NIWA
Taihoro Nukurangi

Aquatic Biodiversity & Biosecurity

Issue 7 2004

a quarterly newsletter from the
National Centre for Aquatic Biodiversity & Biosecurity

Biodiversity in a disappearing river

NIWA scientists are studying the environmental consequences of extreme low flows in the Selwyn River, south of Christchurch. Of particular interest are the effects of seasonal drying and wetting of the riverbed on aquatic biodiversity values.

The Selwyn River drains the central Canterbury foothills, and flows – sometimes – for 60 km across the Canterbury Plains to Lake Ellesmere. Its most striking feature is the absence of water in its middle reaches for most of the year. Where does all the water go? How does this influence biodiversity?

In the foothills, the Selwyn flows year-round. On the plains, the riverbed is highly permeable, and the river overlays a deep and porous aquifer. As soon as the river reaches the plains, water begins leaking down through the bed and into the aquifer. In most months, all river water disappears within 5 km of leaving the foothills. The next 35 km of the river is dry for most of the year, apart from a small section around the confluence with the permanently flowing Hororata River. About 15 km upstream from Lake Ellesmere, shallow groundwater rises back to the surface, and the Selwyn becomes permanent again.

Disappearing river flows have significant ecological effects: when the river's surface water disappears, so does the habitat for many aquatic plants and animals. In response to loss of surface water, aquatic invertebrates and fish must disperse, seek refuge in remnant aquatic habitats, or die. Aquatic plants, algae, and bacteria must form resting stages, or die. The dry central reaches of the Selwyn River also constitute a significant barrier for dispersal of invertebrates and for fish migrating between Lake Ellesmere and the headwaters.


Disappearing flows in the middle reaches of the Selwyn River. Photos were taken at the same location in November 2003 (left) and February 2004 (right).

The environmental effects of changing flows in the Selwyn River are the topics of a new long-term FRST-funded research project being conducted by NIWA and Lincoln Ventures Ltd. We chose the Selwyn River for our research because it responds strongly to changes in runoff from the foothills, and to changing groundwater levels. The Selwyn is also a 'sentinel site' for predicting future conditions in catchments where land-use is shifting toward intensive agriculture with high irrigation requirements.

The first stages of our research focus on patterns in surface water chemistry, benthic invertebrates, and attached algae and plants, and hyporheic (interstitial) invertebrates and chemistry. We collect samples monthly at 14 river reaches down the length of the Selwyn. Results from November 2003, when the entire river was flowing, indicate that longitudinal patterns in invertebrate communities are strongly influenced by flow permanence. Several taxa occur only at sites with permanent flow. These include the large predatory stonefly *Stenoperla prasina*, the dobsonfly *Archichauliodes diversus*, and several cased-caddisflies. In contrast, the mayfly *Deleatidium*, midges (Chironomidae), and oligochaete worms occur at all sites. The former taxa have long larval periods, which make them susceptible to periodic drying, whereas the latter taxa tend to complete river-dependent stages of their life-histories during short periods of flow. We also found that invertebrates characteristic of groundwater habitats (stygofauna) are common in the riverbed where groundwater upwells, such as the deep remnant pools adjacent to the Selwyn's main channel. Future research will use these facultative groundwater taxa to examine surface-subsurface exchange of water and organisms.

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Revealing the diversity of New Zealand hydrobiid snails

Recent research into the taxonomy of New Zealand hydrobiid snails has uncovered remarkable radiation in infrequently sampled freshwater habitats such as seepages, springs, and groundwaters. Little research has been done on this group in New Zealand, which has long been suspected to contain many undescribed taxa. In Australia, 300 species of Hydrobiidae are known and in nearby New Caledonia, which is much smaller than New Zealand, there are at least 100 species.

Over the last two years, sampling from Northland to Stewart Island has focused particularly on springs, caves, and seepages in limestone areas. A wide variety of techniques, including scanning electron microscopy, histological reconstructions, and DNA sequencing, was applied to unravel the taxonomic mysteries of the snails collected. This work has increased the number of known hydrobiid genera in New Zealand to 15 and the species to 63, with many more species still probably undiscovered. Previously only 16 New Zealand species of Hydrobiidae belonging to 6 genera were recognised.

