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Australian Ship Owners Association (ASA) – Commercial Vessel Bio-fouling

AUSTRALIAN SHIPOWNERS ASSOCIATION

ASA

COMMERCIAL VESSEL BIOFOULING – 'NICHE AREAS'
PROGRESS REPORT

Contents

Australian Shipowners Association

every nook and cranny...

Commercial vessel biofouling—'niche areas' progress report

A brief background

The commercial vessels biofouling project is a government and industry cooperative project to determine the risk posed by niche area biofouling on commercial vessels and develop guidelines that can be adopted by shipowners and drydock managers to minimise the risk of marine pest translocation through biofouling.

The project is funded by the Natural Heritage Trust through the Commonwealth Department of Agriculture Fisheries and Forestry and exists with valuable in-kind support provided by Australian shipowners, ASA, the Defence Science and Technology Organisation and Museum Victoria.

Bilge Keel:
Severe fouling along bilge keel and anodes.

ASA is the project manager for the Commercial Vessels Biofouling Project.

where it all began...

Seachest Grate: *Barnacle fouling -seawater intake grate.*

In 2001 the paint patch trials run by ASA independently tested the efficacy of 5 brands of TBT-free antifouling paints. These new generation paints were found to perform as well if not better than the TBT equivalent.

During the inspections of the paint patches, it became apparent that even where antifouling paint is working effectively and the main hull surface is clean and free of fouling, niche areas can often be heavily fouled with marine organisms. Examples of niche areas include:

- Seachests and grates
- Sea water inlet and outlet pipes and grates
- Propellors
- Bilge keels
- Docking block strips
- Anodes

Having identified the specific areas requiring attention a project has begun that looks further at biofouling issues on commercial vessels.

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Aim #1 – to check every nook and cranny for biofouling potential

What are we doing?

Inside Seachest: *Remnants of barnacle fouling inside seachest.*

The project involves opportunistic inspections of 8 commercial vessels at drydock in Australia and Singapore and will for the first time make an assessment of the actual risk of marine pest translocation through niche areas.

Through discussions with antifouling manufacturers, dry dock managers, ship managers and owners and others with expertise in the area, guidelines will be developed that can be implemented in ship design, operation and maintenance to minimise marine biofouling in these areas.

how is it going?

Three dry dock inspections have been completed so far. Sea chests and sea chest intake and outlet grates are proving to be the most problematic areas. Barnacles dominant in presence and have been found alongside clusters of mussels, hydroids and tubeworms. Mobile species such as crabs have also been found in severely fouled areas.

It has become clear that marine growth protection systems can be highly affective in limiting growth and can be successful in destroying established organisms.

ideas for the future?

There are a number of reasons why marine organisms are able to settle and establish within niche areas on ships' hulls including;

Increased or decreased water turbulence in particular area of hull prematurely removing antifouling or preventing active biocide release.
Defects in antifouling paint or primer coating.
Reduced coating thickness on perpendicular angles.
Mechanical damage to hull coating.

These reasons need to be considered when developing successful management options.

Aim #2 – to find practical ways to reduce biofouling

A number of possible ways to reduce fouling are currently being considered for specific niche areas. These include:

- Replacing square bars on intake and outlet grates with round bars.
- Development of a protocol for periodic operation of MGPS.
- Moving position of docking blocks at each dry dock.
- Reducing refuge areas and creating flush surfaces where possible.
- Using different antifouling products for different areas on the hull.

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2

CSIRO Assessment for potential spread of green macroalga

AN ASSESSMENT OF THE POTENTIAL SPREAD AND OPTIONS FOR CONTROL OF THE INTRODUCED GREEN MACROALGA *CODIUM FRAGILE* SSP. *TOMENTOSOIDES* ON AUSTRALIAN SHORES

Centre for Research on Introduced Marine Pests

Note: On line at http://www.marine.csiro.au/crimp/reports/

An assessment of the potential spread and options for control of the introduced green macroalga *Codium fragile* ssp. *tomentosoides* on Australian shores

Summary

The large, green macroalga *Codium fragile* is a research model for many fields from algal physiology and heavy metal accumulation to invasion ecology, algal genetics, and natural products. In different parts of the species' broad geographic range, *C. fragile* is consumed by humans, used as invertebrate food by the mariculture industry, is a pest of natural and cultivated shellfish beds, and is a source of bioactive compounds. The species contains at least six distinct subspecies in addition to morphologically heterogeneous populations (with no subspecific name) on temperate and boreal shores throughout the world. Three of the subspecies occur primarily as introduced forms. Ssp. *tomentosoides* the topic of this review probably originated from Japan and is one of the most invasive seaweeds in the world, with extensive trans-oceanic and inter-oceanic spread this century.

Codium fragile ssp. *tomentosoides* is regarded as a serious ecological and economic pest on NW Atlantic shores, particularly for the shellfish industry. On shores of S England and W Ireland, the alga is not considered a pest but has reputedly replaced the native congener *C. tomentosum*; whether this change was due to a competitive displacement or to a temporal replacement has never been investigated. The current problem is the recent spread of *C. fragile* ssp. *tomentosoides* to SE Australia, presumably from New Zealand. In this report, I describe the biology of the alga, predict the alga's future range on Australian shores, and evaluate the potential ecological, economic, and social consequences of the alga's incursion.

Two native subspecies of *Codium fragile* (*tasmanicum* and *novae-zelandiae*) and several morphologically similar congeners inhabit the invaded region, so the detection and monitoring of the invader will be complex. There are four known incursions of *C. fragile* ssp. *tomentosoides* on Australian shores: Corner Inlet (1995), Port Phillip Bay (1997), and Western Port Bay (1998) in Victoria, and North West Bay and D'Entrecasteaux Channel (pre-1999) in Tasmania. Despite the recent appearance of the alga, its population densities are impressively high, indicating that the alga may become more of a nuisance on Australian shores than it has on New Zealand shores.

Based on the alga's temperature and salinity tolerances, I predict that *Codium fragile* ssp. *tomentosoides* will spread to wave-protected bays, lagoons, and estuaries in New South Wales, Victoria, Tasmania, South Australia, and Western Australia. Primary vectors of introduction and spread are shellfish transplants, algal drifting, and fouling of ship hulls, nets, ropes, etc. Given the alga's high regenerative capabilities, broad distribution in Australasia, and often high population densities, eradication of ssp. *tomentosoides* from an area once it becomes established is not considered possible. Control efforts should be directed at preventing the spread of the alga to areas not yet contaminated. To achieve this, priority should be given (i) primarily to enforcing stringent quarantine and decontamination procedures for shellfish translocations and (ii) secondarily to reduce ship hull fouling by both the undifferentiated and differentiated stages of the alga.

Reference: Trowbridge C.D. (1999). *An assessment of the potential spread and options for control of the introduced green macroalga Codium fragile ssp. tomentosoides on Australian shores.* Report to the Victorian Department of Natural Resources and Environment. 43 pp.

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(full report 1 MB PDF file).

Funding for this project was provided through the Introduced Marine Pests Program of Environment Australia.

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Centre for Research on Introduced Marine Pests

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3

Chatham Islands – New Zealand – Underwater heat treatment

CHATHAM ISLANDS, NEW ZEALAND

UNDERWATER HEAT TREATMENT USED TO SUCCESSFULLY ERADICATE INVASIVE SEAWEED

JUNE 2001

(Undaria pinnatifida)

Contents

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Note

Eradication success down under: heat treatment of a sunken trawler to kill the invasive seaweed *Undaria pinnatifida*

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Abstract

Eradication of invasive species is difficult in the marine environment, and there have only been a few successes. We report the successful eradication of the invasive seaweed *Undaria pinnatifida* from a sunken trawler in the Chatham Islands, New Zealand. New heat-treatment methods were developed as the most cost effective and environmentally acceptable option to kill *Undaria*. Monitoring of the trawler for three years after it sank found no *Undaria* after the vessel was treated. Key factors in the success of the eradication programme included: early detection, a rapid response, pre-existing knowledge of *Undaria*, an adaptive management approach, targeting of multiple life history stages, and the cooperation of the vessel's insurer.

Keywords: Marine pests; Eradication; *Undaria pinnatifida*; Biological invasions; New Zealand; Hull fouling; Biological pollution

1. Introduction

Invasive species are a significant threat to global biodiversity, second only to habitat destruction (Vitousek et al., 1997). Non-indigenous organisms continue to invade marine ecosystems around the world at an increasing rate (Cohen and Carlton, 1998; Thresher et al., 1999; Hewitt, 2003). Control or eradication of invasive species is difficult, especially in the marine environment. There have been few successful eradications of marine pests (for examples see Culver and Kuris, 2000; Bax et al., 2002).

Myers et al. listed six requirements for successful eradication programmes: (1) sufficient resources; (2) clear lines of authority; (3) the target organism is susceptible to control; (4) reinvasion must be prevented; (5) the pest must be detectable at relatively low densities; and (6) restoration or management following removal might be necessary.

The recent sinking of a fishing trawler with *Undaria pinnatifida* (hereafter *Undaria*) growing on its hull highlighted the threat this invasive laminarian kelp posed to the remote Chatham Islands, New Zealand. We report the management response undertaken to reduce the risk of *Undaria* becoming established in the Chatham Islands (see Fig. 1). We describe the eradication programme, efforts to prevent subsequent introductions, and discuss the management lessons learned.

1.1. Biology of *Undaria*

Undaria is a brown seaweed native to Japan, China and Korea. It has been introduced accidentally to New Zealand (Hay and Luckens, 1987), Australia, England, France, Belgium, Italy, Argentina and California (reviewed in Silva et al., 2002).

Undaria has two main life history stages: sporophytes (spore producing plants) and gametophytes (a microscopic gamete producing stage). Each adult sporophyte can produce millions of spores. These spores produce gametophytes, which can lie dormant for up to 3 years until conditions are suitable for growth (Hewitt et al., in press-a).

Undaria is fast growing, with sporophytes maturing after 50–70 days in New Zealand (Stuart, 1997). It grows on any hard substrate including rocky reefs, cobbles,

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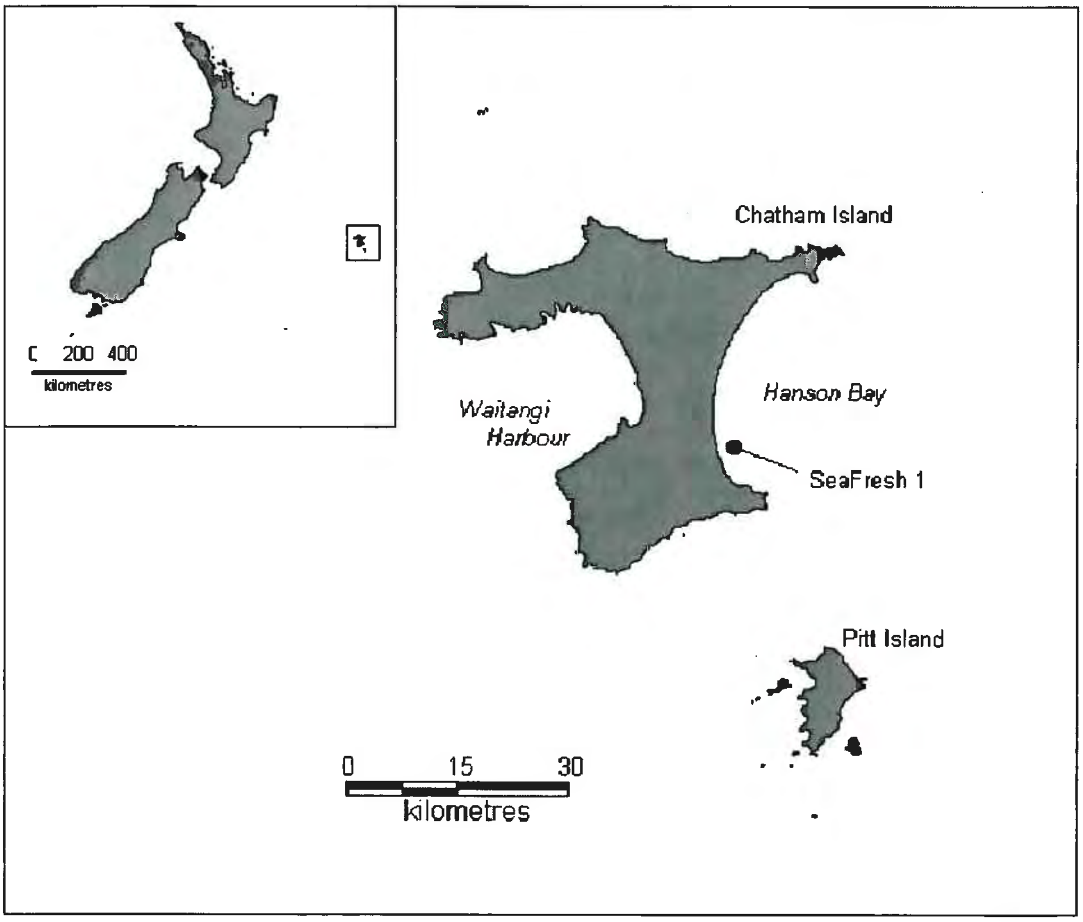

Fig. 1. New Zealand map with Chatham Islands 700 km to the east of the mainland. Close-up of Chathams with the location of *Seafresh 1* wreck and harbour.

wharf piles, and ship hulls. *Undaria's* rapid growth rate and ability to reproduce all year round in New Zealand (Stuart, 1997) means it can outcompete most native seaweeds.

Undaria was first detected in New Zealand in Wellington Harbour, North Island, in 1987 (Hay and Luckens, 1987). From this initial introduction and a subsequent introduction to Timaru in the South Island (Hay and Villouta, 1993), *Undaria* has spread by both natural dispersal and translocation on vessel hulls and marine farming equipment (Hay, 1990). It is now present in numerous locations around New Zealand in North, South and Stewart islands.

2. The incursion

The 40 m steel trawler *Seafresh 1* foundered at Hanson Bay, Chatham Island, New Zealand, after a fire in the engine room on 17 March 2000 (Fig. 1). *Seafresh 1* sank in 20 m of water in sandy habitat, about 2.2 km from the nearest rocky reef. *Seafresh 1* had a history of fouling based on the Department of Conservation (DoC) Vessel Monitoring Programme (M. Stuart, pers. obs.). DoC divers inspected the vessel on 23 March 2000 and found two *Undaria* sporophytes attached to the hull. Despite *Undaria's* widespread distribution on the main islands of New Zealand, macroalgae surveys undertaken during 1999 found no *Undaria* in the Chatham Islands (W. Nelson, pers. comm.). A snorkel survey for *Undaria* in Waitangi Harbour, Chatham Island on 23 March 2000 found no plants (M. Stuart, pers. obs.).

The Chatham Islands are approximately 700 km east of the mainland of New Zealand (Nelson et al., 1991). Their unique biodiversity has evolved due to this isolation, and includes a number of endemic seaweed species (Nelson et al., 1991). The area supports productive rock lobster, paua (abalone), and kina (sea urchin) fisheries. The isolation of the Chatham Islands effectively eliminates the likelihood of 'natural' (non-human mediated) dispersal of *Undaria* from the mainland.

3. Initial management response

The Ministry of Fisheries (MFish), the lead agency for marine biosecurity in New Zealand, undertook a

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qualitative risk assessment using information from a range of experts. The assessment determined that the presence of *Undaria* on *Seafresh 1* posed a sufficient threat to the environment, economy and social values of the Chatham Islands to warrant a response. Three main factors contributed to this decision: the invasive nature of *Undaria*; the demonstrated absence of *Undaria* from the Chatham Islands; and the unique and pristine nature of the Chatham Islands and their biota.

The Biosecurity Act 1993 (the Act) provides a range of tools to manage biosecurity risks. The Chief Technical Officer (CTO)—Marine Biosecurity is a statutory position under the Act with the ability to take steps to prevent the spread of unwanted organisms.

To reduce the risk of *Undaria* establishing in the Chatham Islands, the CTO determined *Undaria pinnatifida* an "Unwanted Organism" under the Act on 24 March 2000 (the day after its presence was confirmed on *Seafresh 1*). This enabled the CTO to use Biosecurity Act provisions on the same day to direct the owners of *Seafresh 1* to move the vessel to an area where *Undaria* was present or sink it in deep water away from the Chatham Islands.

Poor weather conditions delayed salvage attempts. The CTO therefore directed the vessel to be monitored by divers every 30 days and any sporophytes removed until the vessel was shifted. Thirty days was selected as the most appropriate frequency for monitoring; *Undaria* can reach maturity after 50 days (Stuart, 1997) and it was vital to remove sporophytes before they matured and reproduced. MFish commissioned an independent audit of the monitoring programme every second month. Surveys at Waitangi wharf, of moored vessels and on rocky coastline nearest to the wreck were undertaken opportunistically.

Salvage attempts by United Salvage Ltd. during 2000 were unsuccessful, leading to a review of the situation in February 2001. MFish convened a Technical Advisory Group (TAG) to provide advice on management options. Members of the TAG included independent New Zealand and overseas experts on marine salvage, *Undaria*, invasion biology and invasive species management, and a Chatham Island representative. Available options included: additional salvage attempts, leaving the vessel in place and continuing the monitoring programme, a combination of treating the vessel to kill *Undaria* and monitoring, or doing nothing.

Although experts considered that salvaging *Seafresh 1* was still possible, this option was expensive and had been unsuccessful to date. This was probably due to a combination of bad weather and unsuitable salvage techniques. Salvage activities also posed a risk of dislodging gametophytes from the vessel.

The monitoring programme appeared to have successfully detected and removed *Undaria* sporophytes prior to spore release. In addition, the TAG considered new treatment techniques that were available had significant potential to cost-effectively kill *Undaria* gametophytes on the hull. MFish therefore determined that treatment of the vessel to kill *Undaria*, combined with continued monthly monitoring, was the most feasible option.

MFish developed a communication plan to provide updates to the Chatham Island Council (the local government body), Chatham Islanders and the media. MFish provided written briefings to the Chatham Island Council on a monthly basis. Verbal updates were also provided to the Chatham Island Council at key management stages. A letter was delivered to all Chatham Island residents advising them of the decision to treat and monitor the vessel rather than remove it. Media releases were also prepared upon significant changes in management activity.

4. Treatment methods

At the request of Shipowners Mutual Protection and Indemnity Association (the insurers of *Seafresh 1*), New Zealand Diving and Salvage Ltd (NZDS) investigated the options available to eradicate *Undaria* in situ. NZDS developed heat treatment methods as the most practical, cost effective, and environmentally acceptable option. Previous research undertaken for the DoC *Undaria* Programme had determined that the microscopic gametophytes of *Undaria* are killed when exposed to temperatures of 60 °C for more than 5 s (Webb and Allen, 2001), confirming that heat treatment would be effective. This methodology was employed between 28 May and 29 June 2001 to kill *Undaria* gametophytes on *Seafresh 1* (Figs. 2 and 3).

Previous monitoring had identified that the distribution of *Undaria* sporophytes on the vessel was restricted spatially. We treated only those areas close to where sporophytes had been recorded. Most

Fig. 2. Plywood boxes with elements were used to heat the hull of *Seafresh 1* and kill *Undaria* gametophytes (photo: New Zealand Diving and Salvage Ltd.).

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Fig. 3. A diver applying a heat-treatment box to the hull of *Seafresh 1* (photo: New Zealand Diving and Salvage Ltd).

sporophytes were found in the area around a 10 cm wide, white painted decorative strip around the water line. This decorative strip did not appear to have been antifouled along with the rest of the hull when *Seafresh 1* was slipped in November 1999. We treated the vessel from the seabed up to at least 500 mm above the decorative strip on the entire port side, the starboard side for 1 m aft of the bow, and the stern to the port side of the trawl ramp.

NZDS treated the vessel using two methods: plywood boxes attached to the hull and heated by elements (Fig. 2), and a flame torch. Plywood boxes 60 mm in depth were constructed with foam seals on the open side to provide a seal against the hull. Divers attached the boxes to the vessel's hull with magnets (Fig. 4). Elements inside the boxes heated the enclosed seawater to a target temperature of 70 °C, which was maintained for 10 min to compensate for heat loss through the hull plating. A diesel generator powered the elements from a surface support vessel. Two temperature-measuring units were placed inside the box, one each at the bottom and the top. The units were read from the surface to monitor the water temperature in the boxes. A vent at the top of each box allowed expanding water and steam to overflow into a filter bag to contain any dislodged gametophytes. Treated areas were marked with crayon prior to shifting each box to ensure complete coverage of target areas.

Divers used a Petrogen flame torch to treat the areas of the hull where the boxes were not practical due to bent or curved plating. The flame torch was also required for inaccessible areas of the vessel such as near the seafloor and for areas with heavy fouling. It took four weeks to treat the vessel, applying boxes 311 times to the hull. The monthly monitoring continued until March 2003. A final, follow-up inspection of the vessel was conducted in December 2003.

5. Results

A total of 427 *Undaria* sporophytes were removed from the hull of *Seafresh 1* between March 2000 and June 2001 (Fig. 4). No *Undaria* sporophytes were found on *Seafresh 1* after the vessel was heat-treated in June 2001. This included the peak growing season for *Undaria* from August to October in 2001 and 2002; during the same period in 2000, 419 plants were removed. The final inspection in December 2003 did not detect any *Undaria*. Additional inspections of the nearby (2.2 km) shoreline and wharf structures of Chatham Island and Pitt Island did not find any *Undaria*. Resident vessels moored at Chatham Island were not fouled with

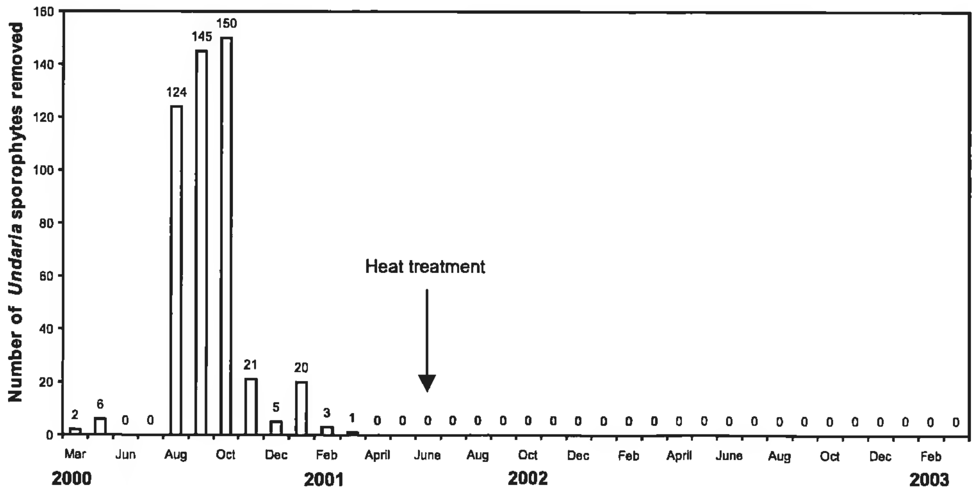

Fig. 4. Results of monthly monitoring of *Seafresh 1* for *Undaria pinnatifida* sporophytes. All sporophytes detected were removed from the hull. The vessel was heat-treated in June 2001 to kill *Undaria* gametophytes.

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Undaria. However, a merchant vessel servicing Chatham Island from Timaru was repeatedly fouled with *Undaria*.

6. Discussion

6.1. Eradication programme

The eradication of *Undaria* from *Seafresh 1* was declared a success in April 2003. Even without treatment, we expected lower numbers of *Undaria* sporophytes to germinate over time as fouling cover on the vessel increased and gametophyte abundance and viability decreased. The treatment effectively killed any remaining viable gametophytes.

The success of the eradication programme on *Seafresh 1* demonstrates what can be achieved if a new incursion is detected quickly and a rapid response undertaken. This programme met requirements (1)–(5) of Myers et al. with requirement (6) being unnecessary.

The insurers of *Seafresh 1*, Shipowners Mutual Protection and Indemnity Association, paid for the cost of the eradication programme, including approximately NZ$2.5 million for salvage attempts, NZ$380,000 for treatment, and NZ$43,500 for monthly inspections. In addition, MFish provided overall management and independent auditing of the monitoring and eradication programme. Eradication was achieved at only 17% of the cost of failed salvage attempts but required a long term commitment.

The microscopic gametophyte stage of *Undaria* makes it very difficult to control. The knowledge that high temperatures are lethal to *Undaria* gametophytes (Webb and Allen, 2001) enabled new techniques to be developed to target this stage of the life cycle and remove the source of new adult sporophytes. The restriction of *Undaria* to a confined area (i.e. a vessel's hull) increased the likelihood of eradication.

Monitoring to detect residual individuals after any eradication attempt is essential to ensure success (Bax et al., 2001). Trained divers could detect *Undaria* sporophytes at low densities on *Seafresh 1*. The limited area of potential infestation enhanced detection. However, the gametophyte stage of *Undaria* is not visible to the naked eye. Any remaining *Undaria* gametophytes could only be detected indirectly through the germination of sporophytes. Monitoring was therefore necessary for the maximum known period of gametophyte viability.

Effective communication with the local community and other stakeholders is key to successful invasive species management. In the initial stages after the vessel sank, Chatham Island residents, conservation organisations and the local council expected the vessel to be removed. When salvage attempts failed, there was concern that *Undaria* would be allowed to establish in the Chathams. The dissemination of information at key stages enabled MFish to manage public expectations and gain support for the programme. This facilitated the establishment of locally-run programmes to prevent *Undaria* and other marine invasives from establishing in the Chathams.

Additional factors that we consider were vital to the success of the eradication programme include an adaptive management approach, integrated management targeting multiple life history stages, and the cooperation of the vessel's insurer.

Although treatment of *Seafresh 1* was successful, *Undaria* could be introduced to the Chatham Islands by other vessels. To reduce this risk MFish has established a voluntary vessel maintenance programme. The programme increases the awareness of vessel owners and encourages the regular inspection and cleaning of vessels that transit from *Undaria* infected regions. Simultaneously, a monitoring programme inspects regular visiting vessels and vessels with visits longer than 12 h for the presence of *Undaria*. A community surveillance programme has also been established to monitor for *Undaria* and other marine pests in the Chatham Islands.

6.2. Management lessons

While responding to non-indigenous species incursions is difficult in the marine environment, a response can still be effective with appropriate planning and tools. Subsequent to the sinking of *Seafresh 1*, MFish developed an Incursion Response Protocol to ensure that decisions are transparent, consistent and documented (Wotton and Hewitt, 2004).

The sinking of *Seafresh 1* at Chatham Island has resulted in a number of precedents in marine biosecurity management in New Zealand. New techniques were developed that are capable of killing a wide range of organisms without releasing toxic chemicals into the marine environment. These techniques can be targeted at specific areas but are likely to be most effective on artificial substrates. Further development of heat treatment methods could produce tools suitable for natural substrates as well.

Despite the advent of effective antifouling paints, faster ships, trans-equatorial shipping routes, and faster turn around times, hull fouling remains a significant modern pathway of invasions (e.g. Rainer, 1995; Cranfield et al., 1998; Thresher et al., 1999; Coutts, 1999). Cranfield et al. (1998) estimated that 69% of the non-indigenous marine species in New Zealand were introduced by hull fouling. At least as many of these species were introduced in the latter half of the 20th century as in the first half (Cranfield et al., 1998). Of the 165 introduced species identified in Port Phillip Bay in Australia, 77% were introduced by hull fouling, including several recent introductions (Thresher et al., 1999; Hewitt et al., 2004). Hull fouling is of particular

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concern in the domestic spread of invasive species (e.g. Hay, 1990; Carlton and Hodder, 1995; Hewitt and Campbell, 2001; Gollasch, 2002; this manuscript). More effective vessel maintenance would significantly decrease the likelihood of spreading marine pests.

Liability for marine pollution such as oil spills is commonly accepted, and generally covered by vessel insurance. This is the first instance in New Zealand, and possibly worldwide, where public liability insurance has paid for the costs of managing an introduced species. This has direct implications for both coastal managers and the shipping industry. Management decisions need to be robust enough to withstand intense scrutiny by insurance companies. In addition, the shipping industry needs to be aware that they could be held liable for causing marine pest introductions. The cost of insurance for coastal shipping in New Zealand has risen as a direct consequence of the biosecurity threat posed by the sinking of *Seafresh 1*.

Acknowledgements

We acknowledge the participation of Shipowners Mutual Protection and Indemnity Association, the insurers of *Seafresh 1*, in the management of this event. Thanks to C.L. Hewitt and Dave Kelly for commenting on a draft of this paper. Chris Beal and Barry Lanauze provided logistical support on Chatham Island.

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ELIMINATING A PEST

In 2000 the fishing vessel **Seafresh 1** caught fire and sank in the remote Chatham Islands, New Zealand. Salvage attempts by an international company failed, and the ship was left where it sank.

Before sinking, **Seafresh 1** had been contaminated with the invasive Japanese seaweed, Undaria Pinnatifida. It quickly took hold of the sunken hull, and any subsequent spreading presented an ecological threat.

Insurers faced expensive options of getting rid of the wreck by:

- trying to raise and remove the hull, (earlier attempts failed)
- cutting it up and removing it in sections
- burying it
- having divers clean the hull off weekly, year round

Approached by the insurers for a solution, **New Zealand Diving and Salvage Ltd** designed and built a unique hot water "kettle". Results were spectacular - after being treated with hot water, the Undaria was quickly killed off. To treat the ridges and nooks and crannies that were inaccessible to the "kettle", divers delivered gas generated heat through an adapted cutting torch .

The 'kettle" at work on Seafresh 1.

Two clean panels after **New Zealand Diving and Salvage Ltd** heat treatment.

A diver applies heat to clean off areas out of reach of the "kettle."

See also **Didemnum Vexillum** threat in Marlborough Sounds.

www.nzds.co.nz

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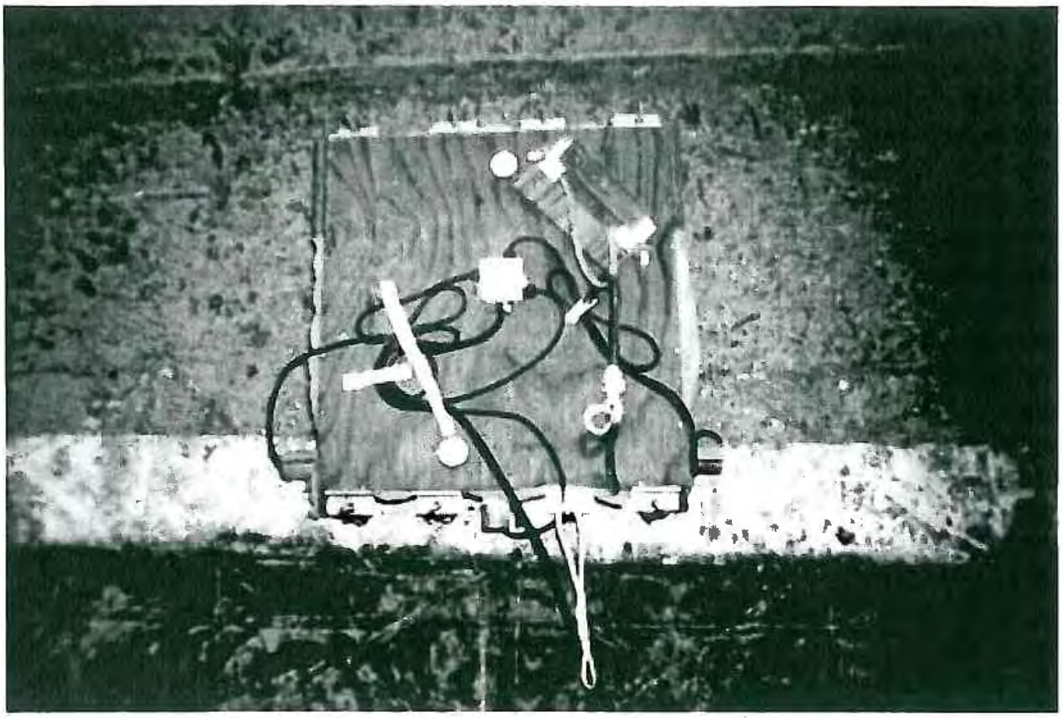

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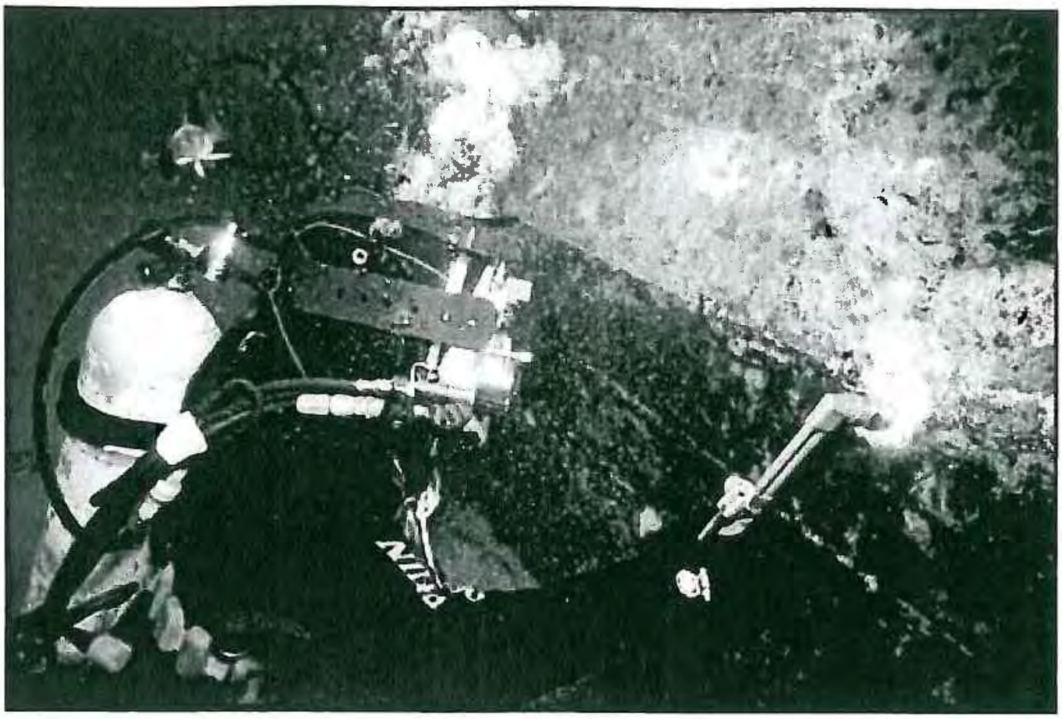

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MARINE BIOSECURITY RESEARCH

New Zealand Diving & Salvage Ltd, as the name suggests, is a diving company, but the range and sophistication of our services go well beyond the provision of men in diving suits. **New Zealand Diving & Salvage Ltd** has participated in a number of marine biosecurity research programmes. In our work we always prioritise customer satisfaction and cost-effectiveness. We are also lateral thinkers and are able to help develop scientific projects in a variety of practical ways, as well as provide research ourselves. Using our skills we have collaborated with some renowned New Zealand scientific institutions, such as the Cawthron Institute, Kingett Mitchell Ltd, the National Institute of Water and Atmosphere Research Ltd (NIWA) and the Ministry of Fisheries, and we have a proven track in removing biosecurity hazards from New Zealand freshwater and marine ecosystems.

New Zealand Diving & Salvage Ltd scientist, Lukasz Lachowicz

Eradication of an invasive seaweed, Undaria Pinnatifida

Native to Japan, China and Korea, this brown seaweed has been introduced into New Zealand, Australia, California, Argentina and numerous European countries. In 2001 **New Zealand Diving & Salvage Ltd** was contracted by the Ministry of Fisheries, the lead agency for marine biosecurity in New Zealand, to help eradicate Undaria from the hull of *Seafresh 1*, a steel trawler that foundered on Chatham Island, New Zealand. **New Zealand Diving & Salvage Ltd** developed a heat treatment method for eliminating Undaria that proved 100% successful, cost-effective and environmentally acceptable. Following our treatment, no further Undaria plants were found on the hull of *Seafresh 1*. This constitutes the rare event of a complete local eradication of this nuisance alga.

