Towards a national emergency management framework for marine bio-invasions

Ian Peebles examines the growing threat of bio-invasion to Australian waters

Introduction

The twentieth century heralded a significant increase in the capacity of major trading nations to transport merchandise, commodities and other goods rapidly between countries via ocean-going vessels. It is well documented that the increase in trade of agricultural and biological commodities derived from livestock (e.g. sera, vaccines) and horticulture (e.g. fruit, grains) presents inherent risks of the inadvertent transfer of associated pathogens. The advent of marine bio-invasions due to the accidental transfer of marine species from one ecosystem to another, represents a more recently recognised trade-related biological emergency (Rawlin and Jones, 2001). As a major trading nation, in which the majority of cargo is borne by ocean-going vessels, Australia's marine ecosystems and, in some cases, public health and maritime industries, face a significant and ongoing biological threat. This is the threat of invasion by 'exotic' marine organisms, that may be present in vessel ballast water or as bio-fouling on vessel infrastructure.

Marine bio-invasions are not only associated with trade-related activities but may also occur due to the introduction of an 'exotic' marine species into a susceptible locality by other vectors. These vectors include commercial fishing vessels, cruise ships, recreational yachts and mobile drilling rigs (Kinloch *et al.*, 2003). As a general rule, ports that receive a high volume of international vessel traffic, with an associated large volume of discharged ballast water, are regarded as being high risk potential entry points (nodes) for an exotic marine 'invader'. Other risk factors generally considered to increase the risk of marine bio-invasion between a 'donor' and 'recipient' port include:

1 environmental similarity in characteristics such as water temperature and salinity; and
2 a relatively short transit time between ports (thus favouring increased survival of marine organisms).

Defouling of an international trading vessel on a Cairns slipway
Photo coutesy of Queensland Environment Protection Agency

Background

The Port of Melbourne, located in Port Phillip Bay, Victoria receives approximately two-thirds of all sea-cargo that enters Australia and therefore could be expected to be a locality at high risk of invasion by exotic marine species. Surveillance conducted in Port Phillip Bay has indicated 99 species that are considered to be introduced and an additional 66 species that are considered to be cryptogenic (of uncertain origin), with introduced species being present from all of the world's major bioregions (except the Antarctic) (Hewitt *et al.*,1999). The rate of bio-invasion in Port Phillip Bay has been estimated at approximately two to three new species every year (Hewitt *et al.*, 1999). Nationally,

Northern Pacific Seastar (Asterias amurensis)

137 introduced marine species that have established in Australia have been identified, with an additional 146 cryptogenic marine species identified (Hayes, pers.comm.)[1].

While many of the introduced species detected appear to be relatively benign in their adopted environment, the Northern Pacific Seastar (*Asterias amurensis*), a species native to coastal waters of Japan, Korea, China and Russia is a clear example of an introduced species that has become a pest in invaded ranges in Australia. This species poses an ever-present threat of invasion to estuarine environments along the majority of mainland Australia's eastern, southern and western coastlines from Sydney to Perth, as well as Tasmania. Since its initial introduction into Australia approximately twenty years ago in the Derwent Estuary, Tasmania, the Northern Pacific Seastar has proliferated rapidly in invaded ranges in both Tasmania and Victoria (Port Phillip Bay). It is likely to have caused significant ecological impacts, although it remains difficult to quantify the impacts in the absence of *a priori* baseline data (Ross *et al.*, 2003).

The Northern Pacific Seastar typically inhabits estuarine locations and is a highly fecund (prolific), voracious predator that feeds on a wide range of marine fauna (crustaceans, sponges, ascidians, and other seastars). This invasion could be expected to have major adverse impacts on biodiversity (with flow-on effects on trophic food webs) as well as direct impacts on commercial shellfish farming operations.

In 2001, an interim list of 15 species of exotic marine pests of national concern (refer Table 1) to Australia, including species such as the Northern Pacific Seastar, was

Cluster of mature Asian green mussels (Perna viridis) detected on the hull of an international trading vessel in Cairns (August 2001)
Photo courtesy of Queensland Environment Protection Agency

adopted by all jurisdictions with legislative responsibilities to protect Australia's marine environment, through endorsement by three national Ministerial Councils[2]. The national Consultative Committee on Introduced Marine Pest Emergencies (CCIMPE) was also established to enable nationally co-ordinated responses to incursions of national concern pending the establishment of formal national emergency management arrangements for marine pests.

