and demersal fish trawls, and video cameras. W&A

Further reading

Hanchet, S.; Judd, W. (2006). The Ross Sea toothfish fishery. *New Zealand Geographic 79*: 16–20.

Knox, G.A. (1994). The biology of the Southern Ocean. Cambridge University Press, Cambridge. 444 p.

Scott, M. (1991). Antarctica, a New Zealand perspective. *New Zealand Geographic 9*: 52–83.

Waterhouse, E.J. (ed.) (2001). Ross Sea region 2001: A state of the environment report for the Ross Sea region of Antarctic. New Zealand Antarctic Institute, Christchurch. 265 p.

This project is supported by the Ministry of Fisheries programme on 'Ecosystem Effects of Fishing in the Ross Sea', and the Foundation for Research, Science and Technology 'Ross Sea Sustainability' programme.

Marine Aquaculture

Land-based polyculture for coastal Māori

Sheryl Miller describes how NIWA and the Hongoeka Development Trust are collaborating on New Zealand's first low-cost, land-based polyculture system.

Photo: Sheryl Miller

The coastal site near Plimmerton managed by HDT.

In New Zealand, the images associated with aquaculture are of bobbing black buoys on the water surface, clusters of mussels hanging below from longlines, or cages of salmon close to the shore. Now NIWA and Hongoeka Development Trust Ltd (HDT) are adding a new image, bringing aquaculture up onto the land and moving from monoculture to environmentally sustainable polyculture.

Several years ago, HDT asked NIWA's advice on possible uses for a strip of coastal land that their people own at Plimmerton, just north of Wellington. With funding from the Foundation for Research, Science & Technology, we began a joint project to investigate a low-cost way for coastal Māori to engage in land-based polyculture. Māori are considerably less involved in land-based aquaculture than in customary and commercial wild fisheries, partly due to high capital costs, and often because conventional aquaculture activities are not readily available to coastal Māori.

The project's objectives include designing new water-recycling and polyculture technologies and developing appropriate husbandry techniques; the goal is to create an economically sustainable system accessible to coastal Māori. HDT sees it as a way of encouraging mokopuna back to tribal areas, through the provision of sustainable employment and a source of customary foods.

Pilot study and a full-scale system

Following the decision to establish a polyculture system at Plimmerton, we began our research with a 1/8 scale pilot system at NIWA's Mahanga Bay Aquaculture facility in Wellington. Paua (New Zealand abalone – *Haliotis iris*) was chosen as the primary crop. We developed novel water-recirculation technologies to ensure that suspended solids, faecal material, and excess nitrogen are removed from the seawater before it is returned to trays containing the paua. Several variables have been monitored within the system, including suspended solids and particle size, pH, ammonium, oxygen consumption, and temperature.

The full-scale system designed for Plimmerton holds 1 tonne of paua, has a volume of 23 m^3 seawater, a flow rate through the system of 40 m^3/h, and 3 m^3 of new seawater entering the system daily. Tipper buckets empty the water into multi-layered trays, each holding up to 40 kg of paua. The water movement suspends the organic wastes (faeces and food particles), making the trays self-cleaning and reducing the labour requirement. Suspended solids are carried through to tanks with filter-feeding bivalves before passing to a settling basin and then through foam fractionators (also known as protein skimmers), which further remove organic compounds such as particles, detritus, and bacteria. The water continues through tanks of seaweed to remove excess nitrogen, particularly ammonium, and then returns to the paua trays. The system is modular, so more tanks and species can be added.

Polyculturing paua

- NIWA and HDT are constructing a land-based polyculture facility on Māori land near Plimmerton.
- NIWA has used a scale model of the system to develop an innovative recirculation system and to test various species.
- In addition to producing paua, future plans for the facility include training courses and ecotourism.

What is polyculture?

Polyculture is the concept of growing two or more complementary species together in a single sustainable system, as opposed to aquaculture, which involves the propagation and rearing of a single aquatic species. The goal of polyculture is to increase productivity of several species by efficient use of ecological resources. The productivity and waste of the primary polyculture species maintains the production of supplementary species. It's not a new concept, having been practiced in China for more than 1000 years.