Heater controls

NZDS diver heat treating *Seafresh 1*

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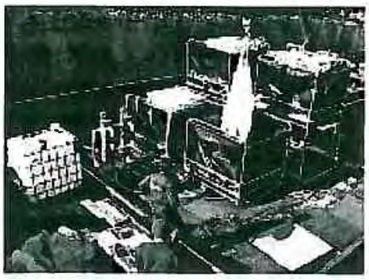
Removal of an ascidian, Didemnum Vexillum

In 2001 heavy Didemnum Vexillum ascidian fouling was found on a steel barge, *Steel Mariner*, and on the seabed directly below the barge in Picton, in New Zealand's Marlborough Sounds. This ascidian was identified as indigenous to New Zealand but able to quickly colonise new substrata, such as mussel lines in the local mussel farms in the Marlborough Sounds. Because of the potentially serious threat to marine farming areas, **New Zealand Diving & Salvage Ltd** worked together with the Ministry of Fisheries and Cawthron Institute to design and test an underwater vacuum and filtering system that removed the bulk of Didemnum Vexillum from the *Steel Mariner* and the seabed immediately below. This filtering system is able to capture particles as small as 50 µm (our field tests showed that even smaller particles could be retained, although with greatly reduced water flow rates), which made our procedure of removing the ascidians from the environment, as well as preventing the release of their larvae, highly effective.

Didemnum Vexillum



Didemnum Vexillum vacuumed from the *Steel Mariner* and baled up for safe removal

Looking for invasive marine species: survey of merchant vessels

Recently, **New Zealand Diving & Salvage Ltd** was contracted by Biosecurity New Zealand (MFish) in order to conduct a series of scientific surveys of merchant vessels arriving in New Zealand. For the purpose of this research project, our company established a fully equipped and functional marine laboratory, where samples of invertebrate and algal growth are analysed and preserved. Currently under way, this project targets a range of international commercial vessels and attempts to estimate the degree to which these vessels can be a potential vector for introducing non-indigenous species into New Zealand's marine environment. This research involves, among other matters, collaboration between NIWA and the **New Zealand Diving & Salvage Ltd** diving team. The **New Zealand Diving & Salvage Ltd** team includes marine biologist Lukasz Lachowicz, who is responsible for the sampling regime, data analysis and reporting to Biosecurity New Zealand.

NEW ZEALAND DIVING AND SALVAGE LIMITED

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Undaria pinnatifida (algae, aquatic plant)

Click here to go back

Details of this species in Chatham Is.

Status: Alien
Invasiveness: Invasive
Occurrence: Eradicated
Source: The Biosecurity Strategy for New Zealand, August, 2003

Arrival Date: 2000
Introduction: Unintentional (accidentally)

Species Notes for this Location:
In March 2000 the fishing vessel Seafresh 1 sank 2 km off Chatham Island, with 2 small undaria sporophytes on its hull. Since then the vessel has been monitored monthly and 476 sporophytes have been removed (indicating a substantial crop of microscopic gametophytes was present). In June 2001 the vessel hull was treated with hot water to kill any gametophytes remaining. Between August and September 2000, 269 sporophytes were removed, in the same period in 2001 no sporophytes were found. Monthly inspections will continue until undaria has been eradicated from the vessel.

Management Notes for this Location:
Report on Eradication: The remoteness of the Chatham Islands has helped protect it from exotic species,including undaria, an unwanted seaweed already established in New Zealand. So it was a potential disaster when in March 2000, a fishing boat sank with undaria on its hull. Ministry of Fisheries, New Zealand ordered the vessel to be moved (using its powers under the Biosecurity Act) but weather prevented salvage attempts.MFish then decided to use new treatment techniques to eradicate the seaweed from the hull. The hull was heat-treated (effectively,the vessel was 'cooked ') to kill the microscopic stages of undaria, which can't survive high temperatures. Plywood boxes with foam seals were attached to the hull by magnets. Electric elements (powered by a diesel generator on the surface support vessel) inside the boxes heated the seawater to 70 °C for 10 minutes, with a flame torch used for inaccessible areas. It took divers four weeks to complete the treatment, but a monthly monitoring programme over three years indicates the eradication has been entirely successful. The Chatham Islands' shoreline has been surveyed regularly for undaria and no plants have been found.

Location Notes:
The Chatham Islands are located 850 km east of mainland New Zealand.

Last Modified: 8/04/2004 12:35:50 p.m.

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NEW MONITORING AND ERADICATION PROGRAMME FOR UNDARIA ON SEAFRESH 1

29 March 2001

A comprehensive new monitoring and eradication programme has been announced that will eliminate the invasive seaweed Undaria pinnatifida (undaria) from the trawler Seafresh 1, which sank off Hanson Bay, Chatham Island in March last year.

"My aim is to prevent undaria spreading from Seafresh 1 to Chatham Island, so I have put in place measures that will contain the remaining undaria and eradicate it within four years," said Ministry of Fisheries Chief Technical Officer for Marine Biosecurity, Dr Chris O'Brien.

The new programme will include:

- Monitoring and eradication of any undaria found on Seafresh 1 for at least four years;
- Additional surveillance of inshore areas near to Seafresh 1;
- Hot water treatment of the vessel to kill any remaining microsopic stages of undaria;
- Development of an undaria incursion response protocol for the Chatham Islands;
- Annual review of the management programme by a Technical Advisory Group organised by the Ministry.

Dr O'Brien said two major factors led to his decision to implement the new approach. One was the development of heat treatment techniques that kill the microscopic stages of undaria.

The other factor was the success of the existing monitoring and eradication approach, put in place when the salvage operation was postponed in June last year.

Under this approach 479 undaria plants have been found and removed, 423 of these from one area - a decorative strip on the hull that was not treated with antifouling paint. Only one of the plants was fertile, but it showed no signs of having released spores.

"These new management tools mean the risk of undaria spreading to Chatham Island can now be managed effectively without removing the vessel," Dr O'Brien said. "This is a significant change from the situation last year, when removing the vessel was the only viable option to manage undaria.

"No management approach in this situation has zero risk. Even the original plan to move the vessel posed a risk. For example, it is possible the vessel could have broken up into several pieces, or it could have been dropped during salvage in a position closer inshore, or the salvage operation itself might have mobilised undaria spores, gametophytes or plants.

"Under the new management approach there is a low risk of spreading undaria to the coast, and ultimately undaria will be completely eradicated from the vessel."

ends

For further information please contact:
Dr Chris O'Brien
Chief Technical Officer - Marine Biosecurity
Ministry of Fisheries
Tel. 04 470 2609

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Archive - these pages are part of the continuing record of Executive Government - for the current Administration , see www.beehive.govt.nz

20 /3 /2000

Hon Marian Hobbs

Invasive seaweed on sunken boat

Officials are meeting this evening to decide how best to handle another underwater threat to the Chatham Islands following the sinking of the fishing boat Seafresh 1, three kilometres offshore, the Minister for Biosecurity, Marian Hobbs.

The sunken vessel is known to have had the invasive Asian seaweed, Undaria, on its hull. This weed is not thought to be present in the Chathams.

The Ministry of Fisheries is responsible for marine biosecurity and officials will be meeting with colleagues from the Maritime Safety Authority and the Department of Conservation to devise a strategy to address the threat posed by any Undaria that may be on the Seafresh 1. The MSA is also working to prevent damage to the ecosystem from the up-to-100 tonnes of oil in the sunken vessel's fuel tanks

Marian Hobbs said Undaria is a prolific weed that can outcompete local species and which threatens our biodiversity.

"Expert advice is that few of our native seaweeds can compete with Undaria's invasive characteristics," she said.

"The object of tonight's meeting will be to develop a strategy to stop the spread of any seaweed from the sunken vessel to the Chathams' shore."

Undaria is thought to have been introduced to New Zealand in ballast water discharged by foreign ships in the late eighties. It was discovered in Wellington Harbour in 1987 and spread to the Marlborough Sounds and east coast harbours. In 1997 it was found in Big Glory Bay, Stewart Island.

To address wider management issues, the Ministry of Fisheries is well on the way with a proposal for a National Pest Management Strategy for Undaria.

Press Release

Kingett Mitchell Ltd
RESOURCE & ENVIRONMENTAL CONSULTANTS

Info Sheet

Biosecurity

As a geographically isolated country, New Zealand's living communities (and our productive economy which depends upon them) are often biologically distinctive. Introduced organisms and pathogens from other parts of the world often compete or negatively impact these communities (i.e., through predation or the introduction of associated diseases) and have serious consequences for our native biodiversity and production capacity. The increasing movement of people and goods to and from New Zealand means that such Biosecurity threats are also increasing. Biosecurity itself aims at excluding, eradicating, or managing the effects of these unwanted pests or diseases. An effective Biosecurity response and management system focuses on minimising the risks to our biodiversity and productive economy. This applies across all marine, freshwater, and terrestrial habitats and production.

Project Experience

A wide range of Biosecurity-related work has been conducted for a variety of clients. This work has included:

- Eradication of invasive invertebrates.
- Directing and undertaking delimiting surveys for exotic mosquitoes at ports of entry.
- Preparation of management strategies to limit the spread of existing marine pest species to the Chatham Islands and SubAntarctic Islands.
- Developing an incursion response 'toolbox' for marine Biosecurity managers.
- Delimitation surveys of unwanted marine organisms.
- Development of guidelines for managing the Biosecurity risks of vessel hull fouling.
- Management of nuisance insect populations in wetlands and wastewater treatment plants.

Exotic Mosquito Eradication

At least 14 separate mosquito species have been recorded as invading New Zealand shores and of these 4 have established themselves. These are *Ochlerotatus notoscriptus, Ochlerotatus camptorhynchus, Ochlerotatus australis,* and *Culex quinquefasciatus*. Fortunately none of these established species vector any diseases here, although they are known to do so in their countries of origin. It is the ongoing monitoring and incursion responses against mosquito species such as *Aedes aegypti* and *Aedes albopictus* that keep debilitating and fatal arboviruses out of New Zealand.

Kingett Mitchell staff have been instrumental in establishment of national mosquito sampling protocols at ports of entry, national mosquito Biosecurity training, and establishing a national mosquito database to begin longitudinal tracking of mosquito fauna and incursions responses. Routine sampling has lead to successful incursion responses satisfying the Biosecurity objectives of the government.

Kingett Mitchell staff 'ran the science' behind the successful eradication of the Australian southern saltmarsh mosquito (SSM) from the Hawkes Bay. The protocols and procedures that were put in place were adopted as the blueprint for the further eradication of this species from the remainder of New Zealand. The eradication of the SSM was acknowledged as a world first and the ingenuity and methods used throughout the programme are now employed in other similar programmes worldwide.

Eradication of *Undaria* from the Chatham Islands

Undaria is an adventive brown seaweed native to eastern Asia that first appeared in New Zealand in 1987. Since that time it has been spread around the country attached to vessel hulls and equipment. This invading seaweed is not, however, found outside the Stewart, South and North Islands. In 2000 the fishing vessel Seafresh 1 foundered in Hansen Bay off Chatham Island. This vessel was fouled with *Undaria* and the Ministry of Fisheries (the agency responsible for marine Biosecurity at the time) directed the owners to remove the vessel due to the risk it posed to the unique biodiversity of the Chatham Islands.

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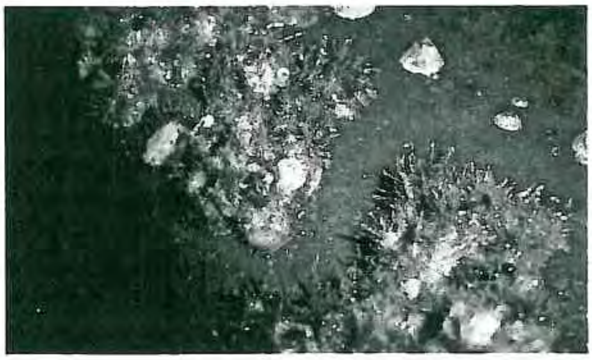
When attempts at salvage failed, a programme of vessel sterilisation was undertaken. Divers contracted direct to the Ministry developed a system of hot water treatment for sterilising the external surfaces of the vessel, and Kingett Mitchell personnel provided scientific advice on the eradication effort, as well as monitoring the vessel after the sterilisation. The eradication was declared a success in 2003, after repeated monitoring failed to detect any new plants on the hulk. Kingett Mitchell is also coordinating related projects aimed at keeping *Undaria* out of the Chathams, as well as the SubAntarctic Islands.

Vessel Hull Inspections

International movement of potentially invasive marine organisms can be facilitated if they readily attach to and can live on vessel hulls or floating structures (e.g., barges, oil platforms). A variety of marine species are known to have been translocated to and around New Zealand in this manner, including *Undaria* and a seasquirt *Didenmum*. In an effort to understand whether different types of vessels pose different Biosecurity risks, Kingett Mitchell has inspected the hulls of international cruise ships and fishing vessels.



Vessels are intercepted on their first (or occasionally second) port of arrival in the country and details of their maintenance and voyage history logged. Dive teams using surface supply with a live video feed to the surface then photograph and sample (where present) the fouling present on the hull and structures (e.g., rudder, propshaft, bilge keels, seachest gratings, bow thrusters) for analysis. A qualitative level of fouling present at each site is also noted for future reference. Samples are identified, and an overall risk profile for different vessel types prepared.

Plant and Animal Pest Management

Kingett Mitchell offers sound advice to a number of councils and utility companies (e.g., wastewater treatment plants) regarding management of various pest, nuisance, and unwanted plant and animal species. Kingett Mitchell undertakes surveys, research, makes successful treatment applications, instigates ecological and management control options, and aids in reducing public complaints about pests such as mosquitoes and midges.

Other pest management projects are more focussed on maintaining and protecting New Zealand's biodiversity from extant pests. In these project, Kingett Mitchell works closely with councils, industry and individual land-owners to develop and implement pest management and monitoring strategies. For example, we have developed city-wide weed management strategies to enable prioritisation of weed control operations in urban and peri-urban parks and reserves for several councils.

Capability

Kingett Mitchell can deploy specialist experts in Biosecurity management, eradication and response to assist local councils, government, and industry in dealing with Biosecurity risks. This can include specialists in:

- ❑ Risk management for potential and existing Biosecurity threats.
- ❑ Strategic management advice and training.
- ❑ Planning and undertaking eradication, control and containment of undesirable organisms.
- ❑ Delimiting surveys to assess the extent of spread of a population.
- ❑ Identification of introduced species.
- ❑ Literature and control product reviews.
- ❑ Evaluation and consideration of Biosecurity policy issues.
- ❑ Preparation of incursion response protocols and pest management plans.

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Code of Practice for Anti-fouling and in water hull cleaning and maintenance

CODE OF PRACTICE

FOR

ANTIFOULING

AND

IN WATER HULL CLEANING AND MAINTENANCE

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Code Of Practice

for
Antifouling

and
In-water Hull Cleaning and Maintenance

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Preface

This Code of Practice for application, use, removal and disposal of antifouling paints was prepared by the ANZECC Maritime Accidents and Pollution Implementation Group with the help of consultants on behalf of ANZECC.

The process leading up to preparation of the Code of Practice has included reviewing (1) fouling problems in Australia and New Zealand, and (2) current and alternative antifoulants. In addition, a widely advertised call for submissions has been made in both countries, several consultative meetings have taken place and there has been a further period of review by ANZECC during preparation of the Code. The Code has been reviewed by regulatory agencies and has agreement from agencies for implementation.

The following document represents a culmination of this process.

Acknowledgments

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Code of Practice for Antifouling

1. Application, Maintenance, Removal and Disposal of Antifouling Paints

This Code of Practice applies to the use of all products designed to keep marine vessels and structures free of marine organisms. There are two fundamental modes of action of such products:

1. The coating releases chemicals which inhibit settlement of marine biota *i.e.* acts as an "antifoulant", or
2. The coating inhibits successful attachment of marine biota *ie.* acts as a foulant-release coating.

Typically, the inhibition of settlement is achieved by means of the leaching from the coating of toxic chemicals such as tributyltin or copper, while the inhibition of attachment is achieved through non-stick surface-bound properties associated with chemicals like silicones and PTFE's that reside in the coating. The principal intended function of all such products, where they are used, whether toxic or not, is as an additional outer coating on vessels, floating, submerged or fixed structures, serving to protect fabric and superstructure against the potentially destructive action of marine biota. It is appropriate to refer to such a product as a "marine protective coating" - MPC. The coating may contain several layers, and may also sub-serve other protective functions beyond that described above.

The leaching of tributyltin from marine paints has been associated with extensive impacts on aquatic organisms, particularly intertidal organisms such as oysters. This has resulted in restrictions on the use of tributyltin worldwide. In Australia, tributyltin can only be used on vessels that are greater than 25m in length (except where exemptions are granted for aluminium vessels) and in New Zealand tributyltin cannot be applied to any vessel. The rules for other marine structures are less clear. The Australian Navy has introduced additional voluntary restrictions on tributyltin usage, with many vessels under 40m in length being required to use copper-based materials.

All antifouling paint formulations, containing substances which could adversely affect the marine environment or agricultural and fisheries industries, must be registered with the National Registration Authority. This registration process helps to ensure that aquatic environments, or the people that work with these coatings, do not become exposed to inappropriate chemicals. It also ensures that appropriate labelling of containers occurs so that hazards to human health can be avoided.

Following is a summary of the major issues involved in protecting the environment whilst handling antifouling paints. Occupational health and safety should be a principal concern and guidelines associated with protection of human health should be adhered to. When best practice improves on the suggestions that follow, best practice should be followed.

2. General Requirements

Some form of labelling should be placed on MPC formulations that have been registered, or permitted for use as antifoulants, or are exempt from registration by the National Registration

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Authority so that applicators know that all such products meet current local standards. This would assist in the protection of both human health and of the environment.

The application, maintenance and removal of all antifouling coatings should only be done above the tidal zone at facilities capable of meeting New Zealand and Australian state, territory and commonwealth regulatory requirements for dangerous goods, occupational health and safety and environmental protection, and appropriate standards of best practice. The sale of antifoulants should be restricted to facilities capable of meeting the above requirements. Therefore, Australia and New Zealand should work towards uniform licensing procedures for such facilities.

For example:

- The practice of beaching small vessels for antifouling removal or application is prohibited if the hull is coated with a toxic antifoulant or is being coated with a toxic antifoulant.

- The practice of mooring small vessels in bags, and adding herbicides and/or biocides to the adjacent waters, is not a registered antifouling method with the National Registration Authority and therefore is not legal.

- The underwater cleaning of small and large vessel hulls enhances antifouling release to the water column when the vessel is coated with antifoulants that release toxic substances, as opposed to foulant release coatings (like silicones or teflons) or to untreated hulls. Vessel operators should consult the relevant State agency to determine if in-water cleaning is permitted. All wastes should be contained. The release of coloured materials or turbidity to the water column is an offence under environmental protection regulations.

- Where large vessels (>25m) exclusively or predominantly operate in confined waterways, bays, rivers or estuaries (eg. ferries, barges fishing boats, work vessels, privately-owned pleasure craft), they may be a significant source of toxic substances in the locality. The relevant State agency may prohibit use of particular antifoulants on such vessels (eg. those containing tributyltin). Therefore, operators and those responsible for vessel maintenance should check with the relevant State agency before applying antifoulants.

- New dry docks, slipways and hardstands - no water should run off work areas without treatment to remove toxic substances, turbidity and discolouration. New facilities should be designed and managed so as to allow for eventual disposal to sewer of treated waste water and first-flush runoff.

- Existing dry docks, slipways and hardstands - measures should be adopted to minimise water runoff and certain potentially toxic, turbid or discoloured discharges. Bunds may be used on sealed concrete. Sumps may be used to contain waste water and spillages. Straw bales and woven fibre material may be used to retain suspended solids. Existing facilities should plan for upgrading to allow for eventual disposal to sewer of waste water and first-flush runoff.

Further restrictions on the use of tributyltin in Australian waters are not recommended until adequate alternatives are available. The basis of this recommendation is that efficient antifoulants are required to ensure that exotic species are not imported into local waters. Exotic species can have major impacts on local species and local aquaculture. The effects of

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tributyltin are reversible and will be confined to areas dealing with large vessels. The impacts of exotic species are unpredictable and may not be able to be controlled or restricted. Conversely, the impacts of exotic species may not be reversible. It is proposed to allow for more restrictions on the use of tributyltin paints on larger vessels (>25m) operating in confined waterways, bays, rivers or estuaries.

3. Application

Requirements under dangerous goods and occupational health and safety laws must continue to be met.

3.1 Techniques for Pollution Abatement

- Preparation areas should be bunded to ensure accidental spillage cannot escape to water.
- Spillage should be treated with a suitable absorbent and disposed of as a controlled waste.
- Facilities should be well designed and carefully managed. Alternatively, poorly designed existing facilities should be managed to optimise human and environmental protection;
- All plant and equipment from work areas should be subject to regular preventative maintenance programs to ensure optimum performance.
- Stocks of antifouling paint should be held in labelled containers.
- Antifoulants should be stored in secured and preferably bunded areas.
- Preparation of all antifoulants should take place in areas protected from traffic, with overhead cover.
- Site operators should assume any removed coating is contaminated with biocides and dispose of in accordance with requirements of local environmental and/or waste disposal authorities.
- Established written operational procedures should exist.
- Paint spraying should not be performed in high winds.
- Sheeting should be used to prevent spray drift.

3.2 Specific Requirements During Application - All Vessels

- Cleaning using water is preferred to chemicals.
- High pressure liquid cleaners that operate with detergents, solvents, caustic or acid should only be used if a system exists for collection of waste waters.
- Use of degreasers should be avoided.

- Discharge of coloured water to the waterway should be avoided.

- Low pressure, high volume spray guns are preferred over high pressure guns.

- Efficient use of all antifouling paints, during their application, should ensure that total losses due to all causes do not exceed 30% of the coating to be applied to the substrate. Consideration should be given to:-

  1. maximising coating transfer efficiency during application;
  2. blowing back hose lines to the pump on completion of work;
  3. using returnable bulk containers;
  4. careful planning of coating operations to minimise coating residues and losses;
  5. application during optimal weather conditions, if possible.

3.3 Application Procedures for Small Vessels (<25m)

- All surfaces should be protected from over-spray through the use of tarpaulins and sheeting.

- All work should be carried out above the tidal zone.

- Brushes and rollers are preferred over spray equipment, where environmental conditions could result in spray drift off-site.

- Drop sheets should be placed under all surfaces to be painted.

3.4 Application Procedures for Large Vessels (>25m)

- All application of TBT requires the approval of the State agency and the facility must meet the specific requirements of that agency.

4. Maintenance

In general maintenance of small and large vessels should be conducted at an appropriate facility, either above the tidal zone or in a dry dock. The hulls of vessels pose a number of risks to the local environment including the release of toxic chemicals from antifouling paints and the release of exotic species that may have fouled the hull. With respect to exotic species, in particular, large vessels (>25m) should be maintained out of the water, whenever possible.

- In-water cleaning of hulls may be permitted in some localities. Consult the relevant State agency and ensure containment of all wastes.

- Cleaning of sea chests, sea suction grids and other hull apertures may be permitted (in Victoria) providing that any debris removed is not allowed to pass into the water column or fall to the sea bed (debris includes all organisms which may be attached). Vessel operators should consult the relevant State agency.

- Polishing of propellers may also be permitted, if vessels are greater than 200t. The relevant agency should be consulted.

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The water blasting, particularly of large vessels (>25m) with self-polishing co-polymer painted hulls is used to remove the hydrolysed layer as well as slimes and light fouling prior to repainting. This process can generate coloured waste water. Coloured run off should be avoided and, where practical, water should be recollected for recycling or released to sewer (with approval of sewerage authorities).

5. Removal

Removal processes on small craft (<25m) should use the best available techniques that do not entail excessive cost. The same tarpaulin and sheeting processes should be used when removing paints as have been specified for the application of paints. This would allow cheap collection of wastes for off site disposal.

No removal should be undertaken while the vessel is in the water. Removal should not be undertaken on beaches or in the intertidal zone. All removal should be undertaken at appropriately equipped and approved facilities.

Old antifouling coatings are not to be burnt off. Over the past fifty years antifouling formulae have used a variety of extremely hazardous active chemicals and the practice of burning these paints may place both the operator and people in the immediate vicinity at risk. Further, the burning of antifouling paint residues after removal may generate highly toxic fumes, smoke and gases. All antifouling paint residue should be treated as contaminated waste and should be disposed of in accordance with the requirements of local environmental and/or waste disposal authorities.

5.1 In General

- Measures must be undertaken to contain wash waters and to segregate wash water from non-contaminated flows.

- Measures should be taken to prevent particulate matter being flushed from a dry dock, slipway or hardstand when a vessel is being treated or refloated.

- Measures should be taken to reduce wind-blown particulates.

- Release of either particulates or wet waste, contaminated with tributyltin, into the adjacent water way must be avoided.

- All antifouling wastes should be treated as controlled wastes as they are all contaminated with biocides. Such waste should be collected for disposal at an appropriate facility, in accordance with local environmental and/or waste disposal authorities.

- Paint scrapings should be treated as contaminated waste and disposed of in accordance with the requirements of local authorities.

- Residues should not be washed into the sea.

5.2 Releases to Air

- Wet abrasion is preferable to dry abrasion, which can create toxic dust.

- Dry grit blasting creates dust problems and methods should be employed to contain this dust.

- Use of wet methods controls particulate emission to air but generally creates high volumes of liquid waste. Ultra high pressure water blasting, with lower volumes of liquid waste, is likely to become widely available in the future.

- Vacuum blasting, or containment blasting, with reusable abrasives and separation equipment is the current best option for removal of used antifouling coatings.

If vacuum or containment blasting is employed emission targets should be as follows:-

1. if operating without wet particulate arrest, exhaust emissions of $35mg/m^3$ should be targeted;
2. if operating with wet particulate arrest, exhaust emissions of $20mg/m^3$ should be targeted.

5.3 Releases to Water

- Use of water during removal should be minimised by moving towards ultra high pressure water blasting, vacuum or containment blasting.

- Use of high pressure blasting should be minimised and coloured run off should be avoided.

- Where practical, water should be recollected for either recycling or for release to sewer (with the approval of local sewerage authorities) so that the water can be treated.

- Release to sewer, where approved by local authorities, should be controlled to allow maximum dilution in the sewerage system.

The discharging of wastewater, contaminated by antifouling paints, to the sewerage system may cause concern with sewerage managers because sewage treatment is dependent on bacterial processes. Antifouling paints have broad toxic effects and their biocidal impacts on bacteria in sewage systems is unknown. However, the quantities of water flowing through the sewage systems compared to the quantities of waste water evolved during boat cleaning are sufficiently different to allow the yard operator to take advantage of dilution effects. Gradual release of waste water from shipyards to the sewer, i.e. by releasing the water through a very small aperture pipe, will assist in minimising any potential biocidal effects. Approval would need to be sought from the relevant sewerage manager.

- Hosing and brushing down activities, without the use of detergents or abrasives to remove weed and barnacles, generally do not require specialised treatment to retain and dispose of material removed. However, if the material includes live organisms from another country or a distant part of Australia, all debris should be collected for disposal as solid waste. Check with the port or marina management on controls on ballast or fouling organisms.

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6. Disposal of residues

- All antifouling residues should be treated as contaminated wastes, as they are all contaminated with biocides. Such wastes are to be collected for disposal in accordance with requirements of local environmental and/or waste disposal authorities, and prevented from entering adjacent waterways.

- Keeping and disposal of tributyltin contaminated wastes may require special approval (*eg.* in NSW), and users should notify local environmental authorities.

- Contaminated wastes, of all types, should be kept in sealed containers.

- Antifouling paint residues should not be burnt owing to their potential high toxicity.

- Contaminated wastes, of all kinds, should be removed by licensed contractors who are advised of the type of the waste, and records should be kept of all such disposed wastes.

- Contaminated grit should be treated as antifouling waste and disposed of in the same way as antifouling paint residue.

- Biological materials (marine biota) removed from antifouled hulls, should be disposed of as solid waste in accordance with local requirements eg. to landfill.

- Liquid wastes are not to be poured into drains. All liquid wastes should be placed in suitable containers, sealed, and disposed of in accordance with local environmental and/or waste disposal authorities.

Where antifouling paints have been removed from old vessels (greater than 10 years old), it should be assumed that the paint residue contains tributyltin, unless test results prove otherwise, and the paint residue should be disposed of at the approved local landfill facility. Antifoulants removed from vessels constructed before the 1970's may contain a variety of extremely hazardous chemicals, including substances like arsenic, mercury and DDT, and should be disposed of at a local approved landfill facility in which leachates are contained.

7. Conclusion

This Code of Practice covers the processes of applying, maintaining, removing and disposing of antifouling paints.

7.1 Major issues addressed include:

- the need to limit application, maintenance and removal of antifouling coatings to approved, licensed facilities;
- the need for uniform licensing of such facilities;
- the need for more restrictions on use of tributyltin-based antifoulants on craft >25m in length, where these operate in confined waters;
- the need to ensure that new facilities include design and management provisions, to enable eventual disposal to sewer of treated waste waters;
- the need to ensure that existing facilities plan for upgrading to eventual sewer disposal of waste waters.

This Code of Practice also includes other measures aimed at protection of the health of workers and of the environment. When best practice improves on these measures, best practice should be adopted.

Code of Practice for In-water Hull Cleaning and Maintenance

1. Background

(1) In recent years much attention had been focussed on the introduction of exotic marine organisms via ship's ballast. Another way of transporting exotic marine organisms is via a ship's hull.

(2) To minimise the risk of further exotic organisms establishing in Australian waters, ANZECC in consultation with the Australian Quarantine Inspection Service has established the following *Code of Practice for In-water Hull Cleaning and Maintenance.*

2. Application

(1) These requirements shall apply in the Australian waters and are applicable to all commercial vessels.

(2) These requirements are to be used with any relevant state environmental protection agency requirements.

3. Procedures

(1) No part of a vessel's hull treated with antifoulant is to be cleaned in Australian waters without the written permission of the Harbour Master, local government or state environmental protection agency (administering authority).

(2) In-water hull cleaning is prohibited, except under extra ordinary circumstances and permission will not normally be granted.

(3) The cleaning of sea chests, sea suction grids and other hull apertures may be permitted provided that any debris removed (including encrustation, barnacles, weeds) is not allowed to pass into the water column or fall to the sea bed and subject to any other conditions attached to the permit. An application seeking permission to carry out this work must be lodged with the administering authority at least five (5) working days prior to commencement of the anticipated start date. Such application will detail how encrustations, barnacles and other debris will be contained and or collected for disposal as well as the method of disposal.

(4) The polishing of ship's propellors may be permitted subject to any conditions attached to the permit. An application seeking permission to carry out "propellor polishing" must be lodged with the administering authority at least five (5) working days prior to commencement of the work.

(5) Applications for permits may be facsimiled to the administering authority.

4. Permit Application

(Insert logo and contact details)

Application for Permission to clean sea chests and/or other hull apertures and/or propeller polishing and/or in-water hull cleaning and/or maintenance

To administering authority: ....

Telephone: .... Facsimile: ....

Port of: ....

From *(Master/Owner/Agent/Contractor)*: ....

Telephone: .... Facsimile: ....

Permission is requested to carry out the following work on: ....

Vessel: ....

From *(Time/Date)*: .... To *(Time/Date)*: ....

At *(Berth, if known, or slipway)*: ....

Detail of Work: ....

....

....

....

Method of collection and disposal of encrustation, barnacles etc: ....

....

....

Office Use Only:

Application Denied ☐ **Approved** ☐

Approved subject to: ....

....

Signature: Position: Date:

5

Development of a Regional risk management framework for APEC economies for use in the control and prevention of introduced marine pests – November 2001

DEVELOPMENT OF A REGIONAL RISK MANAGEMENT FRAMEWORK FOR APEC ECONOMIES FOR USE IN THE CONTROL AND PREVENTION OF INTRODUCED MARINE PESTS.

NOVEMBER, 2001

A SUMMARY AS IT RELATES TO HULL SURFACE TREATMENT

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Development of a Regional risk Management Framework for APEC Economies for Use in the Control and Prevention of Introduced Marine Pests (November 2001). A summary as it relates to HST.

The Asia-Pacific Economic Cooperation secretariat (APEC) with the assistance and support from the Centre for Research on Introduced Marine Pests (CRIMP) a division of the CSIRO and the Inter-American Centre for Sustainable Ecosystems Development (ICSED) held a workshop in Hobart Tasmania, to discuss different approaches and to identify common factors that could be used in a final risk management framework.

All APEC economies were invited to attend. Australia, Brunei Darussalam, Canada Chile, China, Chinese Taipei, Hong Kong China, Indonesia, Korea, New Zealand, Papua New Guinea, Peru, Philippines, Russia, Thailand, United States of America, and Vietnam attended. In addition the International Maritime Organisation (IMO) and the South Pacific Regional Environment Programme (SPREP) and representatives from a wide range of stakeholders participated at the workshop.

Some of the facts and discussion at the workshop are summarised and outlined below:

- Hull fouling was the most important vector historically and is gaining prominence.
- An effective response to the introduced marine pest problem will require management at the Regional, economic and local level.
- Commercial shipping and the number of trading partners are the most important factors affecting pathway strength.
- Bio-Geographical Regions - ***Biological invasions are one of the most serious ecological problems of the early 21st century. Since the 1950's, world trade has increased 14 fold.***
- A *Pathway* is the geographical corridor between Point A and Point B. Once a *pathway* between two places has been established, there are numerous *vectors* that can physically transport the species from one place to another. Any mechanism that transports marine organisms from shallow coastal water to similar habitats outside the species home range is acting as a *vector* for marine introductions.
- Evaluation of the introduced species in Australian waters suggests that the dominant modes of introduction historically are hull fouling.

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- ***It is clear that invasive marine species constitute major threats to the economic and environmental health of marine ecosystems, and may also pose substantial risks for human health.***

- APEC economies depend on sea-borne trade, and major international trade routes and sea-lanes pass through and around the region.

- Commercial shipping vessels transport marine organisms ranging from microscopic viruses and plankton to macro algae and fish across the seas in a multitude of habitats. With more that 35,000 vessels at sea on any given day, there are 998 recognised ports within APEC's pacific borders.

- APEC economies ranked commercial shipping as the most important factor affecting the strength of pathways transporting introduced marine pests.

- Shipping carries more than 80% of the world trade. Over the last 30 years world seaborne trade has more than doubles, from 2,490 million tonnes in 1970 to 5,330 million tonnes in 2000. In 2001 the registered merchant fleet consisted of 45,000 vessels.

- It is estimated that more than 10,000 vessels form 300 overseas ports visit Australia's 64 international Ports each year. The speed of conventional shipping is gradually increasing, reducing the time that an organism has to survive on the hull , thereby increasing the chances that it will reach the recipient port in good condition for colonisation

- The APEC Workshop on introduced marine pests noted that the translocation of marine organisms and micro-organisms beyond their natural environment is a serious and escalating problem in the APEC region, particularly given the environmental, economic, cultural and social impacts of Marine pests species and the reliance of many APEC economies on their marine and coastal resources.

- THE PRECAUTIONARY APPROACH has been generally supported and in short..........**The Precautionary Approach is generally understood as requiring action that anticipates and prevents environmental degradation, even in the absences of scientific certainty about damage and without a thorough proof of a cause and effect relationship. The 'Rio Declaration' notes that.....*Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.***

- Intervention, Prevention, Detection, Eradication and Control are the five areas identified.

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Inter-American Centre for Sustainable Ecosystems Development (ICSED)

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APEC Marine Resource Conservation Working Group

Development of a Regional Risk Management Framework for APEC Economies for Use in the Control and Prevention of Introduced Marine Pests

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FOREWORD

Economies in the Asia Pacific Region share their ocean and marine environment, and a common commitment to address threats to this environment in a coordinated way.

Alien species introductions, both intentional and unintentional, can become a major threat to our marine environment. Species that do not have natural competitors or predators can cause significant economic damage to aquaculture, fisheries, and the ecosystems we rely on for conservation and productivity.

In a spirit of cooperation within APEC, and with the objectives of the Marine Resource Conservation Working Group (MRCWG) in mind, Australia and Chile decided during 1999 to propose to the MRCWG a project to address the threat of introduced species that can become pests.

Following approval in 2001, the project commenced with two consultancies to characterise economies' strategies to control marine pests and to identify considerations for, and draft elements of, a regional risk management framework for possible use by APEC member economies.

In November 2001, a workshop was attended by most of the member economies, to discuss different approaches and to identify common factors that could be used in a final risk management framework.