Most of the new species occurred in small seepages, and several were restricted to groundwaters or streams flowing through caves, especially in northwest Nelson. Often, new species were found only at their type locality, despite intensive searches in neighbouring habitats, suggesting that radiation has occurred over small spatial scales in some areas. Given the localised distribution of many species and the susceptibility of seeps, springs, and groundwaters to modification from land-use change and water abstraction (see *Aquatic Biodiversity & Biosecurity Update 5* (p. 5) and 6 (p. 8)), urgent attention is required to incorporate these habitats into conservation planning and management. Such action would help meet the objectives of the Biodiversity Strategy.

This work was conducted over the past two years by Martin Haase, a post-doctoral researcher with NIWA, in collaboration with the Museum of New Zealand Te Papa Tongarewa, the University of Waikato, Landcare Research, and the Australian Museum, as part of NIWA's FRST–funded programme Biodiversity of New Zealand Aquatic Environments.

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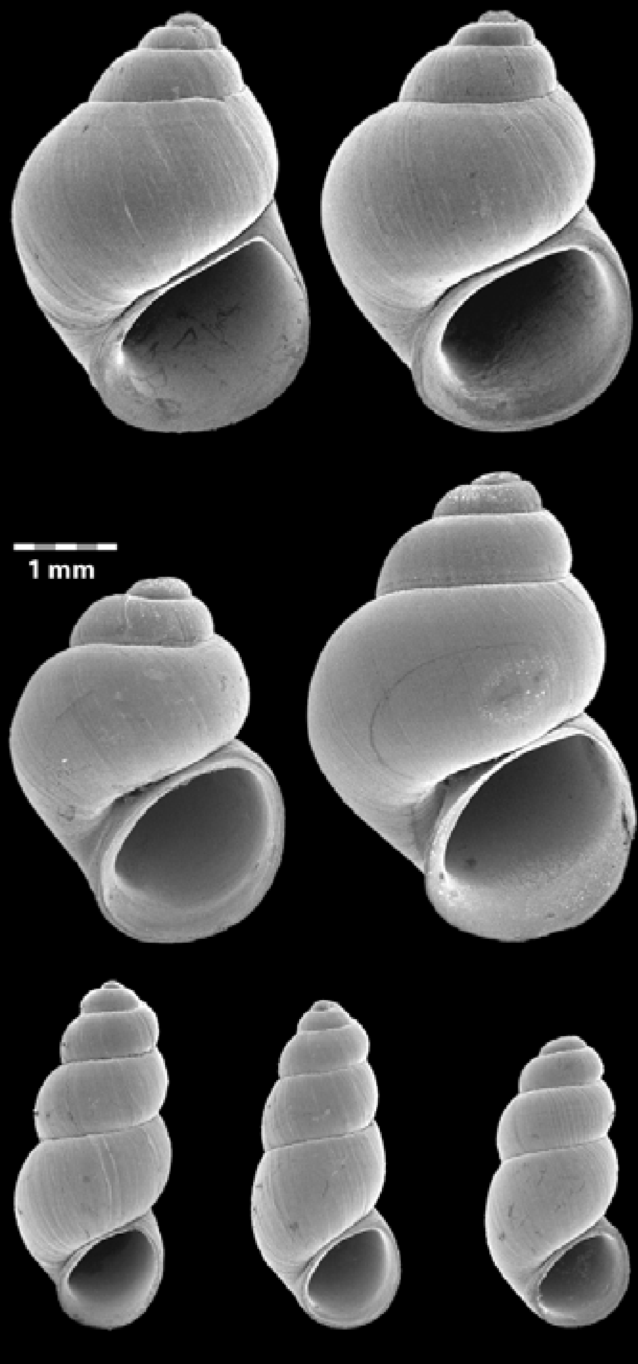


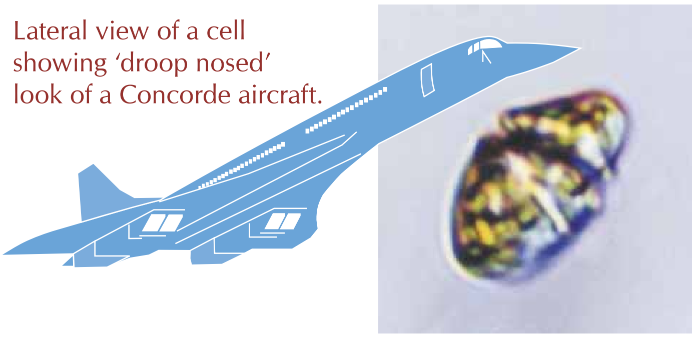
Some of the new species of Hydrobiidae currently being described. Top to bottom: species belonging to the genera *Potamopyrgus*, *Opacuincola*, and *Leptopyrgus*.