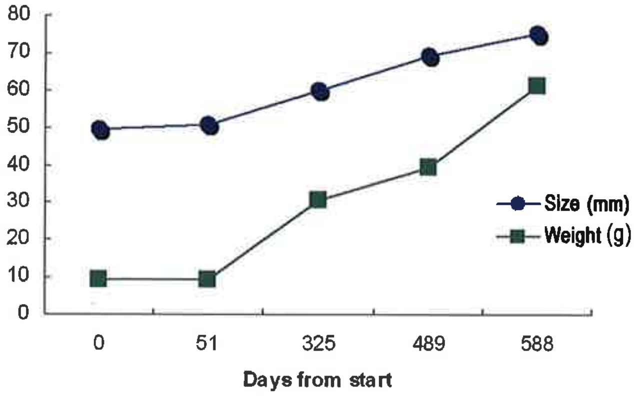
Paua and blue mussels.

Photo: Mike Cunningham

Photo: Sheryl Miller

Finding the right species mix

The system is designed to initially contain three species, and has been set to run at optimal growing conditions for paua, based on an initial stocking size of 20–30 mm: flowing water at 18–20 °C, and pH 7.8–8.2. The paua are fed an artificial diet, occasionally supplemented with seaweed, and are kept in a darkened room, as they actively feed at night. In our pilot system, which is stocked with 125 kg of paua, growth and weight increased exponentially over time, with growth rates ranging from 50 to 100 µm per day (depending on variables such as stocking density and temperature).



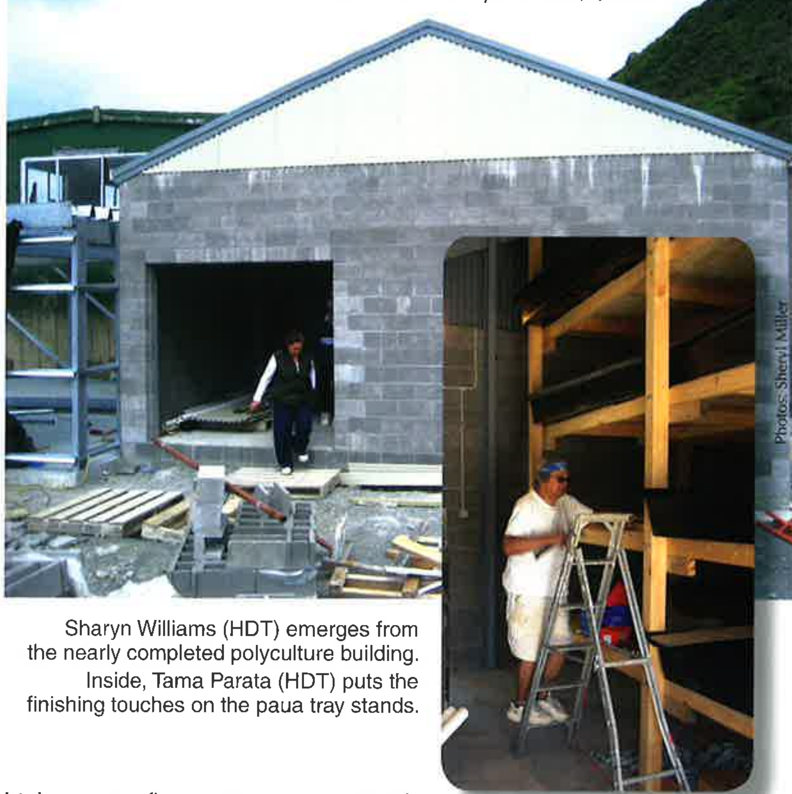
Paua growth rate and weight gains from the pilot system.

We began with Pacific oysters (or tio, *Crassostrea gigas*) as the filter-feeding bivalve to remove the suspended solids washed out of the paua trays. However, oysters had high mortality, with their shells thinning and becoming brittle, so we replaced them with blue mussels (*Mytilus galloprovincialis*), which show better survival in the system.

An additional species trialled was the sea cucumber (*Stichopus mollis*). Experiments show that, on average, 135 sea cucumbers could potentially remove all the organic waste produced by 125 kg of paua. However, the sea cucumbers could only grow on the waste of paua fed a diet of fresh algae or kelp flakes, not the artificial diet currently used in the paua-farming industry. Future research may lead to an artificial diet for paua with a higher percentage of seaweed (macroalgae).

To prevent a build-up of ammonium within the system, the seawater is passed through tanks of seaweed, which essentially sucks up the excess ammonium and uses it to maintain growth. We're testing two species of red seaweed, *Porphyra* (Māori name karengo). Growth rates of *Porphyra viridentata* and *P. cinnamomea*, local to the Wellington region, have been trialled at high and low water flow. Overall, both species grew better at higher water flows. However, optimal growth temperature for *Porphyra* is lower than that for paua, so we're still investigating growth and ammonium uptake at various temperatures.