The present report includes a range of information and the next steps necessary to address, in a coordinated and widely acceptable way, the problem of marine pests in the APEC region. We hope, that this work carried out by CRIMP and ICSED will be a keystone in the establishment of future, coordinated strategies designed to face a common and growing problem to us all.

Dr. Alex Brown
Director

Environmental Affairs and Sport Fisheries
Under-Secretariat of Fisheries Chile
Ministry of Economy of Chile

Mr. Philip Burgess
Director

Marine and International Section
Marine and Water Division
Environment Australia
Department of Environment and Heritage of Australia

PREFACE

The Marine Resources Conservation Working Group (MRC WG) approved a proposal by Australia and Chile at the 13th meeting of the MRC WG to conduct a project on ***The Development of a Regional Risk Management Framework for APEC Economies in the Use in Control and Prevention of Introduced Marine Pests***. This project, overseen by Environment Australia and the Under-Secretariat of Fisheries Chile was funded by the Asia-Pacific Economic Cooperation Secretariat and produced by two consultancy groups. Group A, the Chilean Consultancy, was conducted by the *Inter-American Centre for Sustainable Ecosystems Development (ICSED);* and Group B, the Australia Consultancy, was conducted by the *CSIRO Centre for Research on Introduced Marine Pests (CRIMP)*.

This project highlights the threats of introduced marine pests to APEC economies, prioritizes the vectors by which they could arrive in an APEC economy and summarises existing infrastructure to combat that threat. It presents considerations for a risk management framework could be initiated at local and regional levels to help prevent and control incursions of introduced marine pests. The project overseers split the review of APEC economies between the two consultancy groups and assigned the development of the risk management framework to Group B.

All APEC economies were invited to attend the APEC Introduced Marine Pest Workshop held in Hobart, Australia November 12th-15th, 2001. Australia, Brunei Darussalam, Canada, Chile, China, Chinese Taipei, Hong Kong China, Indonesia, Korea, New Zealand, Papua New Guinea, Peru, Philippines, Russia, Thailand, United States of America and Vietnam attended. In addition the International Maritime Organization (IMO) and the South Pacific Regional Environment Programme (SPREP) and representatives from a wide range of stakeholders participated at the workshop.

The draft risk management framework and economy investigations were reviewed and discussed by the participants of the workshop. This informal review process included group exercises and the presentation and release of two working progress papers entitled "Workshop Synopsis of IMP Management Across APEC Economies" (Group A) and "The Development of a Regional Risk Management Framework for APEC Economies in the Use in Control and Prevention of Introduced Marine Pests"(Group B). Additional questionnaires were used to supplement information available from individual economies during and after the workshop. On completion of the workshop, the project overseers and consultancies decided that the final report should be a single document. Through the workshop, it was evident that a general lack of awareness of introduced marine pests existed within the APEC fora. In order to address the need to promote awareness, the structure and content of the final report was altered to allow for ease of reading and for it to stand as an information source for researchers and managers.

This final report presents the results of the investigations into the current status of introduced marine pests and marine pest management in APEC economies. It highlights the considerations needed for developing a comprehensive risk management framework for use by all APEC economies as a practical, on-ground management tool to help protect APEC regional marine and coastal environments from introduced marine pests and relevant human and fish marine pathogens. Several of the latter are detailed in the report since their importance was recognised at the workshop.

This report covers the following areas:

Section 1. Introduction provides a background on the threats due to introduced marine pests, the role of APEC and the investigative methods used for this report. Introduced marine pests are defined and the introduction processes, observed impacts and general management are discussed.

Section 2. Management Capabilities and Approaches is composed of two sections: (1) International agreements and instruments, and (2) Status and discussion of APEC economies. These provide an overview of regional initiatives in place and economy obligations. It also discusses the management approaches and capabilities of each APEC economy according to their current institutional structure and administration.

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Section 3. Priorities and Hazards for APEC Economies comprises five sub-sections; 3.1 Impacts and Management priorities, 3.2 Vector hazards, 3.3 Factors affecting pathway strength, 3.4 Taxonomic hazards and 3.5 Regional priorities and hazards summary. This section evaluates the hazards identified by APEC economies associated with vectors, pathways and species and is supported by historical and current case studies of the role of vectors and pathways in introductions within APEC. It also present a list of known introduced species of concern identified within APEC economies – though it should be noted this list is not intended to be exhaustive.

Section 4. Considerations for a Risk Management Framework discusses the development of a risk management framework and incorporates international literature on marine pests as well as established management approaches to terrestrial diseases and pests as an overview of the invasion process and to detail opportunities for management intervention. This section also addresses the socio-economic implications of introduced marine pests, including how to assess alternative management strategies and measures..

Section 5. Conclusion and Recommendations provides recommendations and concluding remarks.

Both groups wish to thank the government and non-government institutions, international organizations, government officials and scientists of all APEC economies, who contributed valuable information on introduced marine pests and their management, without which this work could have not been completed. We especially thank Mr. Philip Burgess, Environment Australia and his team and by Dr. Alex Brown, the Under-Secretariat of Fisheries of Chile, for their administrative and technical support. Finally, the editors of this report thank the team members of both groups for their hard work and effort without which this report could have not been successfully completed.

GLOSSARY OF TERMS AND DEFINITIONS

The following definitions of relevant introduced marine pest terminology have been collated from a variety of relevant references, chiefly; ANSTF 1996; Carlton 1996; Subansingh *et al.* 1996; FAO 2000; Shine *et al.* 2000; Carlton 2001, and Hayes in prep.

APEC	Asia Pacific Economic Cooperation
Ballast water	Any water and associated sediments used to manipulate the trim and stability of a vessel.
Baseline port survey	Biological surveys that determine the baseline level of introduced marine species in a port.
Biocontrol	Refers to the release of one species to control another.
Bioinvasions	A broad based term that refers to both human-assisted introductions and natural range expansions.
Border	The first entrance point into an economy's jurisdiction.
Cost benefit analysis	Analysis of the cost and benefits of a course of action to determine whether it should be undertaken.
CRIMP	CSIRO Centre for Research on Introduced Marine Pests.
Cryptogenic	A species that is not demonstrably native or introduced.
CSIRO	Commonwealth Scientific and Industrial Research Organisation.
Disease	Clinical or nonclinical infection with an aetiological agent.
Fouling organism	Animals and plants, such as barnacles, mussels, and seaweeds that attach to human-made substrates, such as piers, navigation buoys, and the bottom of ships.
Hazard	A situation that in particular circumstance could lead to harm. The measure of the likelihood of these circumstances and the magnitude of the subsequent harm is a measure of risk.
Hazard assessment	An assessment of associated hazards to qualitatively evaluate the likely risks posed to an environment on the basis of past activities (Hewitt and Hayes in press).
ICSED	Inter-American Centre for Sustainable Ecosystems Development.
IMO	International Maritime Organization.
Indigenous or native	Species that would be present without human interventions.
Intentional introduction	The knowing import or introduction of nonindigenous species into, or transplant through, an area or ecosystem where it was not previously established.
Introduction or translocation	The human assisted movement of an animal to an area outside its natural range.
Introduced marine pest	An introduced marine species that threatens human health, economic or environmental values.
Introduced marine species	A marine species that's movement has been assisted by human activities to an area outside its range.

Invasive	An alien species that becomes established in natural or semi-natural ecosystems or habitat, is an agent of change, and threatens native biological diversity.
Marine pathogen	A disease causing marine agent.
Naturalised or established	A non-indigenous species that produces self-sustaining populations.
Non-indigenous, alien, exotic, introduced or adventive	Species that have been transported by human activities – intentionally or unintentionally – into a region in which they did not occur in historical time and are now reproducing in the wild.
Non-invasive	A non-indigenous species that does not spread but remains localised within its new environment.
Native invasive	Species that get into modified habitats by their own means and then go through population explosions.
Pathway	The route (the geographic corridor from point A to point B).
Pest	A non-indigenous species that threatens human health, economic or environmental values.
Pre-border	Prior to introduction into an economy's jurisdiction.
Post-border	Within the economy's jurisdiction.
Quarantine	The holding of organisms under conditions that restrict their escape or the escape of organisms associated with them into the open natural environment.
Risk	The likelihood and magnitude of an event.
Risk analysis	Risk analysis is made up of three components: risk assessment, risk management and risk communication. The process seeks to identify the relevant risks associated with a proposed introduction and to assess each of those risks.
Risk assessment	The means by which the frequency and consequences of such events (risks) are determined.
Risk management	The culture, processes and structures that are directed towards the effective management of potential opportunities and adverse effects.
Risk management framework	An overview of the culture, processes and structures of risk management.
SPREP	South Pacific Regional Environment Programme.
Unintentional introduction	An introduction of nonindigenous species that occurs as a result of activities other than the purposeful or intentional introduction of the species involved, such as the transport of nonindigenous species in ballast or in water used to transport fish, molluscs or crustaceans for aquaculture or other purpose. Involved is the release, often unknowingly, of non-indigenous organisms without any specific purpose.
Vector	The physical means or agent by which a species is transported. Ballast water, ships' hulls, and the movements of commercial oysters are examples of vectors.

EXECUTIVE SUMMARY

Marine pests are species moved by human activities to an area outside their natural range, and which threaten human health, economic or environmental values. The introduction of marine pests is a major threat to the marine environment and adversely affects economically important marine-based activities and uses. Impacts of introduced marine pests can be dramatic and are usually irreversible. Introduced marine pests have collapsed fisheries, destroyed aquaculture stock, increased production costs, threatened human health and altered biodiversity.

Introductions can be either accidental or intentional, and arise from a wide range of commercial and private practices. Globally, at any given moment, some 10,000 different species are being transported between bio-geographic regions in ballast tanks. Hull fouling was the most important vector historically and is again gaining prominence with the phasing out of tri-butyl tin (TBT) and increasing small boat traffic. Viruses and pathogens have been spread between APEC economies as part of aquaculture products and processed fish products, with devastating consequences to local aquaculture. Fortunately, most potential invaders die before they can establish because environmental conditions at the time and port of discharge are not suitable. Even when they establish, most do not become invasive -- at first. Nonetheless, ballast water has become cleaner, ship's transit speeds continue to increase, new vectors and new trade routes are developing, and environmental management of ports has improved water quality and provided suitable habitats. In response, the rate at which foreign organisms are establishing in ports worldwide is increasing exponentially. A new introduced species establishes in San Francisco Bay and Port Phillip Bay every 3 – 6 months, for example.

This report was developed as part of an APEC Introduced Marine Pest Workshop held in Hobart, Australia November 12th-15th, 2001, and was updated to include information from attending APEC economies. The report:

- reviews international agreements and protocols relevant to introduced marine pests;
- examines the approaches to detection and management of introduced marine pests in APEC economies;
- identifies and reviews the impacts, management priorities and hazards of introduced marine pests to individual economies and the APEC region as a whole;
- details introduced marine pests recognised by APEC member economies in the Asia Pacific region; and
- details the necessary considerations for developing a risk management framework to respond to the threat of introduced marine pests in APEC economies and the APEC region as a whole.

Key Findings

Key findings are itemised below under headings that match section headings in the report. Recommendations are collated at the end of this executive summary.

Management Capabilities and Approaches

There are many international and regional agreements and protocols relevant to introduced species – but few specific to introduced marine species. Many of these instruments could be extended to include introduced marine species. APEC and the Marine Resource Conservation Working Group has a role to fulfill in liaising with relevant international and regional bodies, including IMO, FAO, NACA and SPREP, to enhance the effectiveness of existing instruments relevant to the APEC region.

At the level of individual APEC economies:

- Institutional arrangements and processes for managing the marine environment and maritime activities is fragmented in most economies:
    - there is no comprehensive strategy/policy framework for management and decision making;
    - vectors and introduced marine pests are often managed by a number of agencies and authorities;
    - there is often a lack of clear responsibility for the problem of managing introduced marine pests.
- Baseline surveys to identify introduced marine pests are limited.
- The capacity to detect new marine pest incursions varies greatly between economies.
- There is a lack of public awareness of introduced marine pests and their impacts.
- Vector management is limited and unbalanced -- the predominant focus is on managing ballast water alone.

At the APEC regional level:

- There are inadequate linkages throughout the region for data exchange, support and communication purposes.
- The variable management capabilities and hazards within individual member economies ultimately leave the whole APEC region vulnerable to bioinvasions.
- An effective response to the introduced marine pest problem will require management at the regional, economic and local level.
- A number of international initiatives have identified alien invasive species as a major challenge for decision makers at local, national, and regional levels.
- Many international instruments, including work by the International Maritime Organization (IMO), are designed to provide guidelines to be implemented by the member parties, supplemented by initiatives and work programs undertaken by regional groupings such as APEC.
- As APEC economies border the world's major ocean and are linked by shipping routes, APEC has an opportunity to influence global action on this issue and more effectively manage the risk to each economy through its regional response.

Priorities and hazards for APEC economies

To gain most benefit from the resources available to reduce the risk of introduced marine pests, it is important to know the relative threat posed by each vector and whether the threat is increasing, decreasing or stable. Detailed questionnaires completed by eleven APEC economies, supplemented by biological data indicated that:

- Hazards vary between the economies based on the levels of activities, management capabilities and bioregion.
- Ballast water and hull fouling (commercial ships, fisheries vessels, recreational boats, and drilling platforms) are the most important vectors for introduced marine pests.
- International shipping, aquaculture and marine biodiversity are the maritime values most heavily impacted by introduced marine pests.
- Commercial shipping and the number of trading partners are the most important factors affecting pathway strength.

- A limited number of introduced marine species have been identified within the APEC region, with information scattered through many sources.

Considerations for a risk management framework

Risk management – "the culture, processes and structures that are directed towards the effective management of potential opportunities and adverse effects" – could become an important tool in reducing the risk of new introductions and responding to existing introductions. Cost-benefit analysis can augment risk management and provide a mechanism for prioritizing management response. The following points need to be considered when developing a risk management framework:

- Risk management can be achieved by economies working collectively, to an agreed timeframe, on the common requirements, protocols and procedures for the reduction of the spread and further introduction of introduced marine pests (including micro-organisms and pathogens) across local boundaries.
- The invasion process can be broken down into discrete phases providing discrete opportunities for risk management – the pre-border, border and post-border phases.
- The border can be the border of a region, an economy or a local jurisdiction – any place on the transport pathway where jurisdiction exists or could be developed to protect areas inside the border. The first border from an APEC perspective would be that of the Pacific Ocean; the second border that of an individual economy or biogeographical province; the third that of a province, port or island.
- Once an introduced marine species has established inside the border, further spread occurs through secondary, to tertiary introductions.
- Changes in commercial vessel movements, trade routes, aquaculture, recreational traffic and transport of marine products affect the magnitude of the hazard associated with each vector and allow new vectors to appear.
- Change complicates extrapolating from known hazards in an individual economy to different economies and future hazards.
- However, analysis of past trends in the species introductions by major vectors will provide some indication of future trends.
- Effective assessment of the social, economic and environmental costs of introduced marine pests and the benefits of alternative management options would assist choosing between management interventions.
- The changing risk environment means that effective risk management of marine pests will not be a single intervention.
- Effective risk management requires developing:
    - an awareness of the problem in APEC economies;
    - appropriate information systems and tools to react to the problem; and
    - developing or adapting current institutional structures at the level of individual economies and the region to monitor, report and implement the necessary response.

Recommendations

This report makes the following recommendations for immediate action to address the increasing threat of introduced marine pests to APEC economies:

Prioritisation

- Introduced marine pests become a standing item for the Marine Resource Conservation Working Group (MRC-WG).
- Cooperative projects be established to develop a strategy for managing introduced marine pests in each individual economy and in the APEC region as a whole, as the first step in developing a regional response to introduced marine pests.

Comprehensive assessments of the situation

APEC should support the establishment of the following regional tools or initiatives for assessing the situation and reducing problems posed by introduced marine pests:

- Construction of a comprehensive hazard analysis and assessment of APEC member economies and APEC as a whole, using a standardised set of analysis tools.
- The development of a complete list of introduced marine species in the APEC region.
- The undertaking of baseline port surveys of all major trading ports in the APEC region using consistent protocols.
- Valuation of the environmental, social and economic impacts of introduced marine pests and the potential management strategies, policies and measures that can be applied to them, as a basis for sound decision-making.

Intra-APEC fora collaboration

- This issue crosses the mandates of several APEC working groups. It should be coordinated by the Marine Resource Conservation Working Group.

International fora collaboration

- APEC (MRC-WG) should liaise with relevant international and regional fora including IMO, FAO, NACA and SPREP to enhance the effectiveness of regional approaches and of relevant international instruments and their implementation.

Regional communication/technical support

- APEC should develop an effective regional system for information sharing, capacity building, tool development and reporting procedures. The development should be led by a small representative task group working by correspondence and reporting through a central information server system established on the Internet.
- The establishment of a central server on the Internet that provides easy accessible information on; potential marine pests, their distributions and vectors; their impacts, and management and response strategies in place and being developed.

Institutional framework strengthening

- Each economy should dedicate authority to an existing agency or establish a new agency, to manage introduced marine pests and to provide reports to the Marine Resources Conservation Working Group.
- A reporting procedure should be developed for all economies.
- Each economy should act to facilitate APEC and other responses at local levels.

Capacity building

- Each economy should encourage participation in capacity building exercises and cooperative projects that enhance awareness, monitoring and response.
- APEC should provide, or facilitate, assistance for developing economies through training and exchange programs.

SECTION 1
INTRODUCTION

Biological invasions are one of the most serious ecological problems of the early 21st century – and the trade policies of the new global economy are an unwitting contributor to this problem. Since the 1950s, world trade has increased 14-fold, during this same time, biological invasions in terrestrial, freshwater and marine habitats has increased exponentially (Ruesink et al. 1995; Ruiz et al. 1997; Nordstrom and Vaughan 1999).

Scientists and policy makers increasingly see the introduction of alien species as a major threat to marine biodiversity and a contributor to environmental change (Bax *et al.* 2001). These marine introductions, intentional and accidental, can result from numerous human mediated activities that are typically driven by global trade and human movement. Given that scientists have only begun to realise the magnitude of the problem, comprehensive global and local management is in its infancy (Bax *et al.* 2001). Nevertheless, through increasing the awareness of the global community and highlighting the need for action through regional forums such as APEC, these limitations seen today can be overcome. Within APEC, responses have been initiated by several economies to prevent and control introduced marine pests. However, these individual responses will only be effective if they are complemented by neighbouring economies and trading partners. Section 1 outlines the background of the introduced marine pest problem and the approach taken in the construction of this report.

1.1 BACKGROUND

Ever since people began travelling in ships, they have inadvertently carried "pests" with them, including diseases, rats and, largely unnoticed marine organisms. Historical records and studies on modern replicas indicate that wooden sailing ships were often heavily encrusted with fouling organisms, that were scrubbed off at stops along the voyage. It is perhaps not surprising, therefore, to find that many wood-boring species, like the teredo "shipworm" (actually a mollusc), *Teredo navalis*, have cosmopolitan distributions.

Marine invasions are not just historical. At any given moment some 10,000 different species are being transported between bio-geographic regions in ballast tanks alone (Carlton 1999). Fortunately, most of these potential invaders die. Many cannot survive the dark and often dirty conditions in ballast tanks; for others, environmental conditions at the port of discharge are not suitable. Nonetheless, as ballast water has become cleaner, ships transit speeds have increased, and environmental management of ports has improved water quality, marine organisms are finding commercial shipping and other vectors increasingly hospitable means of transport world-wide. Reflecting these factors, the rate at which foreign organisms are establishing in ports has increased dramatically since the 1970s. In both San Francisco Bay (California), and Port Phillip Bay (Australia), two well studied areas, on average, a new exotic species now establishes itself every 3-6 months.

1.1.1 WHAT IS AN INTRODUCED MARINE PEST?

Currently, there is no universally accepted term for a species that occurs outside its natural range; commonly used terms include; alien, exotic, nonindigenous and introduced species. If this introduced species has threatening characteristics, it is referred to as a nuisance or pest species. In the marine realm, the most common terms are "nonindigenous aquatic organisms" and "introduced marine species". "Introduced marine species" and "introduced marine pests" are the terms used throughout this report, though they do encompass all other relevant terms.

The distinction between an introduced marine species and an introduced marine pest is the impact of its introduction. By definition, an **introduced marine species** is a species that's has been moved by human activities to an area outside its **natural** range (FAO 2000). Whilst **an introduced marine pest** is an introduced marine species that ***threatens*** human health, economic or environmental values (Hayes in prep).[1]

Not all introduced marine species become pests. Ecological factors such as predation and water quality prevent some species from reaching the densities required to achieve pest status. Some species, by their very nature, are unlikely to be more than ecological nuisances, though all will likely have some impact on native marine communities and hence will be undesirable from that perspective alone. The point at which an introduced species becomes an introduced pest is vague, in most instances (an exception would be species that threaten human health), and often depends on population density. In some cases, species that have been relatively harmless for long periods suddenly increase sharply in abundance and become pests. A good example is the Chinese mitten crab, *Eriocheir sinensis*, which was first discovered into the river Thames in 1935 (Ingle 1986), but did not reach high populations until after a drought in 1989-1992 (Eno *et al.* 1997). Harmful fish and human pathogens introduced into new marine waters also fit the definition of an introduced marine pest, but will be treated separately (refer to Box 1).

Box 1. Harmful pathogens in the marine environment

Harmful pathogens introduced into new marine waters through human assisted activities are *not* introduced marine pests, however they do present the same problems. Increasing populations in the coastal zone has introduced more enteric bacteria, viruses and fungi into the adjacent waters as waste discharge (Goldberg 1995). The importation of fishery products, feeds and aquaculture stock has also allowed pathogens to enter new marine waters. These waters can be taken up by ships for ballast water and then discharged in ports throughout the ships' voyage. There is speculation about the role of ballast water in introducing a strain of *Vibrio cholera* into Latin America from an Asian origin. More recently, ballast water from vessels docked in the USA, with a last port of call in Latin America have been found to contain this same strain of cholera bacterium (Kumate *et al.* 1998). This report does detail some human and fish pathogens, though the lack of comprehensive information on pathogens and their introduction in the marine environment has limited the extent they are reviewed.

1.1.2 THE THREAT OF INTRODUCED MARINE PESTS AND PATHOGENS

Introduced marine pests are a primary threat to the marine environment (Hatcher *et al.* 1989; Heywood 1989; Lubchenco *et al.* 1991; Norse [Ed] 1993; Suchanek 1994). The impacts of these introductions are diverse, and clearly differ between species, but can affect marine ecosystems, industries, human health and marine uses and values. The case of the green algae, *Caulerpa taxifolia* (refer to Box 2), highlights the range of impacts that one exotic species can have in a new ecosystem.

Box 2. Impacts of *Caulerpa taxifolia* in the Mediterranean Sea

In the Mediterranean Sea, the escape of *Caulerpa taxifolia*, from an aquarium in Monaco in the mid 1980s has resulted in the aggressive spread from a few fronds to a mass of algae overgrowing seagrass beds, mud flats, rocky reefs and other in-shore habitats. In these areas it out-competes native species and forms extensive single-species beds covering up to 97 per cent of available habitats. The invasive strain has now spread as far as the Adriatic Sea, and in 1994 was estimated to cover over 3000 hectares of coastal habitats. It is projected to eventually spread over most of the Mediterranean. Coastal fisheries in invaded areas have declined massively, to the extent that the plant is referred to locally as the 'death weed' and "killer alga".

[1] The process of identifying an introduced marine species and an introduced marine pest is described in Section 3.

1.1.2.1 Environmental impacts

Introduced marine pests are significant stressors, often forcing changes in their new marine communities (Ruiz *et al.* 1999). In the San Francisco Bay and delta, 212 established exotic species have been reported, which are so pervasive that virtually every coastal habitat in the bay is now dominated by one or more exotic species (Cohen and Carlton 1995). In Hawaii, 91 of the nearly 400 species present in Pearl Harbor were, or are very likely to be introduced (Coles *et al.* 1999). One recent invader, a barnacle from the Caribbean, probably arrived as a hull fouler and now dominates the mid-intertidal zone throughout the harbour. A study in 1996 found that three of the six most common benthic marine species in Port Phillip Bay are not native (Hewitt *et al.* 1999), a statistic that does not include two recent and rapidly proliferating invaders - *Sabella spallanzanii* and *Asterias amurensis*. The dominance of exotics in Port Phillip Bay has developed only in the last twenty years.

1.1.2.2 Economic impacts

Introduced marine pests cause two main categories of economic impact; (1) losses in potential economic output, and (2), direct cost of combating invasions (Mack *et al.* 2000). Regarding the first category, the collapse of fisheries and aquaculture operations associated with introduced marine pests is well documented. These collapses have resulted in massive losses in revenue and implications on farmers, fishers and all post harvest industries as well. One species, the Asian clam *Potamocorbula amurensis*, reaches densities of over 10,000 per square metre, and has been blamed for the collapse of the San Francisco Bay fisheries. In the Black Sea, an invasive comb jelly, *Mnemiopsis leidyi* has been blamed for the collapse of pelagic fisheries. The invasive crab, *Carcinus maenas*, a European species now found in Australia, Japan, South Africa and both coasts of North America, is blamed for the collapse of bivalve fisheries on the North American east coast. Aquaculture operations are highly susceptible to organisms such as toxic dinoflagellates, fish and human pathogens in the local marine environments. The introduction of the white spot syndrome virus (WSSV) and *Alexandrium catenella*, a toxic dinoflagellate, have resulted in massive stock losses, farm closures, revenue losses and human health implications globally.

Box 3. Impacts on stakeholders

Given the diverse characteristics of introduced marine pests and pathogens, a large number of stakeholders are negatively impacted. These impacts include decreased productivity for fisheries operators, loss of stock for aquaculture operators, decreased efficiency for shipping operators, human health implications and loss of tourism revenue to name a few. Table 1.1 identifies stakeholders that are potentially impacted by introduced marine pests.

Table 1.1. Potentially impacted stakeholders.

Sector	Stakeholders	Type of impact
Government	Management and regulatory agencies (Maritime transport, ports, fisheries, aquaculture, environment, conservation, customs, quarantine and health)	Need for new policies, legislation, management strategies, actions, responses and departments. Need to enforce compliance of these activities.
Industry	Shipping (international and domestic)	Decrease in efficiency, bad reputation
	Aquaculture operators	Loss of stock, gear fouling
	Fisheries operators	Collapse of fisheries, gear fouling
	Oil, gas and mining	Fouling, damage
	Marine tourism operators	Decrease tourism interests
Social	Humans	Illness, death, loss of employment
Other	Infrastructure	Fouling, damage
	Conservation Groups	Loss of biodiversity

1.1.3 THE INTRODUCTION PROCESS

The intercontinental dispersal of living organisms into new marine ecosystems has been steadily increasing with global human migrations over the past five or more centuries. These migrations are largely accompanied by the **intentional** movement of food species, and the **unintentional** movement of associated species (Crosby, 1986; Carlton, 1989, 1992). At present, human migrations of this magnitude and method are rarely seen. However in their place, the current movement of commodities and people rapidly over long distances in ships and aircraft, has allowed for a **pathway** or route to be established for the movement of species across water systems.

Carlton (2001) describes pathways as the geographical corridor between point A and point B. Once a pathway between two places has been established, there are numerous **vectors** that can physically transport the species from one place to another. Any mechanism that transports marine organisms from shallow coastal waters to similar habitats outside the species' home range is acting as a vector for marine introductions. Most vectors will be carrying introduced species to recipient locations, however they only pose a threat to that location if there is a non-zero probability that the introduced species will survive, establish and become invasive.[2] Anthropogenic vectors for marine introductions as adapted from Carlton (2001) are presented in Table 1.2. This includes 7 vectors for new introductions (New) and vectors that translocate introduced species domestically (Dom).

Table 1.2. Anthropogenic vectors for marine introductions (Carlton 2001).

Source	Vector	Target taxa	Donor region
Commercial shipping	Ballast water	Plankton, nekton, benthos in sediment	New / Dom
	Hull fouling	Encrusting, nestling, and some mobile species	New / Dom
	Solid ballast (rocks, sand, etc)	Encrusting, benthos, meiofauna and flora	New / Dom
Aquaculture and fisheries	Intentional release for stock enhancement	Single species (plus associated species)	New / Dom
	Gear, stock or food movement	Various	New / Dom
	Discarded nets, floats, traps, trawls, etc.	Various	New / Dom
	Discarded live packing materials	Various	New / Dom
	Release of transgenic species	Single species	New / Dom
Drilling platforms	Ballast water	Plankton, nekton, benthos in sediment	New / Dom
	Hull fouling	Encrusting, nestling, and some mobile species	New / Dom
Canals	Movement of species through locks due to water motion or active swimming	Various	New
Aquarium Industry	Accidental or intentional release	Aquarium fauna and flora	New / Dom
Recreational boating	Hull fouling	Encrusting, nestling, and some mobile species	Dom
Dive practices	Snorkeling and scuba gear	Algal spores, bacteria, some small mobile species,	New / Dom
Floating debris	Discarded plastic debris	Encrusting and some mobile species	New / Dom

[2]This subject is discussed further in Section 4.2 A risk management framework.

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Historically vectors have included hull fouling (and boring), dry and semi-dry ballast, ballast water, unintentional introductions associated with the importation of mariculture species, and deliberate introductions of exotic species for mariculture (Campbell and Hewitt 1999) (refer to Box 4). More recent vectors include the aquarium trade, recreational water users, and the oil, gas and construction industries. Advances in technology and changes in the practices of shipping and other marine based industries over the last 200 years has increased the number of vectors available for species introductions and the speed at which they operate. This both increases the probability that a known invasive species will be transported and increases the probability that previously untransported species will find suitable vectors (Carlton 2001).

Box 4. The importance of different vectors

One measure of the relative importance of the different transport vectors is the proportion of invasive species attributed to each by different studies. In San Francisco Bay, four vectors are thought to historically be of roughly equal importance: ship fouling (26 per cent of introduced species), ballast water (24 per cent), accidental introductions due to mariculture (22 per cent), and deliberate introductions (20 per cent). In New Zealand, most invasive species have been attributed to hull fouling (Cranfield *et al.* 1998). Evaluation of the introduced species in Australian waters suggests that the dominant modes of introduction historically are hull fouling and accidental releases associated with mariculture, followed by ballast water, dry ballast and intentional releases. Ballast water accounts for only 15-20 per cent of the invasive marine species found thus far in Australia, but is becoming the major threatening vector in the last two decades (Hewitt *et al.* 1999). The vectors responsible for Australia's designated pest species are also diverse. Of the 12 species introduced into Australian waters (groups) listed on the Marine Target Species List by the Australian Ballast Water Management Advisory Council, only one group (toxic dinoflagellates) almost certainly arrived in ballast tanks. A second (an Asian clam, *Corbula gibba*) could have arrived either in ballast water or as a fouling organism. Of the remaining species: Pacific oysters, *Crassostrea gigas*, were deliberately introduced; *Carcinus maenas* the European shore crab probably arrived in dry ballast; *Maoricolpus roseus*, a screw shell, was accidentally introduced in oyster shipments or dry ballast from New Zealand, and the others appear to be 'fouling' organisms, in the broad sense of the term.

1.1.4 MANAGING THE THREAT

It is clear that invasive marine species constitute major threats to the economic and environmental health of marine ecosystems, and may also pose substantial risks for human health. Toxic dinoflagellates, cholera, and recently *Pfiesteria piscicida*, are all known to have significant human health risks, and all have been identified in ballast tanks. It is also clear that no single vector accounts for all pest species. Consequently, management actions that focus solely on one vector, even if completely successful, will not stop invasions. A comprehensive management system is required that assesses the risks posed by different species and vectors, and then determines appropriate actions.

To date, very few countries have done this. This may be the result of poor appreciation of the economic and environmental costs of bioinvasions, and, for marine invasions in particular, their often hidden nature. A massive invasion by a marine species is often much less conspicuous than, for example, an invasion by a brightly flowering garden plant. Nonetheless, the examples listed above and the work of biologists worldwide have resulted in marine introduced species emerging as a major management issue within the last 20 years.

Specific regulatory initiatives to reduce their impact are only now being developed, and to date have concentrated primarily on international shipping and ballast water. The International Maritime Organisation (IMO) introduced voluntary ballast water guidelines in 1997 and has developed a model management plan to minimise the risk of introductions of potential marine pests. A number of countries (Australia, Canada, Chile, Israel, New Zealand, USA) and provincial jurisdictions within these countries have developed or are developing ballast water legislation.

Initiatives such as New Zealand's proposed Biodiversity Strategy and Australia's proposed National System for the Prevention and Management of Introduced Marine Pests take a more comprehensive approach to target marine introduced species. These initiatives include a range of pre-border to post-border control systems for various vectors, monitoring activities to detect new incursions or the spread of existing pests, pest emergency response procedures including inter-agency coordination and cost-sharing arrangements, and options for long-term control of existing pests.

1.1.5 WHAT CAN APEC DO?

APEC provides a suitable forum through which to develop a regional management response to problems of introduced marine pests. APEC economies depend on sea-borne trade, and major international trade routes and sea-lanes pass through and around the region. Each economy has major international ports that are high-risk sites for introducing marine pests. Intra-economy sea borne trade provides a major means of translocating introduced pests and increases risk. Equally important in the assessment of such risk, is to recognise that the marine zones of APEC economies contain important industries such as aquaculture and capture fisheries that may be adversely affected by such introductions.

The perceived tensions between initiatives for trade liberalisation, on the one hand, and increased awareness of the need to minimise the risks of bioinvasions needs to be reconciled. Successful abatement and management of the threats due to invasive marine species will only be most effective when addressed at global and regional levels, as well as at the level of individual economies. The initiatives of a number of countries to develop and implement pest management strategies are greatly enhanced when integrated into regional management plans and objectives. A regional response within APEC provides a valuable pathway for government and industry to capitalise on shared experiences and to maximise the economic and environmental returns on their collective investments in managing marine pests and their vectors.

1.2 OBJECTIVE

The main objective of this report is to summarise background information on the APEC economies, the threat of marine pests in the APEC region and features necessary for managing the risks of introduced marine pests in their economies and within their region. This information was used to develop a draft risk management framework, at the APEC workshop held in Hobart, Australia on the 12-15th of November 2001. The framework was designed as a practical, on-ground, management tool to help protect APEC regional marine and coastal environments from introduced marine pests and relevant human pathogens through the use of strategic and operational measures.

1.3 METHODOLOGICAL APPROACH

APEC encompasses an extremely large region of the world and includes member economies of varying levels of economic development and political organisation. Incorporating this variation into regional management responses is important for increasing the effectiveness of its implementation. For this report, reviewing information on the management approaches, capabilities and hazards for each APEC economy was a precursor to developing the risk management framework for the use of APEC economies to control and prevent introduced marine pests.[3]

To meet the report objective, the methodology was divided into four stages.

1. **Background**

   1.1. Provide a background to the problem of introduced marine pests.

   A literature review was used to provide background and cases to the global problem of introduced marine pests.

[3] Please make note that as a 'precursor' is does not mean defined steps to make a risk management framework, but considerations needed to be incorporated when developing the risk management framework.

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2. Review APEC economies management approaches and capabilities

2.1. Identify international instruments and agreements concerning introduced marine pests in place and the participation of APEC economies.

A literature review encompassing a web search was used to describe relevant international agreements and instruments and the level of participation of APEC member economies.

2.2. Review of management approaches and capabilities of each APEC economy for the marine environment and introduced marine pests.

Formal qualitative questionnaires were posted to relevant APEC contacts in the economies. Additional information was collected from web searches of each economy. A draft of the available information was presented at the APEC workshop for review.

3. Determine priorities and threats for APEC economies

This stage used an electronic questionnaire, revised from one presented at the APEC Introduced Marine Pest workshop held in Hobart, 2001. This questionnaire was sent to all delegates or advised contact persons.

3.1. Identify impacts and priorities for management.

Economies were asked to rank the level of harm of introduced marine pests on marine values and uses. They also assigned a priority value from 1 to 14 of these marine uses and values at threat from introduced marine pests based on current management importance.

A comprehensive hazard analysis was beyond the scope of this report but hazards were identified through a ranking process. The identification of the hazards was divided into two sections, (a) the hazards associated with the introduction process (vectors and pathways) and the (b) hazards associated with marine species.