A national co-ordination mechanism

The Consultative Committee on Introduced Marine Pest Emergencies

The national co-ordination mechanism for the management of incursions by introduced marine pests is based on similar national arrangements that exist for emergency animal diseases via the national Consultative Committee on Emergency Animal Diseases.

The CCIMPE forum comprises representation from all lead agencies (Australian Government, State and Northern Territory governments) with legislative responsibilities to protect Australia's marine environment. Specialist technical input is provided to the forum through representation by CSIRO Marine Research and is also sought opportunistically from marine biologists and scientists with relevant expertise from a variety of sources both within Australia (e.g. Defence Science and Technology Organisation; Australian Marine Invertebrate Taxonomy network; CRC Reef Research Pty Ltd) and overseas (e.g. USDA–ARS)[3].

The Australian Government Department of Agriculture, Fisheries and Forestry provides a Chair and Secretariat for the CCIMPE forum. CCIMPE is convened on notification by any CCIMPE representative of the suspected incursion in Australia's marine environment by a pest of national concern. Initial advice of a suspected incursion is generally provided within 24 hours of an initial report being received

1 Courtesy of Keith Hayes, CSIRO Marine Research, May 2004.

2 Ministerial Council for Fisheries Forestry and Aquaculture; Australian and New Zealand Environment and Conservation Council; and Australian Transport Council

3 United States Department of Agriculture—Agricultural Research Service

Table 1. Interim CCIMPE trigger list of introduced marine pests of national concern

Scientific Name	Common Name	Taxonomic Classification
Aurelia aurita	Moon jelly	coelenterata
Caulerpa taxifolia (Aquarium strain)	Caulerpa	macroalga
Cyanea spp	Lion's Mane Jelly	coelenterata
Dreissena bugensis	Quagga Mussel	mollusc
Eriochir sinensis	Chinese Mitten Crab	arthropod
Mnemiopsis leidyi	Comb Jelly	coelenterata
Mytilopsis sallei	Black Striped Mussel	mollusc
Pfiesteria piscicida	Pfiesteria	dinoflagellate
Potamocorbula amurensis	Asian clam	mollusc
Rapana venosa	Rapa whelk	mollusc
Sargassum muticum	Asian Seaweed	macroalga
In Australia but limited in distribution		
Asterias amurensis	Northern Pacific seastar	echinoderm
Codium fragile spp. tomentosoides	Dead Man's Fingers	macroalga
Musculista senhousia	Asian date mussel	mollusc
Undaria pinnatifida	Undaria	macroalga

and investigated. A teleconference is generally scheduled within 72–96 hours of receiving notification from an affected jurisdiction to enable its personnel to conduct a preliminary site investigation and provide an informative situation report to the CCIMPE forum for its consideration. Meeting via teleconference provides considerable efficiencies for all parties in terms of both time and money and is a *modus operandi* that facilitates participation by representatives from each jurisdiction.

In response to a situation report provided by an affected jurisdiction, the CCIMPE forum evaluates the relevant information and advises the affected jurisdiction whether any actions proposed are either supported, should be modified or, in the event of a situation that is not considered to represent a marine pest emergency of national significance, that no further action is required (from a national perspective).

