

Abstracts

Invasive species

(Abstracts of papers presented at the “ASFB Invasive species: Fish and Fisheries Workshop”, Australian Society for Fish Biology, Wellington, New Zealand, 29–30 June 2003.)

PREDICTION/SURVEILLANCE

Biological invasions: consequences for parasites, pathogens, emerging diseases, and fisheries in the marine environment

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Biological invasions are a major force in aquatic (including freshwater and marine) ecosystems, driving significant ecological changes and impacting many dimensions of society. Effects of invasions on fisheries species have received considerable attention, demonstrating simultaneously ecological and economic consequences. Most analyses of invasions and invasion impacts have focused on relatively large, conspicuous non-native biota, indicating a size-based taxonomic bias in detection and understanding. Despite this pattern, several attributes of microorganisms (e.g., protists, bacteria, and viruses) increase the likelihood of invasion relative to larger organisms. First, the magnitude of organism transfer (or propagule supply) increases with decreasing size, and invasion success (establishment) has a strong density-dependence. Second, many microorganisms can reproduce asexually, which should serve to minimise the inoculant size required for establishment. Third, many microorganisms have broad environmental tolerances, increasing the geographic range and seasonal window available for colonisation. Fourth, the life-history of microorganisms often includes stages (e.g., resting stages or cysts) that can further extend environmental tolerance by avoiding temporally unsuitable conditions. We predict that invasions by microorganisms are widespread, occurring largely without detection, and may contribute to the observed increase in emerging diseases in marine ecosystems.

Ballast water, sea chests, and foreign species: recent research at the Cawthron Institute, Nelson, New Zealand

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Ships have long been recognised as major carriers of potential marine pests around the world, transporting them in ballast water, sea chests, and as hull fouling. Since 1999, Cawthron staff have been investigating methods for heat treatment and sampling of ballast water and the potential of sea chests as transfer mechanisms of marine species. We present results of exploratory trials on the heat treatment of ballast water conducted during a trans-Pacific voyage of the methanol carrier M/T *Iver Stream*, as well as observations indicating that sea chests may be a more important mechanism in the transfer of marine species than previously thought. Progress in the development of sampling techniques for ballast water and the possible use of existing technologies to reduce the colonisation of sea chests by marine organisms will be discussed.

Baseline evaluation and monitoring of marine invasions in Australia and New Zealand

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The extent of biological introductions into coastal marine waters has become increasingly apparent in recent years. Numerous evaluations of regional and local areas have resulted in a broad understanding of the current state;

however poor baselines and a lack of consistency in approach prevent significant progress in identifying the underlying patterns of marine bioinvasions. Two national programmes of systematic baseline evaluations of high risk entry points (ports and marinas) has been established in Australia (1995–present) and New Zealand (2000–present). These programmes have utilised consistent methodologies, surveying multiple habitats with a known level of rigour. To date, 34 ports (c. 55% of first entry ports) in Australia have been surveyed by over 14 organisations, whereas in New Zealand 13 ports and three marinas of first entry have been surveyed by the National Institute of Water and Atmospheric Research Limited (NIWA) under contract to the Ministry of Fisheries. These surveys provide a broad increase in both native and exotic biodiversity understanding. The need to explicitly link baseline survey outcomes with policy development and management activities is the next phase of an ongoing process.

ASSESSING RISK

Invasive gobies in northern New Zealand estuaries

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Shallow harbours and estuaries in northern New Zealand are inhabited by at least five species of gobies. Two of these, *Favonigobius lentiginosus* and *F. exquisitus* have been present in New Zealand for decades, and are either native or resulted from historical introductions. In the last 5 years, three more goby species have been discovered. The Asian goby, *Acentrogobius pflaumii*, is known from two harbours near Auckland, where it seems to be well established. It was probably introduced to New Zealand via ship ballast water, either directly from its native range in the north-west Pacific Ocean, or indirectly via Australia, which it invaded before 1996. The Australian bridled goby, *Arenigobius bifrenatus*, which is also thought to have invaded New Zealand via ballast water, is known from five different harbours spanning c. 150 km of coastline. This species is more widespread than previously thought and appears well established. The Port Hacking dart goby, *Parioglossus marginalis*, has been recorded from saline

streams emptying into estuaries at two widely separated locations. It is not known whether this species is native to New Zealand, and has previously been overlooked because of low sampling effort in appropriate habitats, or whether it too is introduced. There is currently no information on the ecological impact of the invasive gobies.