3.2. Identify hazards within APEC economies associated with the introduction process.

The hazards associated with the introduction process and vectors were identified during the APEC Introduced Marine Pest workshop held in Hobart, 2001. Economies were asked to rank (high, medium and low) to the hazards based on the current levels of activities, legislation and regulations and management capabilities. To gain an overview of the level of risk associated with the hazards, individual economy data were compiled and aggregated. This provided a simple average risk and range associated with the identified hazards. To supplement the hazard ranking, a literature review was used to produce a short background description of each vector identified.

3.3. Identify hazards within APEC economies associated with species.

An 'example' list of 104 introduced marine species and pathogens (human and fish) were profiled following a review of the Centre for Research on Introduced Marine Pests (CRIMP) database, literature, the CRIMP 'next pest' database (Hayes, unpub. data) and communication with contacts within APEC economies. We present only a list of species of concern. Species were chosen based on whether they had been introduced into the APEC region (we only focussed on the Pacific Ocean for economies with shared oceanic coastlines), if there was comprehensive data coverage and if they had known impacts. A comprehensive list of all introduced marine species was not attempted due to time constraints and the nature of such a task.

4. Determine considerations for a risk management framework

4.1. Risk management framework.

Managing introduced marine pests is a relatively new activity, and there are no management frameworks that address all potential risks. We reviewed the international literature on marine pests and borrowed from the established management of terrestrial diseases and pests to provide overviews of the invasion process and the changing risk environment, and to detail opportunities for management intervention.

4.2. Review cost benefit analysis.

Box 5. Operational definitions

Introduced marine pest research and management, like many other specialist science disciplines, has its own terminology. Terms used within this report may not have been heard before or only known in a different context. To accommodate this and variations in knowledge of introduced marine pests, a glossary has been provided. This is found on page vi - viii. It should also be noted that several terms are used interchangeably. These include; mariculture and aquaculture; invasive alien species and introduced pests; exotic, alien and introduced. Acknowledgment of this is important for clarity of this report.

Limitations to research:

Limitations to these research methods included:

- The lack of available information about marine environmental management for some APEC economies.
- The lack of regional or global experience in managing risks associated with introduced marine pests especially post-border.
- Operational limitations on the time frame and budget.
- The lack of economy-specific information for a comprehensive hazard analysis

While all attempts have been made to use the most current information, the rapid time frame of the report and the difficulty in identifying key experts in each economy has meant that not all information has been reviewed by the relevant economy

1.4 SUMMARY

Introduced marine pest management initiatives have historically lagged behind responses for all other major threats to the marine environment and biodiversity. Ship borne pollution and overfishing has been approached by numerous international organisations, committees and conventions; and thus incorporated into economy legislative and regulatory measures. Though introduced marine pests are a primary threat to the marine environment, relatively little global recognition or understanding has been achieved until more recently.

Invasions of introduced marine pests can be catastrophic, and as APEC encompasses such a large region of the world and includes all major economies on the Pacific rim, it is a suitable forum for initiating and encouraging response, both regionally and at the individual economy level. This response needs to be transparent for ease of implementation and direct as the threat of introduced marine pests continues to increase. **We recommend that introduced marine pests become a standing item for the Marine Resources Working Group (MRC-WG).**

SECTION 2
MANAGEMENT CAPABILITIES AND APPROACHES

Government agencies and others have been working to control alien species on land and freshwater for decades, with mixed success, but control of alien marine species is in its infancy (Bax et al. 2001).

Particular institutional arrangements and processes influence management of the marine environment within each APEC economy. These arrangements and processes have a direct influence on the effectiveness and efficiency of such management. Those relevant to introduced marine pests and human pathogens are complicated by the diversity of the vectors. Potential vectors for the introduction of marine organisms, as well as the organisms themselves once introduced, are often managed by a number of authorities including, for example, transport, port/harbour, quarantine/customs, fisheries, and environment/ conservation. The implementation of policy and practice relevant to the management of introduced marine pests is influenced by; the national regulatory system, the relationships between national and sub-national governments (if present), the role of local authorities and the amount known about the local native and introduced marine species.

Developing management arrangements for introduced marine pests requires a review of the current status of legislation and administration of economies within the APEC region. This review can identify gaps in management and knowledge. In the long term, these gaps present hazards or impediments for the success of introduced marine pest management. This section presents the international and regional instruments currently in place and the management capabilities and approaches of each APEC economy.

2.1 INTERNATIONAL INSTRUMENTS AND AGREEMENTS

2.1.1 GLOBAL RESPONSES

A number of international activities have recently identified alien invasive species as a major future challenge for decision makers at local, national, and regional levels. These include the Convention on Biological Diversity (Decision V/8- Alien species that threaten ecosystems, habitats or species), which has been ratified by the majority of APEC economies covered by the Australia Consultancy, the IUCN guidelines for the Prevention of Biodiversity Loss caused by Alien Invasive Species, and the Draft Invasive Species Strategy for the Pacific Islands Region, which covers the APEC economies Australia, Papua New Guinea, and New Zealand. None of these initiatives specifically target marine introduced pests. Other international instruments and developments have application in developing a regional response to introduced marine pests. These include the "**precautionary approach**"(refer to Box 6), the reach of World Trade Organisation (WTO) Agreements, and the Convention on Biological Diversity and the Cartagena Protocol on Biosafety.

Box 6. The Precautionary Approach

The application of the precautionary approach is relatively recent, gaining considerable impetus from the outcomes of the United Nations Conference on Environment and Development (UNCED) in 1992 (including the Rio Declaration and Agenda 21). In short the precautionary approach is generally understood as requiring action that anticipates and prevents environmental degradation, even in the absences of scientific certainty about damage and without a thorough proof of a cause and effect relationship. The Rio Declaration notes that 'where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation'

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2.1.1.1 *Policies/Non-Binding Instruments*

The following instruments are not binding unless implemented at a national level by States. They each concern introduced marine pests and offer guidelines/strategies to prevent, control and eradicate introduced marine pests.

International Maritime Organisation (IMO) Resolution A.868 (20) 1997 Guidelines for Control and Management of Ships' Ballast Water to minimise the transfer of Harmful Aquatic Organisms and Pathogens
Resolution 868 (20) and Appendix 2 provide guidance and strategies to minimise risk of unwanted organisms and pathogens from ballast water and sediment discharge. In July of 2000, a Global Taskforce was convened by IMO, in coordination with United Nations Development Programme (UNDP) and the Global Environment Facility (GEF), which launched the Global Ballast Water Management Programme in response to the problem of harmful marine organisms.

The World Conservation Union (IUCN) Guidelines for the prevention of Biodiversity Loss Caused by Alien Invasive Species (2000)
These guidelines, designed for increasing the awareness of the impacts of alien species, provide for the prevention, eradication, control and re-introduction of alien species.

International Council for the Exploration of the Sea (ICES) Code of Practice on the Introductions and Transfers of Marine Organisms (1994)
This code recommends practices and procedures to diminish the chance of detrimental effects from the introduction or transfer of marine organisms.

Food and Agriculture Organisation of the United Nations Code of Conduct for Responsible Fisheries (1995)
This code (Article 9.3.2) recommends the adoption and implementation of international codes of practice and procedures for introductions and transfers of aquatic organisms.

2.1.1.2 *Treaties/Binding Instruments*

Convention on Biological Diversity (Nairobi, 1992)

Entry into force: 29.12.1993

Relevant Provisions:

Article 8 In-situ Conservation: Each contracting party shall, as far as possible and as appropriate:

(h) Prevent the introduction of, control or eradicate those alien species, which threaten ecosystems, habitats or species.

APEC economies that have ratified the Convention:

Australia, Indonesia, Korea, Malaysia, New Zealand, Papua New Guinea, Philippines, Singapore, Vietnam.

APEC economies that have signed the Convention:

Thailand

Cartagena Protocol on Biosafety to the CBD (Montreal, 2000)

Date of adoption: 29.01.2000

Relevant Provisions:

Objective is to contribute to ensuring an adequate level of protection in the field of the safe transfer, handling and use of living modified organisms resulting from modern biotechnology that may have adverse effects on the conservation and sustainable use of biological diversity, taking also into account risks to human health, and specifically focusing on transboundary movements.

APEC economies that have signed the Protocol:

Korea, Indonesia, Malaysia, New Zealand.

Contents

Law of the Sea Convention (LOSC)

Entry into Force: 16.11.1994

Relevant Provisions:

Article (196): States shall take all measures necessary to prevent, reduce and control pollution of the marine environment resulting from the use of technologies under their jurisdiction or control, or the intentional or accidental introduction of species, alien or new, to a particular part of the marine environment, which may cause significant and harmful changes.

APEC economies that have ratified the Convention:

Australia, Indonesia, Korea, Malaysia, New Zealand, Papua New Guinea, Philippines, Singapore, Vietnam.

The Agreement for the Implementation of the Provisions of the Convention Relating to the Conservation and Management of Straddling Fish Stocks and Highly

Migratory Fish Stocks (United Nations Fish Stocks Agreement).

Entered force: 11 December 2001

Relevant Provisions:

While not directly related to management of introduced marine pests the Agreement elaborates principles established in the Law of the Sea Convention. These principles include, *inter alia,* that States should cooperate to ensure conservation and promote the objective of the optimum utilisation of fisheries resources both within and beyond the exclusive economic zone.

APEC Economies that have ratified agreement:

USA, Russian Federation, Papua New Guinea, Canada, Australia, New Zealand.

International Health Regulations (Geneva, 1982).

Entry into Force: 01.0.1982

- Currently being revised -

Relevant Provisions:

Purpose is to ensure maximum security against the international spread of diseases. Goals are to: (1) detect, reduce or eliminate sources from which infection spreads; (2) improve sanitation in and around ports and airports and (3) prevent dissemination of vectors. The Regulations include mandatory declaration of cholera.

APEC economies that have ratified the Regulations:

Australia, Indonesia, Korea, Malaysia, New Zealand, Papua New Guinea, Philippines, Singapore, Thailand, Vietnam.

Convention on International Trade in Endangered Species of Wild Fauna and Flora (Washington, 1973)

Entry into Force: 01.07.1975

Relevant Provisions:

CITES offers an alternate model for regulating invasive species not already covered in other conventions. This convention prevents harm in the exporting country. It can only be applied when the species is endangered in the exporting country and considered invasive in the importing country and it only regulates intentional introductions.

APEC economies that have ratified the Convention:

Australia, Indonesia, Korea, Malaysia, New Zealand, Papua New Guinea, Philippines, Singapore, Thailand, Vietnam.

The WTO Agreement on Application of Sanitary and Phytosanitary Measures (Marrakech, 1995)

Entry into Force: 01.01.1995

Relevant Provisions:

As a supplementary agreement to the World Trade Organisation (WTO) Agreement, the SPS provides a uniform framework for measures governing phytosanitary measures for human, plant and animal life or health. Sanitary and phytosanitary measures are defined as any measure applied a) to protect human, animal or plant life or health (within the Member's territory) from the entry, establishment or spread of pests, diseases, disease carrying organisms; b) to prevent or limit damage (within the Member's territory) from the entry, establishment or spread of pests.

APEC economies that are members of WTO:

Australia, Indonesia, Korea, Malaysia, New Zealand, Papua New Guinea, Philippines, Singapore, Thailand.

APEC economies that are observers to WTO:

Vietnam

Convention on the Law of the Non-navigational Uses of International Watercourses (New York, 1997)

Date of adoption: 21.05.1997

Relevant Provisions:

Article (22). Watercourse States shall take all measures necessary to prevent the introduction of species, alien or new, into an international watercourse, which may have effects detrimental to the ecosystem of the watercourse resulting in significant harm to other watercourse States.

APEC economies that have ratified the Convention:

<No information available to date>

In addition to these treaties that concern introduced marine pests, there are numerous binding instruments that address or a related to non-specific introduced species. These are listed as follows:

- **Agreement on the Conservation of Nature and Natural Resources**
- **Convention on the Conservation of Migratory Species of Wild Animals**
- **Convention on Wetlands of International Importance especially as waterfowl habitat**
- **International Plant Protection Convention**

2.1.2 REGIONAL RESPONSES

The majority of regional initiatives currently focus on pathogens and aquaculture operations. FAO have been working in conjunction with the NACA to ensure that effective health management systems are introduced into Asia for the purposes of aquatic animal quarantine (Subasinghe, *et al.* 1996, Humphrey, *et al.* 1997, FAO/NACA, 2000). Within the South Pacific region, a focus on terrestrial introduced species exists, however marine pest related initiatives have begun (Tim Adams, pers comm 2001).

Some regional initiatives developed include:

- **Asia Regional Technical Guidelines on Health Management for the Responsible Movement of Live Aquatic Animals (FAO/NACA)**
- **Beijing Consensus and Implementation Strategy (FAO/NACA)**
- **Plant Protection Agreement for the Asia and Pacific Region**
- **Convention on Conservation of Nature in the South Pacific**
- **Protocol for the Conservation and Management of Protected Marine and Coastal Areas of the South East Pacific**

2.2 STATUS AND DISCUSSION OF APEC ECONOMIES

Profiles for the APEC economies were constructed as the basis from which to examine the management of the marine environment in general, and more specifically the current management/research initiatives regarding introduced marine pests and human pathogens.

The following economy profiles are ordered and according to APEC protocol. Information for Australia, Brunei Darussalam, Canada, Chile, Chinese Taipei, Indonesia, New Zealand, Papua New Guinea, Philippines, Singapore, Thailand, USA and Vietnam has been reviewed and/or provided by a government official. Information on the remaining economies was compiled from documentation and information from an extensive web search.

2.2.1. AUSTRALIA

Australia has rights and responsibilities for 16 million square kilometres of ocean—twice the size of its continental landmass. This includes an EEZ of over 11 million square kilometres, plus adjacent ocean areas over Australia's continental shelf. Australia's ocean environments are linked to three of the world's large ocean basins, the Pacific, Indian and Southern Oceans, and encompass all five of the major climate zones, from tropical and subtropical through to southern temperate, subpolar and polar.

Australia has the third largest fishing zone in the world, however its productivity is limited by the low levels of nutrients in the water. The fisheries sector catches 200 marine species and employs nearly 30,000 people. The aquaculture industry focuses upon farming high value species.

MARINE ENVIRONMENT MANAGEMENT PROFILE

Institutional Structure:

The federal nature of Australian government and the interrelationship between the Commonwealth, six States, two Territories and local government has meant the jurisdiction and management of marine is complex. Around 97 per cent, of Australia's marine area, is under Commonwealth government jurisdiction, however coastal areas where most introduced species occur, are covered in State and the Northern Territory jurisdiction. In addition to Australia's small island external territories and some areas of the Great Barrier Reef Marine Park, the Commonwealth responsibilities extend from the outer limits of the EEZ and continental shelf into three nautical miles from the territorial sea baseline. Within the three nautical mile zone the Commonwealth has handed the title to an area called 'coastal waters' and partial management responsibility to the States and Northern Territory under a series of arrangements reached with the States known as the Offshore Constitutional Settlement (OCS). The Commonwealth still retains concurrent legislative powers in this area and manages such matters as historic shipwreck protection and sea dumping.

Australia has introduced vertical integration of its sectoral management policies over the past thirty years.

A further advance in ocean management followed the release of *Australia's Oceans Policy—Caring, Understanding, and Using Wisely* on 23 December 1998. This policy, with commitments to integrated ecosystem based planning and management for multiple-uses, is to be implemented through regional marine plans. These regions are based on large marine bioregions around the Australian coastline.

Marine administrative agencies:

Department: Agency/Statutory body	General role	IMP role
Commonwealth Authorities		
Department of the Environment and Heritage-Environment Australia (EA)	Provide advice of policy and programs to protect and conserve the environment	Yes
- Coasts and Oceans: Introduced marine pest program	Support actions that will lead to the control and local eradication of IMPs; provide advice and funds to help combat outbreaks	Yes

***Marine administrative agencies** (cont.)*

Department: Agency/Statutory body	General role	IMP role
National Oceans Office (NOO)	Regional marine planning for governments approach to oceans management	Yes
Department of Agriculture, Fisheries and Forestry Australia (AFFA)	Address challenges of natural resource management	Yes
- Australian Fisheries Management Authority (AFMA)	Manages all commonwealth fisheries under the Offshore Constitutional Settlement	In emergencies
- Australian Quarantine and Inspection Service (AQIS)	Administration and enforcement of quarantine regulations in the case of intentional and unintentional introductions of organisms	Yes
Department of Transport and Regional Services (DoTRS)	Administering of marine safety and environment issues related to shipping	Yes
- Australian Maritime Safety Authority (AMSA)	Administering and enforcing maritime, safety and environment protection related regulations	Yes
Australian Customs	Administering and enforcing regulations related to customs and intentional introductions of organisms	Yes
Department of Industry Tourism and Resources		
- Commonwealth Scientific and Industrial Research Organisation - Centre for Research on Introduced Marine Pests (CSIRO-CRIMP)	Controlling the introduction and spread of exotic species in the marine environment and assessing the impacts of known marine pests require a multi-disciplinary approach involving areas as diverse as economics, engineering, environmental impact assessment, eco-physiology and taxonomy.	
- Australian Institute of Marine Science (AIMS)	Research on issues regarding introduced marine pests	
State Authorities		
Department of Primary Industries, Water and Environment, Tasmania	All are state members of the National Introduced Marine Pests Coordination Group (NIMPCG)	Yes
Queensland Environmental Protection Agency		
Primary Industry and Resources, South Australia		
Natural Resources and Environment, Victoria		
Fisheries Western Australia		
Department of Primary Industry and Fisheries, Northern Territory		
New South Wales Fisheries		
New South Wales Department of Transport		
Research Centres		
State research laboratories	Research on issues regarding introduced marine pests	
Various universities	Research on issues regarding introduced marine pests	

INTRODUCED MARINE PEST AND PATHOGEN MANAGEMENT PROFILE

Agency Responsibilities:

It was evident that there were no clear lines of responsibility delineated between Commonwealth, Territory and other States during a bioinvasion in 19998. This event instigated the Joint Standing Committee on Conservation (SCC)/Standing Committee on Fisheries and Aquaculture (SCFA) National Taskforce on the Prevention and Management of Marine Pest Incursions which reported in December 1999. This report outlined a national system for all transport vectors and phases of marine invasions. Accordingly, a response to any marine pest emergency will be run from within the Commonwealth/State/Territory jurisdiction where it occurs. This will be enhanced through national coordination to provide advice and support as required for a successful response. Currently, the central Commonwealth agencies and councils involved in administering introduced marine pests are:

- The National Introduced Marine Pest Coordinating Group (NIMPCG)

  Oversee introduced marine pest policy coordination and development. Membership comprised of state government agency representatives, industry/environment representatives, federal agency representatives and observers.
- Australian Quarantine and Inspection Service (AQIS)

  The lead agency for the management of international ballast water
- Australian Introduced Marine Pests Advisory Council (AIMPAC)

  AIMPAC are yet to meet.
- The Consultative Committee on Introduced Marine Pest Emergencies (CCIMPE)

  Provides national consultation and co-ordination during emergencies has funding available for allocation to an affected State or Territory and immediate incursion response capabilities
- Environment Australia (EA):

  Introduced Marine Pest Program is used to facilitate the government's response to the introduction of exotic marine pests. EA is currently working on building the elements of a national incursion response capability, particularly control of existing pests in Australia.

At a State and Territory level, several agencies have initiated programs relevant to the management of introduced marine pests. It should be noted that all states and the Northern Territory are represented in the national committees and CCIMPE.

- Department of Primary Industries, Water and Environment Tasmania - Introduced Marine Species
- NT Department of Primary Industry and Fisheries: Aquatic Pest Management Unit
- Fisheries Western Australia - Introduced Marine Invaders
- Natural Resources and Environment Victoria - Marine Pests

Summary of current and historical search effort for introduced marine pest:

To understand the current scale and scope of marine invasions in Australian coastal waters, CRIMP and Australian Association of Ports and Marine Authorities (AAPMA) established a National Introduced Species Port Survey Program. This includes a set of standardised survey design protocols and sampling methodologies (the CRIMP Protocols) to be implemented in all Australian ports. Through the use of these port surveys and literature reviews conducted by the Centre for Research on Introduced Marine Pests (CRIMP), port authorities and States, over 250 marine species have been identified as having been introduced into Australian waters. There have been more than twenty port surveys undertaken to date.

Identified marine pests and human pathogens under legislation:

The Australian Ballast-Water Management Advisory Council (ABWMAC) adopted the target pest list developed in 1994 by CRIMP in conjunction with several international experts. This lists 12 pest species, 1 feral species, and is specific to species introduced through ballast water. ABWMAC has since been transformed into the Australian Introduced Marine Pests Advisory Council (AIMPAC). In 1999 the SCC/SCFA National Taskforce on the Prevention and Management of Marine Pest Incursions Report included an interim trigger-list of species applicable to all vectors, not just ballast water. This list contains 16 species. Furthermore, a recent CRIMP study has identified a further 34 potential "next pest" species.

Marine pest control, prevention and management initiatives:

Australia is now implementing a quantitative risk management framework based on the process of hazard identification and risk assessment to implement a scientifically based quarantine policy. From a biosecurity perspective, all initiatives taken by Australia can be summarised under generic headings of pre-border, border and post-border initiatives.

Pre-border:

These initiatives focus primarily on potential vectors and also extend to increasing the awareness of the threat of introduced marine pests to potential sources.

Vector related:

- Australian Ballast Water Management Requirements (AQIS)

Voluntary ballast water management guidelines were adopted by AQIS in 1991. However mandatory ballast water management requirements were introduced and as of 1July 2001, all international vessels will be required to manage the ballast water in accordance with AQIS requirements and not discharge high-risk ballast water in Australian ports or waters.

- The Australian Ballast Water Decision Support System (AQIS)

The Australian Ballast Water Management Requirements incorporates a Decision Support System (DSS) that provides a species-based quantitative risk assessment that ranks vessels on the likelihood of introducing exotic marine species into Australian ports or waters.

- The National Taskforce on Imported Fish and Fish Products guidelines
- AQIS's Import Risk Analysis on live ornamental finfish
- Research
    - Species hazard analysis
    - Ballast water risk assessment

Public awareness related:

- Adoption of international instruments pertaining to introduced marine pests
- Participation and information dissemination in global and regional workshops/programs

Through increasing the awareness of the threats of introduced marine pests and the vectors responsible for their introduction throughout the world, Australia is assisting in preventing further introductions of pest species.

- Community awareness programs
- Industry awareness programs
- Next pest lists

Another preventative mechanism used by Australia is the development of a 'next pest' methodology used to predict potential pest species that may be introduced in ballast water or through hull fouling. The lists are constructed from the use of selection criteria similar to those used to identify disease agents by AQIS.

Border:

The border controls focus upon the detection and identification of introduced marine pests.

- National Port Survey Program
- National Introduced Marine Pests Information System (NIMPIS)
- Community Detection Kits (CRIMP)
- Quarantine regulations (AQIS)
- Vessel sampling protocols (NTDPIF)
- Small craft hazard analysis

Post border:

Australia has implemented two post border elements: the ability for rapid response to an introduced marine pest incursion, and the management of the introduced marine pests.

Rapid response:

- The Draft Australian Emergency Marine Pest Management Plan (EMPPLAN)
- EA Rapid Response Toolbox – part of NIMPIS[4]

Reducing internal translocations

- Demonstration domestic ballast water risk assessment

[4] Refer to NIMPIS website http://crimp.marine.csiro.au/nimpis/.

- National Translocation Policy for aquatic organisms

Management of pests:

Australia is developing and applying control management techniques (biological, genetic, physical and habitat restoration).

National and provincial legislation and regulatory measures:

Australia has implemented several legislative initiatives to protect the marine environment from potential threats and has identified introduced marine pests as one of these threats. This threat has been addressed in several pieces of legislation and regulations.

- *Australia's Ocean Policy*

This policy is committed to developing a comprehensive marine pest incursion management system. The policy pertains to a species-specific approach in management as specified in three measures. These include the need of a decision support system for ballast water management, the continued implementation of the Australian Ballast Water Management Strategy to identify and minimise incursions of pests, and the support of an 'alert list' of introduced species in Australia that have the ability to cause risk to the environment.

- *The Environmental Protection and Biodiversity Conservation Act 1999*

This is the primary Commonwealth legislation for protecting the environment. It provides for the development of statutory plans to reduce, eliminate or prevent the impacts of introduced marine species on the biodiversity of Australia under Section 310(a). This provision has not been used in relation to introduced marine pests as yet. It allows for the Commonwealth to work with the States and territories and has put in place a streamlined environmental assessment and approvals process.

- *National Policy for Translocation of Live Aquatic Organisms (Ministerial Council on Forestry, Fisheries and Aquaculture, 1999)*

This policy provides a risk assessment framework for minimising the risk of harmful outcomes from intentional translocation of marine organisms for mariculture. It is similar to the International Council for Exploration of the Sea (ICES) Code of Practice on the Introduction and Transfer of Marine Organisms.

- *Quarantine Act 1908 and Quarantine Amendment Act 1999*

These give the mandatory Australian Ballast Water Management Requirements a legislative backing through the enforcement of the Quarantine Act 1908. The Quarantine Act was amended through the Quarantine Amendment Act 1999. The new arrangements incorporate a species specific risk assessment based Decision Support System (DSS) that provides an assessment of the likelihood of target species being present on a vessel for each voyage.

- *Interim Victorian Protocol for Managing Exotic Marine Organism Incursions (DNRE, Victoria)*
- *Action Statement No. 100: Introduction of Exotic Organisms into Victorian Marine Waters (DNRE, Victoria)*
- *Draft Industrial Waste Management Policy (Ship's Ballast Water And Hull Cleaning) (EPA, Victoria)*
- *Fauna and Flora Guarantee Act (Victoria)*
- *Environment Protection Act (Victoria)*
- *Marine Act (Victoria)*
- *Living Marine Resources Act (Tasmania)*
- *ANZECC Code of Practice for Antifouling and In-water Hull Cleaning and Maintenance*

Private sector initiatives:

With the increased emphasis on co-management applied in the marine environment, the private sector has been involved with the development and implementation of the majority of government initiatives. In addition to this, the shipping industry supplied $A2 million towards the development of the Ballast Water Decision Support System. In Victoria the ports are conducting their own baseline port surveys as prescribed by the Ballast Water Management Regulations so that the species-specific approach can be implemented. In Darwin, the marinas have put in place a pre-inspection measure for all foreign recreational vessels wanting to enter the Darwin marinas. The shipping industry has also published a report on the use of heat as a ballast water treatment measure. The aquaculture industry has taken several initiatives, though these predominantly focus on preventing the introduction and transfer of fish pathogens and fouling species affecting aquaculture. It has been suggested by the aquaculture industry to use their facilities as monitoring sites for introduced marine pests.

Public awareness initiatives:

Australia has constructed numerous information materials regarding the identification of introduced marine pest species, the problems that introduced pests cause and the current research initiatives being conducted. There are Commonwealth websites devoted to the problem of introduced marine pests. Several programs have included involving the community, for example the 'starbusters' program in Tasmania where the community assisted in physically removing northern Pacific seastars. Furthermore, AQIS has used a Maritime Awareness Campaign to assist in the compliance with ballast water reporting requirements.

SUMMARY

- Australia has identified over 250 introduced marine species in its marine environment.
- Australia is developing a vertically integrated national system to respond to the threat of marine pests, including: reducing the risk of introductions, early detection, rapid response, management of secondary translocation within Australia. This is supported by an active research programme.
- Compulsory ballast water management was introduced on 1st July 2001, for all commercial vessels arriving from overseas. Vessel risk is estimated with a quantitative, species-based Decision Support System.
- Australia conducted one of the world's first eradications of an established marine pest in 1999. This led Australia to develop formal agreements between the different levels of government to ensure that response to marine pests could be rapid and effective.
- Australia is completing development of sophisticated web-based information tools to assist the management of marine pests. These tools could have regional applications.

2.2.2. BRUNEI DARUSSALAM

Negara Brunei Darussalam, is a monarchy located on the northern coastal of the island of Borneo, bordering the South China Sea and Malaysia. Its urban centres are in the coast and more than 85% of its population lives in the coastal zone and most economic activities take place in this area. The country's most important economic activities are oil and gas exploitation. Other relevant activities are fisheries, mangrove harvesting, water transportation, beach sand mining, agriculture and, other industries and services. Approximately, one-half of the fresh fish and shrimp consumed in Brunei Darussalam come from local fisheries industry.

Brunei Darussalam considers the sustainable development of its coastal zone a priority. Brunei's waters do not generally suffer serious pollution, however increasing industrialisation, urbanisation and introduction of more intensive agricultural practices could add significantly to existing pollution levels.

MARINE ENVIRONMENT MANAGEMENT PROFILE

Institutional Structure:

Brunei's administrative system is centred on the Prime Minister's Office. Under the Prime Minister's Office there are eleven Ministries, among these, the Ministry of Industry and Primary Resources is in charge of all economic activities and natural resources use, marine fisheries and aquaculture. The Department of Fisheries is located under this ministry and is responsible of fisheries development and management.

Contents

Marine administrative agencies:

Department: Agency/Statutory body	General role	IMP role
Government Authorities		
Ministry of Industry and Primary Resources		
	Fisheries stock evaluation, resource planning and management	Yes
	Aquaculture development	
	Verification and development of fisheries production techniques	
	Maintenance of marine environment	
	Implementation of safety and quality control programme in seafood industry	
- Department of Forestry	Management of Forests and Mangrove Areas	Yes
Ministry of Communication		
- Ports Department	Administration of Ports	Yes
- Marine Department	Administration of Maritime Transport	Yes
Ministry of Health	Prevention and treatment of human diseases	Yes
Research Centres		
University of Brunei Darussalam	Research on aquaculture and human pathogens, research on terrestrial and marine introduced species	

INTRODUCED MARINE PEST AND PATHOGEN MANAGEMENT PROFILE

Agency responsibilities:

There are no clear lines of responsibility delineated between the identified ministries and departments in relation to prevention and control of introduced marine pests.

Summary of current and historical search effort for introduced marine pests:

The Department of Fisheries has identified six introduced marine species (including two fish pathogens). Despite this, there is no information on current or historical search efforts for introduced marine pests.

Identified introduced marine pests and human pathogens under legislation:

There is no information on introduced marine species declared as introduced marine pests or human pathogens under any legislation in Brunei Darussalam.

Marine pest control, prevention and management initiatives:

There is no information on specific initiatives for introduced marine pest control, prevention and management within Brunei Darussalam.

National and provincial legislation and regulatory measures:

Brunei Darussalam's environmental legislation addresses several aspects of water quality maintenance and pollution prevention and control; nonetheless, there are no specific provisions regarding the prevention or control of introduced marine pests.

Private sector initiatives:

There is no information on private sector initiatives for the management of introduced marine pests.

Public awareness initiatives:

There is no information on public awareness initiatives regarding introduced marine pests.

SUMMARY

- Six types of marine organisms have been identified as introduced marine species and pathogens, which exhibit threatening characteristics, though they have not been legally declared as such.

- There are a number of institutions in charge of coastal and marine resources management and human pathogens prevention and control, though there are no clear lines of responsibilities for introduced marine pests and human pathogens management.
- There is no specific body of legislation regarding introduced marine pest and human pathogen prevention, control and management.

2.2.3. CANADA

Canada borders the Northern Atlantic Ocean and Northern Pacific Ocean.

MARINE ENVIRONMENT MANAGEMENT PROFILE

Institutional Structure:

In Canada, the Department of Fisheries and Oceans (DFO) conduct management of the use of the marine environment and its resources. DFO plays a leading role in managing and safeguarding oceans and inland waters and their resources through its three main branches (i) Fisheries Management, (ii) Science and (iii) Canadian Coast Guard Service. Fisheries Management branch is responsible for conservation, protection and sustainable use of marine and freshwater environment and resources use, including enforcement of ocean and fisheries laws. Science branch is responsible of conducting scientific and technical research about Canadian aquatic ecosystems, throughout various facilities such as the Institute of Ocean Science. The main divisions under the Science branch are: (i) Aquaculture, (ii) Canadian Hydrographic Service, (iii) Marine Environment and Habitat Science, (iv) Ocean Science & Productivity and, (v) Stock Assessment.

The Canadian Coast Guard Service (CCG), as a branch of DFO, is in charge of all navigation and ocean environmental issues. The CCG mission is to ensure the safe and environmental responsible use of Canada's waters, support understanding and management of oceans resources, facilitate the shipping, recreation and fishing, and provide marine expertise in support of Canada's domestic and international interests. The Institute of Ocean Sciences (IOS), through its Marine Environment and Habitat Science Division (MEHSD) is involved in research for ocean and marine ecosystems management. In addition, the Department Transport Canada is in charge of developing and administering policies, regulations and services related to all transportation means in Canada, including maritime transportation and related issues.

Marine administrative agencies:

Department: Agency/ Statutory Body	General role	IMP role
Government Authority		
Department of Fisheries and Oceans (DFO)		
- Fisheries Management	Responsible for conservation, protection and sustainable use of marine and freshwater environment and resources use, including enforcement of ocean and fisheries laws.	Yes
- Science	Responsible of conducting scientific and technical research about Canadian aquatic ecosystems, to provide sound and timely advise for decision-making.	Yes
- Canadian Coast Guard Service	To ensure the safe and environmentally responsible use of Canada's waters, support understanding and management of oceans resources, facilitate the shipping, recreation and fishing, and provide marine expertise.	Yes
Transport Canada (TC)	In charge of developing and administering policies, regulations and services related to all transportation means in Canada, including maritime transportation and related issues.	Yes

Contents

INTRODUCED MARINE PESTS AND PATHOGEN MANAGEMENT PROFILE

Agency responsibilities:

Transport Canada plays a leading role in the control of ballast water. DOF is involved in management of aquatic invasive species through two of its branches, the Canadian Coast Guard Service (CCG) and the Environmental Science Program. The Canadian Coast Guard Service (CCG) deals with ballast water closely collaborating with Transport Canada. The Environmental Science Program provides scientific support to all activities related with the management of aquatic invasive species. In addition, Environment Canada is in charge of both terrestrial and marine alien species.

Summary of current and historical search effort for introduced marine pests:

The Coastal and Marine Habitat Science Division of DFO is conducting a Project entitled Development of Scientific Criteria for Ballast Water Disposal. The expected result of this project is information and criteria for ballast water disposal sites and methods to help reduce risk of Non-indigenous Species in the Pacific Coast of Canada.

Personnel of the Marine Environment and Habitat Science Division at the Institute of Ocean Science in Sidney, British Columbia, have identified at least four species of marine invasive organisms established in the Pacific coast of Canada: (i) European Green Crab (*Carcinus maenas*), (ii) Eel grass (*Spartina alterniflora*), (iii) European shipworm (*Teredo navalis*) and, (iv) the Atlantic Salmon (*Salmo salar*).

Identified introduced marine pests and human pathogens under legislation:

At present, there is no information on introduced marine species legally declared as introduced marine pests or pathogens in Canada.

Marine pest control, prevention and management initiatives:

Transport Canada and Canadian Coast Guard Service are applying ballast water management guidelines in order to reduce the chances of introduction of alien species via ballast water. There are plans to establish a land-based treatment facility for ballast water in Quebec under the US/Canada International Joint Commission.

National and provincial legislation and regulatory measures:

Presently, there are no laws and regulations that specifically concern introduced marine pests and their management in Canada. However, Canada is involved in the management of aquatic invasive species or introduced marine pests through its participation in the following international and regional agreements:

- As member of the North American Free Trade Agreement (NAFTA) Canada has signed a Cooperation Agreement regarding the NAFTA's Commission of Environmental Cooperation under which measures related to the prevention and control of introduced alien species are very seriously considered.
- Canada is an active member of the International Maritime Organization (IMO) and plays an active and supportive role in initiatives on ballast water control. Transport Canada in collaboration with Canadian Coast Guard are implementing guidelines for water ballast management in order to reduce the chances of introduction of alien species via ballast water.
- Canada is a member of the International Joint Commission, an US/Canadian body that deals with cross border issues. There is a US-led initiative to have a land-based treatment facility for ballast water that would be located in Quebec.
- Canada is member of the Puget Sound Georgia Basin Task Force. One of the seven initiatives taken by this task force has been the introduction and eradication of alien species.

Private sector initiatives:

The shipping industry plays a key role on the Federal Government's National Work Group of the Canadian Marine Advisory Council in all matters related to ocean and marine habitat issues, including the management of introduced marine pests. The fish monger, aquarium trade and aquaculture industries are equally involved in this issues.

