AMSA position paper on marine pests

1.0 Description of the problem

Marine pests are those species that do not occur naturally in an environment but rather have been introduced into that environment in relatively recent times, usually by anthropogenic means. Marine pests have also been referred to as non-endemic, non-indigenous or invasive species. Marine pests, like their terrestrial counterparts (rabbits, foxes, blackberries, etc), pose a significant threat to the Australian environment and economy by disrupting ecological processes, posing risks to fish stocks and aquaculture operations, and threatening both the interstate and international trade. Once established, marine pests often have long lasting impacts, and they are usually impossible to eradicate. Even controlling the abundance of most marine pests is not currently possible as there are very few tools available for control, and knowledge of the ecology of Australian marine ecosystems is inadequate.

Typically, after a new exotic species is introduced it takes several years for it to become abundant enough to be considered a pest. Consequently, the agent responsible for the introduction can seldom be identified precisely enough to be held responsible. Typically negative effects of an introduction accrue to the broader public that use the marine environment, particularly for recreation or livelihood purposes.

At present there are few reliable cost estimates of impacts due to invasive marine species in Australia, but eradication of the black striped mussel from three marinas in Darwin cost in excess of $2.2 million. In late 2006 a dredge with the Asian green mussel entered the port of Dampier. The vessel was required to go to Singapore where it was dry docked and cleaned before returning to Dampier. The cost was in the millions of dollars. In the Great Lakes (USA), introduction of the lamprey has resulted in an ongoing control program costing $15 million annually, and programs to control fouling of infrastructure by the zebra mussel cost more than $500 million annually. There are few estimates of the cost of environmental impacts caused by exotic species, but an exotic comb jelly is implicated in the collapse of major fisheries in the Black Sea, and there is strong evidence that dieback of pilchards across southern Australia was caused by an exotic virus. Similarly, there is strong evidence that the invasive northern Pacific seastar has caused a large decline in the biomass of fish in Port Phillip Bay, and may have hastened the decline of Australia's first listed endangered marine fish, the spotted handfish, in Tasmanian waters. Concern to prevent the spread of the northern Pacific seastar has also resulted in restrictions on ballast water uptake for vessels en route from Port Phillip Bay and Hobart to New Zealand.

Improved knowledge of the number of marine invaders will require more comprehensive surveys and a much better characterisation of Australia's marine biodiversity. There remain many organisms (eg plankton, meiofauna and parasites) where taxonomic knowledge is inadequate to determine how many species are exotic. It is generally accepted that in some major groups the vast majority of invertebrates in Australia's marine realm are as yet undescribed or undiscovered (see AMSA's position paper on taxonomy). In addition, Australia currently has a critical skills shortage of marine taxonomists, with little indication that the situation will improve in

the near future. The scarce knowledge of Australia's marine biodiversity, along with the paucity of marine taxonomic expertise, together pose a major limitation for the detection and management of marine pests. The challenge may be even greater with the combined threat of climate change that may also result in environmental disturbance (i.e. via changes to temperature, salinity, pH, foodwebs, habitats, etc) and facilitate the success of invasive species.

The available data suggest that introductions of exotic species are greatest in temperate coastal areas of Australia. Port Phillip Bay appears to be Australia's most invaded port with between 100 and 200 exotic species having been recorded, and an estimated 3-4 new invasives establishing there annually. But only a small fraction of these species (~10) appear abundant enough to be considered pests. While fewer exotics have been recorded in northern Australia, if the Asian green or black striped mussel were to establish in this region, major impacts would be expected.

1.1 Understanding processes leading to invasion

Ecologists are still trying to understand why only a small proportion of exotic species become pests. Do particular exotic species have some competitive advantage over the native fauna, or is disturbance of native ecosystems an important aspect of transforming exotic species into pests? Of course, both processes may be important in different circumstances.

Exotic species may arrive in their new environment without their full complement of parasites and predators, or, if they are themselves predators, then they may not be recognised as dangerous by their new native prey. Reducing the risk of their initial establishment by reducing the number of exotic organisms reaching Australian waters may be the only practical defence. Alternatively, if human disturbance of the receiving environment is a major determinant of the success of pests, then resources may be best directed at minimising those human disturbances that facilitate the growth of each pest population. For this approach to be successful ecological studies are required to identify those disturbances important to each pest species.