Karengo and sea cucumber.



Sharyn Williams (HDT) emerges from the nearly completed polyculture building. Inside, Tama Parata (HDT) puts the finishing touches on the paua tray stands.

Watch this space

As this issue of *Water & Atmosphere* goes to press, the system at Plimmerton is close to completion. Once the facility is up and running, NIWA and HDT plan to continue their collaboration by running a training course at Plimmerton that combines the theory of paua farming and water quality management with practical experience they have gained from setting up and maintaining a polyculture system. HDT's vision is to include the polyculture system as part of an ecotourism venture. W&A

Further reading and useful link

Lutz, C.G. (2003). Principles of polyculture. *Aquaculture Magazine 29(2)*: 34–39.

To learn more about aquatic polyculture, visit the University of Auburn webpage: www.ag.auburn.edu/fish/international/polycul.htm

Dr Sheryl Miller (Ngāi Tahu, Kāti Mamoe, Waitaha) specialises in seaweed ecophysiology and aquaculture, as well as biosecurity issues. She works with Te Kūwaha o Taihoro Nukurangi (NIWA's Māori Research and Development Unit) and is based in Wellington.

This project is funded through the FRST research programme 'Developing a Low-cost Aquaculture System Accessible to Coastal Iwi'. Special thanks go to NIWA staff Dr Phil Heath, Graeme Moss, Bob Hickman, John Illingworth, and Mike Tait, who have put in many hours developing this technology, Johnny Wright for maintaining the system, and Kimberley Maxwell for use of her MSc thesis on energy budget and potential use of sea cucumbers within the polyculture system. Thanks also to our research partners, Hongoeka Development Trust Ltd.

Native Freshwater Fish

Fish-finding with statistical models

***John Leathwick** has mined NIWA's New Zealand Freshwater Fish Database and modelled the statistical likelihood of finding fish A in stream B. The next step is predicting where to look.*

Over the years, a considerable number of New Zealand's rivers and streams have been fished to collect information about the distribution and abundance of native fish such as eels and galaxids, and introduced fish such as brown and rainbow trout. This information is stored in NIWA's Freshwater Fish Database, which now contains data from over 20 000 sites. We have been working with these data to create statistical models that describe how the likelihood of capturing individual fish species varies depending on the nature of the river or stream.

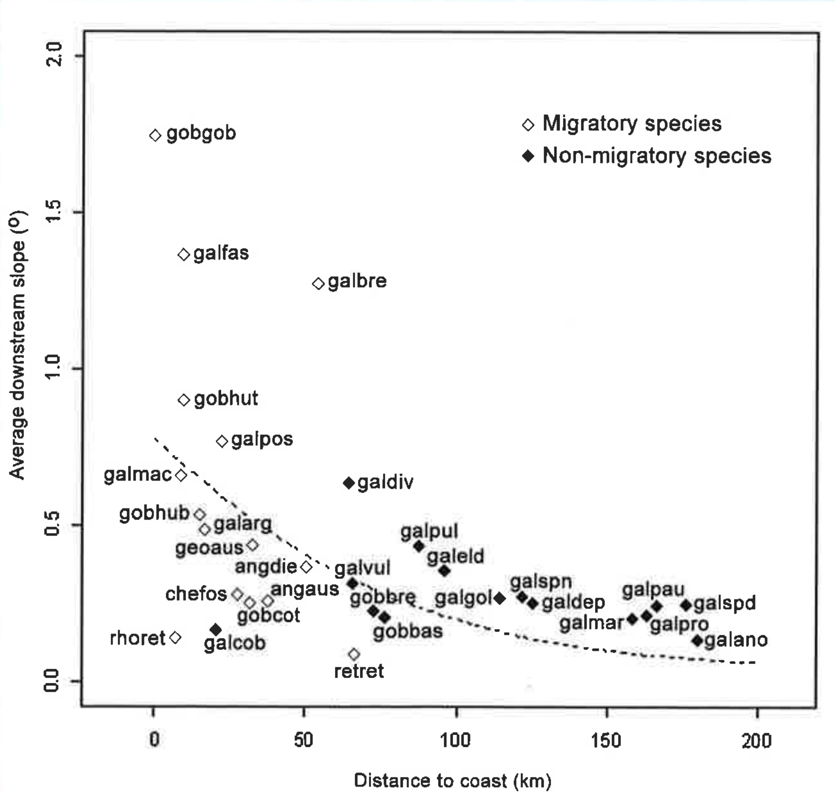
So far, we've developed descriptive models for more than 30 native fish species. About half of these are migratory, spending at least some part of their life in the sea, while the remainder are relatively sedentary, spending all their lives in freshwater. The migrants include some well-known fish such as longfin and shortfin eel, along with several species of whitebait, including inanga, koaro, and banded and giant kokopu. The non-migratory species are much less commonly seen, and occur mostly in the eastern South Island; several of these are now rare or threatened.