Public awareness initiatives:

There are active government campaigns at community and industry level directed at removal of introduced species such as: green crabs, eelgrass and Atlantic salmon.

SUMMARY

- Six marine organisms have been identified as introduced in Canada. Nonetheless, none of them have been legally declared as marine pests or pathogens.
- The Department of Fisheries and Oceans (DFO) and Transport Canada are the government institutions responsible for prevention, control and management of introduce marine pests and human pathogens.
- There is no specific legislation regarding prevention, control and management of introduced marine pests and pathogens
- Canada is primarily concerned with ballast water and is intending to address the need for a land-based treatment facility.
- The shipping industry plays an important role in the Federal Government's National Work Group of the Canadian Marine Advisory Council.

2.2.4. CHILE

Chile is located Southern South America, bordering the South Atlantic Ocean and South Pacific Ocean, between Argentina and Peru.

MARINE ENVIRONMENT MANGEMENT PROFILE

Institutional Structure:

The Ministry of Economy, through the Under-Secretariat of Fisheries (USoF) and the National Fisheries Service (NFS) are the leading government agency responsible for the development of the fisheries sector and the freshwater and marine environment and resources management in Chile.

USoF is responsible for the administration of the fisheries sector, including aquaculture and its main duties are: (i) design and implementation of policies and strategies for the development of the fisheries sector, including aquaculture and (ii) the formulation of all legislation and regulations related to the fisheries activities, the marine and freshwater environment and resources.

The NFS is responsible for the implementation of all policies, the monitoring of the fisheries and aquaculture activities and the enforcement of all related laws and regulations. Some of its most relevant tasks are: (i) the collection, publication and dissemination of official fisheries statistics; (ii) supervision of the sanitary quality of all fish product; (iii) formulate development plans for the sport fishing activity; and (iv) the administration of all marine parks and reserves.

A third government institution related to fisheries activity and fisheries management is the National General Directorate of the Maritime Territory and Merchant Marine (GDMT), which is a branch of the Chilean Navy. It closely collaborates with the USoF and NFS in several matters regarding monitoring and law enforcement. In addition, GDMT is the institution in charge of all international agreements regarding human safety at sea and marine environmental issues. Other important institutions related to fisheries management are the National Fisheries Council (NFC), the Zonal Fisheries Councils – ZFC (five in total) and the Regional Fisheries Councils – RFC (twelve in total).

The NFC has a resolving, consulting and advisory role in all subjects related to the fishery law and the fishery activity, including aquaculture. The NFC is comprised of representatives for the public sector (USoF, NFS, and GDMT), representatives from private sector (large-scale and small-scale fishing sector, processing activity) and seven Advisors appointed by the President of the Republic with the consent of three-fifths of the Senate. The ZFCs are decentralized in nature facilitating the participation and decision-making at zonal level and they also have a consulting and resolving nature in all matter related to the fishery law. The RFCs functions are to identify the problems of the fisheries sector at regional level, discussing and preparing reliable technical reports and proposal to the USoF and the corresponding ZFC.

Finally, the National Commission for the Environment (NCE) is the governmental agency responsible for promoting environmental protection and sustainable use of the environment and natural resources; it coordinates with all the above-mentioned institutions in relation to freshwater and marine environment and resources use and management.

Marine administrative agencies:

Department: Agency/ Statutory body	General role	IMP role
Ministry of Economy (ME)		
- Under Secretariat of Fisheries (USoF)	Responsible for the development of the fisheries sector and the freshwater and marine environment and resources use and management.	Yes
- National Fisheries Service (NFS)	Responsible for the implementation of all policies, the monitoring of the fisheries and aquaculture activities and the enforcement of all related laws and regulations.	Yes
- Fisheries Development Institute (FDI)	Conducts research in support of fisheries management; as well as, research related to fish-shellfish pathogens and harmful algal blooms.	Yes
Chilean Navy		
- General Directorate of the Maritime Territory and Merchant Marine (GDMT)	Responsible for all navigational safety issues and marine pollution control. Closely collaborates with the USoF and NFS in several matters regarding monitoring and law enforcement.	Yes
National Commission for the Environment (NCE)	Responsible for promoting environmental protection and sustainable use of the environment and natural resources.	Yes
Research Centres		
Technological Institute for Salmon	Conducts periodic sanitary and oceanographic research and for the Salmon Aquaculture Industry, including monitoring for pathogens and harmful algal blooms.	
Universities	Training and research on various technological and scientific aspects of marine and freshwater environment and resources use and management, including research on harmful algal blooms and fish – shellfish pathogens.	

INTRODUCED MARINE PESTS AND PATHOGENS MANAGEMENT PROFILE

Agency responsibilities:

The UsoF authorizes the import and local movement of any aquatic species, setting the conditions, limitations and information requirements. The GDMT is responsible for maritime traffic, including avoiding any contamination from vessels. Contamination includes biological contamination – ballast water and hull fouling. GDMT developed the ballast water exchange regulations. NFS and GDMT are responsible for enforcing aquatic species introduction regulations.

Summary of current and historical search effort for introduced marine pests:

At least two studies on introduced exotic marine and freshwater organisms, has been conducted by government institutions. The USoF conducted in 1998 a project to formulate a strategy for the importation of exotic ornamental species in the aquarium industry, oriented to prevent escapes and pathogens. In 2000, NEC conducted a review of the Chilean situation on the introduction of exotic hydrobiological species with purpose of identifying the country's present situation, its strengths and weaknesses as the basis for the formulation of a national policy for the management of introduced exotic marine and freshwater species. In 1998, the University of Antofagasta prepared a methodological approach for the analysis of ballast water in order to produce a standard for control. In addition, the NFS, and the National Health Service (NHS) are presently implementing a monitoring system for detection and control of fish diseases in aquaculture. Eight organisms have been identified by local experts as introduced marine species.

Identified introduced marine pests and human pathogens under legislation:

There are two bacteria and one virus declared as introduced marine pests or human pathogens under legislation in Chile.

Marine pest control, prevention and management initiatives:

Presently, the USoF, NFS, NEC and GDMT are joining efforts to formulate and implement an integrated and comprehensive plan for prevention, control and management of introduced marine pests. In addition to ballast water treatment procedures, USoF and NFS issue a white list of authorized species for aquaculture purposes. A set of sanitary procedures for import of exotic species, also exist.

The GDMT requires vessels coming from inter-oceanic ports to conduct water ballast exchange in high seas areas (40 NM from the entry port) but according to vessels technical capabilities and marine weather conditions that would not endanger the safety of the ship. Presently the GDMT is not applying the IMO Guidelines for ballast water treatment – Resolution A.868(20) (Commandant Cofré, GDTM International Affairs Directorate, personal communication).

Area closures and prohibitions to extract, process and market shellfish resources, due to red tide bloom episodes, have been implemented in the south of Chile by the NHS, NFS and USoF.

National and provincial legislation and regulatory measures:

All fishery activities in Chile are regulated by the "General Law of Fisheries and Aquaculture" (DL No 430, 1991). The Fisheries Law includes the following regulations related the introduction of exotic species: (i) the import of hydrobiological species will always require the presentation of health certificates (article 11); (ii) the first import of hydrobiological species will require a health study, including environmental impacts and analysis for the presence of diseases or the deterioration of ecosystems; (iii) every year, during the month of September the USoF should send the NFS a list of all species authorized for import (article 13); and (iv) whoever introduces or orders the introduction into sea, rivers, lakes or any body of water, of chemical, biological or physical pollutants that harm hydrobiological resources, without previously neutralizing them to avoid such damages, will be penalized with a fine of 50 to 3'000 Tax Units (article 136). Any specie that do no appear in this clean list (article 13), is understood to be imported for the first time and must comply with the requirements and procedures established in article 12 of the Fisheries Law.

Other relevant legislation and regulations are:

- SD 30 (1997) from the Ministry of Secretary of the Presidency that establishes the regulations for the Chilean System of Environmental Impact Assessment (SEIA), which in its article 6 specifically mentions the introduction of hydrobiological species for aquaculture purposes as a mandatory subject for EIA.
- The Navigation Law (SD 2222, 1978) establishes the prohibition to pollute jurisdictional waters, port waters and river and lake waters. This law specifically restricts the discharge of ballast waters and regulates where and how to conduct ballast water exchange. It also mandates the GDMT as the monitoring and enforcement agency for these purposes.
- The Regulations on the Pollution of Waters (SD 1, 1992) establishes the prohibition to discharge ballast [water] and defines clean ballast [water] as those not leaving visible traces. This regulation authorises the discharge of clean ballast [water] under the flotation line, after examination to verify the absence of hydrocarbons.

Contents

- Resolution 12600/1049 (1999) of the GDMT establishes the regulations regarding the control of ballast water discharge in coastal waters of the Republic. Specifically, establishes to conduct ballast water exchange out of the 12 NM and mandates annotation in the ship logbook. Mandates the monitoring and enforcement of this procedure by the Port Authority [Capitanía de Puerto].

Private sector initiatives:

Research and monitoring programs for fish diseases and micro algal blooms carried out by Chilean Technological Salmon Institute and other universities are good examples of private sector initiatives on the control and prevention of introduced marine pests.

Public awareness initiatives:

There is no information on public awareness initiatives regarding prevention, control or management of introduced marine pests.

SUMMARY

- Eleven types of marine organisms have been identified as introduced in Chile, but only pathogens in aquaculture have been declared as introduced marine pests or pathogens legally.
- Even though there is a number of government institutions in charge of prevention, control and management of introduce marine pests and human pathogens, there are no clear lines of responsibilities for introduced marine pests and human pathogens management.
- Although the existing legislation has clear references to introduction of exotic species and fish diseases, as well as, to the management of ballast water; the re is a need for an integrated and comprehensive management plan for introduced marine pests and human pathogens and its related legislation.
- The USoF, NFS, NEC and GDMT are working on such a management plan.
- The private aquaculture sector and several universities are actively involved in research and monitoring regarding introduced marine pests and human pathogens.

2.2.5. CHINA (Peoples Republic of China)

People's Republic of China (PRC) is located in Eastern Asia, bordering the East China Sea, Korea Bay, Yellow Sea, and South China Sea, between North Korea and Vietnam.

MARINE ENVIRONMENT MANAGEMENT PROFILE

Institutional Structure:

Two government institutions are in charge of marine and fresh water ecosystems and resources development and management, the Bureau of Supervision and Administration of Fishery and Fishing Ports of the People's Republic of China (Bureau of Fisheries -BOF) under the Ministry of Agriculture (MOA) and the State Oceanic Administration (SOA) under the Ministry of Land and Resources (MRL).

The Bureau of Fisheries (BOF) is responsible for managing the national fishery production, processing and marketing sectors; design and implementation of policies, strategies and plans for fisheries and aquaculture development and management; formulation and inspection of laws and regulations for the fisheries sector, including aquaculture.

The State Oceanic Administration (SOA) is responsible for the supervision and management of sea area use and sea environment protection, vindication of maritime interests in accordance with law and, organization of oceanographic studies and research. Specific tasks includes: (i) the design and implementation of policies, laws and regulations; (ii) supervision and administration of marine environments and resources use; (iii) formulation and implementation of plans, criteria and standards for the protection and restoration of marine environment and resources and; (iv) organization and implementation of scientific and technical research on marine environments, resources and natural phenomena; among other.

Marine administrative agencies:

Department: Agency/ Statutory body	General role	IMP role
Government Authorities		
Ministry of Agriculture (MOA)		
- Bureau of Fisheries (BOF)	Responsible for the development and management of fisheries sector, including aquaculture; as well as, the formulation and inspection of laws and regulations for the fisheries sector, including aquaculture.	No
- Chinese Academy of Fisheries Science (CAFS)	To conduct research in almost all relevant fields (biology, environmental, technology, social, legal and policy) related to fisheries and aquaculture in both marine and fresh water environments, through its 21 institutions along China.	
- Institute of Oceanology	Involved in almost all fields in marine science, including marine life science and aquaculture.	
- Institute of Hydrobiology	Involved in fresh water biological science, including fish diseases, fish genetics and fish ecosystems.	
Ministry of Land and Resources (MLR)		
- State Oceanic Administration (SOA)	Responsible for the supervision and management of sea area use and sea environment protection, vindication of maritime interests in accordance with law.	Yes
- Institutes of Oceanography	Involved in almost all fields of marine science, including marine life science and aquaculture, through its three institutes in the north, east and southeast of China.	
- Maritime Technology. Research Institute		
- Research Institute for Maritime Development Strategy		
- Hangzhou Research & Development Centre for Water Treatment Technology		

INTRODUCED MARINE PESTS AND PATHOGENS MANAGEMENT PROFILE

Agency responsibilities:

The State Oceanic Administration (SOA), through its Department of Marine Environment Protection, is the government agency responsible for the formulation and implementation of regulations and plans for the management of introduced marine pests in China. The National Marine Environment Monitoring Center from SOA is responsible for providing scientific and technical expertise for the protection of the marine environment and the methods and techniques for prevention, control and management of introduce marine pests. The Maritime Safety Administration is responsible for ballast water management.

Summary of current and historical search effort for introduced marine pests:

The only current effort for searching for introduced marine pests is the participation of the PRC through its Maritime Safety Administration in IMO's Globallast Project entitled "*Removal of Barriers for the Effective Implementation of Ballast Water Control and Management Measures in developing Countries*".

Identified introduced marine pests and human pathogens under legislation:

Contents

There is no information on introduced marine species legally identified as introduced marine pests in China.

Marine pest control, prevention and management initiatives:

Even though SOA has been identified by government officials as the agency responsible for introduced marine species, in the description of its responsibilities and main issues to solve, no specific mention is made to introduced marine pests, nor in the legislation supporting its work. The sole mention of related problems is made in the Marine Environment Protection Law (article 25), which states that "if exotic marine organisms (alien species) are introduced to China, any probable infections (diseases) must be appraised in advance".

This mainly refers to the introduction of species for aquaculture or fisheries enhancement purposes and to possible accidental introductions of diseases, not to the introduced exotic marine organisms and their possible negative impact on ecosystems, humans and economic activities. The only present initiative is the one conducted by the Marine Safety Administration through its IMO project on ballast water management.

National and provincial legislation and regulatory measures:

In addition to SOA role and structure described in previous sections, the Peoples Republic China has created a large body of laws and regulations regarding environmental and natural resources use and management. A list of the most relevant legislation of the Peoples Republic of China, related to the marine and freshwater environment and resources use and conservation is:

(i) the **Fishery Act (1986)**and its regulations (1987), which lays down the principles and mechanisms for fishery management including aquaculture, fishing, fishery resource enhancement, utilisation and conservation;

(ii) the **Wild Animal Conservation Act (1988)**, which lays down the principles and mechanisms for wild animal conservation;

(iii) the **Water Act**, which states the principles mechanisms for management, utilisation and protection of water resources;

(iv) the **Environment Protection Act (1989)**, which is the basic law for comprehensive environment protection;

(v) the **Marine Environment Protection Act (1982)**, which sates the principles and mechanisms for the protection of the marine environment alone;

(vi) the **Water Pollution Control Act (1984)**, which states the principles and mechanisms for the control of inland water pollution;

(vii) the **Animal and Plant Import & Export Quarantine Act (1991)**, which is a law directed at preventing animal and plant disease and pest infection;

(viii) the **Marine Waste Disposal Management Regulation (1985)**, which is the detailed regulation for the implementation for the Marine Environment Protection Act and;

(ix) the **Regulation for Preventing Marine Pollution from Ships (1983),** which is an additional regulation for the implementation of the Marine Environment Protection Act.

Though each of these legislation make a careful treatment of most relevant issues related to marine and freshwater environment and resources use and management, none of them makes explicit mention to introduced marine pests.

Private sector initiatives:

There is no information on private sector initiatives regarding introduced marine pest control, prevention or management.

Public awareness initiatives:

There is no information on governmental or non-governmental public awareness initiatives regarding introduced marine pest control, prevention or management.

SUMMARY

- China has not identified any introduced marine pests under law.
- The State Marine Safety Administration is participating in an IMO – Globallast project.
- The State Oceanic Administration (SOA), under the Ministry of Land and Resources was identified as the lead agency responsible for introduced marine pest prevention, control and management.
- Current Chinese laws and regulations do not provide for specific mechanisms on introduced marine pest prevention, control or management.

2.2.6. HONG KONG, CHINA

Hong Kong, China, is located to the east of the Pearl River Estuary on China's south coast and borders the South China Sea. Hong Kong is now one of the world's greatest centres of trade. In addition to being the medium for considerable vessel traffic, Hong Kong's marine environment provides for primary activities – such as fishing and aquaculture.

MARINE ENVIRONMENT MANAGEMENT PROFILE

Institutional structure:

Hong Kong is a Special Administrative Region (SAR) of the Peoples Republic of China. Under basic Law 12, Hong Kong has a high degree of autonomy in all matters, except foreign and defence affairs. Under international law, Hong Kong does not possess the status of a State, and therefore not all international instruments apply. As the LOSC does not apply, Hong Kong only has jurisdiction over its territorial sea (3nm).

As a dependency of China, Hong Kong has set up various territory institutions. The Environment and Food Bureau, under the Department of Administration chiefly administers marine resources and conservation. The Economic Services Bureau, under the Department of Finance administers the maritime transport and marine areas.

Marine administrative agencies:

Ministry: Division/Department/Agency	General role	IMP role
<u>Territory Authorities</u>		
Department of Administration		
Environment and Food Bureau		
- Country and Marine Parks Authority		
- Environmental Protection Department		
- Advisory Council on the Environment		
- Food and Environmental Hygiene Department		
- Agriculture, Fisheries and Conservation Department		
Department of Finance		
Economic Services Bureau		
- Marine Department	Responsible for general compliance, safety and navigation administrative matters in Hong Kong.	
- Hong Kong Port and Maritime Board		
Commerce and Industry Bureau		
- Customs and Excise Department	General customs administration	

INTRODUCED MARINE PESTS AND PATHOGENS PROFILE

Agency responsibilities:

There is no government agency specifically responsible for introduced marine pests. The Food Supply and Food Safety policy programme put in place by the Environment and Food Bureau does mention preventing the introduction and spread of animal and plant diseases, though there is no information as on if this includes marine pathogens. The Pollution Control Unit, under the Marine Department is responsible for preventing and cleaning oil discharges in the sea and harbour cleaning services, though there is no information on whether this includes biological pollution – such as mass fouling.

Summary of current and historical search effort for introduced marine pests:

There has been no government instigated search effort for introduced marine pests in Hong Kong waters, however several international researchers have focussed their efforts in Hong Kong (eg, Morton 1980).

Identified introduced marine pests and human pathogens under legislation:

Hong Kong has not identified any introduced marine species as an introduced marine pest or pathogen under local law.

Marine pest control, prevention and management initiatives:

There is no information on any control, prevention or management initiatives.

National and provincial legislation and regulatory measures:

No legislative or regulatory measures for introduced marine pests are identified within Hong Kong.

Private sector initiatives:

There is no information on private sector initiatives on the prevention, control or management of introduced marine pests.

Public awareness initiatives:

There is no information on public awareness initiatives on the prevention, control or management of introduced marine pests.

SUMMARY

- Hong Kong is a major trading economy, heavily reliant on shipping for revenue.
- There are no government agencies responsible for introduced marine pest prevention, control or management. No management initiatives are in place.

2.2.7. INDONESIA

Indonesia is an archipelagic country containing five main islands, two major archipelagos and 60 smaller archipelagos and encompasses 13,667 islands. Two of the islands are shared with other APEC economies – Malaysia, Brunei and Papua New Guinea. The marine environment is used as a medium for inter-island movement, a source of protein and for employment. Seafood comprises of two-thirds of the total supply of protein and over five million Indonesian people are involved in fishing or fish farming.

The growth of aquaculture has seen an increase in the importation of live fish in an attempt to bring new species with farming potential into Indonesia. Overall there has been a general trend of Indonesian fishers transferring from marine fishing to fish farming. This has arisen from declining fish stocks and government action to overcome overcrowding and resource depletion. The government has directed marine fisheries development to fishing in other waters within the EEZ, mariculture, brackish water culture and fish processing.

There are approximately 300 registered ports in Indonesia, with 21 considered as commercial ports. Four of these are termed 'gateway ports' and are primarily used for international purposes. In addition to the high level of domestic and international vessel movements within the Indonesian EEZ, the proximity of the Straits of Malacca signifies that Indonesia is vulnerable to marine environmental disasters.

MARINE ENVIRONMENT MANAGEMENT PROFILE

Institutional structure:

Government administration occurs through descending levels of administrative sub-units. Indonesia is made up of twenty-seven provincial-level units. The nation is centrally governed from Jakarta in a system which the lines of authority, budgets and personnel appointment run outward and downward. The role of regional and local governments is largely administrative – implementing policies, rules and regulations.

Indonesia's environmental management is based on the Archipelagic Concept where the central government can confer certain authority to central agencies located in the regions. The management on the national level is carried out in an integrated manner by means of institutional arrangements headed by a minister established by legislation. Regional governments, in accordance with existing legislation, carry out national policies. The Law No. 22 of 1999 on Regional Autonomy provides for provincial authority over management and conservation of marine areas out to 12 nautical miles.

Sea-use planning provides for improving the existing network between the 20 ministries, 5 non-departmental government agencies and two state companies involved in managing the marine and coastal sector, with fewer changes than other marine environment management approaches. The Ministry of Marine Affairs and Fisheries (the former Ministry of Sea Exploration and Fisheries) is the central administrative agency for the marine environment in Indonesia. It operates through the Department of Marine Affairs and Fisheries (DKP) and refers to the National Guidelines for its programs.

The planning is conducted in three categories: annual, medium and long term. This strategy uses the long-term, medium-term and annual plans to balance the short-term results with long term optimal and sustainable use. Under the long-term development plan REPELITA VII (1998/1999 to 2002/2003), management of the marine environment will be carried out through partnerships between community, government and industry. This plan includes the need for administration changes, including the development of a framework for the integration of marine management. It also allows for Provincial Development Agencies to play a key role in formulating sectoral agency programs aimed at the provincial level.

Marine administrative agencies:

Ministry: Division/Department/Agency	General role	IMP role
Central government authorities		
Ministry of Marine Affairs and Fisheries		
- Department of Marine Affairs and Fisheries	Governance and development in the field of marine affairs and fisheries	
Ministry of Agriculture		Yes
- Centre for Agricultural Quarantine (PUSKARA)	Animal, plant and fish quarantine	
State Ministry of National Development Planning	Resource allocation	
- National Development Planning Agency (BAPPENAS)	Coordinates and integrates sectoral and regional plans into a national development plan.	
Ministry of Industry and Trade	Maritime industry and inter-island trade	
Ministry of Health	Public health in the coastal community	
State Ministry of Environment	Marine environmental regulation	
Ministry of Finance		
- Customs	Customs	
Research Centres		
Indonesian Institute of Sciences (LIPI)	Marine research and development	
Impact Management Agency (BAPEDAL)	Enforcement of marine environment regulation	

INTRODUCED MARINE PEST AND PATHOGEN MANAGEMENT PROFILE

Agency responsibilities:

There is no information available as to which organisations are involved in managing introduced marine pests in Indonesia. The exception is the Ministry of Agriculture's role in quarantine.

Summary of current and historical search effort for introduced marine pests:

There has been no form of organised search effort undertaken within Indonesia regarding identifying introduced marine pests.

Identified introduced marine pests and human pathogens under legislation:

Indonesia has not identified any marine species as an introduced marine pest or human pathogen under legislation.

Marine pest control, prevention and management initiatives:

There is no information available on any management initiatives developed by Indonesia regarding introduced marine pests.

Pest Risk Analysis (PRA) has been applied to plants to guide quarantine recommendations, based on biological and economic analysis and consultation. It was suggested that this should be applied to aquatic animal quarantine. However to date there is no information on whether this has been done.

National and provincial legislation and regulatory measures:

Indonesia has adopted a 'sea-planning' approach in its marine policies in contrast to the 'legislative approach' seen in many other economies. This includes sectoral and regional plans on marine and coastal resources use. The following is a list of Indonesian legislation and regulatory measures that specifically mention or pertain to introduced marine pests:

- Law No. 9 of 1985, concerning fisheries
- Law No. 16 of 1992, concerning animal, fish and plant quarantine
- Decree No 265, of the Ministry of Agriculture, concerning Quarantine Requirements for the Importation of Live fish into the Territory of the Republic of Indonesia
- Decree No 245/Kpts/LB.730/4/90, Quarantine Measures taken on Live Fish Exported from the Territory of the Republic of Indonesia
- Act No. 5 of 1990, concerning the Conservation of Living Resources and their Ecosystems (Conservation Act)
- Decree No. 32 of 1990, concerning the protection and preservation of coastal zone areas
- Law No. 23 of 1997, regarding Environmental Management
- Act No.4 of 1982, concerning Basic Provisions for the Management of the Living Environment
- Decree No. 48 of 1989, on Guidelines for the Determination of Regional Identities of Flora and Fauna
- Law No. 5 of 1983, regarding the Indonesian Exclusive Economic Zone

Private sector initiatives:

There is no information available on any private sector (industry/community) initiatives regarding marine pests in practice in Indonesia.

Public awareness initiatives:

There are no public awareness initiatives in place within Indonesia specific to introduced marine pests.

SUMMARY

- Indonesia's marine area provides significant potential vectors for introduced marine pests due to its diversity and extensive use of water transport. There are approximately 300 ports, 30 of which are commercial and 4 of which are gateway international ports.
- Indonesia shares two of its islands with other APEC economies.
- Indonesia's structure of governance provides opportunities for local action, although at present there appears to be limited management initiatives developed specifically to address introduced marine pests.

2.2.8 JAPAN

Japan is located in Eastern Asia and it is an island chain between the North Pacific Ocean and the Sea of Japan, east of the Korean Peninsula.

MARINE ENVIRONMENT MANAGEMENT PROFILE

Institutional Structure:

The Fisheries Agency (FA), a branch of the Ministry of Agriculture, Forestry and Fisheries (MAFF), is the government institution in charge of all issues related to fisheries and aquaculture development and management in Japan. FA not only is involved in policy design and implementation, but also on fisheries and aquaculture development, marine and freshwater ecosystems and resources enhancement, the enforcement of related laws and regulations, research and more.

The Fisheries Agency is comprised of four departments and their respective divisions. These departments are: (i) Fisheries Policy and Planning Department, (ii) Resources Management Department, (iii) Resources Enhancement Promotion Department and, (iv) Fisheries Infrastructure Department.

In addition, the FA conducts research through its Fisheries Research Agency on several areas such as: fisheries engineering, policy design for fisheries management, stock assessment, and aquaculture, among other topics. The Fisheries Research Agency is comprised nine research institutes distributed along the country. The National Fisheries University and the National Salmon Resources Center conduct both training and scientific research in support of the fisheries and aquaculture sector.

Marine administrative agencies:

Department: Agency/ Statutory Body	General role	IMP role
Ministry of Agriculture, Forestry and Fisheries (MAFF)		
- Fisheries Agency (FA)	In charge of all issues related to fisheries and aquaculture development and management	No
- National Fisheries Research Agency (NFRSI	To conduct technical and scientific research on fisheries engineering, policy design for fisheries management, stock assessment, aquaculture, marine ecosystems and resources enhancement, etc.	No
Research Centres		
National Fisheries University	To conduct training and scientific research on fisheries and aquaculture.	
National Salmon Resources Center	To conduct research on resource biology and stock dynamics of salmon and salmon aquaculture	

INTRODUCED MARINE PESTS AND PATHOGEN MANAGEMENT PROFILE

Agency responsibilities:

There is no information on any government agency in charge of introduced marine pest prevention, control or management.

Summary of current and historical search effort for introduced marine pests:

There is no information on current or historical efforts towards identification, prevention, control or management of introduced marine pests.

Identified introduced marine pests and human pathogens under legislation:

There are no introduced marine species listed or identified by law as introduced marine pests in Japan.

Marine pest control, prevention and management initiatives:

There is no information on marine pest control, prevention or management initiatives in Japan.

National and provincial legislation and regulatory measures:

There is no information on any specific legislation and regulatory measure in place for introduced marine pest control, prevention or management in Japan.

Japan has signed the UNEP Convention on Biological Diversity (1991) and it is undertaking several activities in order to meet the mandates and objectives of this convention. Nonetheless, a review of Japan's First National Report (Government of Japan 1997) shows that their National Strategy on CBD makes a small reference to Alien Species, mostly on terrestrial animal and plants, with sole exception of the black bass intentional releases for inland water fisheries. Their approach on protection of Biological Diversity is based on the implementation of Protected Areas (terrestrial and aquatic) and on a set of general concepts toward the sustainable use of ecosystems and natural resources. No specific and mention is made with respect to introduced marine pests.

The discussion on the major legislation related to the protection of biological diversity mentions the Basic Environmental Law; the Nature Conservation law; the Natural Parks Law; the Law for the Conservation of Endangered Species of Wild Fauna and Flora; the Law for the Protection of Birds and Mammals and Hunting; the Law for the Protection of Culture Properties; the Forest Law and the Forestry Basic Law; the Fisheries Law and the Preservation of Fisheries Resources Law, among others. None of these laws seems to have specific mention to introduced marine pests and their control, prevention or management.

Private sector initiatives:

There is no information on private sector initiatives regarding introduced marine pests and their management.

Public awareness initiatives:

There is no information on public awareness initiatives regarding introduced marine pests and their management.

SUMMARY

- There is no information on introduced marine species identified as introduced marine pests by law, nor information on any initiative related to introduced marine pests identification, prevention, control or management.
- There are no Government agencies identified as responsible for introduced marine pest prevention, control or management.
- Current laws and regulations do not provide for introduced marine pest prevention, control or management.

2.2.9. KOREA (Republic of Korea)

The Republic of Korea has estimated that there are 905 species of fish and over 3,500 invertebrates in its' waters. Fishing is an important industry in the Republic of Korea. Aquaculture has become an important element of the fisheries industry with operations focusing on approximately 50 fish species, 15 shellfish species and 10 seaweeds A focus on a production-orientated policy led to concerns over the overexploitation of fishery resources. The 1990s saw a review of fisheries policy and reform of government administration. Korea also has an export-orientated economy with the USA, Japan and the European Union its main trading partners. There are eleven major international ports in Korea, a total of 26 foreign trade ports and four coastal ports. In 1999 these Korean ports had over 300,000 vessel calls.

MARINE ENVIRONMENT MANAGEMENT PROFILE

Institutional Structure:

The Ministry of Maritime Affairs and Fisheries (MOMAF) has primary responsibility for management of the marine environment in Korea. It is responsible for the development and co-ordination of a comprehensive and systematic marine administration, including a number of bureaus and research divisions. The Marine Environment and Safety Research Division investigates coastal and marine environment preservation, integrated coastal zone management, sea and port safety management and oil spill responses.

Marine administrative agencies:

Ministry: Division/Department/Agency	General Role	IMP Role
Government Authorities		
Ministry of Environment	Administration of environmental affairs	
- Korean Biodiversity Clearing-House Mechanism	Conservation	
Ministry of Maritime Affairs and Fisheries (MOMAF)	Marine affairs (fisheries, marine environment and shipping)	
Ministry of Finance and Economy		
- Korea Customs Service	Customs, quarantine	
Research Centres		
National Institute of Environmental Research (NIER)	Environmental research, Environmental Ecology Division- alien species impact and management research	
Korea Ocean Research Development Institute (KORDI)	Marine environment research, research on introduced marine pests	
Korea Maritime Institute (KMI)	Studies policy issues ocean governance, environment, fisheries, shipping and port.	

INTRODUCED MARINE PEST AND HUMAN PATHOGEN MANAGEMENT PROFILE

Agency Responsibilities:

There is no information available as to which agencies are in charge of introduced marine pests in the Republic of Korea.

Summary of current and historical search effort for introduced marine pests:

Korea has not attempted any form of organised search effort to identify introduced marine pests.

Identified introduced marine pests and human pathogens under legislation:

There are no marine species that have been identified through legislation as an introduced marine pest or human pathogen.

Marine pest control, prevention and management initiatives:

There are no specific initiatives related to introduced marine species currently being undertaken in the Republic of Korea. The Ministry of the Environment (MOE) has developed a National Biodiversity Strategy in accordance with the Natural Environmental Conservation Act (NECA). This strategy is the Master Plan for natural environmental conservation in Korea. Part III of the strategy outlines the biodiversity conservation strategy, in particular the Control of Threatening Activities – Management of LMOs and Alien Species (4.2). This section stresses that endemic ecosystems are threatened by alien species and that there is a lack of information regarding alien species that are harmful to biological diversity in Korea. It also notes that the present management system does not provide effective control over introduced species. The strategy aims to strengthen management of alien species, recognising the need for use of EIA to better evaluate the potential hazards and the need to improve legislation and administration to control alien species. The strategy also highlights needs to strengthen research on eradicating hazardous alien species, develop and execute a control program and strengthen public education.

This initiative provides a base to effectively address introduced pests, although it does not specifically focus on marine pests. The plan indicates that the national government has instructed governors of provinces to establish local natural environmental conservation plans based on the Master Plan. The MOE believes that the management of alien species is closely related to protection of rare and endangered species. MOE is concerned about the status and management of invasive alien species and supports various kinds of research on alien species. In addition, NIER's Environmental Ecology Division is also conducting research on the impacts of alien species and their management.

National and provincial legislation and regulatory measures:

Korean legislation and regulatory measures regarding introduced marine pests includes:

- Natural Environmental Conservation Act (NECA)
- Enforcement Ordinance of NECA
- National Biodiversity Strategy
- Customs Act

Legislation and regulatory measures related to generic matters such as possible vectors, biodiversity issues and marine/maritime issues includes:

- Fisheries Act
- Wetlands Conservation Act
- Special Act for the Ecosystem Conservation of Uninhabited Islands
- Public Order in Open Ports Act
- Harbour Act
- Prevention of marine Pollution Act
- Inspection of Fishery Products Act

Private sector initiatives:

The private sector organisation the Korea Association of Conservation of Nature (KACN) was founded in early 1994. It held a "Symposium and Open Discussion" in June 1994 and in September 1994 it released a National Strategy for Biological Diversity Conservation in Korea.

Public awareness initiatives:

There is no available information

SUMMARY

- The Republic of Korea has significant maritime interests and a number of potential vectors for introduced marine pests. With eleven major ports, a total of 26 foreign trade ports and four coastal ports, shipping plays a central role in commodity transport.
- Attention is directed to the problems of introduced pests, with a basic governance framework established. While this framework appears to focus on terrestrial pests, it may be possible to incorporate management of marine pests under these arrangements.

2.2.10. MALAYSIA

The marine environment is an important component of the Malaysian economy. The commercial fisheries sector supplies over 60% of the total animal protein intake of the Malaysian population and the rapid expansion of aquaculture has increased the export trade of live fish and other marine organisms. This sector alone supplies employment for over 99,000 people. Though the domestic supply of seafood is great, Malaysia also imports fishery products to meet high domestic demand. The main suppliers of these fishery products are its neighbouring East and South East Asian countries. The seas provide a medium for the transport of cargo with ten major marine ports. Malaysia actively trades goods and services with over one hundred countries.

In addition to providing economic and social benefits, the Malaysian marine environment contains a diverse range of marine organisms with over 4000 identified species of marine fish. The high terrestrial and marine biological diversity has put Malaysia as one of the top twelve 'megadiverse countries' in the world.

MARINE ENVIRONMENT MANAGEMENT PROFILE

Institutional structure:

Malaysia has a federal form of government, with some legislative powers resting with the states. This federation comprises of thirteen States and two Federal Territories. The Federal territory of Kuala Lumpur and eleven States are located in West Malaysia on southern end of the Malay (or Kra) Peninsula. The Federal Territory of Labuan and the States of Sarawak and Sabah in East Malaysia are on the northern coastline of the island of Kalimantan.

The Ministry of Agriculture, Ministry of Transport and the Ministry of Science, Technology and Environment manage the Malaysian marine environment.