A new toxic dinoflagellate for New Zealand

In the late spring of 2002 an undescribed *Karenia* species was found in the Hauraki Gulf in an algal bloom that contained several dinoflagellate species – *Karenia brevisulcata*, *K. mikimotoi*, and *Noctilcuca scintillans* (see *Aquatic Biodiversity & Biosecurity No. 3*). The bloom coincided with the death of a large number of midwater and bottom-dwelling estuarine fish – parore (mangrove fish), flounder, yellow-eyed mullet, eel, goby, and spotty. Most of the kills were recorded around Orewa and the Whangaparaoa Peninsula, but about 8500 abalone died at Kennedys Bay, eastern Coromandel Peninsula.

The undescribed *Karenia* has been confirmed as new to science and its formal description, as *K. concordia*, will be published in the international journal *Phycologia* by Hoe Chang (NIWA) and Ken Ryan (Victoria University of Wellington).

Like most other toxic *Karenia* species (e.g., *K. mikimotoi* and *K. brevisulcata*), cells of *K. concordia* are dorsal-ventrally flattened with a straight apical groove. Light and scanning electron microscopy revealed that large cells, in particular, are dorsally convex and ventrally concave. In lateral view the cells 'arch' forward giving them the 'droop-nosed' look of a Concorde aircraft. Unlike cells of other *Karenia* species, the apical groove of *K. concordia* is very long, extending from the apex to the edge of the cingulum (the horizontal groove in the middle of the cell), and is apparently the longest such groove of all known species. Another previously described New Zealand species, *K. brevisulcata*, has the shortest apical groove. This feature is diagnostic.



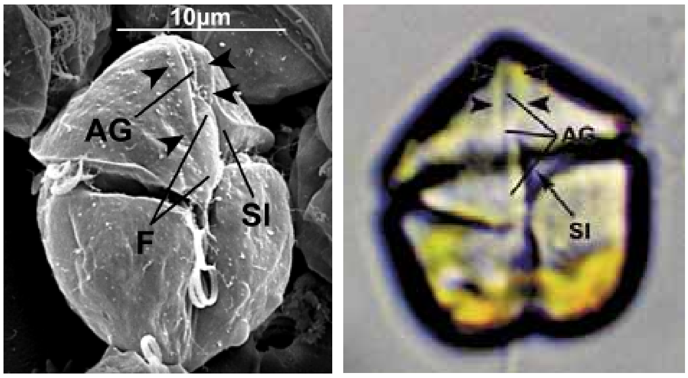
Lateral view of a cell showing 'droop nosed' look of a Concorde aircraft.

Part of the apical groove is on a keel-like bulge. Near to this the groove is partly concealed by an unusual flap of cell membrane. The flap is transparent under the light microscope, but obstructs a view of the apical groove extension towards the cingulum; only a very few cells show an unobstructed view of the entire groove. This complex arrangement is also apparently unique to *K. concordia* and is also diagnostic.

Toxicity test

Karenia concordia cultured from the 2002 kills was tested for cytotoxicity. Two other species, non-toxic *Eutreptella* sp. and toxic *K. brevisulcata*, were also tested using the same approach. Cultures were first extracted with the mixed organic solvent dicholoromethane/methanol and final cell extracts were concentrated in 80% methanol. Cell extracts of all three species were then tested in duplicate for cytotoxicity using the N2a cell line (mouse brain neuroblastoma) bioassay. Both cell extracts of *Karenia concordia* and *K. brevisulcata* tested positive and the non-toxic *Eutreptella* sp. negative for cytotoxicity.

It is now also clear that putative '*Gymnodinium* cf. *breve*' recorded off the northeast coast of the North Island in early 1993 was *K. concordia*. At that time, neurotoxic shellfish poisoning (NSP) and human respiratory syndrome were reported. The new *Karenia* species will therefore be tested for NSP.