Potential spread and impact of a little known alien fish introduced into Australia: the Oriental weatherloach (*Misgurnus anguillicaudatus*)

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Oriental weatherloach, *Misgurnus anguillicaudatus*, a coldwater fish endemic to eastern Asia, was first recorded from the wild in Australia in 1980 and has become established and is expanding its range. It has received very little attention from fisheries agencies, and little is known of its biology and ecology in western literature, and more importantly of the potential risks and impacts the species may pose on native aquatic fauna in recipient waters. As part of a Murray-Darling 2001 FishRehab funded programme, a scoping study was undertaken to define the biology and ecology of Oriental weatherloach, determine factors responsible for its continued spread in Australia, define its current and potential future range, and the potential risks and impacts of the species. A comprehensive understanding of current knowledge on this species is required to underpin future management decisions. We present the results of the study, detailing the introduction and spread of weatherloach into Australia, aspects of their biology which make them suited to Australian environments, disease, vectors of dispersal, current management and control options. Their environmental adaptability, high competitive ability, reproductive output, survivorship, and dispersal, indicate that weatherloach could potentially expand their range over a large portion of Australia. Although impacts are poorly known, experience in pest management suggests we should adopt a precautionary approach to the management of this species.

Invasion of New Zealand waters by Murphy's mackerel (*Trachurus symmetricus murphyi*)—another American in the south-west Pacific

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Murphy's mackerel (*Trachurus symmetricus murphyi*) was first identified from New Zealand waters in 1987. Before then it was thought to occur only off the Pacific coast of

South America. It is now known to be synonymous with the North American species *T. symmetricus*, ranging from California to southern Chile, and across the south Pacific to New Zealand and Australia. The migration across the south Pacific and eventual invasion of New Zealand is linked to several El Niño events that played important roles in a biomass explosion of *T. s. murphyi* that began in the 1970s, and in providing appropriate oceanic habitat to support what was probably a large proportion of this biomass. I will discuss these events with reference to the somewhat extreme biology of this species, describe its entry into New Zealand waters, and summarise subsequent events in the context of the suitability of *T. s. murphyi* to the New Zealand habitat.

Niche overlap between larvae of exotic and native fish in a lowland river

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Fish larvae of different species at first feeding often have similar morphology, body size, swimming abilities, and dietary requirements. Therefore the potential for interspecific competition may be quite high at the early life stages, perhaps even forcing co-occurring larvae or juveniles through a competitive bottleneck that may influence the strength of the future adult population (Werner & Hall 1979; Persson & Greenberg 1990). Competition for resources is a commonly stated potential impact of exotic fish on native species (Fletcher 1986; Li & Moyle 1993). However, most studies of the effects of competition focus on the adult stages of the life cycle, and rarely consider possible interactions between exotic and native fish during the early life history stages. This paper examines the potential for ontogenetic niche overlaps in time, habitat and dietary requirements, between two exotic fish, common carp (*Cyprinus carpio*) and gambusia (*Gambusia holbrooki*), and two small native species, Australian smelt (*Retropinna semoni*) and crimson-spotted rainbowfish (*Melanotaenia fluviatilis*), in an Australian lowland river. Sampling was conducted fortnightly, during the spring–summer period of 1998/99, in the lowland reaches of the Broken River in north-east Victoria, Australia. Sampling was mainly conducted using the Sweep Net Electrofishing method designed for capturing small-bodied fish (King & Crook 2002). Sampling was conducted in a stratified hierarchical design with five replicates taken of six habitat types within each of three sites, and these sites were sampled day and night on each sampling trip. Six broad habitat types were identified: pools, runs, still littoral, slow flowing littoral, and fast flowing littoral areas and backwater habitats. All collected fish were preserved, identified, and over 1200 fish from all developmental stages of