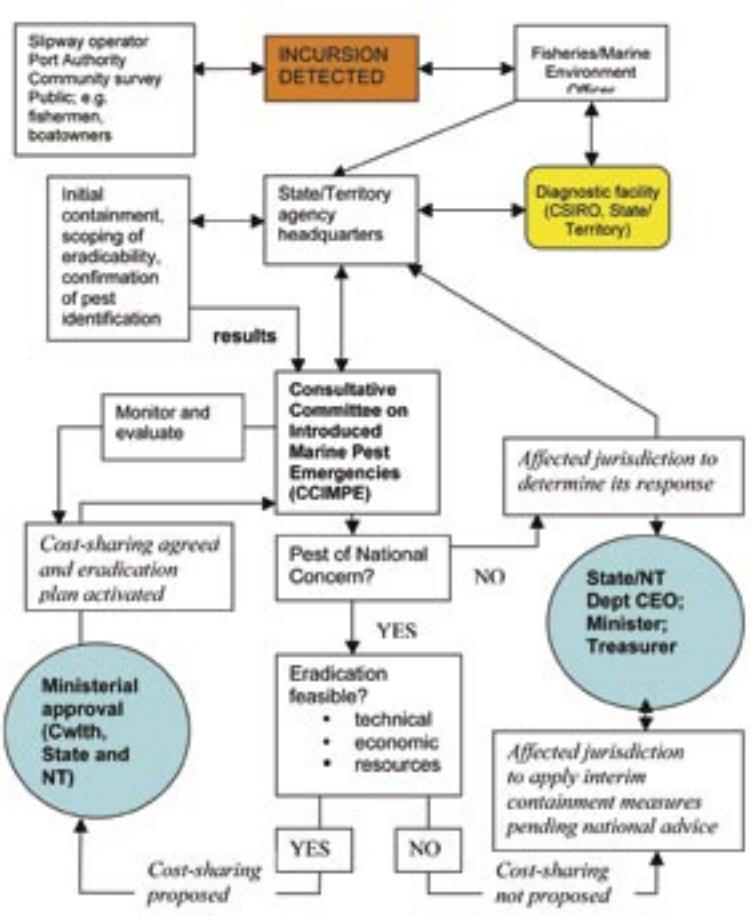

Figure. 1. Schematic Outline of National Emergency Response Framework for Incursions by Introduced Marine Pests

CCIMPE's charter is restricted to the emergency management of incursions by introduced marine pests[4] of national concern. It does not encompass the emergency management of incursions by indigenous marine pest species that are translocated across regions within Australia, nor of freshwater aquatic pests (either exotic or indigenous).

To facilitate resourcing of an emergency response, interim national cost-sharing arrangements were established in 2001. Under the terms of those interim arrangements, the Australian Government, States and Northern Territory agreed an expenditure ceiling of $5 million over a two year period. When all parties agree to provide funding to assist an affected jurisdiction to conduct an emergency response, the Australian Government contributes 50 percent of funds, with an equal commitment provided collectively by all States and the Northern Territory on a per capita basis.
A national Emergency Marine Pest Plan (EMPPlan), that was developed based on AUSVETPLAN response plans for emergency management of diseases of terrestrial livestock and AQUAVETPLAN[5] emergency management response plans for diseases of aquatic animals, is also in place and provides guidance on costs that are eligible for funding under the interim national cost-sharing arrangements. EMPPlan provides a structured emergency management framework that comprises four phases of activation:

1 Investigation;
2 Alert;
3 Operations; and
4 Stand-down.

Table 2. Existing criteria against which CCIMPE evaluates an introduced marine species

Demonstrable invasive history
Demonstrable impact in native or invaded ranges on: – economy; – environment; – human health;or – amenity
Inferred as likely to have major impacts in Australia based on the overseas data and characteristics of Australian environments and marine communities; and
Whether one or more relevant transport vectors are still operating

The decision-making process

To reach agreement to mount a cost-shared eradication response, the CCIMPE forum has to make two principal determinations:

1 whether the pest in question is a pest of national concern[6];and
2 whether it is likely to be eradicable.

A schematic outline of the national emergency decision-making process following reporting of an introduced marine pest is provided in Figure 1.

Any of the 15 pests listed on the CCIMPE 'trigger list' (refer Table 1), as endorsed via relevant ministerial councils in 2001, are considered to be pests of national concern. For species that are not included on the interim 'trigger list', the CCIMPE forum endeavours, on a case by case basis, to access as much information as possible both from within Australia and from relevant overseas specialists to evaluate whether a newly detected introduced species warrants activation of emergency response actions.
In situations where there is little or no overseas information available, a decision to mount an emergency response may need to be based solely on the post-introduction behaviour (e.g. smothering, fouling, establishment of monocultures, displacement of indigenous species) of an introduced species in its new environment. Once all information that can be readily gathered in a timely fashion is obtained, the pest in question is evaluated against the criteria outlined in Table 2 to determine whether or not activation of an emergency response is warranted.

Existing arrangements provide considerable scope for conservative decision-making in that an introduced marine species of uncertain pest potential is only required to satisfy one of the evaluation criteria to be considered as potentially warranting an emergency response.

There are relatively few successful eradications of marine pests that have been documented and accordingly, relatively few guidelines for determining whether or not a marine pest is likely to be eradicable. Successful eradication of marine pests has only been achieved where incursions have been relatively limited in distribution and/or able to be confined. Successful eradications have involved the use of chemicals (*Mytilopsis sp.* in Northern Territory, Australia;), physical removal and burial (*Perna canaliculus*, South

4 An introduced marine pest is defined as one that was originally considered to have been exotic to Australia
5 Aquatic Veterinary Emergency Plan
6 That is, one included on a nationally agreed trigger list, or if not, one deemed likely to have similar significant negative effects in Australia in terms of economic, environmental, public health or amenity values.