Vital statistics

- Models based on the NZ Freshwater Fish Database show where in a stream different species are likely to live – or to have lived before landscape modification.
- Fish preferences are tied to stream slope and distance from the coast.
- The models can generate maps to show present-day and likely past distributions.

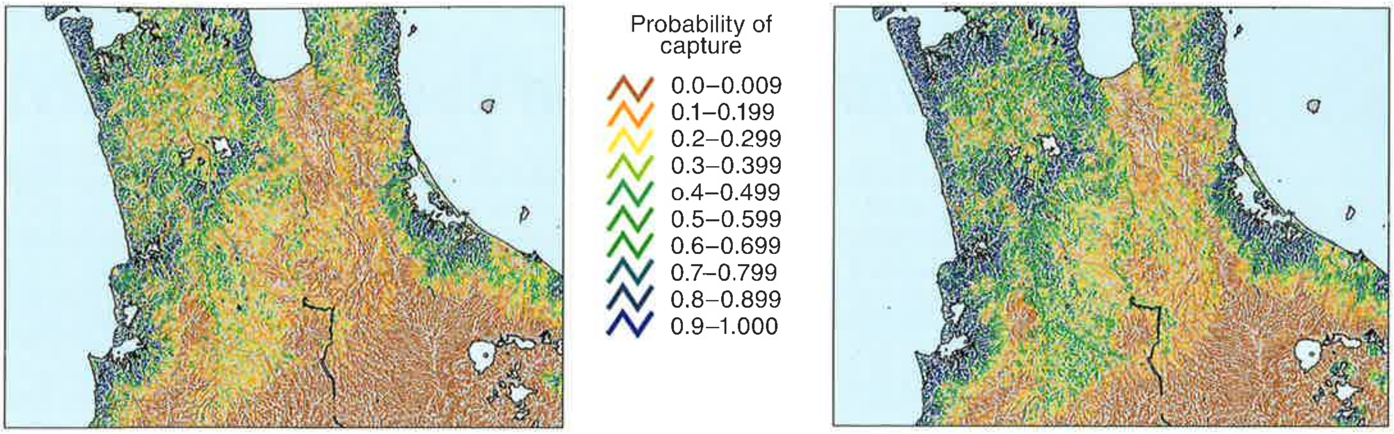
Some like it flat

The models indicate some very strong contrasts in the conditions preferred by these two groups of species. The majority of migratory species are most commonly caught within 50 km of the coast, although species such as longfin eel and koaro move considerable distances inland. However, the distributions of these species are also affected by the downstream river gradient – most species will penetrate some distance inland where river gradients are gentle (less than 0.5°), but become increasingly restricted to more coastal sites as river gradients increase. Steep river segments and waterfalls also play an important role for migrants, blocking the path



Sample of output from the individual statistical models shows where different native fish species are likely to be found relative to distance from the coast and a stream's slope. The fish code names combine genus and species.