the four species were dissected to examine their dietary composition. Larvae of Australian smelt (native species) and carp (exotic species) occurred at the same time, mainly in November. The larval stages of both species were found to use backwaters and still littoral areas as nursery habitats during this period, with significant ontogenetic habitat shifts occurring for both species as juveniles and adults (see King (2002) for further details). Larval rainbowfish (native species) and gambusia (exotic species) also occurred at the same time, predominantly during December and January. Both of these two species were found to use the same habitats (backwaters and still littoral areas) as larvae, juveniles, and adults, suggesting the potential for significant habitat overlap between these two species throughout all stages of their life cycle. Major ontogenetic dietary changes occurred for all species, and their diets were broadly similar at similar sizes and ontogenetic stages (see King (2002) for further details). However, there was little evidence of any significant dietary overlaps between these four species, and also between the two co-occurring species pairs in the same habitats. Additionally, neither of the exotic species were found to be directly preying on the larvae of any native species. This study has demonstrated the possibility of niche overlap between the early life stages of exotic and native fish species. However, the natural resource use of native species may have been altered because of the presence of introduced species and perhaps even the interactions between these species were greater when the exotics were first introduced into the system. Further research is therefore required into the dietary and habitat requirements of these now coexisting species using enclosure/exclosure experiments and by comparisons between allopatric and sympatric populations.

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Rise and rise of *Gambusia holbrooki* in Australia—serious threat or scapegoat for poor environmental management?

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Since their introduction into Sydney's Royal Botanic Gardens in 1925, *Gambusia holbrooki* have spread rapidly throughout Australia, assisted by human dispersal and an amazing ability to cope with a range of extreme environmental conditions. *Gambusia* are now the most widespread freshwater fish in Australia, occurring in all states and territories on the mainland, as well as recently being discovered in the Tamar River region of Tasmania. *Gambusia* show a preference for warm, slow flowing waters amongst aquatic vegetation at the edge of water bodies with depths of 10 cm or less. This habitat preference puts this species in direct competition with many small bodied native fish, and although no local extinctions have been directly attributed to *Gambusia*, they are thought to have played a role in the decline of species from six genera (*Mogurnda*, *Ambassis*, *Melanotaenia*, *Pseudomugil*, *Craterocephalus*, and *Retropinna*). Although competition with native species can occur in a variety of forms, it is the aggressive nature of *Gambusia*, and their tendency to nip at the fins of other species, which often receives the most attention, with several recent studies quantifying this deleterious trait. Although a nationwide approach to *Gambusia* control is yet to be implemented, a recent report to the Murray-Darling Basin Commission has recommended the formation of a *Gambusia* task force to tackle the problem. This presentation will attempt to shed light on the current status of *Gambusia* in Australia, as well as discussing evidence of actual impacts on freshwater fauna and potential management techniques.

MANAGEMENT ACTION

Eradication of exotic pest fish—present and future options

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A wide range of techniques have been proposed to manage, if not actually eradicate invasive fish species. A number have been tried (e.g., physical removal, biocides), usually with limited success, others are currently being attempted (e.g., sterile male releases), and still more are under development (e.g., genetic technologies). These techniques

and attempts will be reviewed briefly, the strengths and weaknesses of each will be discussed, and their potential for pest eradication evaluated in a general framework that looks at both the likelihood they will achieve eradication, or at least substantial and sustained reduction of pest impacts, and the likelihood the public will ever let them be used.