SEM (left) and light (right) micrographs – ventral views of cells showing a keel-like bulge (arrowheads), very long apical groove (AG), unusual flap of cell membrane (F), and sulcal intrusion (SI).

Culprits in the 2002 algal blooms

Positive tests imply that *K. concordia* and *K. brevisulcata* are cytotoxic and can cause marine life kills. Additionally, both *K. brevisulcata* and *K. mikimotoi* have been linked to previous marine kills, either in the same region or other areas along the central east coast of New Zealand, so all three *Karenia* species may have contributed to the spring 2002 marine kills.

Although the phosphorescent dinoflagellate *Noctiluca scintillans* also built up to bloom proportions during the 2002 harmful episodes, it was not considered to have any negative effects on marine life. In fact, this non-photosynthetic species itself was a victim of the toxic outbreaks. A large number of *Noctiluca* cells collected simultaneously with the *Karenia* species were found dead, most of them devoid of food vacuoles and protoplasmic strands. Only healthy *Noctiluca* cells, sampled further north in the Bream Bay area away from the *Karenia* blooms, contained diatoms and other food particles in their food vacuoles.

This study adds another important species to the growing list of harmful marine microalgae found in New Zealand . Other toxins produced by this new species are now under study. The number of harmful marine microalgae associated with human health risks and environmental impacts in New Zealand continues to grow as more species are discovered. Most of these species are dinoflagellates. We don't know if these are part of New Zealand's natural flora and we cannot therefore discount that some may have arrived in ship ballast water from other parts of the world.

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New Zealand's cirolanid isopods – highlighting the diversity of these marine garbage cleaners

Isopods are usually inoffensive small animals like the slaters that live under stones or leaf litter in gardens and forests. Fishers and anglers know isopods better as parasites of marine fishes and call them sea-lice, tongue-biters, or fish doctors, but one of their most significant roles is that of scavenger.

Have you ever wondered what happens to the dead whales, fish, and all the other carrion that sinks to the sea floor? It would surprise many people to learn that one marine isopod family, the Cirolanidae, contains not only some of the largest crustaceans but also the most voracious predators and scavengers in the ocean, with species that are known to attack humans (usually on tropical surf beaches). Carrion is a major food source in most environments, and the recycling of dead matter is an important ecological process that contributes to healthy habitats, a fact long recognised for terrestrial habitats. In marine environments it has been increasingly evident that small crustaceans play a large role in recycling marine 'waste', and that the most important scavengers are to be found in the isopod family Cirolanidae, the amphipod superfamily Lysianassoidea, and the 'clam shrimps' or Ostracoda; other crustacean scavengers include crabs and shrimps.

New Zealand's cirolanids

We are clarifying the diversity of New Zealand cirolanids. This large family occurs in all oceans and marine habitats, from the intertidal to about 3000 m depth. Worldwide, there are nominally 450 species in 60 genera, with 21 of these genera known only from cave waters. There are certain to be vast numbers of species new to science. Cirolanids range in length from about 3 to 450 mm, a proportionate range in size probably matched only by the mammals (shrews to whales). In some genera, such as the worm predator *Metacirolana*, nearly all species are tiny, but most marine cirolanids measure between 5 and 20 mm. There are three notable exceptions: the giants of the genus *Bathynomus*, with several species exceeding 330 cm in length, and large species of *Parabathynomus* and *Booralana*, which reach 6 cm, as does the New Zealand species *Cirolana quadripustulata*.

New Zealand's cirolanid isopods are poorly documented and existing collections are also poor. Knowledge of the family in New Zealand is very limited compared to that of North America, Europe, southern and eastern Africa, and Australia. The recorded New Zealand fauna totals 17 species in six genera, as little as 20% of the probable number of species. In comparison, southeastern Australia, covering a similar latitudinal spread to New Zealand, has 44 species in 14 genera, with numerous known undescribed species. Some of New Zealand's yet-to-be described species are common around our shores, indicating that the most basic documentation of these animals is yet to be done. Their abundance — a single overnight trap can yield as many as 30 000 individuals — suggests that cirolanids must be of some ecological significance.