angaus	*Anguilla australis*	shortfin eel
angdie	*Anguilla dieffenbachii*	longfin eel
chefos	*Cheimarrichthys fosteri*	torrent fish
galano	*Galaxias anomalus*	roundhead galaxias
galarg	*Galaxias argentus*	giant kokopu
galbre	*Galaxias brevipinnis*	koaro
galcob	*Galaxias cobitinis*	lowland longjaw
galdep	*Galaxias depressiceps*	galaxias
galdiv	*Galaxias divergens*	flathead galaxias
galeld	*Galaxias eldoni*	dwarf galaxias
galfas	*Galaxias fasciatus*	Eldons galaxias
galmac	*Galaxias maculatus*	inanga
galmar	*Galaxias macronasus*	dwarf inanga
galpau	*Galaxias paucispondylus*	inanga
galpos	*Galaxias postvectis*	alpine galaxias
galpul	*Galaxias pullus*	upland shortjaw
galspd	*Galaxias* species d	Clutha flathead galaxias
galspn	*Galaxias* species n	northern flathead galaxias
galvul	*Galaxias vulgaris*	galaxias
geoaus	*Geotria australis*	lamprey
gobbas	*Gobiomorphus basalis*	Cran's bully
gobbre	*Gobiomorphus breviceps*	upland bully
gobcot	*Gobiomorphus cotidianus*	common bully
gobgob	*Gobiomorphus gobioides*	giant bully
gobhub	*Gobiomorphus hubbsi*	bluegill bully
gobhut	*Gobiomorphus huttoni*	redfin bully
retret	*Retropinna retropinna*	common smelt
rhoret	*Rhombosolea retropinna*	black flounder



Now and then: the statistical models can be used to map where a species – in this example, banded kokopu in the Waikato – is found today (left) and where it would have lived 150 years ago (right), before major modification of the landscape.

upstream to varying degrees. Fish such as inanga, smelt, black flounder, and grey mullet, show very little climbing ability, while others, such as longfin eels, koaro, and banded kokopu, are capable of negotiating local obstacles with considerable slope, particularly if they are close to the coast.

By contrast, the majority of non-migratory species are caught most frequently in inland rivers and streams, and a number of these species appear to be remarkably tolerant of cold temperatures, particularly in winter. Most of these natives also occur in catchments where significant rain (more than 25 mm in a day) is infrequent, and with strongly fluctuating river flows through the year. This might reflect conditions that are less favourable for introduced species such as trout, which are a significant predator of these natives.

Power of prediction

One interesting spin-off from these models is their usefulness for making predictions across New Zealand's entire river and stream network. We can use each species model to predict the probability of capture for rivers and streams throughout New Zealand, including those not fished. Predictions are made on the basis of the statistical description of the relationship between capture of each species and the environment, adjusted for the time of year and fishing method. The predictions reflect the individual species' responses to factors such as the distance from the coast, downstream slopes, the temperature, the amount of water flow and its variability, the degree of riparian shading, the frequency of rain-days, and the degree of native vegetation cover in the upstream catchment.

Predictions can be made not only for current environmental conditions, but also for those that were likely to prevail before human modification of New Zealand's landscapes. This allows comparison, for example, of the expected distribution of banded kokopu (which prefer small, coastal, densely shaded streams) prior to human settlement and following the extensive clearance of riparian vegetation that has occurred over the last 150 years.

Dr John Leathwick is an ecosystem modeller based at NIWA in Hamilton. His research interests include native biodiversity, environmental classification, conservation management, and statistical modelling.

From models to maps

By combining the predictions for all these species, we can create maps showing the expected native fish community patterns for our rivers and streams. This is valuable for conservation management, allowing assessment of the degree of protection afforded to different fish species and communities. This information can, in turn, be used to highlight those species or communities that are least protected, and to identify sites where restoration of more favourable conditions (for example, through riparian planting or ameliorating obstructions caused by culverts) could be expected to provide the greatest biodiversity benefits.

Similar models have also been fitted for a range of introduced fish, including brown and rainbow trout, and pests such as koi carp, gambusia (mosquito fish), and catfish. Models for trout are proving valuable for understanding the interactions between these species and our native fish. Similarly, models for pest fish that are patchily distributed, such as catfish and koi carp, are useful for indicating suitable environments for these species; managers can use this information to set up surveillance in likely environments to insure that the pests never have a chance to become established.

The logical conclusion: predictive models of native fish distributions provide a powerful tool for conservation planning in New Zealand's rivers and streams. W&A

Further reading and useful links

Richardson, J. (2006). Database tops 25,000 records. *Water & Atmosphere 14(3)*: 6.

New Zealand Freshwater Fish Database: www.niwascience.co.nz/services/nzffd

Natives and introduced species in the NIWA Atlas of Zealand Freshwater Fishes: www.niwa.co.nz/rc/freshwater/fishatlas

Teacher Feature

Using *Water & Atmosphere* in your classroom

One of NIWA's aims with this magazine is to contribute to science education in New Zealand. To this end, we distribute *Water & Atmosphere* without charge to New Zealand high schools. Articles are assigned 'Curriculum Connections' to indicate which of the NZ NCEA Achievement or Unit Standards they can complement as a classroom resource. These links are assigned by Royal Society of New Zealand Teacher Fellows who are working with NIWA scientists.