Eradicating the European carp (*Cyprinus carpio*) from Tasmania, Australia

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European carp (*Cyprinus carpio*) was discovered in 1995 in two Tasmanian lakes. The decision was made to eradicate the carp from these lakes before they could spread downstream and further degrade the environment and recreational fisheries. Draining or poisoning the lakes was not a preferred option because of engineering and environmental constraints. The carp would be eradicated from the lakes through fishing. Unlike many fisheries, our objective is total eradication of the population—this fishery has no catch restrictions and no direct commercial value. We describe the approaches used to maximise the effectiveness of our fishing effort—the many gear types used, recruitment reduction, radio-tagged Jonah fish, sex-ratio biasing, etc. We describe the difficulties that we are facing in removing the last few fish—gear avoidance, changes in behaviour, eagles stealing the tracker fish, etc. To support the eradication effort we developed a model, which uses daily catch and tag return data to find maximum likelihood estimates of population size, tag shedding rates, and mortality rates. We present the results from this model. Finally, we comment on the lessons learnt from this eradication and the implications for the eradication of other carp populations through fishing.

CARPISM: a tool for evaluating management strategies for carp (*Cyprinus carpio*)

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Common carp (*Cyprinus carpio*) are widely implicated in freshwater aquatic habitat degradation and are thus considered an important invasive pest fish species in Australasia for which resource managers and broader communities are currently seeking effective control measures. Extensive sampling of Victorian carp stocks—including age-validation and over 6000 age-determinations, and rigorous reproductive biology investigations has substantially increased our knowledge of feral carp population dynamics. CARPISM was developed as a simple age-based model to simulate the effects of a range of management scenarios on feral carp stocks. The model simulates change in population biomass by age and sex-specific growth; and simulates change in population abundance through recruitment and sex-specific mortality. Using empirical published stock-recruitment data and stochastic recruitment weighting-factors derived from local hydrological data or the southern oscillation index, the model simulates the population dynamics of carp populations during a 200-year period. Carp management scenarios simulated included the effects of fishing the spawning stock; of fishing the whole stock; of spawning or recruitment sabotage; and of driving the population sex ratio towards male dominance (e.g., via daughterless carp). This paper compares outcomes of the simulated management using previously estimated biological parameters for two populations, as inputs. Model predictions suggests that faster growing, shorter-lived populations may be better controlled by biasing sex-ratio to male-dominance, or spawning-sabotage methods, whereas slower growing, long-lived populations may respond best to removal type approaches.

Diet, vertical distribution, and movements of brown bullhead catfish (*Ameiurus nebulosus*) in southern Lake Taupo, New Zealand

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Brown bullhead (*Ameiurus nebulosus*) have been reported present in Lake Taupo, New Zealand since 1985. It is unclear how they arrived in the lake. Previous studies indicated that catfish in shallow, weedy, or rocky habitats did not include trout in their diet and that crayfish were a rare item found in their stomach. The catch per unit effort (CPUE) of catfish monitored monthly since 1996 doesn't point to any increase in population. The monitoring results show that during summer 1997–98, catfish vacated the shallow weedy and rocky habitat. Subsequent underwater observations revealed large numbers of catfish (shoals up to 1000 fish) in mid water along the drop-off of the lake and close to the river mouths. Catfish caught in these habitats were larger than in shallow water and their diet included more smelt, bullies, and freshwater crayfish (koura) but no trout were found in the stomachs of catfish. Ultrasonic telemetry revealed that catfish swam in water

from 0 to 17 m deep but showed some seasonal preferences. Catfish were more active at night when they used shallow water extensively. The fish also made short dives and ascents, especially at dusk as they moved from deep to shallow water. Brown bullhead were the most mobile in spring when they left Motuoapa Bay, suggesting migratory behaviour. During winter the fish remained more stationary, moving around inside the bay only. The results of this study provide guidance for establishing a catfish control programme should it become necessary.

POLICY AND MANAGEMENT

Invasions of temperate Australian waters by the tropical seaweed *Caulerpa taxifolia*