Human disturbances to marine ecosystems that may facilitate invasions include high nutrient levels, contamination, reduced freshwater flows, habitat changes, high levels of fishing and the presence of other exotic species. The latter may be of special significance as each additional exotic species may facilitate the establishment of further exotic species, and, in time, may lead to essentially irreversible changes to marine communities.

1.2 Major sources/vectors for exotic marine pests.

The main sources of 'accidental' introduction of marine exotic species are ballast water and as biofouling in a range of vessels (ships, smaller international vessels, fishing vessels, recreational vessels, etc), aquaculture, the aquarium and live seafood trades. In addition, some species have been introduced deliberately for aquaculture (Pacific oysters), to stabilise channel banks (*Spartina*), etc, and have subsequently formed feral populations.

1.3 Is the problem increasing?

There is some evidence that introductions of exotic species are increasing worldwide. This may result from the increasing size, speed and frequency of visits from vessels and from the incorporation of new regions into international trade routes. Alternatively, some pest species may result from ecological changes that have made ecosystems more susceptible to invasion. For example, nutrient enrichment, chemical contamination and overfishing in the Black Sea may have contributed greatly to the invasion of this region by an exotic comb jelly, which subsequently dominated the ecosystem. Consequently, it is important to not only reduce the introduction of new invaders, but to also reduce the impact of other human disturbances, which may include the effects of other invasive species.

2.0 Solutions to the problem

2.1 Reduction in the number of new exotic organisms reaching Australia

Prevention is by far the most cost effective means of pest control. Prevention techniques and strategies need to be developed for each of the major vectors, including ballast water, biofouling, aquaculture and the transport of live seafood.

Ballast water

Non-discharge of ballast water is currently the only available management option that will prevent all ballast-related pest translocations, but this option is usually impractical for existing shipping. Exchange of ballast water at sea is a more practical management option, but its efficacy remains uncertain. Bad weather may make exchange at sea impossible, and even when 95% of ballast water is exchanged, the large volumes of ballast involved mean that many live exotic organisms may still be discharged in port. However, in the absence of better management options, non-discharge or at-sea ballast exchange should be implemented for all international and national shipping as soon as possible to reduce the numbers of exotic propagules reaching Australia and their transfer between Australian ports. There remain many uncertainties with this approach, and further research and development are required to reduce the number of new exotic species reaching Australia, in the following areas:

- Development of cost-effective treatment methods, either ship or port-based.
- The development of integrated treatment and risk management systems to reduce the economic impact on shipping. For example, the risk of ballast water discharge from international vessels entering Australian ports, and from domestic vessels in Victorian waters are assessed currently.
- Studies to ensure sites currently designated as “safe” deballasting areas are indeed safe.
- Further development of techniques (including genetic probes) to verify the efficacy of ballast water treatment.
- Improved ship design to facilitate ballast water management.

Biofouling

Biofouling is the colonisation ("fouling") of immersed surfaces by marine organisms, such as barnacles. Biofouling appears to translocate similar numbers of exotic species as ballast water. Anti-fouling systems need to be developed, documented and authorized for all vessel surfaces that can become fouled, including hulls, propellers, sea chests, internal pipes, anchor wells and mobile equipment (eg fishing gear) that is periodically immersed in water. The risk of a surface becoming fouled varies with the type of vessel and its recent history. Different strategies may have to be developed for commercial, fishing and recreational (in water and trailerable) vessels as well as mobile marine infrastructure such as rigs, barges, tugs and dry docks. Further research is required to ensure management of biofouling is well targeted. For example, it remains unclear whether most exotic species are transported on a small number of heavily fouled vessels, or as a result of the cumulative effect of many lightly fouled vessels.

Tin-based antifouling compounds are being phased out globally because of their toxicity to marine animals. Copper-based systems may follow. Research is required to develop, improve and implement effective (and preferably non-toxic) anti-fouling technologies. Successful antifouling management requires the certification of adequate anti-fouling systems and encouragement of their use. Assessing the benefits and detriments of anti-fouling systems is technically complicated, and Australia requires a single competent authority to assess and recommend systems for use. Until an effective nationally accredited system to control biofouling is implemented, there are a number of actions that should be implemented. Proof of adequate antifouling treatment within the recent past (1- 5 years depending on the treatment) should be provided to AQIS before vessels enter Australian ports. Any international vessel found to be heavily fouled should not be allowed into Australian ports. Fouled Australian vessels should be cleaned before being transferred to another port, marina or mooring. In-water hull cleaning of vessels potentially carrying exotic species (except for propeller polishing and controlled cleaning of niche areas) should not be permitted in Australian waters and vessels should only be cleaned in dry docks, where all debris must be fully contained. Improved antifouling treatment must be applied to vessel niches. Such areas have often been ignored, because unlike hull fouling, fouling of these areas does not decrease fuel efficiency.