Are these animals important? Yes, they are. Scavengers are important in maintaining the general health of ecosystems, particularly through cleaning up dead matter, and scavenging cirolanids are ubiquitous and often abundant. They are easy to catch in large numbers, making them particularly

***Bathynomus giganteus*, a Caribbean species, showing the size attained by these whale-scavenging isopods (*Bathynomus* is not yet known in New Zealand waters).**

amenable for population and gene-flow studies using molecular techniques. They are also of potential economic significance as they are known to attack trawl and trap catches, destroying or spoiling the catch by chewing through the skin and reducing the saleability of the fish. Attacks on netted fish by *Natatolana rossi* in New Zealand have been considered as potentially reducing the fish catch, but there are few scientific data.

We don't know how many cirolanid species there are in New Zealand, have only vague data on the species and generic affinities or evolutionary origins, and almost no ecological or biological data – a rewarding area for research.

Some facts about cirolanids

- In Japan, cirolanid isopods have been used for forensic assessment of cadavers retrieved from the sea.
- Some museums have prepared whale skeletons by anchoring the carcass off a jetty in the sea.
- Cirolanid isopods have been used to 'clean' shark carcasses for the retrieval of cartilage for industry.
- The largest of all isopods (and among the largest crustaceans) is the giant *Bathynomus*, which can reach 45 cm in length and attacks trawl catches.
- Cirolanids in Florida and South Australia caused the near collapse of the shark fisheries: for unknown reasons the isopods swarmed, killing the sharks when they ate into the vital organs.
- *Cirolana harfordi* is known to have been translocated from the northeastern Pacific to Australia. This alien carnivore favours mussel bed habitats and is of potential concern.

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Natatolana rossi, one of New Zealand's commonest shallow-water scavenging cirolanids.

The road to parasitism

Cirolanids belong to the superfamily Cymothooidea (pronounced 'cymotho-oydea'), which contains a group of families that includes obligate fish parasites. The families within the Cymothooidea can be seen as a loose 'lineage' running from free-living predators and scavengers, through various symbiotic species (e.g., those living in sponges) to those that are true parasites, often with a unique host and with a trophic dependency on the host.

Some of the predatory and scavenging habits of the cirolanids may have served as pre-adaptations for a parasitic lifestyle. For example, some cirolanids feed by chewing their way into the dead (occasionally living!) animal and can survive anaerobic conditions for a short while, an adaptation to living in temporary mud burrows. Such an adaptation could perhaps facilitate flesh-burrowing as a parasitic habit.

Most isopod parasites are external, and have strongly hooked claws. The family Corallanidae, which is very similar to the Cirolanidae, contains free-living predators that specialise in attacking worms — they have grasping front legs which provide an inescapable grasp on their prey, and mouthparts which narrow, forming a piercing and sucking cone. Such features are typical of most isopod fish parasites. The corallanids include species that are worm predators, sponge associates, and symbionts of fishes, some species feeding on fish mucus, others on blood.

The next 'step' can be considered as represented by the Aegidae, most species being micro-predators with a loose association with their fish prey. These animals have most of the body characteristics of free-living cirolanids, but have strongly hooked front legs and the typical piercing mouthparts.

The Cymothoidae are all obligate parasites of fishes, and, although classified as one family, it is possible that more than one evolutionary transformation to parasitism has occurred. These isopods attach externally, on the gills or in the mouth, and there are a few flesh burrowing species. As adults they are often without pigment, with reduced eyes and smooth bodies and appendages (all the legs are hooked), and females typically produce large numbers of young — all features commonly associated with parasites.

Enemy escapee or Trojan Horse? Looking for parasitic hitchhikers on an introduced crab

Introduced species have a variety of effects on native plants and animals. Some become so abundant that they displace native species or alter their habitats.

One explanation of why introduced species do so well is that they arrive in a country free from natural enemies, such as parasites and diseases, which control their abundance in their native region. A recent study suggests that, on average, introduced populations have half the number of parasite species they would normally carry in their native region, and that they are less afflicted by parasites than species they might compete with in the region that they invade (Torchin et al. 2003). However, this is not always so. Some introduced species do not arrive unencumbered, but bring with them parasites that are capable of infecting native species that have no natural defences against them. When this happens, local populations can be severely affected as the new pathogen takes hold.