Marine administrative agencies:

Ministry: Division/Department/Agency	General role	IMP role
Federal Authorities		
Ministry of Agriculture		
- Department of Fisheries (DoF)	Fisheries research, management, policy development	
- Fisheries Development Authority of Malaysia (FDAM)		
Ministry of Science, Technology and Environment (MOSTE)		Yes
- Conservation and Environmental Management Division	Conservation, Biodiversity	
- Department of Environment (DoE)	Environment protection, pollution control	Yes
Ministry of Transport		
- Marine Department	Administration of port related activities	
Ministry of Finance		
- Royal Customs and Excise Department	Import/export enforcement	
State Authorities		
Department of Fisheries (DoF)	Regional fisheries management	
(Sabah, Negeri Sembilan, Terengganu)		
Marine Department-	Port activities	
(Peninsula Malaysia, Sabah, Sarawak, Kedah)		
Port Authorities-	Port Activities	
(Kuching, Rajang, Bintulu, Miri, Port Klang)		
Royal Customs and Excise Department	Quarantine	Yes

Marine administrative agencies *(cont.)*

Research Centres

Fisheries Research Institute (FRI)	Under the umbrella of the DoF, FRI provides scientific and technical information. It has been involved in work relating to fish health, pathogens and aquatic ecology

INTRODUCED MARINE PEST AND HUMAN PATHOGEN MANAGEMENT PROFILE

Agency responsibilities:

There is no information available as to which agencies are responsible for managing introduced marine pests.

Summary of current and historical search effort for introduced marine pests:

There has been no search effort for identifying introduced marine pests in Malaysia.

Identified marine pests and human pathogens under legislation:

Malaysia has not identified any marine species as introduced marine pests or human pathogens through legislation.

Marine pest control, prevention and management initiatives:

Malaysia has introduced some management measures to prevent, control or deter introduced marine pest species. It has also identified the problem of introduced species, particularly issues associated with the intentional introduction of marine species for aquaculture and mariculture programs. The threat of introducing fish pathogens with these new species has been recognised.

With infectious fish disease highlighted as a major concern of unintentional introductions, the Department of Fisheries Malaysia (DoF) established a fish quarantine system. This system uses a sanitary and phytosanitary approach that utilises Fish Health and Quarantine Centres that cater for live fish/fishery product import and export controls. The Royal Customs and Excise Department also actively enforce federal import and export controls through legislation that prohibits the import and export of fish products, live fish, and corals without a permit. Furthermore, the Malaysian Fisheries Act 1985 states that the Director-General of Fisheries can impose any conditions on the permit to import and export fish to avoid or control the release into the natural environment of non-indigenous species of fish (Part VIII (40.2)).

Malaysia has developed a National Policy on Biological Diversity as part of its commitment to the Convention of Biological Diversity (CBD). This policy includes 15 framework strategies for effective management of biological diversity and was launched in 1998. Though the action plans that accompany the framework strategies are unavailable, the outline of the National Policy on Biological Diversity does not mention the need to prevent, control or eradicate introduced marine pests.

National and provincial legislation and regulatory measures:

There is limited focus on introduced marine pests in Malaysian legislation or regulations. Such issues are, however, noted in the Fisheries Act 1985 (No.317 of 1985) and the Fisheries (Prohibition of Import, etc. of Piranhas) Regulations 1973. Malaysian legislation and regulatory measures regarding possible vectors, biodiversity issues and marine/maritime issues includes:

Federal measures:

- National Policy on Biological Diversity
- Fisheries (Marine Culture Systems) Regulations 1990
- Fauna Conservation Ordinance 1963 (No. 11 of 1963)
- Protection of Wildlife Act 1972 (No. 76 of 1972)
- Wildlife Conservation Enactment (No 6. Of 1997)

- Conservation of Environment Enactment 1996 (No. 14 of 1996)
- Port Authorities Act 1963 (no. 21 of 1963, revised in 1992)
- Environmental Quality Act 1974

State measures:

- State Port Rules
- Second Sabah Agriculture Policy (1999-2010)- Fisheries Chapter

Private sector initiatives:

There is no information available on any private sector (industry/community) initiatives regarding marine pests in practice in Malaysia.

Public awareness initiatives:

There are no public awareness initiatives in place in Malaysia

SUMMARY

- Malaysia has significant levels of activity centred on its marine domain. The current focus on fishery related vectors provides a base for future actions.
- Malaysia has identified key problems associated with introduced marine pests and has institutional and administrative processes that can facilitate actions against particular vectors. These arrangements need to be extended to focus specifically on introduced marine pests.

2.2.11. MEXICO

Mexico is located in mid America, bordering the Caribbean Sea and the Gulf of Mexico, between Belize and the United State and bordering the North Pacific Ocean, between Guatemala and the US.

MARINE ENVIRONMENT MANAGEMENT PROFILE

Institutional Structure:

The United Mexican States is a federal republic and its legal system is a mixture of United State constitutional theory and civil law system. There is a judicial review of legislative acts and it accepts the compulsory ICJ jurisdiction, with reservations. Institutions responsible for freshwater and marine environment and resources use and management in Mexico are the National Commission for Aquaculture and Fisheries (Comisión Nacional de Acuacultura y Pesca - CONAPESCA) and the Secretariat of the Environment and Natural Resources (Secretaría de Medio Ambiente y Recursos Naturales - SERMANAT).

CONAPESCA was created in 2001 as a branch of the Secretariat of Agriculture, Animal Husbandry, Rural Development, Fisheries and Food (Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación - SAGARPA) and is responsible for the administration, regulation and development of fisheries and aquaculture sectors in Mexico. SERMANAT is responsible for the protection, restoration and conservation of ecosystems, natural resources and environmental services and goods with the purpose attain their sustainable use. It is also responsible for the formulation and implementation of national policies related to natural resources, ecology, environmental restoration, water, environmental regulation of urban and fishery activities development. In addition, other SERMANAT responsibilities relevant to freshwater and marine environment and resources are: (i) Environmental Impact Assessment and, (ii) the establishment and promotion of the National System of Environmental Information. All the above responsibilities are carried out in cooperation with state and municipal authorities, research institutes, universities and other relevant government institutions.

There are two branches of SERMANAT directly related to the marine environment. First, the *General Directorate for Primary Sector and Natural Resources*, which is responsible, among other duties, for the design of environmental legislation and instruments for the conservation, restoration and

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sustainable use of water bodies, fishery resources and their ecosystems by the aquaculture and fisheries sectors. Second, the *General Directorate for the Federal Maritime-Terrestrial Zone and Coastal Environment*, responsible for the implementation of environmental protection programs and sustainable development of national endowments and coastal environments; as well as, to participate in the formulation of the Mexican legislation for their environmental regulation.

Other institutions related to the use and management of marine environment and resources are the National Fisheries Institute (NFI) and Mexican Navy.

NFI is a branch of SAGARPA and it is responsible for the design and implementation of the national fisheries research policy in accordance with the national policies and strategies for the sustainable use of the fisheries resources and their environment, including aquaculture. It is the advisory body for SAGARPA and SERMANAT with reference to fisheries and aquaculture and their environment. NFI also conducts scientific and technical research in various aspects of fisheries and aquaculture development and management.

The Mexican Navy is responsible for navigational safety and marine pollution control, besides it's national defence and their rescue and logistic support in emergency situations. Through its Directorate for Marine Environment Protection (DMEP) it is responsible for the implementation and assessment of programs for the control and prevention of marine environment pollution. Also, to advise the Navy's Command on technical and administrative aspects of international agreements and conventions and marine environment pollution.

Finally, The National Commission for the Knowledge and Use of Biodiversity (CONABIO by its Spanish acronym) is an inter-secretariat institution coordinating efforts from ten Secretariats, including SALRDFF and SENR. CONABIO's mission is to promote, coordinate and support activities directed to create, maintain and disseminate information on Mexico's biodiversity in order to attain its conservation, and management for sustainable use. It promotes and develops scientifically based activities whose aim is to explore, study, protect or find a sustainable use for biological resources. CONABIO's efforts are primarily focused on three major areas: (i) research, (ii) sustainable use and, (iii) public awareness.

Marine administrative agencies:

Department: Agency/Statutory Body	General role	IMP role
Government Authorities		
Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food (SALRDFF)		
National Fisheries Institute (NFI)	To design and implement the national fisheries research policy in accordance with the national policies and strategies for the sustainable use of the fisheries resources and their environment, including aquaculture. To conduct research and advise SALRDFF and SENR.	
- National Commission for Aquaculture and Fisheries (NCAF)	Responsible for the administration, regulation and development of fisheries and aquaculture sectors in Mexico	Yes
Secretariat for the Environment and Natural Resources (SENR)		
- General Directorate for Primary Sector and Natural Resources	To design environmental legislation and instruments for conservation, restoration and sustainable use of water bodies, fishery resources and their ecosystems.	No
- General Directorate for the Federal Maritime-Terrestrial Zone and Coastal Environment	To implement environmental protection programs and sustainable development of national endowments and coastal environments; participates in the formulation of environmental legislation.	No

***Marine administrative agencies** (cont.)*

Department: Agency/Statutory Body	General role	IMP role
Navy		
Directorate for Marine Environment Protection (DMEP)	To safeguard all navigational safety issues and to collaborate in the control of marine pollution. To implement and assess programs for the control and prevention of marine environment pollution.	Probably Yes (ballast water)
National Commission for the Knowledge and Use of Biodiversity (CONABIO)	To promote, coordinate and support activities directed to create, maintain and disseminate information on Mexico's biodiversity	No
Research Centres		
Research Center on Food and Development (CIAD)	In charge of database on Aquatic Animal and Quarantine Information System (AAPQIS) (2002), through FAO Project.	
Universities	Training and research on various technological and scientific aspects of marine and freshwater environment and resources use and management, including research on harmful algal blooms and fish pathogens.	

INTRODUCED MARINE PESTS AND PATHOGENS MANAGEMENT PROFILE

Agency responsibilities:

SAGARPA, through CONAPESCA is responsible by law for the control and prevention of the introduction of exotic species for aquaculture or fisheries purposes and the possible related pathogen introductions. SERMANAT acting by the Federal Attorney for Environmental Protection (Procuraduría Federal de Protección al Ambiente – PROFEPA), a decentralized agency of SERMANAT, enforces the laws, Mexican Official Standards (NOMs) and programs related to aquatic flora and fauna. Even though there is no accessible information, the Mexican Navy through its DEMP is likely to be responsible for ballast water treatment procedures.

Summary of current and historical search effort for introduced marine pests:

After a number of workshops related to aquaculture pathogen introduction and control have been conducted in Mexico and the region, the Research Center for Food and Development (Centro de Investigación en Alimentación y Desarrollo-CIAD), in cooperation with FAO, is constructing a database to provide comprehensive tracking and reporting of diseases and parasites on a regional basis. This database, that should be in place by February 2002 is a sister system to the "Aquatic Animal and Quarantine Information System – AAPQIS" established by the Network of Aquaculture Centres in Asia Pacific (NACA). Therefore, main efforts have been directed to the identification of pathogens related to shrimp import for aquaculture purposes.

Identified introduced marine pests and human pathogens under legislation:

Only, Taura Syndrome Virus (TSV) and the viral disease White Spot Syndrome Virus (WSSV), introduced with imports of shrimps (*Penaeus vannamei* and *P. stylirostris)* for aquaculture purposes have been declared as introduced pests under legislation. TSV is said to have been introduced in 1995 and WSSV in 2000.

Marine pest control, prevention and management initiatives:

There is a set of legislation specifying sanitary prevention and control procedures or prohibitions regarding the introduction of TSC and WSSV. CONAPESCA and PROFEPA are the institutions responsible for the monitoring and enforcement of these procedures and prohibitions. There is no accessible information the implementation of ballast water treatment systems by the Mexican Navy, even though Mexico is an active member of IMO.

National and provincial legislation and regulatory measures:

Fuentes (2001) reports that the General Law on Ecological Balance and Environmental Protection (Ley General del Equilibrio Ecológico y la Protección al Ambiente—LGEEPA, 1988), establishes the principle of prevention as the most effective means of avoiding ecological imbalance, as well as the obligation of persons carrying out works or activities that affect or may affect the environment to prevent, minimize or repair any damage caused and to bear the ensuing costs. Thus, the Law aims at promoting sustainable development, and its provisions refer to the preservation, restoration and improvement of the environment as well as the preservation and protection of biodiversity. As a measure of protection for wildlife species, it contemplates the taking of measures to regulate and restrict the export or import of wildlife specimens, in whole or in part, and imposes restrictions on the circulation or transit of wildlife species over national territory.

The Fisheries Law (1992), issuing from Article 27 of the Constitution, ensures the conservation, preservation and rational use of fisheries resources. The Fisheries Law and its Regulation contain provisions governing the introduction of aquatic flora and fauna species into bodies of water under federal jurisdiction, the performance of aquaculture activities, and for control and prevention in the area of aquaculture health.

The sanitary provisions of the Fisheries Law and its Regulation are complemented by the Mexican Official Standards, which are compulsory technical provisions establishing rules, specifications, attributes, guidelines, characteristics and prescriptions relating to products, processes, facilities, systems, services and production or operating methods.

To date, some the relevant Mexican Official Standards (NOMs) in force are:

- NOM-010-PESC-1993 and NOM-011-PESC-1993, which established the sanitary and quarantine requirements, to determine the introduction of aquatic alive animals for ornamental or aquaculture purposes in the Mexican territory.
- NOM-002-PESC-1993, which establishes that shrimp larvae and post-larvae collected on the Pacific littoral may not be farmed in the Gulf of Mexico and Caribbean littoral and vice versa, except where, in the judgment of the authority, there technical reasons to justify such transfers.

In addition, the Mexican legislation includes the concept of Emergency Official Standards (MON-EM), which may be issued directly by the competent authority in emergency cases. Emergency standards are effective for a maximum period of six months and may be renewed only once. Examples of these emergency standards are:

- NOM-EM-001-SEMARNAP-PESC-1999 which established the requirements and measures to prevent and control the introduction and dispersion of the WSSV and YHV into wild and cultured populations through importations into the Mexican territory
- NOM-EM-003-PESC-2000, which establishes the requirements to determine the presence of viral diseases in aquatic animals, alive, dead or their products for its introduction and mobilization into the country.

Private sector initiatives:

The use of post-larvae coming from certified hatcheries instead of imports of wild post-larvae is one of recent bio-security measures taken by the shrimp farming sector that is helping to reduce the level of infected animals in the farms.

Public awareness initiatives:

There is no information on public awareness initiatives specifically focusing on introduced marine pest control, prevention and management.

SUMMARY

- Two types of marine pathogens (TSV and WSSV) have been legally declared as introduced marine pests in Mexico.
- CONAPESCA from SAGARPA and PROFEPA from SERMANAT have clear lines of responsibilities for introduced marine pathogens in aquaculture. Presumably, the DGMEP from the Mexican Navy is in charge of procedures for ballast water treatments.

- Although the existing legislation has clear references to protection and preservation of the marine environment and resources, only specific mention to control and prevention of marine pathogens in aquaculture is made.
- The private aquaculture sector is involved in some measures to decrease pathogens introduction and CIAD is actively involved in research and monitoring regarding introduced marine pests related to aquaculture.

2.2.12. NEW ZEALAND

New Zealand's marine environment contains the most varied and productive ecosystems in the South Pacific. As an island nation, New Zealand relies on maritime transport of goods with a number of major ports and shipping routes. More than 90% of imports and exports (by volume) travel by sea. Fisheries are also a valuable source of social, cultural and economic well being for the New Zealand population.

MARINE ENVIRONMENT MANAGEMENT PROFILE

Institutional structure:

The Ministry of Fisheries manages the majority of issues and activities concerning the marine environment, and particularly marine living resources. The Department of Conservation and Ministries of Agriculture and Forestry and Health also have some responsibilities, along with several other ministries that have minor roles.

Marine administrative agencies:

Ministry/agency	General role	IMP role
Ministry of Fisheries	Responsible for the administration and enforcement of uses of the marine environment and its living resources	Yes, the lead agency
Ministry of Transport	Responsible for the administration of the Maritime Transport Act and maritime matters	Yes
Ministry for the Environment	Responsible for the administration of the Resource Management Act, Environment Act, and associated environmental matters	Yes
Ministry of Agriculture and Forestry (MAF)	Responsible for agriculture and forestry	Indirectly
Department of Conservation	Responsible for general conservation matters and administration of fresh water fisheries.	Yes
Ministry of Health		Yes
Ministry of Research, Science and Technology	Creates national science policy, this includes marine research	
Biosecurity Council	A forum of the various departments with biosecurity responsibilities. It provides a mechanism to establish the needs and prioritise programs associated with managing exotic pests.	Yes
Environmental Risk Management Authority (ERMA)	Responsible for administering the Hazardous Substances and New Organisms Act 1998 and making decisions on applications to introduce new organisms into New Zealand.	Yes
Customs Service	Responsible for administering the Customs and Excise Regulations 1996 and customs related measures.	Yes
Maritime Safety Authority	Responsible for administering marine pollution treaties; control of organisms and hazardous waste on ships; vessel based discharges; oil spills.	Yes
Regional Councils	Implementing national policies at a local level	Yes

***Marine administrative agencies** (cont.)*

Research Centres	
Cawthron Institute	Actively involved in several research programs on introduced marine pests.
National Institute For Water and Atmospheric Research (NIWA)	Diverse Biological and oceanographical programs

INTRODUCED MARINE PEST AND PATHOGEN MANAGEMENT PROFILE

Agency Responsibilities:

The New Zealand governments biosecurity departments within the Ministries and departments of Agriculture and Forestry, Conservation, Fisheries and Health work closely together. The specific role of each department relates to how the introduction of harmful organisms may affect their broader responsibilities. In the case of introduced marine species the Ministry of Fisheries has primary responsibility however the Ministry of Health, in addition to the Ministry of Fisheries, would undertake actions related to the management of introduced human pathogens. The Ministry of Agriculture and Forestry would be contacted in the case of dinoflagellates affecting shellfish harvested for human consumption.

The Biosecurity Council, which includes representatives of the ministries and departments that have biosecurity responsibilities, provides a mechanism to establish the needs and prioritise management programs. It has set several policies regarding all exotic pests, including introduced marine pests. Furthermore, the Environmental Risk Authority (ERMA) set up under the Hazardous Substances and New Organisms Act (HSNO Act), plays a key role in the intentional introduction of marine organisms[5].

Summary of current and historical search effort for introduced marine pests:

Historically an extensive study of Waitemata Harbour was conducted by the Auckland Museum[6]. It found more than 60 new species of marine organisms than a previous study in the 1950s. A National Institute for Water and Atmospheric Research (NIWA) technical report[7] identified 156 adventive marine organisms in the marine environment. No introduced human pathogens have been identified, but further research is needed.

Past research has concentrated on the involvement of ballast water in the introduction of marine pests: species surviving in ballast water and the success of ballast water exchange in reducing numbers of organisms. Today researchers focus on predicting which marine pests are likely to reach New Zealand, and of these, which are likely to spread rapidly and become a nuisance. Furthermore, research is now concentrating on the introduced organisms already in New Zealand waters. Surveillance sites will be set up at high value locations; locations that are at risk of invasion and eight preselected harbour sites.

Identified introduced marine pests and human pathogens under legislation:

There are seven species classified as "unwanted" in New Zealand waters. These are:

- Wakame (*Undaria pinnatifida*)
- North Pacific seastar (*Asterias amurensis*)
- Mediterranean Fanworm (*Sabella spallanzanii*)
- Asian clam (*Potamocorbula amurensis*)
- European green crab (*Carcinus maenas*)
- Chinese mitten crab (*Eriocheir sinensis*)

[5] Note that no application to import new marine organisms has been approved since ERMA was established.
[6] B.W Hayward. (1997). Introduced marine organisms in New Zealand and their impact in the Waitemata Harbour, Auckland. In *Tane*, 36.
[7] Cranfield *et al.* (1998). Species Identified as Adventive in New Zealand. *NIWA Technical Report 34*.

- Caulerpa (*Caulerpa taxifolia*)

Of these, only *Undaria* has been introduced into New Zealand waters and established into pest proportions. Additional introduced marine pest species that have been identified, however which are not under legislation, are *Gymnodinium catenatum*, a toxic dinoflagellate and *Musculista senhousia*, the Asian date mussel.

Marine pest control, prevention and management initiatives:

New Zealand is in the process of developing a comprehensive system of pre border and border controls to stop, prevent and control introduced marine pest incursions. In June 2000 a five year funding package of NZ$9.8 million for research and management in marine biosecurity was announced. This funding coupled with the NZ$14.1 million over five years for research on biodiversity, will assist in the construction of a comprehensive marine biosecurity/biodiversity system. In September 2001, the New Zealand government agreed to develop a biosecurity strategy for terrestrial, freshwater and marine environments over the next three years. This strategy follows the development of plans that specifically address introduced marine pests.

Pre-border:

- New Zealand introduced mandatory ballast water reporting and management procedures in 1998.
- An "Import Health Standard for Ships' Ballast Water from all Countries (Biosecurity Act 1993)" has been enacted by the Ministry of Fisheries.
- The identification of high-risk areas where upon ballast water loaded in these areas can not be discharged in New Zealand waters under any circumstances. These areas are Hobart, Tasmania, and Port Phillip Bay, Victoria, (both in Australia).
- *Ballast water and Ships hull de-fouling strategy, January 1998*

The Ministry of Fisheries has proposed regulations under the Biosecurity Act 1993 to regulate hull cleaning to address the biosecurity risk posed by such activities. This proposal aims to reduce the risk of undesirable organisms being introduced and spread in New Zealand coastal waters. The proposed regulation is seen to be preparing the way for future quarantine controls to be imposed on vessels entering New Zealand waters with heavily fouled hulls. The proposal also aims to ensure that cleaning facilities and processes that reduce risk to an acceptable level are in place when carrying out directions under the Biosecurity Act relating to vector control and fouled hulls at the border. Guidelines to accompany the regulation will be published jointly by the Ministry of Fisheries and Ministry for the Environment. This will describe methods for complying with regulations and will assist operators of hull cleaning facilities and processes, vessel owners and regional councils by giving practical advice. A checklist will be prepared to facilitate compliance and monitoring.

- Development of a list of six potential pest species that New Zealand fear if introduced will cause severe environmental problems.
- ERMA's risk analysis on new organisms
- Development of a risk management framework

There is preliminary work on a risk management framework being conducted in New Zealand to assist the decision making and risk assessment process.

Border:

There are several quarantine policies and strategies in place regarding the intentional import and transport of marine organisms. The Ministry of Agriculture and Forestry (MAF) has set import health standards for the importation of live fish and fish products pursuant to the Biosecurity Act 1993.

- Import health standard for the import into New Zealand of marine fish for pet-food from all countries

- Import health standard for the import into New Zealand of fish food, fish bait and *Artemia salina* from all countries
- Import health standard for the import of Antarctic fish into New Zealand
- Import health standard for the import into New Zealand of ornamental fish and marine invertebrates from all countries
- Individual action plans for six potential pest species have been constructed
- Port Surveys are to take place in the immediate future.

Post-border

- *Closed areas for gathering of seafood*

The Ministry of Health has enacted a system of closed areas and open areas in response to the threats of human consumption of introduced toxic dinoflagellates. It provides the community with information materials on what seafood can be taken and eaten in the specified regions.

- *Incursion Response Protocol*

The Biosecurity Ministries, through the Biosecurity Council have developed an 'Incursion Response Protocol' to guide the response to incursions. This is now underpinned by the Biosecurity clause generic policy on exotic organism incursions.

- *National Framework for Managing Undaria*

The Ministry of Fisheries is developing a national framework for managing *Undaria* that will include early detection of the spread of *Undaria*. This will be performed in conjunction with the Department of Conservation, marine environment users and local authorities to develop ways of reducing the impact of *Undaria*.

National and provincial legislation and regulatory measures:

New Zealand has several legislative measures to assist in the prevention and control of introduced marine pests:

- *Biosecurity Act 1993*

In response to the biosecurity risks posed, the Biosecurity Act was enacted. This act addresses the threats and provides options and legislative powers to act on introduced pest incursions and management options.

- *"Import Health Standard for Ships' Ballast Water (Biosecurity Act 1993)"*

This import health standard states: "no ballast water may be discharged into New Zealand waters without the permission of an inspector" (4.1). To satisfy an inspector, the vessel's master must demonstrate that one of three options has been undertaken. Option 1: the ballast water is fresh water or has been exchanged en-route to New Zealand in areas free from coastal influences. Option 2: the ballast water has been treated using an approved shipboard treatment system[8], Option 3: the ballast is discharged in an approved area or onshore treatment facility[9]. The import health standard has identified high-risk areas (Annex 1) where upon ballast water loaded in these areas cannot be discharged in New Zealand waters under any circumstances.

- *Resource Management Act 1991 (RMA)*

The Resource Management Act requires that discharges of water or contaminants require resource consent unless allowed by a regulation or rule in a regional plan. It is hoped that the proposed regulations for hull cleaning discharges, although made under the Biosecurity Act, will guide decisions on resource consents for hull cleaning discharges made under the RMA.

- *Hazardous Substances and New Organisms Act 1998 (HSNO Act)*

This act sets the standards for intentional introductions into New Zealand.

[8] There are presently no approved shipboard treatment systems.
[9] There are presently no approved areas or onshore treatment facilities in New Zealand.

The Biosecurity Council has developed the following polices:

- Biosecurity Council Position statement on the application of precaution in managing biosecurity risks associated with the importation of risk goods under the Biosecurity Act 1993
- Ministry of Fisheries Policy on determining Organisms to be unwanted under the Biosecurity Act 1993
- Ministry of Health Policy statement on unwanted organisms for the purpose of the Biosecurity Act 1993.
- Policy statement on interdepartmental consultation on risk analyses and import health standards under section 22 of the Biosecurity Act 1993
- Policy statement on responding to an exotic organism incursion

Private sector initiatives:

Numerous community and private sector initiatives have been undertaken to assist in the control or prevention of introducing marine pests within New Zealand. These are primarily initiated by industries that have been identified as potential vectors for introducing marine pests.

The New Zealand Fishing Industry Association developed a 'code of practice on hull fouling on chartered vessels'. The code calls for New Zealand companies that charter overseas vessels to ensure that the vessel hulls are inspected before departing their home port. The chartering company is to ensure that hulls are "substantially free from plant and animal growth". If this fails to occur, the company is to ask the ship owners to take action to have the hull cleaned promptly in New Zealand, with the waste disposed of in an appropriate manner. This code of practice is voluntary, and the Fishing Industry Association (now superseded by the New Zealand Seafood Industry Council) has not monitored the extent of the companies' adoption or compliance with the code.

The mariculture industry has developed an 'Industry approved *Undaria* management plan for marine farms at Collingwood, Golden Bay'.

There are industry initiatives relating to toxic algal blooms of *Gymnodinium catenatum*. The oyster and mussel industry collaboratively developed a 'protocol on transfer of spat and marine farming equipment between infected and uninfected areas'.

Public awareness initiatives:

There have been various initiatives taken to promote community awareness of the issues of introduced marine pests. Information materials such as posters and pamphlets have been constructed. These have been made available to the community, in addition to the thorough information content available on the government agency internet sites.

A guide to identifying marine pests in New Zealand's waters was produced by the Ministry of Fisheries with support from the Cawthron Institute and NIWA. This guide includes information, photos and schematics of the six species identified as to cause serious problems should they invade the New Zealand marine environment. A Ministry of Fisheries biodiversity pamphlet also notes how the marine biodiversity can be impacted by the introduction of exotic pests through shipping.

With the agreement to develop a biosecurity strategy for New Zealand, the government launched a public education campaign, "Protect New Zealand- Tiakina Aotearoa", with the theme that everybody has a role to play. This public education message will be spread through TV adverts and with the assistance of "Biosecurity Officer Max the Beagle".

SUMMARY

- New Zealand has identified 156 introduced marine species, two of which have been determined 'unwanted' for management purposes.
- New Zealand's reliance on ship-born trade and its significant fishing industry provide a number of potential vectors for introduced marine pests.

- New Zealand has identified the problems associated with introduced marine pests and established processes and arrangements to restrict such introductions.
- New Zealand has acted to address the problems associated with introduced marine pests and has implemented a number of key legislative and administrative arrangements.
- New Zealand's focus on biosecurity and monitoring of introduced marine pests are key strategies and central elements in its approach.
- New Zealand has several private sector initiatives to control marine pests.

2.2.13. PAPUA NEW GUINEA

Papua New Guinea (PNG) comprises of the eastern half of New Guinea plus an archipelago of 600 islands. The marine environment in PNG supports subsistence fishing as well as small-scale commercial fisheries. At present aquaculture is not economically important, however the need to increase protein sources for human consumption did lead to the introduction of alien species into PNG waterways and reservoirs. This intentional introduction of carp, rainbow trout and at least seven other species ceased in 1997[10]. Fish products are imported, with major suppliers Thailand and New Zealand.

MARINE ENVIRONMENT MANAGEMENT PROFILE

Institutional structure:

PNG's government operates a system of administrative and financial decentralisation with both a national government and 19 semi-autonomous provincial governments. The provincial governments have considerable autonomy in regard to the marine environment and usage of its resources. They have a similar constitutional arrangement to the National Government and have concurrent power with the latter in areas such as agriculture, business development, town planning, forestry and natural resources. This system is initiated by the Organic Law, an extension to the constitution that takes precedence over Acts of Parliament. The Organic Law requires that the national government bodies devolve as many of their functions to the provincial authorities or carry them out at a provincial level. . The management of the marine environment is achieved through a number of sectoral policies and legislation addressing the requirements of several Departments with marine environment interests.

Marine administrative agencies:

Department: Agency/Authority	General role	IMP Role
National Authorities		
Department of the Prime Minister and the National Executive Council (NEC)	Lead by the Prime Minister the NEC is responsible for all executive power within the national government. The NEC implements international instruments through executive decisions. It also forms various committees under these decisions.	
Department of Fisheries and Marine Resources	Administration of the use of living marine resources	
National Fisheries Authority (NFA)	To manage commercial fishery activities, develop policies, and enforce regulations and legislation on domestic and foreign fishing operations and to conduct related research.	
Department of Environment and Conservation	Administration of environmental and conservation regulations, including the marine environment.	
Marine Scientific Research (MSR) Consent Committee	According to the NEC decision no. 45/97 the MSR (which is coordinated by the Department of Mineral Resources) was established to address specific MSR activities and examine the legislative framework governing MSR interests.	
National Agriculture Quarantine Inspection Authority (NAQIA)	Enforcement of quarantine measures	
Bureau of Customs	Responsible for quarantine measures imports and export controls.	

[10] There are discussions about conducting a post environmental impact assessment on this project.

***Marine administrative agencies** (cont.)*

Department: Agency/Authority	General role	IMP Role
Papua New Guinea Harbours Board (PNGHB)	The PNGHB is a self-financing statutory authority which provides wharf infrastructure and related facilities to serve oversees and coastal shipping and to facilitate cargo movement and handling throughout PNG.	
<u>Research Centres</u>		
University of Papua New Guinea		

INTRODUCED MARINE PEST AND PATHOGEN MANAGEMENT PROFILE

Agency responsibilities:

There is no management authority identified as responsible for controlling or preventing introduced marine species in PNG.

Summary of current and historical search effort for introduced marine pests:

To date there has been no organised search effort for identifying introduced marine pests or human pathogens identified in PNG waters.

Identified introduced marine pests and human pathogens under legislation:

There are no marine species identified as introduced marine pests or human pathogens under PNG legislation.

Marine pest control, prevention and management initiatives:

There appears to be little or no work on introduced marine pests within PNG. In the late 1990s concerns were raised over giant clam mariculture. Possible problems identified included parasitic transfers and introductions of symbiont algal strains that may not adapt to local conditions and thus impact upon growth rates. To remedy this situation a set of working guidelines was proposed.

Research is currently being undertaken on terrestrial animal and plant invasive species in PNG by the National Agricultural Research Institute and the University of PNG, Biology Department. The University of PNG is in the final stages of developing a database on invasive organisms that brings together the available information and records, which will be followed up by some survey work and policy developments.

National and provincial legislation and regulatory measures:

PNG has put in place several pieces of legislation and regulatory measures regarding the marine environment though none specifically mention or pertain to controlling, preventing or managing introduced marine pest species. The following legislation governs activities undertaken within the marine environment:

- Fisheries Management Act 1998
- Fisheries (Torres Strait Protected Zone) Act 1983
- Organic Law on Provincial and Local-level Governments of July 1995
- Harbours Board Act

Though this list is not comprehensive it does present the cross-sectoral approach of enforcement through several departments and authorities. The Organic Law is a key component to any legislation or regulatory measure.

The Environmental Protection Bill was taken before parliament in 2000. This bill proposes to integrate the Environmental Planning Act, Environmental Contaminants Act and the Water Resources Act and has includes relevant provisions of the LOSC as related to the marine environment.

Private sector initiatives:

Contents

The location of several primary conservation organisations in PNG has lead to the application of global strategies and programs within the PNG environment. There has been a move within these organisations to operate programs related to the marine environment. There has not as yet, however, been a focus on introduced marine pest species.

Public awareness initiatives:

Currently there are no public awareness campaigns within PNG to increase the awareness of introduced marine pests or related issues.

SUMMARY

- Papua New Guinea has significant potential vectors related to introduced marine pests.
- Although there appears to be a limited response to the threat of introduced marine pests and human pathogens in PNG, the problem has been recognised in relation to aquaculture operations.
- There appears to be considerable opportunity to implement local actions to address the issue of introduced marine pests given Papua New Guinea's structure of government.

2.2.14. PERU

Peru is located in the southeast of the Pacific Ocean. The marine ecosystem includes the Peruvian Current (also known as the Humboldt Current) moving from south to north and bringing to the coast subantarctic and subtropical waters, which create one the most productive and diverse coastal marine areas of the world. In the Peruvian coastal zone inhabit approximately 900 species of fish, 917 species of mollusc, 502 species of crustaceans and 687 species of algae.
Peru has one of the largest fisheries of the world based on large quantities of small pelagic fish anchovies, sardines and horse mackerel. Other marine resources exploited are tunas, hake, abalone, mussels, scallops, razor clams and squids, among others. Aquaculture is still in its infant stage mainly oriented to the culture of scallops, shrimp and trout.

MARINE ENVIRONMENT MANAGEMENT PROFILE

Institutional Structure:

The Ministry of Fisheries is responsible for all-marine and freshwater resources management and related fisheries and aquaculture development. The mission of the Ministry of Fisheries is to ensure equilibrium between the sustainable use of hydro biological resources, the protection of the environment and the socio-economic development in the context of responsible fisheries.

The Ministry of Fisheries is comprised by five Directorates: (i) National Directorate of Aquaculture which oversees all mariculture and inland aquaculture activities, (ii) National Directorate of Artisanal Fisheries which oversees all productive and management aspects of small-scale fishing in Peru, (iii) National Directorate of Capture Fisheries and Processing oversees all management and administrative aspects of large-scale fisheries and processing, (iv) National Directorate of Monitoring, Control and Surveillance is in charge of all aspects of monitoring and enforcement of fisheries law and regulations, (v) National Directorate of the Environment is in charge of all aspects related to control and prevention of environmental impacts of fisheries an aquaculture activities.

In addition, there are four decentralised and semi-autonomous institutions related to the Ministry of Fisheries. These institutions are:

- The Marine Research Institute of Peru (IMARPE) Fisheries, which conducts all scientific research necessary to advise the Government on decision making concerning the rational use of fishery resources and the conservation of the marine environment;
- The Institute of Fisheries Technology of Peru (ITP), whose objective is to promote and conduct technical and scientific research for the best use and transformation of marine resources and, to disseminate the best practices and techniques for product handling, processing and packing. ITP also conducts sanitary control and surveillance in all fisheries activities;

- The National Fund for Fisheries Development (FONDEPES) whose mission is to create and promote necessary capabilities for the development of fisheries and aquaculture production for human consumption throughout research, technological transference and financial support and;
- Fisheries Training Center of Paita (CEP-PAITA) oriented to provide technical training in different aspects of capture fisheries, aquaculture, marketing, product handling, cold storage and processing.

Marine administrative agencies:

Ministry/agency	General role	IMP role
Government Authorities		
Ministry of Fisheries	In charge of all capture fisheries and aquaculture development and management aspects.	Not specified
	To coordinate with other ministries, municipalities and other relevant institutions all prevention and control actions related to pollution originated by or negatively affecting the fisheries activities	
Ministry of Defence through Coast Guard Service and Harbour Authorities	To conduct activities and measures related with human life safety and marine environment protection.	Not specified
	To collaborate in the surveillance and enforcement of fisheries laws and regulations.	
Ministry of Agriculture	In charge of flora conservation units.	Not specified
Ministry of Health	To conduct activities related to control and prevention of human diseases and causing vectors.	Not specified
Research Centres		
Marine Research Institute IMARPE	To conduct research for fisheries management, marine environment conservation, fish production and marketing.	
Technological Institute of Peru (ITP)	To conduct technical and scientific research related to product handling, processing, cold storage and marketing. To conduct monitoring and surveillance of sanitary standards in all fisheries activities.	