For recreational and small commercial vessels an ethic of cleaned vessels needs to be developed with the small boating community, to prevent the spread of exotic species between infested and uninfested waters.

Strategies for the prevention and control of fouling in internal piping systems must also be developed. Commercial Marine Growth Protection Systems (MGPS) are available and commonly used on in some shipping and boating sectors, but a clearer understanding of their action and efficacy is needed. Effective and environmentally safe dosing or treatment methods to remove or kill biofouling in pipework on small craft or vessels without an effective MGPS are also needed. In the interim, the likelihood of fouling occurring in internal systems should be assessed and actions taken to isolate and clean the systems taken if a risk exists.

Aquaculture, aquarium and live seafood trade.

Industries that involve the transportation of live marine organisms, such as aquaculture or the marine aquarium trade, need to be controlled to ensure that pests and diseases are not introduced into or spread around Australia by pests and diseases surviving transport. Intensive farming also provides a high density of hosts that may facilitate the establishment of any exotic disease introduced. These industries require the development of sterilization methodologies for the transport of equipment (eg nets, cages, vessels), water, and live organisms (eg fish, mussels ropes, fish food, spat, bait). The marine aquarium trade should be encouraged to use the huge diversity of native Australian species available. It would be prudent to ban the importation of species for the marine aquarium trade, to prevent their release into the wild, and to encourage the use of native species by this developing industry.

2.2 Prevention of establishment of marine pests

Many of the same species occur in many ports throughout the world, suggesting that ports may be their preferred habitat. Research is required to design ports that are more resistant to invasion by exotic species. This will act as a second line of defence should propagules be released, so they are less likely to become established.

Small pest infestations of species with limited dispersal abilities can be eradicated if detected early. Routine monitoring of ports and jetties targeted at new pests, where early detection could lead to rapid eradication, should be undertaken, and the authority responsible for this action identified. The Consultative Committee on Introduced Marine Pest Emergencies (CCIMPE) currently supports a rapid response capability to eradicate newly located aquatic pests. The National Introduced Marine Pests Co-ordination Group (NIMPCG) should ensure the development of minimum monitoring requirements for ports and the development of contingency plans for the rapid eradication of new infestations of those species where this approach appears feasible.

2.3 Management of established exotic species

Control of existing pests needs to be given a high priority for research, both to minimise their impacts and because exotics contribute to cumulative ecological change that make ecosystems more vulnerable to further invasions. Furthermore, if there are too many invasions (eg. 80-90% of species in San Francisco Bay are exotics) then ecological changes probably become irreversible.

There is no example of a deliberately introduced species resulting in biological control of a marine pest, and very extensive research would be required before any new species was introduced for marine biocontrol. However, the unintentional introduction of a predatory ctenophore appears to have been an important factor in controlling a comb jelly population that had previously devastated the ecology of the Black Sea. Where human disturbance is shown to be an important factor in elevating an exotic species to pest status then reversal of the initiating disturbance, in conjunction with additional ecological restoration where necessary, may result in effective control of the pest. There are also new genetic techniques (eg. daughter-less

males) that appear to have considerable potential for controlling the abundance of a range of exotic species that need further development.

Where it is unclear which exotic species are causing the most impact, and this inhibits attempts at control, or causes scarce resources to be devoted to low impact species, studies of impacts are justified. However, it is important that excessive resources are not devoted to the prioritization process, and in some instances resources may be better directed at reducing a disturbance that facilitates the dominance of a suite of exotics in the same habitat, rather than dealing with individual species.

2.4 Governance and jurisdictions

Shipping operates across international and state boundaries and understandably the shipping industry desires internationally consistent regulation. Unfortunately, reaching international consensus takes a long time, and state and national regulations are being introduced while international discussion on more consistent regulation continues.

Long Term Monitoring is Critical

Recent surveys of Australian ports have improved our knowledge of the distribution of exotics around the Australian coast, but ongoing monitoring and the identification of new exotic species remain problems.

Long term monitoring is required to assess impacts of exotic species on natural ecosystems, and to assess the effectiveness of new measures introduced to minimise new introductions. If well designed, these monitoring programs would also enable assessment of ecological changes due to a range of other human impacts. It is also important that specimens from long-term monitoring and port surveys are deposited with institutions conducting long-term biodiversity research (usually museums, herbariums).

