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Special Invasive Alien Species Issues: challenges for the marine systems

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Abstract

On a global scale, introduced marine species pose a significant threat to marine environments. Within this paper four challenges to delivery of marine biosecurity outcomes are identified, with a brief discussion on how these challenges are being met within the New Zealand context. Currently within New Zealand, only 3% of the total biosecurity funding is expended on the marine environment. To be effective with such a small component of the total budget, marine biosecurity has directed research into six programmes: 1) risk profiling; 2) compliance monitoring of ballast water exchange; 3) alternative management tools for marine vector threats; 4) baseline information to support border control; 5) surveillance for marine pests; and 6) incursion response options and systems. At present, the marine biosecurity system developed in New Zealand offers a good example of an outcome-oriented system that balances costs and benefits across economic, environmental, social and spiritual values. The short-term costs to establish such a system may be significant however; the long-term benefits far outweigh the initial investment.

Introduction

The 21st century is a time of 'bigger, faster, better': advances in technology have enabled humans to spread across the planet, and this extension has led to direct and indirect alterations of ecosystems. While human migrations have been documented over the last 40,000 – 80,000 yrs, it is the spread of Europeans over the last 500 years (Crosby, 1986) that has resulted in significant ecosystem changes. Modern humans travel between two points with relative ease, taking their 'creature comforts' along, either intentionally or unintentionally. The ability to have an 'English cottage garden' in Australia, for example, may be aesthetically pleasing to the individual or even the community, but at what cost to native ecosystems? In the terrestrial context, the threat posed by the human-mediated introduction of species has long been recognised (e.g., Elton, 1958). This realisation however, while identified by Elton (1958), has only recently emerged as a significant issue in the marine context (e.g., Carlton, 1985, 1996, 2001; Ruiz *et al*. 1997, 2000; Hewitt, 2003; Smith, 2003).

The human-mediated movement of species has been facilitated by a wide range of vectors (the mechanism of transport; e.g., live seafood trade, the aquarium trade, ballast water, ship hull fouling or boring). Some historic vectors no longer operate, while others are new; yet all have the propensity to transport intentionally or accidentally species from regions where they evolved to regions where they were not present in evolutionary or ecological time. Intentional introductions have occurred *inter alia* as part of the naturalisation of societies, fish stocking efforts, and aquaculture operations. These mechanisms of transport have been reduced largely and play relatively insignificant roles in modern introductions (with the exception of smuggling and intentional release).

Accidental introductions, however, are increasing at an accelerating rate (e.g., Cohen &Carlton 1998; Ruiz *et al*. 2000; Hewitt, 2003), exposing all regions of the world, including the pristine reaches of polar seas (e.g., Orensanz, 2002; Lewis *et al* 2003, 2004). As trade increases and accelerates, new opportunities for transport of species from one region of the world to another occur (Hewitt *et al*. 2004a).

Despite significant efforts to develop international regulatory frameworks to reduce the rate of introductions associated with ballast water, it has taken 12 years to develop an international instrument (Hewitt, 2003; McConnell, 2003): The International Convention for the Management of Ships' Ballast Water and Sediments was adopted only in February 2004. While international instruments and agreements are desired, regional and national legislation and regulatory frameworks are most likely to be used for the management of the vast majority of introduced species and vectors.

In most countries the current status of marine biological invasions research is primarily descriptive, with relatively little effort focused on active control and eradication strategies (but see Culver & Kuris, 1999 and McEnnulty *et al.,* 2001). This epitomizes a lack of robust, rigorous data that can be used by biosecurity (biological security) agencies, and which ultimately restricts management options and limits the efficacy of risk assessment in the marine environment. Progress cannot be made without significant quantitative and targeted research.

The current and future challenges to marine biosecurity delivery can be summarised as:

1) institutional and regulatory frameworks, inconsistent legislation, and poor international linkages;
2) lack of baseline knowledge of current status and rates of invasions in coastal waters and the drivers of invasion success;
3) reduced capability in many critical research (e.g., taxonomy, invasion biology) and operational (incursion response and pest management tools) areas; and
4) minimal capacity to deliver marine biosecurity due to decreasing budget allocations.

In this paper, we use the New Zealand example to identify the current and future activities to meet these challenges.