INTRODUCED MARINE PESTS AND HUMAN PATHOGEN MANAGEMENT PROFILE

Agency responsibilities:

There is no management authority identified as responsible for controlling or preventing introduced marine species.

Summary of current and historical search effort for introduced marine pests:

There are very few documented search efforts for IMPs in Peru, the only two identified are the ones of the Secretariat of CDB-UNEP through the Peruvian National Environmental Council (CONAM) as focal point regarding invasive alien species in general and the one from Lo *et al.* (1999). The Rainbow Trout has been identified by the Secretariat of CBD-UNEP (2001) as an IMP, reporting strong ecological impacts as it has displaced native species such as *Trychomycterus sp*, *Orestias sp* and *Astroblepus sp*. Japanese Oyster and one specie of Prawn (*Machrobrachium rosembergii*) have been identified as potential IMPs. The White Spot Syndrome Virus (WSSV) is also identified as causing problems in the shrimp aquaculture industry. Both, Hepatitis B and Vibrio Cholera are well known threats to human health and life and they are cryptogenic species (i.e. uncertain whether they are introduced or native). In 1991, for instance, Cholera caused an epidemic episode that extended from to Peru to Chile in the south and as far as the USA in the north.

Identified introduced marine pests and human pathogens under legislation:

No introduced marine organisms or pathogens have been legally declared as introduced marine pests and human harmful pathogens in Peru. The Fisheries Law does not make explicit reference to introduced marine pests.

Contents

Marine pest control, prevention and management initiatives:

There is no information on any initiatives related to IMP control, prevention and management in Peru. There is no information on implementation of the IMO Guidelines for the control and management of ships ballast water.

The Ministry of Health has initiatives related to the monitoring and control of human pathogens such as Cholera. .

National and provincial legislation and regulatory measures:

The General Law of Fisheries of 1992 (DL No 25977) regulates all fisheries activities in Peru. Reategui (2001) reports that complementary laws are under construction to regulate the promotion and development of a national industry.

The General Law of Fisheries includes the following regulations regarding the conservation of the marine and aquatic environment that could be called for to justify management of introduced marine pests:

- The prohibition to leave in beaches and river sides or to throw out in the water (marine, brackish or freshwater) waste, toxic substances, pollutants or other elements or objects that will endanger navigation or life, or cause damage to the environment, alter the ecosystem equilibrium or cause other harms to coastal populations.
- The prohibition to destruct of damage mangrove areas and estuaries

In addition, the Regulations associated with the General Law of Fisheries (SD No 011-94-PE) indicate in its Article 126t that the import of hydrobiological species for aquaculture purposes (in any stage of their life cycle) requires approval from the Ministry of Fisheries and sanitary certification from the country of origin, in addition to any other requirements imposed by the Code of the Environment and Natural Resources. The introduction of new species into the national territory of Peru requires in addition the presentation of an Environmental Impact Assessment Study. Similarly, the relocation of hydrobiological species in different ecosystems inside the national territory requires approval from the Ministry of Fisheries.

Article 127 states the obligation to the holder of an aquaculture license to report to the Ministry of Fisheries any out break of diseases in the cultured species and to request the undertaking of required sampling and analysis at its own costs.

The Regulations of the Law of Conservation and Sustainable Use of Biological Diversity (SD N° 068-2001-PCM) includes concepts and objectives that may be considered as appropriate grounds for future creation and implementation of management plans for introduced marine pests. As an example, Article 22 indicates that the objective of environmental management is the establishment of territorial use and occupation conditions in accordance to the ecological, economic and cultural characteristics of the geographical space, with due consideration of the ecosystems and species fragility, vulnerability an endemism, as well as, of the genetic erosion, with the purpose to obtain their maximum utilization without compromising their quality and sustainability.

Private sector initiatives:

There is no information available on any private sector initiatives related to management of IMPs.

Public awareness initiatives:

There is no information available on any public awareness initiatives regarding introduced marine pests and the need for their management.

SUMMARY

- Peru has no introduced marine species legally declared as introduced marine pests or harmful pathogens. Nonetheless, six marine species (crustacean, mollusc, fish, virus and bacteria) have been identified as present or potential IMPs.

- Even though the Peruvian General Law of Fisheries and its Regulations, as well as the Law of Conservation and Sustainable Use of Biological Diversity, include concepts, concerns and management instrument directly related to sustainable use of the environment and biological diversity, no direct mention is made about introduced marine pests their potential effects and management.
- Even though, presently there is no authority or institution officially identified as responsible for the management of IMP, due to their stated mission, objectives and conceptual approaches, the Ministry of Fisheries and its National Directorate of the Environment, along with the Port Authorities and the National Environmental Council (CONAM) may become the depositories of this responsibility in the future.
- Even though Peru is a member of IMO, presently they have not yet subscribed, nor implemented the IMO Guidelines for the control and management of ship's ballast water to minimise the transfer of harmful aquatic organisms and pathogens -Resolution A.868(20)-.

2.2.15. PHILIPPINES

The Philippines is an archipelago of 7,107 islands on the western rim of the Pacific Ocean. Nearly five thousand species of marine plants and animals have been found in its marine and coastal environment. The Philippines is ranked second in terms of the richness of fish and coral species well as seagrasses. Twenty-eight percent of the species identified are considered as economically important.

The fisheries sector is divided into three subsectors: municipal fisheries (within 15 km from the coastline and using a vessel less than 3 GRT), commercial fisheries (using vessels over 3 GRT) and aquaculture. Aquaculture has a long tradition in the Philippines and accounts for 31 percent of the total value of fisheries production. Brackish-water aquaculture is the primary aquaculture activity, but mariculture and integrated agriculture-aquaculture systems are also common. . In total the Philippines fisheries sector employs over one million people and is ranked thirteenth as an important producer of fish at the global scale.

Considering its geographic configuration, the Philippines is dependent on efficient water transport for trade. There are 42 ports considered crucial to the Philippines economic development which are to be equipped with infrastructure and landslide equipment to enhance their competitive global advantage. Philippine ports are used for handling almost 98 percent of the total imports and exports. There are also over 1000 small, domestic ports within the Philippine archipelago.

MARINE ENVIRONMENT MANAGEMENT PROFILE

Institutional structure:

A National Marine Policy was developed by the Philippines in the mid 1990s to promote a future for the management of the Philippine marine environment and its uses. This policy identified national concerns, called for a shift in the current development policy and introduced the common principles of marine resource usage (sustainable development, integrated coastal zone management and the polluter pays principle).

Currently, the marine environment is primarily managed under four departments: Agriculture, Natural Resources and Environment, Transport and Communications and Science and Technology. Attached to these departments are numerous agencies, bureaus, institutes, councils and authorities that are involved with the administration/management of specific sectors of the marine environment which often tend to overlap.

The Bureau BFAR was originally a staff bureau under the Department of Agriculture, but was transformed into a line agency under the Philippine Fisheries Code of 1998. It is responsible for managing and protecting the fisheries and aquatic resources and interacting with local bodies to ensure its presence throughout the regions and provinces of the Philippines. Under the Philippine Fisheries Code of 1998 the National Fisheries Research and Development Institute (NFRDI) was also created to research the development, management, conservation and protection of fisheries and aquatic resources.

Agencies involved in fisheries research are coordinated by the Bureau of Agricultural Research (BAR) under the Department of Agriculture. The Philippine Council for Aquatic and Marine Research and Development (PCAMRD) was established in 1988 and operates under the Department of Science and Technology (DOST). It uses a multi-disciplinary, inter-agency and systems approach in promoting fisheries research and development.

Marine administrative agencies:

Department: Agency/bureau	General role	IMP role
<u>Government Authorities</u>		
Bureau of Fisheries and Aquatic Resources (BFAR)	Ensuring long-term sustainability of fisheries and aquatic resources.	Yes
- Fisheries Regulatory and Quarantine Division		Yes
- Fish Health Section		
Department of Science and Technology		
- Philippine Council for Aquatic and Marine Research and Development (PCAMRD)		
National Committee on Biosecurity of the Philippines (NCBP)	Administering general biosecurity guidelines and for intentional releases of harmful exotic species and GMOs.	Yes
Department of Environment and Natural Resources	Administers biodiversity, environmental impact assessments,	Yes
- Environmental Management Bureau	Administers biodiversity, environmental impact assessments,	
Department of Transportation and Communications		
- Maritime Industry Authority (MARINA)	Supervisory and regulatory authority for maritime operations. (central office and ten maritime regional offices)	
Department of Agriculture		Yes
- Committee on the Introduction of Exotic Aquatic Organisms	Quarantine matters regarding aquatic organisms	Yes
- National Agriculture and Fisheries Council (NAFC)	Advisory body to DA through policy recommendations	
Department of Trade and Industry		
- Philippine Shippers Bureau	Licensing and accreditation, consumer protection and advisory and promotion of shipping activities and related issues.	
Department of Health		Yes
- Bureau of Food and Drugs	Biosecurity aspects regarding human pathogens and harmful exotic species. Responsible for the registration of animal feeds	Yes
Economic Intelligence and Investigation Bureau	Law enforcement functions in territorial waters and coastal areas	
Philippine Ports Authority	Law enforcement functions in territorial waters and coastal areas	
Bureau of Customs	Enforcing import/export restrictions	Yes
Local Government Units (LGUs)	Management of coastal resources within municipal waters	

MARINE PEST AND HUMAN PATHOGEN MANAGEMENT PROFILE

Agency responsibilities:

The Bureau of Fisheries and Aquatic Resources is the central management agency for fisheries quarantine, however it is not clear which agencies are responsible for introduced marine pests. The

National Committee on Biosecurity of the Philippines (NCBP) are responsible for intentional introductions. There is mention in literature of the formation of the Committee on the Introduction of Exotic Aquatic Organisms..

Summary of current and historical search effort for introduced marine pests:

The Philippines government has monitored algal blooms after the introduction of the toxic dinoflagellate – *Pyrodinium bahamense* var. *compressum*. As this species has impacted on aquaculture operations, areas where shellfish mariculture is performed are monitored. The monitoring of fish pathogens also occurs.

Identified introduced marine pests and human pathogens under legislation:

There are no marine species identified as introduced marine pests under Philippine legislation, however the *Pyrodinium bahamense* var. *compressum* is addressed through Local Orders.

Marine pest control, prevention and management initiatives:

The Philippines have put in place various quarantine measures to control the introduction of marine organisms into the economy. When under the DA, BFAR was mandated to recommend legislation/actions on aquatic quarantine, this has continued since BFAR has become a line agency[11]. BFAR has created several Fisheries Administrative Orders[12] (FAOs) and Executive Orders regarding the importation and exportation of fish and fishery products. There has been an emphasis on prohibiting the import of exotic species, though these are mainly freshwater species like the piranha. In 1992 the Central Bank Circular No 1356 removed the import requirements of concerned government agencies in an attempt to remove import restrictions that affect international trade. This left the decision making procedures regarding introductions and transfers of aquatic organisms to BFAR. BFAR developed a Fisheries Regulatory and Quarantine Division that would consult with other BFAR divisions/sections regarding requests. The Fish Health Section of BFAR issues health certificates concerning the presence or absence of parasites for outgoing shipments of ornamental fish upon requirement of the importing country. It should be noted that this certification does not occur at any port of entry into the Philippines.

DA created a national "Committee on the Introduction of Exotic Aquatic Organisms" under the Special Order No. 642, which comprised of BFAR, PCAMRD, SEAFDEC and UPMSI. This committee acts as an advisory body to the DA on matters concerning aquatic introductions.

The Food and Agriculture Organisation is assisting the BFAR in restructuring its fish inspection and quarantine services, however there is no indication as to whether this has included any form of quarantine guidelines or a risk analysis on intentional introductions of marine organisms.

The National Committee on Biosafety of the Philippines (NCBP) has identified the threats posed to the intentional release of harmful exotic species. The "Guidelines for planned release of genetically manipulated organisms (GMOs) and potentially harmful exotic species (PHES) was the third set of guidelines for NCBP. The guidelines provide the legal procedures for planned releases including the appropriate application and an insight into the review process. The review process includes conducting risk-benefit analysis on the species. The appropriate government authorities are required to monitor the release and inspect the site at future dates.

Regarding introduced pests, the Philippine government has set up special projects to control, eradicate and mitigate the negative impacts on production systems of specific alien invasive species. Though it is evident that this concern is predominantly related to terrestrial plant species, it is seen to be moving into other realms.

There is a focus on red tide causing organisms after their discovery and impacts. A National Red Tide Taskforce was formed by the Research Division, Bureau of Fisheries and Aquatic Resources and Inter-Agency Committee on Environmental Health. This taskforce developed the Philippine

[11] DA is still involved in quarantine matters relating to fish, plants and animals.

[12] A FAO pertains to all regulations and rules regarding all fishery and aquatic resources.

Guidebook on Toxic Red Tide Management through a series of consultative workshops with other concerned government agencies and NGO. The guidebook focuses on managing the problems caused by red tides and covers basic concepts, legal, administrative, mitigation, preparedness, response and recover aspects.

After the introduction of the fish pathogen white spot syndrome virus (WSSV) into cultured shrimp the Bureau of Fisheries and Aquatic Resources formulated a national action plan immediately. The program consists of exclusion, containment, monitoring and increasing the good farm management practices. A Code of Practice for Sustainable Shrimp Farming has also been developed. It addresses biosecurity measures at the farm, provincial and national levels.

National and provincial legislation and regulatory measures:

Several regulatory and legislative measures in the Philippines concern potential introductions of marine pests:

- *Philippine Fisheries Code of 1998 (R.A. 8550)*

(Section.10) States that "No foreign fin fish, mollusc, crustacean or aquatic plant shall be introduced into Philippine waters without a sound ecological, biological and environmental justification based on scientific studies subject to the bio-safety standard as provided by for existing laws"

(Section 67) States that for the purposes of monitoring and regulating the importation and exportation of fish and fishery/aquatic resources, the Fisheries inspection and Quarantine Service can perform various examinations and inspections. It also allows them to implement international agreements on biodiversity.

(Section 100) Prevents the export of prohibited breeders, spawners, eggs or fish.

- *Guidelines for planned release of genetically manipulated organisms (GMOs) and potentially harmful exotic species (PHES)"*

This guideline defines a PHES as meaning a potentially harmful exotic species and refers to any exotic species that may constitute significant negative risks to human health and the environment. It has also defined a pest as "any living stage, whether active or dormant, of insects, nematodes, slugs, annelids, snails, protozoa, bacteria, fungi and other parasitic plants or reproductive parts of; viruses; any plants or animals that can damage aquatic or terrestrial ecosystems; or any infectious agents or substance".

Additionally the Philippine government has enacted Fisheries Administrative Orders that regulate the quarantine of proposed introductions of exotic aquaculture species form other countries. Local ordinances prohibiting the harvesting and sale of shellfish products have also been issued in areas where seasonal toxic dinoflagellates are in bloom.

Private sector initiatives:

There is no information available on any private sector initiatives regarding introduced marine pests.

Public awareness initiatives:

The focus on the problems caused by red tides has resulted in the construction of posters and information materials by the government. These address the prohibition of dumping red tide contaminated shellfish into uncontaminated areas. Flyers for the National Action Program to Control White Spot Syndrome Virus (WSSV) in Shrimps have also been constructed to promote the program.

SUMMARY

- The Philippines government has recognised the problem of introduced marine pests and has a range of programs that can be used to address the problems of such introductions.
- This effort will be strengthened by ongoing research on introduced marine pests and the range of potential vectors.

- The main focus of management has been on species that affect mariculture operations such as pathogens and red tide causing organisms.

2.2.16 RUSSIA (Russian Federation)

MARINE ENVIRONMENT MANAGEMENT PROFILE

Institutional Structure:

The Russian Federation considers three levels of fisheries administration. Central authority for management decisions flows from the Federal Fisheries Committee (FFC), created in 1992, in Moscow, within the Ministry of Agriculture and Food. FFC is responsible fro the management, monitoring, and enforcement in fisheries, and conducts research, through several different branches and regional offices.

The FFC has several departments to conduct science and research, and the setting of harvest quotas and allocations. These include the Russian Federal Research Institute of Fisheries and Oceanography (VNIRO), and the regional Scientific Research Institutes of Fisheries and Oceanography (TINROs), and the enforcement and monitoring department whose formal name is the National Administration of Fishery Enforcement, Resources Restoration and Regulation of Fishing (Glavrybvod).

Pautzke (1997) also reports that the second level of administration are Regional Scientific-Industrial Councils (created in 1992), which represents the oblasts, krais, and okrugs along the coasts of Russia, and recommends fishing quotas and regulations at the regional level. The FFC in Moscow retains final approval authority. At a more basic regional jurisdiction, more local level committees named Territorial Fishing Industry Committees were created to coordinate allocations and usages in their own areas and industries.

Marine administrative agencies:

Department: Agency/Statutory Body	General role	IMP role
Government Authorities		
Ministry of Agriculture (MOA)		
- Federal Fisheries Committee (FFC)	Responsible for the management, monitoring, and enforcement of fisheries. In addition, it conducts research, through several different branches and regional offices.	No
- National Administration of Fishery Enforcement, Resources Restoration and Regulation of Fishing (Glavrybvod)	Responsible for the enforcement of fisheries laws and regulations.	No
- Regional Scientific-Industrial Councils	Responsible for the management and monitoring of fisheries at regional level.	No
- Territorial Fishing Industry Committees	Responsible for the management and monitoring of fisheries at local level.	No
Research Centres		
Federal Fisheries Committee (FFC)		
- Russian Federal Research Institute of Fisheries and Oceanography (VNIRO)	Responsible for fisheries research and suggestion of quotas at national level.	
- Scientific Research Institutes of Fisheries and Oceanography (TINROs)	Responsible for fisheries research and suggestion of quotas at regional.	

INTRODUCED MARINE PESTS AND PATHOGEN MANAGEMENT PROFILE

Agency responsibilities:

At present there no clear government agencies responsible for the control, prevention or management of introduced marine pests. This, since this issue has been addressed by scientist and local experts

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which for the past two years have been trying to create non-governmental institutions with support from international organisations, on this issue (T. Shiganova, personal communication).

Summary of current and historical search effort for introduced marine pests:

There have been efforts to identify and control introduced marine pests by the scientific community such as the cases documented in the Black Sea where two Ctenophore species (*Mnemiopsis leidyi* and *Beroe ovata*) were introduced via ballast water from USA. The introduction of *Beroe ovata* has been a biological control to *Mnemiopsis leidyi*. A third case reported is *Rapana thomasiana* introduced the Black Sea from the Japan Sea also via ballast water. These are not addressed in this report, as they have not been introduced into the focal areas (Pacific).

Identified introduced marine pests and human pathogens under legislation:

There is no information of aquatic invasive organisms identified by law as introduced marine pests in Russia.

Marine pest control, prevention and management initiatives:

There is no information.

National and provincial legislation and regulatory measures:

Presently none existent.

Private sector initiatives:

There is no information on private sector initiatives regarding prevention, control or management of introduced marine pests.

Public awareness initiatives:

There is no information on government or non-government public awareness initiatives regarding prevention, control or management of introduced marine pests.

SUMMARY

- There is no information on aquatic invasive species identified as introduced marine pests by law.
- Only three species are considered introduce marine pests by the scientific community. They are present in the Black Sea.
- There are no Government or non-government institutions or organisations identified as responsible for introduced marine pests prevention, control or management.
- There is no information on Laws and regulations for introduced marine pests prevention, control or management.

2.2.17. SINGAPORE

Singapore, an island state located off the bottom of the Malay Peninsula is comprised of the main island of Singapore and additional 57 smaller islands. With no EEZ, Singapore focuses its management of the marine environment at the port level. The commercial fisheries sector is not understandably as extensive as in other economies, though the ornamental fish industry is considered highly regarded.

Singapore operates a free trade policy, offers a prime location and is used by many companies as a base for their regional expansion. For this reason the marine environment is predominantly used for shipping related activities. In 2000 145,383 vessels arrived in Singapore. Singapore exports the majority of its products to the USA, Asia, Europe and Australia, while it imports from the Middle East, Asia, Europe and the USA.

MARINE ENVIRONMENT MANAGEMENT PROFILE

Institutional structure:

The Singapore Maritime and Port Authority (MPA) has adopted a comprehensive marine environment management approach based upon prevention and preparedness. Policy towards the prevention of pollution of the marine environment is based on enhancing safety of navigation and the strict enforcement of legislation. It aims to ensure that ships are designed, equipped, operated and managed to prevent pollution of the sea, based on internationally adopted regulations. While the MPA is the sole regulatory body overseeing Singapore's port and maritime affairs, responsibility for introduced marine pests is spread between other agencies and departments.

Marine administrative agencies:

Ministry: Division/department	General role	IMP role
Ministry of Environment (ENV)		
- Pollution Control Department (PCD)	Responsible for ensuring that environmental factors are incorporated into land use planning and water pollution control	
- Quarantine and Epidemiology Department (QED)	To prevent and control diseases and environmental related health problems	
Ministry of National Development		Yes
- Agri-food and Veterinary Authority (AVA)	Quarantine, research on the impacts of alien species on plant and animal health (biosafety), responsible for implementing CITES	Yes
- Urban Re-Development Authority	Implementing development strategies and safeguarding	
- National Parks	Management of marine parks and nature conservation	
Ministry of Finance		
- Custom and Excise Department (CED)	Enforcing customs related import and export measures	Yes
Ministry of Transport		
- Maritime and Port Authority of Singapore (MPA)	Prevention of pollution of the marine environment from sea-based activities. Overseeing port and maritime affairs	
Research Centres		
Environmental Technology Institute (ETI)	Research and development in environmental technology	
National University of Singapore – Tropical Marine Science Institute	Conducts research on marine environment and ecology	

INTRODUCED MARINE PEST AND PATHOGEN MANAGEMENT PROFILE

Agency responsibilities:

The Agri-food Veterinary Authority is involved in the quarantine aspects of fishery trade in Singapore. There is no available information on which specific agencies manage introduced marine pests in Singapore. However, Singapore has noted that introduced marine pests are managed at a national level by the national governmental departments.

Summary of current and historical search effort for introduced marine pests:

Singapore has identified a Caribbean bivalve, presumably the black striped mussel, *Mytilopsis sallei,* as an introduced species. There is no available information on the actual search effort for identifying introduced marine pests in Singapore.

Identified introduced marine pests and human pathogens under legislation:

Singapore has not identified any marine species as an introduced marine pest or human pathogen through its legislation.

Marine pest control, prevention and management initiatives:

The Tropical Marine Science Institute will be initiating research on alien invasive species as part of a larger program on biofouling early 2002. In addition a pilot project on the exotic Caribbean bivalve *Mytilopsis sallei*, which is present in Singapore, is currently being undertaken.

The Environmental Technology Institute (ETI) and MPA Singapore organised the First International Conference on Ballast Water Management – Best Practices and New Directions on the 1-2 November 2001, in conjunction with the Global Ballast Water Management Program and the Universities of Strathclyde and Newcastle, UK. This conference brought together a range of interests, including the global shipping, maritime, port and research and development community to discuss the new concepts and practices in ballast water management.

The Agri-food and Veterinary Authority (AVA) monitors the ornamental fish industry and regulates the import and export of animals and plants in Singapore. AVA focuses on the biosafety issues regarding introduced pests through quarantine measures, though there is no specific information available on their role in introduced marine pests.

Despite the lack of comprehensive management initiatives for introduced marine species, there is a significant amount of research and prevention/management procedures undertaken for exotic plants in the rainforests and National Parks. In addition, the Vector Control and Research Department (VCRD) set up by the Ministry of the Environment aims to maintain a high standard of public health by keeping vector populations at low level in order to prevent outbreaks of vector-borne diseases. It focuses upon five main vectors: mosquitoes, flies, cockroaches, rodents and fleas. Though these are terrestrial vectors the framework of this organisation could be applied to marine vectors.

National and provincial legislation and regulatory measures:

There is no legislation or regulatory measures directly addressing introduced marine pests. Legislation and associated regulatory measures regarding generic matter, such as possible vectors, biodiversity issues and marine/maritime issues are as follows:

- The Environmental Pollution Control Act 1999
- Fisheries Act (its subsidiary rules and regulations relating to marketing and fishing harbour activities)
- Infectious Diseases Act

Private sector initiatives:

There is no information available on any private sector (industry/community) initiatives regarding marine pests in practice in Singapore.

Public awareness initiatives:

There are no public awareness initiatives in place.

SUMMARY

- Singapore has significant maritime interests through shipping and maritime transport that provide potential vectors for introduced marine pests.
- Singapore is addressing the problems of introduced pests, and while these initiatives appear to be directed to terrestrial pests, the potential of marine introductions has also been recognised.

2.2.18. CHINESE TAIPEI

Chinese Taipei is located in Eastern Asia, islands bordering the East China Sea, Philippine Sea, South China Sea, and Taiwan Strait, north of the Philippines, off the south-eastern coast of China.

MARINE ENVIRONMENT MANAGEMENT PROFILE

Institutional Structure:

Institutions related to marine and ocean resources and habitat management in Chinese Taipei are: the Fisheries Administration (FA), created in 1998, by the Council of Agriculture (COA) as the highest fishery policy-making agency. The FA is comprised by five departments: (i) Planning & Programming Department; (ii) Fisheries Regulation Department; (iii) Deep Sea Fisheries Department; (iv)

Aquaculture, Coastal and Off-shore Fisheries Department and, (v) Deep Sea Fishery Research & Development Center.

FA's mission is the design, supervision and implementation of all fisheries policies, laws and regulations, projects and plans. Other responsibilities are: (i) Management and monitoring of vessels and fishermen; (ii) Operation, coordination and encouragement for fisheries surveillance; (iii) Guidance, supervision and training for the fishermen association and fishery organization; (iv) Planning and supervision of fishing ports and related public facilities and; (v) Supervision and coordination on the distribution and processing of fish products and, fish marketing, among others.

The Taiwan Fisheries Research Institute (TFRI) is another branch of COA and conducts scientific and technical research in support of capture fisheries development and management, fish preservation and processing and technical training in fishing techniques and fish handling and processing.

The Taiwan Endemic Species Research Institute (TESRI), as another branch of COA, conduct research in support of protection and restoration of native resources and habitats including those in coastal and wetland ecosystems. TESRI, through its Division o Habitats and Ecosystems is presently conducting surveys and research on animal and plant life of the south-western coast and the threats facing it. In addition, its Wetland Ecosystem presently centres its research in support of mangrove ecosystems restoration.

Marine administrative agencies:

Department: Agency/Statutory Body	General role	IMP role
Government Authorities		
Council of Agriculture (COA)		
- Fisheries Administration (FA)	To design, supervise and implement all fisheries policies, laws and regulations, projects and plans.	No
- Taiwan Fisheries Research Institute (TFRI)	To conduct scientific and technical research in support of capture fisheries development and management.	No
- Taiwan Endemic Species Research Institute (TESRI)	To conduct research in support of protection and restoration of native resources and habitats including those in coastal and wetland ecosystems.	No
Research Centres		
National Taiwan Ocean University	Research and education on Environmental Biology and Fisheries Science, Aquaculture, Nautical and Maritime Technology, Marine Engineering, Marine Law, Fisheries Economics, etc.	

INTRODUCED MARINE PESTS AND PATHOGENS PROFILE

Agency responsibilities:

There are no agencies identified as responsible for introduced marine pest management or related issues.

Summary of current and historical search effort for introduced marine pests:

There is no information on current or historical efforts on the identification of introduced marine species or pests.

Identified introduced marine pests and human pathogens under legislation:

There are no introduced marine species identified as introduced marine pests under legislation.

Marine pest control, prevention and management initiatives:

There is no information on any control, prevention or management initiatives within Chinese Taipei.

National and provincial legislation and regulatory measures:

There are no laws and regulations directly related to aquatic invasive species or introduced marine pests. The Fisheries Law refers to various matters regarding marine resources, use rights, licenses and other, but no reference is made in relation of aquatic invasive species or introduced marine pests. The Water Pollution Control Act (1991) provides regulations for pollutants related to urban and industrial wastewater, no mention is done with respect to ballast water and aquatic invasive species or introduced marine pests.

Private sector initiatives:

There is no information on private sector initiatives in relation introduced marine pests.

Public awareness initiatives:

There is no information on public awareness initiatives in relation to the prevention, control or management of introduced marine pests or related issues.

SUMMARY

- There is no information on introduced marine species identified as introduced marine pests through law, nor information on any initiative related to introduced marine pest identification, prevention, control or management.
- There are no Government or non-government institutions or organisations identified as responsible for introduced marine pest prevention, control or management.
- Laws and regulations do not provide for introduced marine pest prevention, control or management.

2.2.19. THAILAND

In addition to providing protein to the population, the marine environment is central to Thailand economy. The seafood industry is a major income generator, employing in excess of 700,000 people. Over the decades the local fish stocks have been depleted, with the majority of the marine fish catch coming from the East Coast of the Thailand peninsula. Aquaculture has expanded rapidly since the 1980s, with Thailand developing into a major producer of marine shrimp. This expansion has encouraged many other aquaculture industries and services including using trash fish processed into fishmeal for aquaculture feeds.

Thailand's eastern seaboard contains numerous deep-sea ports. The two major Thai international seaports had 6,145 vessels call through in 2000, following a steadily increasing trend over the past five years. With the intention of the Thai government to promote free trade, reduce customs procedures and promote service sectors vital to trade and investment (namely shipping), the marine environment will be increasingly used as a shipping and maritime related medium.

MARINE ENVIRONMENT MANAGEMENT PROFILE

Institutional structure:

At the national level it is principally the Ministries of Agriculture and Cooperatives, Science Technology and Environment, Transport and Industry that manage Thailand's marine environment. Thailand has opted for a sectoral management system for the marine environment with the sectors being addressed by different agencies. In all there are 40 government agencies under eleven ministries that deal directly with the different sectors of the marine environment and its uses.

The national "Policy and Perspective Plan for Enhancement and Conservation of National Environmental Quality" has included provisions for the protection of the marine environment. In addition policies on the polluter pays principle, co-management, oil spill contingencies, coastal resource and environmental management have been developed. At a provincial level, Thailand is comprised of 76 provinces with 24 of them located along coastlines. This implies that some provincial councils will be concerned with the coastal and marine environment to an extent.

Marine administrative agencies:

Ministry: Department/Agency	General Role	IMP Role
Ministry of Agriculture and Cooperatives		
- Department of Fisheries	Sustainable use of fisheries and living marine resources	
Aquatic Animal Health Institute (AAHI)	Issues quarantine certificates for exports.	
- Natural Resources and Biodiversity Institute (NAREBI)	Facilitate ecosystem management	
Ministry of Science, Technology and Environment		
- Pollution Control Department (PCD)	Marine environmental protection.	
- Marine Pollution Sub division		
- Office of Environmental Planning (OEEP)	Coordinates environmental planning and operations.	
- Natural Resources and Environmental Management Division		
- Department of Environmental Quality Promotion (DEQP)	Provide awareness, promote the role of individuals in environmental issues.	
Ministry of Finance		
- Thai Customs Department	Inspection of goods exported from Thailand and enforcing customs acts	
Research Centres		
Burapha University	Institute of Marine Science	
Chulalongkorn University	The Department of Marine Science scope of research includes oceanography, marine environmental quality, aquaculture, mangrove ecology, coral reef and seagrass ecology, biodiversity of marine organisms, harmful algae, integrated coastal management, fisheries biology and fisheries management. This department also takes an active role in the ASEAN-Canada Marine Pollution Monitoring and Marine Environment Quality Criteria Working Group.	

MARINE PEST AND PATHOGEN MANAGEMENT PROFILE

Agency responsibilities:

The Natural Resources and Biodiversity Institute (NAREBI) was enacted under the Ministry of Agriculture and Cooperatives as an agency to facilitate and coordinate ecosystem management in contrast to the traditional sectoral approaches used in the past. NAREBI has programs focused on alien species.

The Department of Fisheries and the Aquatic Animal Health Research Institute (AAHRI) focus on the condition of aquatic animals being exported from Thailand, though there are no regulations or certification required for importing aquatic animals into Thailand.

Summary of current and historical search effort for introduced marine pests:

There has been no organised search effort conducted in Thailand to identify introduced marine pests or human pathogens.

Identified introduced marine pests and human pathogens under legislation:

Thailand does not have any marine species identified as introduced marine pests or human pathogens under their legislation.

Marine pest control, prevention and management initiatives:

With the assistance of an AusAID project on quarantine technical assistance, the Thai Ministry of Agriculture and Cooperatives is developing the technical capacity in quarantine science to enable the analysis and detection of a range of plant and animal quarantine problems in line with international standards. This includes pest risk analysis. In addition, a revision of the Epidemic Act to control aquatic animal pathogens including marine pests is being undertaken.

National and provincial legislation and regulatory measures:

- Thai Marine Navigation Act 1941
- Environmental Quality Conservation and Enhancement Act 1992
- Fisheries Act 1957
- Epidemic Act

Private sector initiatives:

There is no information available to date on any private sector initiatives taken in Thailand.

Public awareness initiatives:

There is no available information on any public awareness initiatives conducted in Thailand regarding introduced marine pests.

SUMMARY

- Thailand is yet to establish a program focused on introduced marine pests, although work in being initiated that focuses on the problems posed by alien species.
- This work could be extended to take account of marine introductions, potential vectors and hazards.

2.2.20. UNITED STATES OF AMERICA

The United States of America (USA) is located in the North American continent, bordering both the North Atlantic Ocean and the North Pacific Ocean, between Canada and Mexico.

MARINE ENVIRONMENT MANAGEMENT PROFILE

Institutional Structure:

The main Government institution concerned with marine ecosystems and resources management is the National Oceanic and Atmospheric Administration (NOAA), which is dependent from the Department of Commerce of the United States of America. (USDOC).

The National Marine Fisheries Service (NMFS) is NOAA's branch oriented to the management and sustainability of marine fisheries and coastal marine habitats. NMFS has a rich history of working in partnership with stakeholders, academia, conservation organisations, states and tribes for the management of living marine resources. . Important current partners are the eight Fisheries Management Councils (created under Magnuson Fishery Conservation and Management Act of 1976 and renamed the Magnuson-Stevens Fishery Conservation and Management Act when amended in 1996). Other important partners for the NMFS are the three Interstate Marine Fishery Commissions, which are crucial to the management and conservation of the coastal fisheries within the first three miles of the nation's marine areas.

The National Ocean Service (NOS) under NOAA's is the branch concerned with coastal and ocean stewardship and, to this end, it has developed the national foundation for coastal and ocean science, management, response, restoration and navigation. NOS is bridging the gap between science, management and public policy in four areas: (i) helping to achieve an inter-temporal balance for healthy coastal zones through research, response to coastal threats, restoration of damaged areas and management of coastal resources; (ii) providing a wide range of products for safe navigation, through a set of information for accurate positioning including nautical charts, coastal surveys and the National

Spatial Reference System; (iii) providing sound coastal and ocean science aiming to the understanding and prediction of natural or man-made impacts on sensitive habitats and; (iv) providing the community with information and knowledge on natural coastal hazards so they can better react and reduce the destructive effects of such natural events as tsunamis, hurricanes or others.

NOAA also conducts and funds technical and scientific research in several topics. NOAA's research on ocean and coastal marine areas and resources is conducted through a set of research facilities and programs. Among these, the National Sea Grant College Program is great example of the efforts on research, education and outreach developed by NOAA in areas such as: aquaculture, biotechnology, coastal hazards, ecosystems, habitats, fisheries and invasive species, among others.

In addition and as a very important complement to NOAA's activities, the US Coast Guard Service (USCG) is the agency in charge of enforcing fisheries laws as tasked by the Magnuson-Stevens Fisheries Conservation and Management Act of 1996, both in coastal waters and in key areas of the high seas. The USCG is also in charge of enforcing international fisheries agreements in US waters. The USCG also oversees and enforces all regulations related to navigation safety and environmental disasters related to navigation and fisheries activities in US waters.