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Caulerpa taxifolia is a seaweed native to tropical regions throughout the world, including tropical and subtropical parts of Australia, with its southern limit at Moreton Bay in Queensland. It has been widely used in the marine aquarium trade. The “aquarium strains” can invade cool temperate waters, and *C. taxifolia* has become established in several countries and areas where it is not naturally found. Since March 2000, *C. taxifolia* has been located in eight New South Wales (NSW) estuaries and has covered an area of c. 340 ha. This has raised significant concerns as *C. taxifolia* has the potential to grow rapidly and smother native seagrass. Evidence from the Mediterranean indicates that it may degrade marine ecosystems and threaten biodiversity. The NSW Government has created an aquatic pest management group with a major focus on a control programme for *C. taxifolia*. The programme includes declaring the weed noxious, removing it from the aquarium trade, controlling infestations in priority areas and eradicating them where possible, educating the public, and restricting the use of fishing gear to help stop the weed spreading. NSW Fisheries researchers have tested a variety of control methods, including handpicking, dredging, smothering, and applying salt. For most situations salt treatment appears to be the most efficient control method. Research work has focused on developing effective salt dosage rates and application methods, and the impact of salt on native seagrasses and benthic infauna.

Incursion response to *Undaria pinnatifida* in southern New Zealand

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Undaria pinnatifida, a laminarian kelp native to coasts of Japan, Korea, and parts of China, has become widespread along the central and eastern coastlines of New Zealand since its discovery in Wellington Harbour in 1987. In March 1997, *U. pinnatifida* was discovered on mussel farms at Big Glory Bay, Stewart Island, well outside its known range. An incursion response was initiated by the Department of Conservation based upon independent technical advice and peer review. An eradication programme was established to prevent the spread of *U. pinnatifida* around Stewart Island, Fiordland, and the subantarctic islands. These ecosystems are recognised nationally and internationally for the intact nature, diversity, and/or unique features of their marine communities. Monthly manual removal of plants (sporophyte stage), coupled with the removal or sterilisation of infested farm equipment and harvest of infested mussel farms, has succeeded in reducing *U. pinnatifida* to near zero populations in Big Glory Bay. Subsequent invasions of nearby Bluff Harbour and Halfmoon Bay from northern populations were detected and contained by manual removal and treatment of infected substrate with heated water. Monitoring of coastal shipping in southern ports identified potential vectors requiring treatment. Surveillance monitoring also identified an *Undaria* infected vessel that grounded and later sank in the shallow coastal waters of the Chatham Islands. Treatment of the hull was initiated once it was clear the vessel could not be refloated and towed away from the shore. The long-term viability of the incursion response is uncertain, but it has demonstrated what can be achieved with a targeted, rapid response to a marine invasive species. Lessons learnt and the development of tools should contribute to refined marine biosecurity responses.

Dumb barge teaches important lessons: the translocation and management of a cryptogenic sea squirt (*Didemnum vexillum*)

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This paper presents a case study about a slow moving barge, the "Steel Mariner" and a cryptogenic compound ascidian. The barge was responsible for the translocation of *Didemnum vexillum* from Tauranga Harbour, North Island to the heart of the New Zealand Greenshell™ mussel industry: the Marlborough Sounds in the South Island. Some scientists considered the species to be a serious biosecurity threat to the mussel industry, given its fouling and smothering capabilities, particularly of artificial structures such as mussel lines. Despite the Ministry of Fisheries (MFish) contracting two world authorities on ascidian taxonomy to identify the species, controversy still exists over the origin (native or introduced) of the ascidian. Consequently, the delegation of responsibility (MFish and regional councils) for managing the biosecurity threat has been significantly delayed. Since its arrival on the "Steel Mariner" in Picton on 23 April 2001, the species has spread to the seabed below the "Steel Mariner", another barge the "Waimarie 1", and the Waimahara wharf (500 m away in Shakespeare Bay). *D. vexillum* look-a-likes have also been witnessed on salmon cages in Shakespeare Bay. Despite an attempt to reduce the biomass of *D. vexillum* on the "Steel Mariner" in early August 2002, colonies reached an estimated 1945 kg of wet biomass weight in March 2003. This exceeded an initial biomass estimate of 1396 kg in February 2002. In addition to the presence of the undesirable *D. vexillum* on the "Steel Mariner" the Marlborough District Council (MDC) was also concerned about the seaworthiness of the barge. Hence MDC applied to the Environmental Court for enforcement orders under Section 316 of the Resource Management Act 1991 to scuttle the "Steel Mariner". On 16 April 2003, the Environmental Court ordered that by 31 August 2003 the bulk of the *D. vexillum* be removed from the barge and that it then be scuttled in Cook Strait.