Charybdis japonica belly side up.

In September 2000, an Asian species of swimming crab, *Charybdis japonica*, was discovered in Waitemata Harbour, Auckland (*Biodiversity Update 1*). The crab is a large (about 100 mm carapace width), mobile, and aggressive estuarine predator whose native range is the western Pacific from China and Korea to Japan, Thailand, and Malaysia. This region has a particularly rich fauna of swimming crabs, with more than 36 species in the genera *Charybdis* and *Thalamita* alone. It is also home to a variety of crustacean parasites and diseases that are not present in New Zealand, including white spot syndrome baculovirus, an extremely virulent aquatic disease that has had a devastating effect on crustacean aquaculture in Asia and, recently, parts of the USA (see box).

NIWA's National Centre for Aquatic Biodiversity and Biosecurity has been investigating whether *Charybdis* arrived in New Zealand free from parasites or whether it brought with it some undesirable hitchhikers. In June 2003, the National Centre for Disease Investigation, with assistance from NIWA, undertook a survey of the introduced *Charybdis* population in Waitemata Harbour to test for the presence of white spot syndrome. Fifty-five *Charybdis* and 51 specimens of the native New Zealand paddle crab, *Ovalipes catharus*,

Isla Fitridge throwing crab traps overboard.

were examined for white spot syndrome. Thankfully, no evidence was found of the disease in either population.

In a second study, Aroha Miller, a Tuapapa Putaiao Maori Fellow based at NIWA, has been investigating the macro-parasites carried by this exotic crab. To date, she has dissected more than 100 *C. japonica* from Waitemata Harbour and 300 *O. catharus* from throughout the country. Only four *O. catharus* and two *C. japonica* harboured parasites. Nematodes were found in the cardiac stomach in *O. catharus*, and in the hindgut region in *C. japonica*.

Samples of nematodes from *C. japonica* were sent to a specialist in the Czech Republic, who identified them as juvenile stages from one of two families – Acanthocheilidae, parasites of sharks, or Anisakidae, parasites in some marine teleosts. Fish become infected when they eat an infected crab, but little else is known about either family. It is not yet clear whether the nematodes from *C. japonica* and *O. catharus* belong to the same species, and if not, whether

White spot syndrome baculovirus (WSBV) is an extremely virulent rod-shaped virus that affects crustaceans. It was first described in the cultured giant tiger prawn (*Penaeus monodon*) and in redtail prawn (*P. penicillatus*) in Taiwan in 1993. It is now known to have a wide range of hosts and can infect prawns, crabs, and lobsters. Since its appearance in 1993, strains of WSBV have spread rapidly throughout most of the shrimp-growing regions of Asia and the Indo-Pacific. It is now found throughout China, Japan, Korea, Indonesia, Taiwan, Vietnam, Malaysia, and India, and was first detected in farmed prawns in Texas in 1995. The disease is lethal, with cumulative mortality reaching 100% within 2–7 days of infection. Despite its pathogenicity, the free virus is viable in sea water for only 3–4 days. This disease is not known in New Zealand.

they came with the exotic crab and have since transferred to the native species, or vice versa. Since these first nematodes were discovered, more have been found in subsequent dissections, and will also be sent for identification. The study is continuing.

Reference
Torchin, M.E. et al. (2003). Introduced species and their missing parasites. *Nature 421*: 628–630.

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Charybdis japonica right side up.

Species identification guides – identifying user needs

A recent survey of user needs for tools to identify freshwater biota has helped to prioritise groups of aquatic plants and animals requiring future research. NIWA held meetings in Hamilton and Christchurch to determine the identification issues faced by a range of users, and to help define the content for a questionnaire.

There was a response rate of 28% from the 208 recipients of the questionnaire, mostly in statutory authorities, government departments, and Crown Research Institutes (CRIs).

Most respondents identified biodiversity conservation and/or management (37%) or ecosystem health (35%) as the primary issues that would be helped most if better identification guides were available. Rare species conservation, nuisance species spread, biosecurity incursions, and fisheries management were all identified by 12–16% of respondents as important issues that would be assisted.