New Zealand

New Zealanders are instilled with a strong bond with the marine environment, which is particularly evident in the indigenous Maori population (Biosecurity Council, 2003). It is this bond that drives New Zealand's management of introduced marine species. Consequently, biosecurity in New Zealand was established to deliver to the outcomes associated with strong economic, environmental (including biodiversity) and cultural (social and spiritual) values (Hewitt *et al*. 2004b). New Zealand has embarked on the development of a marine biosecurity system to complement the world-class terrestrial system already in place. Biosecurity is governed primarily under the Biosecurity Act of 1993 (and subsequent amendments) and secondarily through the Wildlife Act (1953), Hazardous Substances and New Organisms (HSNO) Act (1996), Health Act (2002), and the Conservation Act (1987).

Marine Biosecurity

Since 1966, marine biosecurity has been delivered by the Ministry of Fisheries (MFish).However, following a three-year, whole of government review, the Biosecurity Strategy (2003) was developed and confirmed by Cabinet. This strategy identified numerous issues with current biosecurity delivery and identified 57 expectations, four of which are explicitly marine, for the development of a new system. As a consequence, the four central government Biosecurity agencies (Department of Conservation, Ministry of Agriculture and Forestry, Ministry of Fisheries and Ministry of Health) were tasked with developing and 'end-to end' approach to biosecurity that would deliver to explicit outcomes identified in the Strategy. The result was the establishment of Biosecurity New Zealand (BioNZ), an authority within the Ministry of Agriculture and Forestry (MAF) responsible for the 'end-to-end' delivery of biosecurity in all sectors and habitats. As a direct result, all marine functions and personnel were transferred from MFish to BioNZ in November 2004.

Current actions

The original budget allocation of 0.326 million USD (NZD 0.455 million) per annum for ballast water management was increased in 1999, when a Biodiversity budget package was delivered by Government that included 1.3 million USD (NZD 1.8 million) per annum for marine biosecurity. This allocation was identified to 1) increase knowledge in critical areas; 2) develop new policy arrangements; and, 3) increase operational capacity within government. Six specific programmes were established to deliver to these three outcomes as listed below.

Risk profiling for marine species that may arrive in New Zealand
The aim of this programme was to identify species likely to be present in ballast water or on the hulls of vessels entering New Zealand. Initial hazard identification, with some consequence analysis is critical to the success of this programme. As a start, seven species were identified and listed as Unwanted Organisms under the Biosecurity Act 1993. These are: the Northern Pacific seastar (*Asterias amurensis*); the European shore crab (*Carcinus maenas*); the green alga (*Caulerpa taxifolia)*; the Chinese mitten crab (*Eriocheir sinensis*); the Chinese clam (*Potamocorbula amurensis*); the European fanworm (*Sabella spallanzanii*) and the Japanese seaweed (*Undaria pinnatifida*). Of these species, only *Undaria* is currently present in New Zealand waters.

Compliance monitoring of ballast water exchange
This programme aims to reduce the threats associated with ballast water-aided introductions by improving the compliance of vessels entering New Zealand. New Zealand established mandatory ballast exchange-at-sea under a ballast water Import Health Standard.

Alternative management tools for marine vector threats
This programme aims to investigate the threats to marine biosecurity and biodiversity from known vectors (including ballast water and hull fouling) and to investigate measures to mitigate these threats effectively.

Baseline information to support border control
This programme conducts baseline surveys in 13 of the busiest harbours and three marinas following an internationally recognised set of protocols (Hewitt & Martin, 2001). Re-surveys (following a three-year time-lag) of eight primary ports, using identical methodologies as the baselines, will allow the detection of new invasions and provide an opportunity to determine the current rate of new introductions and the efficacy of vector management regimes put in place. The programme will also make recommendations on the location and priority of sites to be included in an ongoing surveillance regime.

Surveillance for marine pests
This programme aims to develop and implement surveillance for identified marine pests in locations with high likelihood of incursion (ports of first entry) or high biodiversity values. The development of appropriate surveillance tools, evaluated for detection likelihoods, is key to the success of this programme. The current regime is a six-monthly evaluation of eight ports of first entry for the seven declared Unwanted Organisms.

Incursion response options and systems for the marine environment
This programme aims to develop and document rapid incursion response options and systems for marine biosecurity. Marine incursion responses and pest management programmes have been documented from around the world and compared against existing terrestrial analogues in New Zealand to develop a system that is consistent with best practice. The development of incursion response and pest management tools for the marine environment has included physical removal, wrapping of piles, capping with sediments (Wotton & Hewitt 2004), and heat treatment of specified areas (Wotton *et al* 2004).