Invaders in the north—an appraisal of Queensland's (Australia) strategic approach to pest fish management

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Invasive fish species have long been considered a problem in Queensland, Australia with 17 species forming self-sustaining populations in Queensland waters. The Queensland Fisheries Service (QFS) established a project

in 1999 to develop a strategy for controlling these fish. "Controlling exotic pest fishes—an operational strategy for Queensland Freshwaters 2000–2005" (the strategy) was released in early 2001 and has been progressively implemented since that time. QFS have worked very closely with the community and industry in the management of invasive species and the pest fish project has had some notable successes. These include a well-recognised state-wide education programme and the installation of multi-million dollar screens on impoundments to prevent inter-basin transfer. In recognition of the increasing rate of fish smuggling into Queensland, a process has been developed to amend the current legislation to ensure that it is enforceable, accepted by the community and industry, and scientifically valid. This workshop will explore the reasons for these successes and some of the challenges encountered whilst implementing the strategy. The future policy direction of the pest fish programme will also be discussed as QFS intends to manage pest fish within a wider habitat management framework. This holistic approach to habitat management will incorporate many of the approaches to community engagement and education developed during the pest fish project.

Impacts of alien salmonids on freshwater biota in Australia: background, review of impacts, and defining the issues

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Salmonids, mainly brown and rainbow trout (*Salmo trutta* and *Oncorhynchus mykiss*) were introduced into Australia in the mid 1860s and mid 1890s respectively, and now support economically valuable recreational fisheries. These alien species have established self-sustaining populations in many aquatic environments in south-eastern and south-western Australia, and stocking of hatchery-produced fish in larger systems is undertaken when fisheries targets are not met (e.g., fish numbers or appropriate size). Salmonids have established self-sustaining populations in many waters not targeted or managed as fisheries, colonising the entire catchment in cooler upland areas of Australia. These populations usually

consist of a high abundance of fish in small first to third order tributaries. These waters are infrequently targeted by anglers, and populations may not contribute individuals to downstream fisheries. Negative impacts of alien salmonids on native aquatic fauna (e.g., fish, frogs, spiny-crabs), mainly through direct predation, and to a lesser degree competition for resources, have been noted for over 140 years. Impacts on some faunal groups have been so severe as to eliminate entire populations and severely fragment species across their range. Despite these impacts, salmonid management is focused largely on providing improved recreational angling opportunities, whereas management of their impacts is almost non-existent. Management of the symptom of salmonid impacts, declining native species, begins only after native species have become imperiled. This presentation, part one of two, describes salmonid origins and distribution in Australia, reviews their impacts on native aquatic fauna, and outlines issues and challenges in current management, which are dealt with in part two.

Spread of coarse fish in New Zealand

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New Zealand native freshwater fish fauna is unusual internationally, with a high rate of endemism. The native fauna is dominated by galaxiid species, with some families that dominate elsewhere, like carps, being wholly absent. Salmonids were introduced as sports fisheries in the early days of settlement, with brown and rainbow trout and Chinook salmon being particularly successful and now widespread in largely self-sustaining populations. Limited introductions of coarse fish, notably tench and perch, were made in the early days of settlement. Coarse angling, however, has had a very limited following until comparatively recently. Recent European and Asian immigrants have sought coarse-fishing opportunities, largely for sport and food respectively. Liberations of new species into new areas has increased in the North Island over recent decades. New Zealand authorities, the Department of Conservation and Fish & Game New Zealand, have generally not favoured the authorisation of liberations of new fish species into new areas to extend coarse-fishing opportunities, despite pressure from coarse-fishing enthusiasts. Recent discoveries of new populations of coarse and other introduced fish outside their previously known range in the southern North Island and northern South Island has challenged agency response and raised practical questions of how to deal with this issue. An example is provided of a response-in-progress from the Nelson Marlborough region, which questions whether the issue is a technical, legal, or a sociological issue.