Incident #1. Caribbean tubeworm *(Hydroides sanctaecrucis)*

Hydroides sanctaecrucis is a sedentary fouling serpulid worm that constructs calcareous tubes approximately 20mm long on hard substrates

Location and Date of Detection
Cairns, Queensland in May 2001 on the hulls of two navy 'landing' vessels slipped for routine maintenance.

Impacts
A nuisance fouling species due to excessive proliferation of calcareous tubes that can form extensive reefs on submerged structures including wharves, pontoons, mariculture equipment and slow moving vessels. Potential to establish in vessel cooling systems and cause engine damage/malfunction.

Lead agency
Queensland Environment Protection Agency

Phases of Activation
Investigation, Alert, Stand-down

Outcome
Emergency investigation conducted via dive surveillance of numerous hard substrates indicated infestation with *H. sanctaecrucis* was widespread around the port of Cairns. Examination of archived specimens collected from anti-fouling paint test rafts confirmed presence of *H. sanctaecrucis* in Cairns since at least January 1999. Eradication was not considered feasible. Short and long term management actions implemented focused on boat-owner awareness, improved antifouling and vessel maintenance practices.

Comment
Early and accurate detection did not occur as *H. sanctaecrucis* was mistaken for *Hydroides elegans,* a related fouling organism already present and widespread in Australia.

Australia, Australia), physical removal of potential hosts (parasitic sabellid shell borer; California, United States), repeated physical removal (*Caulerpa taxifolia;* Cala D'or, Spain), and physical smothering in combination with chemicals (*Caulerpa taxifolia;* California, United States).

In reviewing rapid response options, McEnnulty *et al.* (2001) note that the potential of most control techniques available for pest species to cause collateral damage for other species and/or the environment, is a particular constraint to the eradication of marine pests. Although chemicals such as copper sulphate and chlorine have been used to achieve eradication outcomes in certain marine environments (Bax, 1999; Anderson, pers. comm.[7]), the broad application of hazardous chemicals in open-water environments is likely to be unacceptable due to the considerable potential for harm to non-target species. In addition, particularly for chemicals with poor bio-degradability, there is considerable potential for residual adverse environmental effects well beyond the intended time-frame of action. Accordingly, for many marine pests, physical removal remains the only acceptable eradication option available, thus presenting significant limitations to the eradication of pests of national concern, particularly in low visibility environments.

While the lack of readily applicable tools provides significant limitations to the eradication of incursions by marine pests of concern, McEnnulty *et al.*(2001) provide a number of useful parameters that are likely to increase the feasibility of achieving a successful eradication outcome, as outlined below:

- Knowledge of the basic ecology and physiology of an invasive pest
- Early and accurate detection post-introduction
- Ability to quarantine an area while eradication is being considered
- Survey capacity to determine whether pest is restricted to quarantine area
- Low risk of reintroduction
- Pre-existing knowledge of available eradication options
- Pre-existing decision-making procedures and structures with powers to determine whether eradication should proceed, how and who should fund it;
- Sufficient technical, field, administrative, funding and legal resources to plan an eradication campaign;
- Ongoing monitoring to modify, amplify or end eradication campaign; and
- A willingness to act by all parties.

In situations where CCIMPE considers that a pest is either not a pest of national concern, or that an incursion is not likely to be eradicable and therefore activation of an emergency response operation is not warranted, an affected

7 Courtesy of Dr Lars Anderson, USDA Agricultural Research Service, March 2003

jurisdiction is responsible for implementing interim containment measures to minimise the risk of further local spread. This includes minimising the risk of translocation pending appropriate consideration by the relevant national policy forum, the National Introduced Marine Pest Coordinating Group, on national arrangements for long-term ongoing management and control.

Legislative basis to act

The interim emergency management arrangements for marine pests have operated primarily under State and Territory legislation and it is intended that this should continue to be the modus operandi when formal emergency management arrangements become established. Formal arrangements will be underpinned by an intergovernmental agreement that outlines agreed co-ordination and funding responsibilities between the Australian Government and the governments of the States and the Northern Territory.

Giant fanworm (Sabella spallanzanii)—*A european invader widespread in southern Australian waters*

Case studies

Following establishment of the interim national emergency management arrangement in 2001 there have been a number of incidents when the national Emergency Marine Pest Plan has been activated and national co-ordination arrangements have come into effect. These are outlined below in report card format.