The way forward

After five years of initial Biodiversity Package funding, additional monies were sought to strategically enhance marine delivery following the release of the Biosecurity Strategy (2003). New funding in 2004 of 3.65 million USD (NZD 5.1 million) per annum brought this annual budget to 4.9 million USD (NZD 6.8 million) per annum (approximately 3% of the total biosecurity expenditure). The development of this new programme critically identified the current state of knowledge, additional gaps in capability and capacity, and the institutional arrangements required to deliver biosecurity outcomes in the marine environment. As a result, the comprehensive strategy has re-oriented the existing six programmes into a matrix approach of Pre-Clearance and Post-Clearance intervention points (mirroring the BioNZ structure) versus Risk Evaluation, Operational Tools, Data Management and Performance Measures. Given the cross-cutting nature of most of marine biosecurity activities, this matrix approach allows for an explicit evaluation of gaps and delivery points.

The existing programmes have largely been expanded upon, with additional resources for risk evaluation across the entire system allocated to link species profiling with vectors and pathways. An evaluation of the realised risks associated with hull fouling across the primary vessel sectors (recreational, fishing, commercial passenger and commercial freight) is being conducted now. This two year programme will require extensive sampling and taxonomic work to determine the relative risks associated with these sectors. Simultaneously, the identification of surrogate criteria to determine risk based on voyage and vessel characteristics will be determined. This will enable the rapid development of a tool for Quarantine inspectors.

An evaluation of ballast exchange-at-sea efficacy and a tool to determine the compliance with the standard is being developed. This tool mirrors the prototype developed by the Smithsonian (Murphy *et al* 2004). We have selected Port Phillip Bay, Victoria, Australia as the source region for these voyages, given this region's high number of introduced organisms and presence of three of Unwanted Organisms (Hewitt *et al*. 2004). Using the same voyages, we will evaluate the residual risks following complete ballast exchange-at-sea using molecular and immunoflourescent probes for the target Unwanted Organisms. This information will then feed into the determination of surveillance regimes.

We have established a Risk Management Framework to aid marine biosecurity prioritisation. This framework identified four core values that marine biosecurity is to deliver economic, environmental (including biodiversity), social and spiritual. In order that these values provide useful input into the biological risks of incursions, we must identify the key components within each value (e.g., commercial sectors within economic value) and determine the spatial distribution of these values in an explicit fashion. Using GIS, we will undertake a value identification and mapping project. This tool will couple with the species level hazard identification and impact analyses to create a rapid prioritisation framework for risk mapping, surveillance activities, incursion response prioritisation, and pest management options.

We have identified the development of internal borders as critical to Post-Clearance management. The need to minimise the spread of a species once detected in New Zealand waters is paramount. Currently, limited options exist and the significant tools and powers offered by the Biosecurity Act 1993 are blunt. Unwanted Organisms are declared for the whole of New Zealand, creating a bureaucratic delay in focussed responses. Internal borders may allow a practical and pragmatic solution to some of these dilemmas. At present, some industries have established internal borders using voluntary guidelines to minimise the transfer of pests that will cause harm to their industry. In the absence of a holistic approach however, one poor-player can negate significant gains.

Baseline surveys and resurveys are to expand to encompass all ports, including domestic ports in support of the internal border evaluation. These surveys will also provide the indication of the true extent of invasions in New Zealand. Based on the outcomes, additional incursion responses and pest management activities may be developed. But to do so, tools are required for local and broad scale implementation. For many species, once introduced, eradication may be impossible. While prevention may be better than cure, the need to have

tools in the face of a leaky border means that resources and development efforts must be put in place to increase our arsenal.

Lastly, the development of a comprehensive research strategy that brings together blue-ocean invasion biology questions with applied operational research delivery is necessary. The Ministry of Research, Science and Technology, combined with MAF BioNZ, is leading the development of a Biosecurity Research Strategy. This document however must have the buy-in by end-users (central government agencies and Regional Councils), research purchasers (some end-users and the Foundation for Research, Science and Technology), and research providers (e.g., Crown Research Institutes, Universities) in order to meet the needs of biosecurity delivery in New Zealand.

Conclusions

While marine biosecurity is a relatively young field, many gains have been made in New Zealand towards establishing a high quality, outcome-oriented system that balances costs and benefits across economic, environmental, social and spiritual values. However, in order that biosecurity is delivered in marine environments we must identify critical gaps in knowledge and capability and seek appropriate funding to address these needs. While the costs to establish a functional marine biosecurity programme may be significant in the short term, the long-term benefits far outweigh the initial investment.

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