A wide range of identification guide types is potentially available, but respondents frequently rated the complexity and accessibility of most existing keys, and the related issue of distinguishing important diagnostic features, as impediments to using them. Researchers (mostly in CRIs and universities) preferred quick-guides and conventional keys, in contrast to management workers who most strongly favoured pictorial guides, such as photo books and quick-guides, and preferred computer guides over conventional keys. Several features of computer guides were considered moderately to highly useful by both groups of respondents, including photos with hyperlinks to data, the ability to eliminate taxa without key traits, and being able to select by habitat type or region.

The review showed that a set of freshwater species identification guides appropriately targeting user needs is not currently available. Conventional taxonomic keys based around formal descriptions are fundamental to the development of all kinds of guides. Without this fundamental taxonomy, more popular forms of presentation are not possible. Based on an analysis of the current taxonomic knowledge and status of different types of freshwater biota identification guides, and considering user requirements for up-to-date and easily accessible information, a priority list of the freshwater taxa most urgently requiring improved identification guides was developed.

Work is now underway to develop quick-guides for adult and juvenile (whitebait) galaxiid fish, bullies, algae, aquatic plants (including pest species and threatened native species), and aquatic oligochaete (worm) genera. Examples of currently available quick-guides for several invertebrate groups can be found on the Tools and Resources pages of NIWA's National Centre for Aquatic Biodiversity and Biosecurity web site (www.niwa.co.nz/ncabb/tools). The new quick-guides will also be available from this site once they are completed later in the year.

This survey and subsequent development of priority identification guides have been funded through the Terrestrial and Freshwater Biodiversity Information System (TFBIS) Programme.

A copy of the full report on end-user identification guide needs is now available on the programme's web site (www.biodiversity.govt.nz/pdfs/ID_guide_report.pdf)

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NIWA scientist receives hands-on training in marine alien-species research in USA

Isla Fitridge, a key member of NIWA's Marine Biosecurity team, recently spent 3 weeks in Maryland, USA, working alongside staff in the Marine Invasions Laboratory at the Smithsonian Environmental Research Center (SERC).

Scientists there have been using passive surveillance techniques to monitor aquatic invasive species patterns at 21 sites in continental USA and Alaska and 2 sites in Australia for more than 3 years. Their data are being used to determine the geographic range of the country's national fouling communities and provide synthesis, analysis, and interpretation of invasion-related patterns in the USA.

Aquatic invasive species are a global problem, and international collaborative research can speed the development of tools to prevent invasions and mitigate impacts when invasions occur. NIWA and SERC have common science objectives and concerns in the field of marine biosecurity. The use of common techniques in each country will enhance our ability to answer key questions related to invasion biology by increasing sample sizes and allowing comparisons among regions.

Alien species are a major threat to the ecological integrity of New Zealand's coastlines. Over the past 100 years, foreign species have become established here at a rate of about one every 9 months. The chances of controlling or eradicating an outbreak of an exotic species are greatest if it is detected early, yet surveillance techniques for detecting and identifying marine pests while they are still in low numbers are rudimentary. Of the many non-indigenous species known to have established in New Zealand, 69% are fouling organisms that settle on surfaces such as rock walls, pilings, and ship hulls. 'Passive surveillance' techniques involving the deployment of specially designed settlement surfaces in areas considered to be high-risk points of entry can enhance our ability to detect organisms soon after they arrive in the country.

Isla Fitridge retrieving a settlement plate.

A settlement plate.

While at SERC, Isla participated in an intensive field and laboratory programme to retrieve and analyse almost 300 settlement plates deployed at docks and marinas in Chesapeake Bay. She investigated patterns of invasion by marine invertebrates, and explored the characteristics of habitats and species that influence the success of biological invasions. She received training in the appropriate techniques to estimate biomass, measure patterns of coverage, and identify marine organisms that are known pests in other parts of the world. In addition to the training received at SERC, Isla also attended and successfully completed a workshop on Marine Bioinvasions led by world expert Dr James T. Carlton at the Oregon Institute of Marine Biology.

Isla's visit to the USA was funded by a NIWA Technical Training Award with a generous contribution of time and expertise from the Marine Invasions team at SERC.

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Aquatic Biodiversity & Biosecurity is a quarterly newsletter from NIWA's National Centre for Aquatic Biodiversity & Biosecurity, and is published by NIWA. It is available on request and via the web.

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ISSN 1175-9135