The poor documentation of the rich Australian marine flora and fauna, and our increasing trade with regions of the world with even more poorly documented biotas, means that identification of new invaders requires adequate support for museums and research institutions to improve our knowledge of marine taxonomy. This is especially important for species of uncertain geographic origins. Taxonomic uncertainty may impede a rapid eradication response. For example, some pests (eg. *Codium fragile*, *Caulerpa taxifolia*) have both native and exotic/invasive subspecies/strains.

A formal scientific process is required to evaluate and list exotic species. There is as yet no fully agreed list of actual or potential marine pests in Australian waters, and there are also other species not yet in Australia that could become pests if they are introduced. The process of listing an exotic species as a pest should be made more transparent, although a more objective assessment of current pest species requires increased investment in assessments of their impacts. The continuing work of NIMCPG in this area is warmly acknowledged.

Towards a National Management System

In 2001 AQIS introduced a ballast water management system for international vessels entering Australia. Under this system any ship entering Australia must manage any high-risk ballast water. This involves a mid ocean exchange of 95% of ballast water that is assessed as high risk. At the same time the practicality of tighter controls on domestic ballast water were examined at the Port of Hastings in Victoria. For a trial period of 12 months, all domestic vessels entering the port were subject to the same management requirements that are normally applied to international ballast water.

Following the successful completion of this trial, the Victorian Government introduced tighter ballast water controls. Since July 2004, all ships visiting Victorian ports have had to manage their Australian domestic ballast water under a new Waste Management Policy (ships ballast water). A national system for the prevention and reduction of the spread of marine pests (including vectors other than ballast water) is currently being developed. As the risks of pest translocations between Australian ports are much easier to assess than those of new pests coming from overseas, the early implementation of national controls on domestic ballast for all Australian ports is highly desirable.

A national focus

Translocation of exotic species is an international problem, so it is critical that Australian research and management of exotic pests has a national focus. A national effort will provide scientific support when negotiating international agreements, and act as a link between those working on exotic species in state agencies. Currently national policies on marine exotics are developed cooperatively by state and federal agencies. Progress towards a national consensus will be assisted by a stronger national research effort. The broad aims of a new national effort would be to facilitate research, policy development, and education in the following broad areas:

- **Research**
    - Build and design systems that prevent the transport of exotic species, through improved
        - ballast water treatment technology,
        - inhibition of biofouling,
        - methods to identify species present in ballast water,
        - ship design.
    - Improve resistance to invasion, through
        - assessment of the adequacy of “safe” deballasting areas, improved assessment of the role of disturbance in marine invasions, and by minimising and reversing disturbance where possible,
        - development of “invader unfriendly” port designs.
    - Develop new tools to improve management of existing marine pests, including the development of new genetic techniques.
    - Undertake long term monitoring of changes in establishment rates of new exotic species to assess effectiveness of prevention policies.

- Improve knowledge of taxonomy of potential pest species, including groups where taxonomy has limited our assessment of impacts (eg. plankton, meiofauna and parasites).

- **Policy and Management**

  - Implement at-sea ballast exchange for all international and domestic shipping - while more effective methods are developed.
  - Develop integrated treatment and risk management systems to reduce economic impact on shipping.
  - Establish a technical body to recommend antifouling treatment methods specific for different ship surfaces.
  - Develop controls for transport of live marine organisms into and around Australia.
  - Undertake routine surveys of ports and jetties to aid early detection of those species where rapid eradication is possible and to assist in risk assessment.
  - Develop a transparent system for assessing key marine pest species.

- **Education and communication**

  - Act as the primary source of information on exotic species in Australia to support activities in the state research institutions and universities.

3.0 Recommendations

AMSA supports the following strategies towards minimizing the problem of existing and further introductions of marine pest species:

- The development of a national research centre/facility dedicated to identifying, preventing and eradicating marine pests, including contributing to national policy and contributing to smart ship and marine infrastructure design (e.g. a CRC-like arrangement would provide the across agency linkages required for such a complex, multidisciplinary national issue).

- Address the critical skills shortage of marine taxonomists in Australian museum, research and academic institutions, including relevant curricula are available at tertiary level to encourage and support future generations of taxonomists.

- Establish long-term, representative datasets via monitoring major ports and harbour facilities around the country on a regular basis. This would facilitate early detection of pests, and provide a baseline against which future environmental change (including that from climate change) may be assessed.