The magazine and the Curriculum Connections are also available online at **www.niwa.co.nz/pubs/wa/** There you'll find an archive of back issues beginning with September 2000 (vol. 8, no. 3). All online articles include a pdf of the printed version and the articles are indexed via the website's search engine. The Curriculum Connections are compiled at **www.niwa.co.nz/pubs/wa/resources/**

Curriculum Connections for this issue

Pages	Article	Relevant NCEA Achievement Standards (AS) and Unit Standards (US)	Brief summary
8–9	Environmental forensics: cracking the case of the contaminated streams	**Chemistry Level 3 US6340** **Geography Level 1 AS90207, Level 2 AS90336** **Science Level 2 US6352, AS90771, Level 3 US6355, US8153**	High levels of PAH contaminants in some urban streams have been traced back to bygone roading material.
10–11	Tracing the sources of air pollution in New Zealand	**Geography Level 1 AS90207, Level 2 AS90336, Level 3 US5097** **Science Level 2 US 6352, Level 3 US 6355**	Two methods for determining the source of air pollution will help local authorities determine where improvements can be made.
12–15	The 2006 WMO/UNEP Ozone Assessments: what they mean for New Zealand	**Geography Level 1 AS90207, Level 2 AS90336, Level 3 AS90706** **Science Level 1 US21612, AS90187, Level 2 US6352, AS90771, Level 3 US6355**	The latest assessment shows that the Montreal Protocol is working; meanwhile, our summertime UV intensities will remain high.
16–17	Comparing seagrass meadows across New Zealand	**Biology Level 1 US6294, AS90162, AS90164, Level 2 AS90460**	A nationwide survey looks at the way seagrass meadows function in different areas.
18–19	Does seagrass contribute to marine biodiversity?	**Biology Level 1 US6294, AS90162, Level 2 AS90460**	Seagrass contributes to biodiversity primarily by increasing the range of habitats available for nearshore animals.
20–21	Finding the role of Antarctic toothfish in the Ross Sea ecosystem	**Biology Level 1 US18970, AS90162, Level 2 AS90461, AS90769** **Science Level 1 AS90187, Level 2 AS90177**	Modelling the Ross Sea food web will help understand the potential effects of the toothfish fishery.
22–23	Land-based polyculture for coastal Māori	**Biology Level 1 AS90162, US6299, Level 2 US6310** **Environmental Tourism Maori Level 3 US17789** **Science Level 1 AS90187, US6349, Level 3 US21613** **Technology Level 1 US13389, Level 2 US13390**	NIWA is helping Hongoeka Development Trust with a new system that will grow paua as the primary crop.
24–25	Fish-finding with statistical models	**Mathematics Level 2 AS90289, Level 3 AS90641**	Models show where different fish species are likely to live – or to have lived before landscape modification.

Colour key to Achievement Standards:
Biology Chemistry Environmental Tourism Geography Horticultural Science Māori Mathematics Physics Science Technology

Matt inspects one of the artificial seagrass units.

Profile

Matt Smith dives into his work

Raised and educated in Auckland, Matt Smith has parlayed his love of the outdoors into a job that features lots of fieldwork and some unusual diving opportunities. These days his work at NIWA in Auckland encompasses fisheries research, marine ecology, and biosecurity.

Were you always interested in science?

I wasn't one of those kids who decide to be a scientist at year dot. I've always been keen on understanding how things work and spent most of my younger days pulling things apart and rebuilding them (still do). Then, in sixth form at Rangitoto College, I took biology and the light bulb began to glow. Here was a topic with so much incredible stuff to learn – and it literally surrounds us every day. It seemed silly NOT to attempt to understand all this.

What did you study at university?

My first career choice was journalism, so at Auckland University I got stuck into a BA degree, majoring in English literature with biology and physical geography as additional 'side' papers.

Around this time I began diving, doing a PADI (Professional Association of Diving Instructors) Open Water course for certification. A few of the biology papers branched out into marine areas, with options for field work at Leigh Marine Laboratory at Goat Island, a marine reserve north of Auckland.

That was it! I knew this was to be my career. I switched to a BSc, even though this added a year to my undergraduate degree, and I've never looked back. I worked summers as a volunteer assistant at Leigh – diving constantly and helping out with snapper and gurnard physiology experiments, and as a boat ramp interviewer for MAF. Eventually I graduated with an MSc (Hons) degree in marine ecology and aquaculture. I also completed PADI Advanced and Rescue diver qualifications.