Incident #2. Asian green mussel *(Perna viridis)*

Perna viridis is a large bivalve mussel ranging in size between 80-165 mm that forms dense populations (up to 35,000 individuals per square metre) on a variety of structures including vessels, wharves, mariculture and hard substrates. *P. viridis* has a broad salinity and temperature tolerance but is generally found in tropical estuarine habitats. It is widely cultivated as a food species throughout the Asiatic region.

Location and Date of Detection
Cairns, Queensland in August 2001. Significant colony (hundreds) of mature mussels detected on the hull of a Hong Kong registered trading vessel that had been seized in Cairns by Customs (in 2000) due to illegal (people) entry activities and was being slipped for cleaning.

Impacts
A dense, fouling species that affects the cooling systems of industrial complexes, increasing corrosion and reducing efficiency. Fouling of vessel hulls and intake pipes can raise vessel maintenance and running costs. It has the potential to establish in vessel cooling systems, increasing corrosion of internal seawater pipes and cause engine damage/malfunction.

Lead agency
Queensland Environment Protection Agency

Phases of Activation
Investigation, Alert, Operations, Stand-down

Outcome
Emergency investigation identified a number of poorly maintained vessels moored in proximity to the infested vessel. A quarantine zone was established in Trinity Inlet Cairns and at-risk vessels were progressively slipped for cleaning and inspection over a three-month period. Vessel internal sea-water systems were also treated with biodegradable detergent to minimise the risk of patent infestations. Of 56 vessels slipped for cleaning, further infestation was detected on a total of eight vessels. One additional mussel was also detected on a mooring buoy. Subsequent to completion of the intensive vessel treatment and slipping operation in June 2002, mussels have been detected on the hulls of three vessels and in May 2004 one adult mussel was detected on the frame of an anti-foul paint test raft.

Comment
The detection of a sexually mature adult mussel in May 2004 confirms that complete elimination of the mussel population present in Trinity Inlet, Cairns has not been possible. Ongoing monitoring is being carried out via slipway operations and other surveillance in an effort to identify the possible location of other mussels in Trinity Inlet. Although it is likely there have been a number of spawning events, it remains feasible that, with a high rate of larval attrition and a small base population, the remaining (undetected) mussel population present is too small to establish a self–sustaining population.

Incident #3. Northern pacific seastar *(Asterias amurensis)*

Asterias amurensis is a large seastar with a small central disk and five distinct arms that taper to pointed tips. The seastar is a voracious predator and in its native range (China, Korea, Japan, Russia) is a major pest for the shellfish industry sector.

Location and Date of Detection
Seastars were detected in rockpools near Inverloch, Victoria in January 2004. The nearest known population of *A. amurensis* to this locality was at Port Phillip Bay, approximately 120 km west of Inverloch.

Impacts
The seastar feeds on a wide range of marine fauna and can have an adverse effect on the recruitment of shellfish populations that form important components of the marine food chain. Indications are that it can also have significant impacts on farmed shellfish (e.g. oysters).

Lead agency
Department of Sustainability and Environment, Victoria

Phases of Activation
Investigation, Alert, Operations (current at time of writing)

Outcome
Emergency investigation identified a relatively localised infestation within the tidal estuary of Anderson's Inlet. An emergency response operation was established based on physical removal of seastars by scuba divers. Ongoing dive activities supported by volunteers and the local community has lead to the physical removal of over 260 seastars in the affected locality. Indications are that this represents a significant reduction in the available population, as the dive effort required to detect seastars (as at 7 June 2004) is significantly greater than the effort required to detect seastars in April 2004.

Comment
CCIMPE considered the detection of Northern Pacific Seastar at Inverloch to represent a significant translocation from the pest's existing range within Australia (in Port Phillip Bay, Victoria and Tasmania) as it increases the potential for the seastar to establish along the eastern seaboard of Australia, where there is significant fishery sector activity (both recreational and commercial). Based on the existing population of *A. amurensis* in Port Phillip Bay, the seastar is known to spawn in Victorian waters between May and July. Although the emergency response operation appears to have resulted in a significant reduction of the seastar population at Inverloch, it is unlikely that all adult seastars will be removed from the locality before spawning occurs. Follow up surveillance will be required in early 2005 to determine whether additional recruitment of juvenile seastars has occurred in the affected locality.

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