How did you come to work at NIWA?

After my big OE in Europe and the UK, I managed to get a foot in the door at NIWA and began work on snapper, collecting stock size and age information for stock assessments.

What do you like best about your job?

I'm part of the Fisheries and Marine Ecology team. We work on stock assessments for various fin and shellfish, and on fish ecology in harbours, estuaries, and offshore island reefs. I enjoy hands-on work in the field, although roughly half my work is office or laboratory-based.

My favourite part of the job has to be when we embark on a field expedition that's been months in the making. There's usually tonnes of gear and equipment, lots of staff who have reunited from around the country, and a general feeling of 'what the heck have we got ourselves in for!' We set up camp in a strange place and then spend 12-hour days for a week or two, all for the sake of science. At the end of it, even though you're usually exhausted, you realise you've seen something or been somewhere that very few people will ever get to experience – and that without this job you probably wouldn't have dared to go there!

What's an ASU?

Through Mark Morrison's seagrass project (see 'Comparing seagrass meadows across New Zealand', pp. 16–17), I've spent a fair amount time underwater looking at this type of habitat. We're interested to see if seagrass enhances population growth and, conversely, if loss of this habitat reduces growth. It's difficult to experimentally manipulate natural seagrass beds, so we created some artificial seagrass units, or ASUs.

Mark, Crispin Middleton, and I constructed artificial seagrass from plastic plants, mesh, and reinforcing grids. Last December, we put our ASUs into the subtidal areas of Whangapoua Estuary, Coromandel, where very little natural seagrass remains. Our first 'harvest' in late January revealed many small fishes hanging around in the ASUs, including spotties, juvenile snapper, leatherjackets, clingfish, and triplefins. The ASUs are hot real estate for these very recently settled fish.

You're also involved in marine biosecurity?

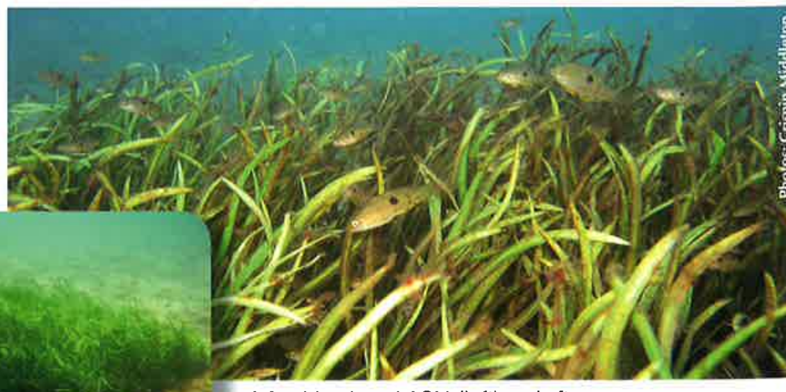
Around five years ago, I was asked to help verify the rumoured arrival of the Japanese paddle crab (*Charybdis japonica*) in Waitemata Harbour. We set some traps and when we hauled them in they were filled with Japanese paddle crabs fighting each other. Great that we had captured this invader, but bad for New Zealand's biosecurity! From there I got involved in baseline port surveys and surveillances, travelling around the country documenting what organisms are where, and what shouldn't be there.

Recently I've helped survey international yachts for fouling organisms. We dive under the boats when they're at a marina clearing customs, shoot video and photographs, and take samples from the hull. These samples are then identified by taxonomic specialists.

As one of NIWA's Regional Dive Safety Officers, would you say it's all work and no play?

Scientific diving is more of a tool of the trade than a recreational sport. A lot of it is in low visibility and can be in places you wouldn't normally want to dive, like around piles and wharfs in major ports. But it can also be great: sponge collecting in the Cook Islands, underwater video surveys of the Poor Knights Islands, or seagrass surveys on Farewell Spit.

Either way, we always have a job to do when we're underwater, and the emphasis is on safety first. NIWA trains its divers very thoroughly. That includes a gruelling week-long Scientific Divers 'boot camp' to become an OSH-qualified diver, with mixed gas, river, deep diving, night, navigation, and search and recovery endorsements. We have yearly refresher training and specialty courses like ice diving as needed.



A freshly placed ASU (left) and after the spotties have moved in.

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