Marine administrative agencies:

Department: Agency/Statutory Body	General role	IMP role
Federal authorities		
US Department of Commerce (USDOC)		
- National Oceanic and Atmospheric Administration (NOAA)	To describe and predict changes in the Earth's environment, conserve and wisely manage the Nation's coastal and marine resources. NOAA's strategy consists of seven interrelated Strategic Goals for the environmental assessment, prediction and stewardship.	Yes
- National Marine Fisheries Service (NMFS)	In broad terms NMFS directs the management of all marine fisheries in the USA. The mission of NMFS is to rebuild and maintain sustainable fisheries, to promote the recovery of protected species and to protect and maintain the health of coastal marine habitats.	Yes
- National Oceans Service (NOS)	To develop coastal and ocean stewardship by bridging the gap between science, management and public policy in Healthy Coasts, Navigation, Coastal and Ocean Science and, Coastal Hazards.	Yes
US Department of Transportation (USDOT)		
- US Coast Guard Service (USCG)	To enforce fisheries laws according the Magnuson-Stevens Fisheries Conservation Act (1996) and to international fisheries agreements signed by the USA.	Yes
US Department of Interior (USDOI)		
- US Fish and Wildlife Service (US FWS)	Management and protection of fresh water resources and ecosystems.	Yes

INTRODUCED MARINE PESTS AND PATHOGENS MANAGEMENT PROFILE

Agency responsibilities:

There are several governmental and non-governmental bodies that address issues relevant to minimizing the spread and impact of marine invasive alien species (IAS). These include the US interagency National Invasive Species Council (NISC or "The Council") and the Aquatic Nuisance Species Task Force (ANSTF), as well as organizations such as the Oceans Conservancy and the Pew Oceans Commission (Questionnaire response by NISC personnel).

The Council is an inter-Departmental council created in 1999 (Presidential Executive Order 13112), with the purpose to provide national leadership on invasive species management and includes: the

Secretaries of State, Treasury, Defence, Interior, Agriculture, Commerce and Transportation and the Administrator of the Environmental Protection Agency. The Council is co-chaired by the Secretaries of Interior, Agriculture and Commerce (NISC 2001).

The duties of The Council as stated by Executive Order 13112 are as follows:

(i) to see that Federal agency activities are coordinated, complementary, cost-efficient and effective, relying to the extent feasible and appropriate on existing organization addressing invasive species, such as Aquatic Nuisance Species Task Force (ANSTF), the Federal Interagency Committee for the Management of Noxious and Exotic Weeds, and the Committee on Environment and Natural Resources;

(ii) encourage planning and action at local, tribal, State, regional and ecosystem-based levels in cooperation with stakeholders and existing organizations addressing invasive species;

(iii) develop recommendations for international cooperation in addressing invasive species;

(iv) develop, in consultation with the Council on Environmental Quality, guidance to Federal agencies pursuant to the National Environmental Policy Act on prevention and control of invasive species, including the procurement, use, and maintenance of native species as they affect invasive species;

(v) facilitate development of a coordinated network among Federal agencies to document, evaluate, and monitor impacts from invasive species on the economy, the environment, and human health;

(vi) facilitate establishment of a coordinated, up-to-date information-sharing system that utilizes, to the greatest extent practicable, the Internet; this system shall facilitate access to and ex-change of information concerning invasive species, including, but not limited to, information on distribution and abundance of invasive species; life histories of such species and invasive characteristics; economic, environmental, and human health impacts; management techniques, and laws and programs for management, research, and public education; and

(vii) prepare and issue a national Invasive Species Management Plan.

Specific Government institutions playing a role in the management of IMP are: (i) the Fish and Wildlife Service (FWS) from the Department of Interior, (ii) the Coast Guard Service from the Department of Transportation, (iii) the Environment Protection Agency (EPA), (iv) Army Corps of Engineer from the Department of Defense and, (v) the National Oceanic and Atmospheric Agency (NOAA) from the Department of Commerce.

Summary of current and historical search effort for introduced marine pests:

Many organisations and institutions, government and non-government, have collaborated through the years to identify more that 800 non-indigenous species that presently established in the coastal waters of the USA (including the Pacific, Atlantic and Gulf of Mexico coasts). The Smithsonian Institution's Environmental Research Center (SERC) has created a National Database on Marine and Estuarine Invasions and NISC will soon have this information web-accessible.

Some examples of other institutions and organisations conducting efforts for the identification and management of invasive species are: the Aquatic Nuisance Species Task Force, the Maryland Department of Natural Resources, The Nature Conservancy, the Partners for Fish and Wildlife Program and the Great Lakes Fishery Commission, among many others.

Identified Introduced Marine Pests and Human Pathogens under legislation:

Historically, prevention and control of all invasive species in the USA, including marine and freshwater species, have been based on a "dirty list" approach as per the Lacey Act (1900, amended 1998). The "dirty list" approach prohibits importation of certain unacceptable species and allows the unlisted species. OTA (1993) reports that US FWS has documented a number of problems with the Lacey Act and the "dirty list" approach. Among them, the most commonly acknowledged problem is that regulation and enforcement hinge on a short and non-comprehensive list of injurious wildlife and adding new species to the list is time-consuming. Between the period 1966 to 1973 only five new species were added to the list and over the next 15 years only one new species was added. Listing the mitten crab (*Eriocheir* spp.) took at least two years and there is some evidence that during this period it was successfully introduced.

Presently, therefore, NISC and all related organisations and institutions are taking a much more comprehensive approach that focuses on: Prevention, Early Detection and Rapid Response, Control and Management, Restoration of native species and habitat conditions, International Cooperation, Research, Information Management and, Education and Public Awareness.

In one of the most recent publications of the Pew Oceans Commission (Carlton 2001), reports significant levels of invasive marine species for the Pacific coast, as follows:

(i) In San Francisco Bay alone, more that 175 species of marine invertebrates, fish, algae, and higher plants have been introduced (Cohen and Carlton 1995, 1998; and A. Cohen and J.T. Carlton unpublished data).

(ii) Puget Sound, in Washington State, harbors at least 50 introductions and; Coos Bay, in Oregon, 60 introduced species (Ruiz *et al.* 2000; J.T. Carlton, unpublished data).

(iii) Even though the history of marine introductions in Alaska is not well known but, that recent studies indicate the presence of a number of non-native species; for example, the Atlantic clam (*Mya arenaria*) is abundant and well established (Carlton 1999 and Ruiz 2001).

(iv) In the Northwestern Pacific coast, a number of exotic species are established in many habitats, Japanese eelgrass (*Zostera japonica*) covers large areas of former mudflats, altering the abundance and density of other species (Posey 1988). Atlantic cordgrass (*Spartina alterniflora*) covers more than 12'000 acres in of Washington States' Willapa Bay which is a critical habitat for shorebirds, shrimp, and oysters (Daehler and Strong 1996). The New Zealand marine pillbug [isopod] (*Sphaeroma quoyanum*) burrows in Styrofoam™, or polystyrene, in Coos Bay, Oregon, releasing millions of microscopic polystyrene particles into the water (J. Carlton, A. Chang, E. Wells, unpublished).

Other relevant bioinvasions in the Pacific coast are: the Atlantic salmon (*Salmo salar*) introduced in 1998 from farm escapes; the Japanese Mahogany clam (*Nutallia obscurata*) introduced in 1991 via ballast water; the European shore crab (*Carcinus maenas*) introduced 1990 via seaweeds accompanying bait worm imports; the Asian kelp (*Undaria pinnatifida*) introduced in 2000 as hull fouling and; the Mediterranean green seaweed (*Caulerpa taxifolia*) introduced in 2000 as home aquarium release

Marine pest control, prevention and management initiatives:

<u>Ballast water introduction of non-indigenous species and management</u>
At present, ballast water exchange is the only management tool used routinely to reduce the risk of ballast-mediated invasion. The Non indigenous Aquatic Nuisance Prevention and Control Act of 1990 (P.L. 101-646) required that all vessels entering Great Lakes ports or the upper Hudson River from overseas undergo ballast exchange or some comparably effective ballast treatment. The National Invasive Species Act (NISA) of 1996 (P.L. 104-332) re-authorized and amended the Non-indigenous Aquatic Nuisance Prevention and Control Act of 1990. NISA requiring mandatory ballast management reporting and voluntary ballast exchange guidelines for most vessels that enters U.S. waters. Ballast water regulations are overseen and enforced by the US Coast Guard Service.

Recognising that ballast water exchange is likely to be only an interim measure, the law also sets up a research program for the development of new technologies for ballast water management. Among technologies being evaluated are filtration, ozone injection, ultraviolet radiation, and chemical treatment.

<u>Control of direct imports</u>
Under the Lacey Act (1900, amended in 1998) the Department of Interior, through the US FWS has a "dirty list" of species prohibited for imports, including molluscs, crustaceans that are harmful to

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human beings, wildlife or wildlife resources and to the interests of industries such as agriculture and others.

In addition, the US FWS, under the Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement, 1995), applies sanitary and phytosanitary measures against pests, diseases, disease-carrying organisms or disease-causing organisms. These measures are applicable to direct imports for aquaculture, aquarium industry or other.

National and provincial legislation and regulatory measures:

There are several legal bodies and government institutions directly or indirectly related to the issue of introduced marine pests and their management. The Invasive Species Web Site (www.invasivespecie.gov) list the Federal Acts, Agencies and Authorities related to invasive species issues. The following is a summary of those related with marine invasive species.

National Invasive Species Act (1996)

- ***Involved departments and agencies***: Dept. of Interior/FWS, Dept. of Transportation/Coast Guard, EPA, Dept. of Defence/Army Corps of Engineers, and Dept. of Commerce/NOAA.
- ***Organisms***: Aquatic nuisance species and brown tree snake.
- ***Referred pathways***: unintentional introductions via ballast water.
- ***Provisions considered***:
  - Amended NANPCA to mandate regulations to prevent introduction and spread of aquatic nuisance species into Great Lakes through ballast water.
  - Authorised funding for research on aquatic nuisance species prevention and control (Chesapeake Bay, Gulf of Mexico, Pacific Coast, Atlantic Coast, San Francisco Bay- Delta Estuary).
  - Required ballast water management program to demonstrate technologies and practices to prevent non-indigenous species from being introduced.
  - Modified composition of Aquatic Nuisance Species Task Force.
  - Required Task Force to develop and implement comprehensive program to control the brown tree snake in Guam.

Non-indigenous Aquatic Nuisance Prevention and Control Act (1990)

- ***Involved departments and agencies***: ·Dept. of Interior/FWS, Dept. of Transportation/Coast Guard, EPA, Dept. of Defence/Army Corps of Engineers, and Dept. of Commerce/NOAA.
- ***Organisms***: Aquatic nuisance species.
- ***Referred pathways***: unintentional introductions via ballast water.
- ***Provisions considered***:
  - Established Aquatic Nuisance Species Task Force to: identify areas where ballast water does not pose an environmental threat, assess whether aquatic nuisance species threaten the ecological characteristics and economic uses of US waters (other than the Great Lakes), determine the need for controls on vessels entering U.S. waters (other than Great Lakes), identify and evaluate approaches for reducing risk of adverse consequences associated with intentional introduction of aquatic species.
  - Directs Coast Guard to issue regulations to prevent the introduction and spread of aquatic nuisance species into the Great Lakes through ballast water.
  - Directs Corps of Engineers to develop a program of research and technology to control zebra mussels in and around public facilities and make available information on control methods.

Water Resources Development Act

- ***Involved departments and agencies***: Dept. of Interior/FWS.
- ***Organisms***: Sea lamprey.
- ***Referred pathways***: Control of existing organisms in and around the Great Lakes.
- ***Provisions considered***:
  - Sec. 506(a)- "In conjunction with the Great Lakes Fishery Commission, the Secretary is authorised to undertake a program for the control of sea lampreys in and around waters of the

Great Lakes. The program undertaken pursuant to this section may include projects, which consist of either structural or non-structural measures or a combination thereof.

Lacey Act (1900, amended in 1998)
- ***Involved departments and agencies***: Dept. of Interior/FWS.
- ***Organisms***: Species injurious to humans or natural resources.
- ***Referred pathways***: Intentional introduction and Trade.
- ***Provisions considered***:
  - Prohibits import of: (i) A list of designated species, (ii) Other vertebrates, molluscs, and crustaceans that are "injurious to human beings, to the interests of agriculture, horticulture, forestry, or to wildlife or the wildlife resources of the United States" Declares importation or transportation of any live wildlife as injurious and prohibited, except as provided for under the Act
  - BUT, Allows import of almost all species for scientific, medical, education, exhibition, or propagation purposes.

National Environmental Protection Act (1970)
- ***Involved departments and agencies***: All
- ***Organisms***: Non-native species posing harm to the environment.
- ***Referred pathways***: Intentional introductions related to major federal actions.
- ***Provisions considered***:
  - Requires federal government agencies to consider the environmental effects of their actions through preparation of environmental impact statements- effects of non-native species, if harmful to the environment, must be included in the EISA.
  - BUT, APHIS may approve and issue permits for importing non-indigenous species following preparation of an environmental assessment rather than an environmental impact statement- permits for importing non-indigenous species into containment facilities or interstate movement between containment facilities are excluded from NEPA requirements

Endangered Species Act
- ***Involved departments and agencies***: Dept. of Interior/ FWS and Dept. of Commerce/NMFS
- ***Organisms***: Non-native species posing a danger to local endangered species.
- ***Referred pathways***: Not specified.
- ***Provisions considered***:
  - Protects endangered species.
  - When non-native invasive species threaten endangered species, this act could be used as basis for their eradication.

Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) (1995)
- ***Involved departments and agencies***: Dept. of Interior/ FWS and Dept. of Agriculture/APHIS
- ***Organisms***: Pests, diseases, disease-carrying organisms, or disease-causing organisms.
- ***Referred pathways***: Imports.
- ***Provisions considered***:
  A supplementary agreement to the World Trade Organisation Agreement. Provides a uniform interpretation of the measures governing safety and plant and animal health regulations. Applicable to all sanitary and Phytosanitary measures directly or indirectly affecting international trade. Sanitary and Phytosanitary measures are defined as any measure applied a) to protect animal or plant life or health within (a Members' Territory) from entry, establishment or spread of pests, diseases, disease carrying organisms; e) to prevent or limit other damage within the (Members Territory) from the entry, establishment or spread of pests (annex A).

Other related authorities to NANPCA are: the Magnuson-Stevens Fishery Conservation and Management Act, the Coastal Zone Management Act of 1972, the Inter-jurisdictional Fisheries Act, the Fish and Wildlife Coordination Act and, the National Marine Sanctuary Act.

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Magnuson-Stevens Fishery Conservation and Management Act

Essential fish habitat provisions of the Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. 1855) provide for review of Federal and/or other actions, which could affect essential fish habitat with authority to make recommendations necessary to conserve essential fish habitat. In addition, a limited amount of funds has been used for control and restoration activities.

Coastal Zone Management Act of 1972

Invasive species issues could be incorporated into State Coastal Zone Management Plans and projects could be eligible for funding through cooperative agreements. In addition, the Act establishes the National Estuarine Research Reserve System. Under this program, monitoring and other invasive species research could be sponsored.

Inter-jurisdictional Fisheries Act

Provides grants for fisheries related activities. Since 1991, $182,368 has been provided for support of the Great Lakes Panel of the Aquatic Nuisance Species Task Force from the State of Indiana's apportionment.

Fish and Wildlife Coordination Act

Authorises the National Marine Fisheries Service to review development projects proposed or licensed by Federal agencies and to make recommendations. It also makes funds available through grants and cooperative agreements that could encompass invasive species projects.

National Marine Sanctuary Act:

Permits may be required for activities in areas designated as marine sanctuaries. Federal agency actions, including private activities authorised by licenses, leases, or permits are subject to consultation with the Department of Commerce. The Act requires the Department to take actions to promote and coordinate the use of sanctuaries for research, monitoring, and education. In addition, grant and contract funds are available for conservation and management activities. The management plan for the Florida Keys National Marine Sanctuary prohibits introduction of exotic species into the Sanctuary.

Private sector initiatives:

There are many examples of private sector initiatives in relation IMP issues. Some of these are the San Francisco Bay Institute, which conducts research, monitoring and communication required to protect and enhance the San Francisco estuary. The Smithsonian Environmental Research Center (SERC) also conducts research and has been involved in the identification of numerous aquatic invasive species. Among many other efforts, they created and manage the National Ballast Water Information Clearinghouse.

The Nature Conservancy mission is to preserve biodiversity and they have promoted and participated in control and eradication actions in the Florida Keys and some coastal California sites.

The Pew Oceans Commission conducts a national dialogue on policies needed to restore and protect living marine resources in US waters, one good example of their efforts on marine introduced pest is the recent report prepare by Dr. James T. Carlton on Introduced Species in US Coastal Waters (see Carlton 2001)

The Ocean Conservancy or the Center the Marine Conservation conducts science-based advocacy, research and public education towards the protection of ocean ecosystems and conserve the global abundance and diversity of marine wildlife. Aquatic invasive species issues is one their important areas of work.

Public awareness initiatives:

Almost all government and non-government institutions and organisation have public awareness programs. Important programs are those of NISC and all related Federal institutions such as NOAA, FWS, USCG and other. Private sector organisations such as SERC and The Nature Conservancy also have important public awareness programs. Most State and private universities have also good public awareness programs on aquatic invasive species and other marine environmental issues.

SUMMARY

- The USA is one of the worlds leading countries in introduced marine pest management.
- More than 800 species of aquatic invasive organisms have been identified in US coastal waters, more of 175 of them in the San Francisco Bay alone.
- In 1999, the National Invasive Species Council (NISC) was created as an inter-Departmental council. Its purpose was to provide national leadership on invasive species management and includes: the Secretaries of State, Treasury, Defense, Interior, Agriculture, Commerce and Transportation and the Administrator of the Environmental Protection Agency. The Council is co-chaired by the Secretaries of Interior, Agriculture and Commerce (NISC 2001).
- There are more than more than eight laws relating to aquatic invasive species management some of the most important ones are: the National Invasive Species Act (1996), the Non-Indigenous Aquatic Nuisance Prevention and Control Act (1990), the Water Resources Act and, the Lacey Act (1900, amended in 1998), among others.
- There is active participation of private institutions and organisations in aquatic invasive species issues. Some of the most important are: the Smithsonian Environmental Research Center, The Pew Oceans Commission, the Ocean Conservancy the Nature Conservancy and the San Francisco Estuary Institute, among others.

2.2.21. VIETNAM

The marine environment is used for fisheries activities, a transport medium for maritime activities and as a source of food for the Vietnamese population. Fisheries provide half of the annual supply of animal protein for the population. With the depletion of inshore fisheries the government is concentrating fishing effort and development into the deep-sea sector. Aquaculture, specifically brackish aquaculture, is expanding.

MARINE ENVIRONMENT MANAGEMENT PROFILE

Institutional structure:

Vietnam is administered under a centralised government system, though this is slowly being transformed into a market economy and integrating measures of reform. The "National Law on Environmental Protection (NLEP)" was passed in 1993. This provided a management and planning framework aiming to improve the organisational structures at State level, increasing environmental awareness in the community and to create an environment for sustainable development.

Vietnam manages the marine environment under a sectoral-based system, using several agencies for policy implementation and enforcement. The principle agencies are; the Ministry of Fisheries, Ministry of Agriculture and Rural Development, Ministry of Science, Technology and Environment and the Ministry of Transport and Communications.

Marine administrative agencies:

Ministry: Department/Agency	General role	IMP role
Ministry of Science and Technology (MOSTE)	Administration of environmental protection and related issues	
Ministry of Fisheries	Administration of living resource management	
Ministry of Transport and Communication	Administration of shipping and maritime related issues	
Ministry of Agriculture and Rural Development	Administration of	
The General Department of Customs	Enforcement of customs measures	

Marine administrative agencies...continued.

<u>**Research Centres**</u>

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Institute of Ecology and Bio-Resources

INTRODUCED MARINE PESTS AND HUMAN PATHOGEN MANAGEMENT PROFILE

Agency responsibilities:

There is no agency identified as dealing directly with introduced marine species in Vietnam.

Summary of current and historical search effort for introduced marine pests:

There has been no organised search effort in Vietnam to identify introduced marine pests and human pathogens.

Identified introduced marine pests and human pathogens under legislation:

Vietnam does not have any marine species identified as an introduced marine pest of human pathogen under its legislation.

Marine pest control, prevention and management initiatives:

Vietnam has not initiated any type of management regarding introduced marine pests and human pathogens. There is a project at national level to address all issues of alien species collaborated between the Department of Agriculture and Rural Development and IUCN, though the proposal has not been supported as yet.

National and provincial legislation and regulatory measures:

- Law on Oceanic Shipping (1990)
- Fisheries Ordinance

Private sector initiatives:

There is no information available on any private sector (industry/community) initiatives regarding marine pests in practise in Vietnam.

Public awareness initiatives:

There is no available information on any public awareness initiatives conducted in Vietnam regarding introduced marine pests.

SUMMARY

- Although Vietnam has not developed any form of response to introduced marine pests it has highlighted its lack of available case studies and methodology for evaluation and the need for a regional program for controlling alien invasive species that it can apply.

2.3 REGIONAL MANAGEMENT SUMMARY

2.3.1 INTERNATIONAL AGREEMENTS AND INSTRUMENTS

There are numerous activities relating to introduced species however initiatives specific to introduced marine species are few. The effectiveness of these instruments lies in the implementation of their guides and frameworks at the level of the economy. The implementation of provisions regarding introduced marine pests in each economy does vary. **We recommend that APEC (MRC-WG) should liaise with relevant international and regional for a including IMO, FAO, NACA and SPREP to enhance the effectiveness of regional approaches and of relevant international instruments and their implementation.**

2.3.2 MANAGEMENT APPROACHES

Introduced marine pest management varies considerably throughout the APEC region. The diverse responses are fragmented with certain economies at the forefront of introduced marine pest management and others barely even recognising the problem. Nonetheless, historical recognition of the problem of introduced marine pests and pathogens has been a gradual process across the region, including all subregions considered.

On one side, this concern started with scientists conducting research on biodiversity problems related to terrestrial animal and plants, originating from the agricultural development process followed in most economies. Scientists have recently been focusing on marine environments given the increasing recognition of the importance of marine ecosystems and coastal zones in our economies. On the other side, efforts to develop sport and commercial fisheries through ranching and stocking of exotic species (trout and salmon, among other species) were an initial factor of introduced marine pest occurrences. More recently, the development of freshwater and marine aquaculture in economies within the APEC region, brought problems of introduced pathogens (shrimp mariculture and salmon aquaculture) accompanied with escapes of individuals of exotic species due to human interventions (thefts), climatic phenomena (storms) or errors in farm management.

In this context, most APEC economies developed institutions, legislation and management approaches with a partial focus on fisheries and aquaculture development and dealt with such problems under an isolated/sectoral/partial approach. Today basic quarantine and customs procedures mainly related to fisheries and aquaculture imports are in place throughout APEC, however their success is questionable[13].

Even in economies with the most advanced introduced marine pest management, such as USA, Australia and New Zealand, it is possible to observe a multiplicity of institutions, legislation and regulations dealing with different aspects of the problem. Only recently (less than 10 years) are their government officials and decision-makers realising the need for a comprehensive and integrated management system implemented by a well-coordinated network of institutions and professionals. A clear case is the USA where, only in 1999 was created the US interagency National Invasive Species Council (NISC) to coordinate all efforts related to alien species management. Only in January 2001 the Council released the National Invasive Species Management Plan, which is presently in its initial implementation phase. This in spite of the fact that USA enacted eleven years ago their Non-Indigenous Aquatic Nuisance Prevention and Control Act (1990). Similarly, only recently have more coordinated and efficient systems come in place in Australia and New Zealand.

Concern over ballast water as vector for the introduction introduced marine pests was raised by cases such as the zebra mussel in the USA and Canada, and by dinoflagellate introductions in Australia and other economies. These economies have set in place legislation, regulations and instruments to control and manage introduction of introduced marine pests through ballast water. The International Maritime Organisation is the international institution leading efforts to attain a worldwide coordinated effort to control this vector of introduction. Today, ballast water management is compulsory only in Australia, New Zealand, and some states of the USA. Voluntary ballast discharge for vessels exists throughout a number of APEC economies that have adopted the IMO resolution A.868 (20), though only through increased port state control will this be achieved. Other economies that have not adopted IMO resolution A.868 (20), such as Chile, have legislation that provides regulations for ballast water exchange but lack the means for enforcement, as they have to rely on ships' logbook recording. This is the case in many economies in the region.

In more specific terms there are no, or only inefficiently implemented, management tools in place. Therefore results represent partial or total failures. This is the case for TSV or WSSV in many economies and many invertebrates on the Pacific coast of USA.

Common measures applied to introductions of harmful pathogens affecting human health or dinoflagellates have been: area closures and prohibitions on extraction, processing and marketing of shellfish and other marine resources (South America-Chile and Oceania-New Zealand for example). These measures have been effective in preventing the effects on human health, but have not prevented the effects on economic activities (fisheries and aquaculture) nor controlled the occurrence of these introduced organisms.

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[13] Later analysis of introduced marine species indicates a large number of species introduced through imports of aquaculture species and products (refer to Taxonomic Hazard Analysis).

Other specific management control options applied to control dispersal of already introduced macro algae or invertebrates have been the implementation of physical removal efforts (with active community and industry participation) or chemical treatments (North America – Canada & USA and Oceania-Australia).

More comprehensive and integrated approaches under implementation are those including systematic research, monitoring and education at industry and community level, as in the cases of Australia, New Zealand and USA. Other economies such as Mexico and many South East Asian (FAO/NACA Program) economies are also in the process of developing research and monitoring systems with respect to pathogens affecting aquaculture activities. The salmon aquaculture industry in Chile is also developing monitoring, research and prevention systems in collaboration with government institutions.

The threat of introduced marine pests is predominantly a coastal threat in contrast to the open waters; hence the overlap between national and local government has been a problem for some economies. This can provide lessons for economies wanting to respond. In addition, the overall lack of comprehensive management for introduced marine pests leaves the APEC region extremely vulnerable to incursions and extreme impacts. It also devaluates the effectiveness of the management regimes that are in place within a small number of economies.

2.3.3 INSTITUTIONAL STRUCTURES AND EXISTING LEGISLATION

Institutional settings related to the marine environment and resources in the APEC economies have a varying level of complexity depending on their cultural and historical development; as well as, the relative economic importance they place on their coastal and marine areas and resources. Nonetheless, it is possible to observe throughout all economies, that the first type of institutions developed were those responsible for fisheries and aquaculture activities, usually depending from Agriculture or Economy Ministries and, later, as the worldwide concern for the environment and natural resources sustainability grew, institutions responsible for environmental protection and sustainable development were created. The latter, usually act in coordination with the first type of institutions.

Today, APEC economies all have significant interest in their maritime zones. Yet they reflect considerable diversity in the management of these maritime areas, with an equally diverse range of institutional arrangements, agency responsibilities and legislation. This diversity also extends to the extent to which the problems of introduced marine pests are recognised, and the specific response strategies developed to tackle them. The previous sections indicate a continuum of institutional and legislative responses to introduced marine pests. This continuum ranges from highly developed institutional and legislative responses to limited action.

An overview of the situation of the five APEC subregions follows:

Oceania

Institutional arrangements and legislation for the management of introduced marine pests in Oceania presents a positive perspective in average, including two of the most advanced economies in these issues, but also one of the less developed. Australia and New Zealand present well organised institutional arrangements, with a high level of scientific research and a number of prevention and management projects and programs financed.

Papua New Guinea shows significant potential vectors related to introduced marine pests, however there appears to be a limited response to these threats.

Australia is developing a vertically integrated national system to respond to the threat of marine pests, including: reducing the risk of introductions, early detection, rapid response, management of secondary translocation within Australia. An active research programme has been developed to support the national system for introduced marine pests management. Compulsory ballast water management was introduced for all commercial vessels arriving from overseas. Vessel risk is estimated with a quantitative, species-based Decision Support System. Australia has developed formal agreements between the different levels of government to ensure that response to marine pests could be rapid and effective. It is also completing development of sophisticated web-based information tools to assist the management of marine pests.

New Zealand is implementing a more horizontally integrated system for the management of introduced marine pests, strongly depending on the existing Biosecurity Council and the close work developed by the biosecurity departments within the Ministries and Departments of Agriculture & Forestry, Conservation, Fisheries and Health. Biosecurity and monitoring of introduced marine pests are key strategies and central elements in its approach. New Zealand has identified the problems associated with introduced marine pests and established processes and arrangements to restrict such introductions; as well as implemented a number of key legislative and administrative arrangements. In addition, there are several private sector initiatives to control marine pests.

South East Asia

South East Asia includes a number of economies strongly related to fisheries and aquaculture activities, as well as, on commercial shipping; thus, they present significant potential vectors for introduced marine pests threats. Throughout this subregion there are no agencies with clear responsibilities for introduced marine pest management and their legislation bodies do not have specific considerations for introduced marine pest control or prevention, except in the cases of marine pathogens or dinoflagellates affecting aquaculture activities or human health.

Brunei Darussalam presents a number of institutions in charge of coastal and marine resources management and human pathogens prevention and control. Nonetheless, there are no clear lines of responsibilities for the management of introduced marine pests. In addition, there is no specific body of legislation regarding introduced marine pests and pathogens prevention, control and management.

Indonesia has a largely vertical and centralized governance system dealing with fisheries, aquaculture and other marine issues. There is no information available as to which organisations are involved in managing introduced marine pests in Indonesia. The exception is the Ministry of Agriculture's role in quarantine. At present, at present there appears to be limited management initiatives developed specifically to address introduced marine pests.

In Malaysia the management of the marine environment is under the responsibility of he Ministry of Agriculture, Ministry of Transport and the Ministry of Science, Technology and Environment. Presently, there is no information available as to which agencies are responsible for managing introduced marine pests. Malaysia has identified key problems associated with introduced marine pests and has institutional and administrative processes that can facilitate actions against particular vectors. These arrangements need to be extended to focus specifically on introduced marine pests.

In the Philippines, the Bureau of Fisheries and Aquatic Resources (BFAR) is the central management agency for fisheries quarantine. However, there are no clear indications as to what agencies are responsible for introduced marine pests. The National Committee on Biosecurity of the Philippines (NCBP) is responsible for intentional introductions for all type of organisms, terrestrial and aquatic. There is mention in literature of the formation of the Committee on the Introduction of Exotic Aquatic Organisms, however there is no indication of when this body was formed and what its present day functions are, if any. The Philippines government, recognising the problem of introduced exotic species has a range of programs under the NCBP that can be used to address the problems of introduced marine pests. Nonetheless, their present focus is mainly on terrestrial animals and plants. Up to date, the main focus of management on introduced marine pests has been on species that affect mariculture operations such as pathogens and red tide causing organisms.

Singapore is addressing the problems of introduced pests, and while these initiatives appear to be directed to terrestrial pests, the potential of marine introductions has also been recognised. The Agri-food Veterinary Authority is involved in the quarantine aspects of fishery trade in Singapore. There is no available information on which specific agencies manage introduced marine pests

In Thailand, the Natural Resources and Biodiversity Institute (NAREBI) was enacted under the Ministry of Agriculture and Cooperatives as an agency to facilitate and coordinate ecosystem

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management in contrast to the traditional sectoral approaches used in the past. NAREBI has programs focused on alien species. Thailand is yet to establish a program focused on introduced marine pests, although work is being initiated that focuses on the problems posed by alien species.

In Vietnam there is no agency identified as dealing directly with introduced marine species. Although Vietnam has not developed any form of response to introduced marine pests it has highlighted its lack of available case studies and methodology for evaluation and the need for a regional program for controlling alien invasive species that it can apply.

Asia

The situation with respect to introduced marine pests issues Asia is similar to the one in South East Asia, with the exception of the People's Republic of China, which has clear institutions in charge of implementing management.

In Chinese Taipei there are no governmental or non-governmental agencies identified as responsible for introduced marine pests management or aquatic invasive species issues. Laws and regulations do not provide for introduced marine pests prevention, control or management.

In Japan there is no information on any government or non-government agency in charge of introduced marine pests prevention, control or management. Laws and regulations do not provide for introduced marine pests prevention, control or management.

In the People's Republic of China, the State Oceanic Administration (SOA), through its Department of Marine Environment Protection, is identified as the government agency responsible for the formulation and introduced marine pests implementation of regulations and plans for the management of introduced marine pests in China. The National Marine Environment Monitoring Center from SOA is responsible for providing scientific and technical expertise for the protection of the marine environment and the methods and techniques for prevention, control and management of introduce marine pests. The Maritime Safety Administration is identified as the government agency responsible for ballast water management. Nonetheless, laws and regulations do not provide for specific mechanisms on introduced marine pests prevention, control or management, except for marine pathogens affecting aquaculture.

In the Republic of Korea attention is directed to the problems of introduced pests, with a basic governance framework established. While this framework appears to focus on terrestrial pests, it may be possible to incorporate management of marine pests under these arrangements. At present, there is no information available as to which agencies are in charge of introduced marine pests.

In the Russian Federation, there are no clear government agencies responsible for the control, prevention or management of introduced marine pests. This issue has been addressed by scientist and local experts, which for the past two years have been trying to create non-governmental institutions with support from international organisations, on this issue. There is no information on Laws and regulations for introduced marine pests prevention, control or management.

North America

North America presents a similar situation on introduced marine pest issues as in Oceania. With USA leading the efforts against introduced marine pests and their threats with a vertically and horizontally integrated institutional system. Canada is rapidly catching up with a well-defined institutional arrangement to deal with marine environment and resources management, as well as, with introduced marine pest control and prevention. It needs to improve its legislation. Mexico is third in the region with a complex institutional system and legislation that seems to be working for marine pathogens affecting aquaculture, but with no specific efforts or instruments regarding other type of introduced marine pests.

In the USA, the National Invasive Species Council (NISC) was created in 1999 as an inter-Departmental council with the purpose to provide national leadership on invasive species management and includes: the Secretaries of State, Treasury, Defence, Interior, Agriculture, Commerce and Transportation and the Administrator of the Environmental Protection Agency. There are more than more than eight laws relating to aquatic invasive species management some of the most important ones are: the National Invasive Species Act (1996), the Non-Indigenous Aquatic Nuisance Prevention and Control Act (1990), the Water Resources Act and, the Lacey Act (1900, amended in 1998), among others. There is active participation of private institutions and organisations in aquatic invasive species issues. Some of the most important are: the Smithsonian Environmental Research Center, The Pew Oceans Commission, the Ocean Conservancy the Nature Conservancy and the San Francisco Estuary Institute, among others.

In Canada, the Department of Fisheries and Oceans (DFO) and Transport Canada are the government institutions responsible for prevention, control and management of introduce marine pests and human pathogens. Transport Canada plays a leading role in the control of ballast water, working closely with the Canadian Coast Guard Service (CCG). In addition, Environment Canada is in charge of both terrestrial and marine alien species. Nonetheless, there is no specific legislation regarding prevention, control and management of introduced marine pests and pathogens

In Mexico, CONAPESCA from SAGARPA and PROFEPA from SERMANAT have clear lines of responsibilities for introduced marine pathogens in aquaculture. Presumably, the DGMEP from the Mexican Navy is in charge of procedures for ballast water treatments. Although the existing legislation has clear references to protection and preservation of the marine environment and resources, only specific mention to control and prevention of marine pathogens in aquaculture is made. The private aquaculture sector is involved in some measures to decrease pathogens introduction and CIAD is actively involved in research and monitoring regarding introduced marine pests related to aquaculture.

South America

South America is in an intermediate condition of development regarding introduced marine pest issues, between Oceania-North America and Asia-South East Asia. Chile is leading the efforts on a more systematic approach for prevention and control of introduced marine pests. Peru is awakening to the implications of the problems as they are developing their aquaculture industry.

In Chile, there is a number of government institutions in charge of prevention, control and management of introduce marine pests and pathogens; nonetheless, there are no clear lines of responsibilities for introduced marine pests management. Although the existing legislation has clear references to introduction of exotic species and fish diseases, as well as, to the management of ballast water; there is a need for an integrated and comprehensive management plan for introduced marine pests and human pathogens and its related legislation. The USoF, NFS, NEC and GDMT are working on such a management plan. The private aquaculture sector and several universities are actively involved in research and monitoring regarding introduced marine pests and human pathogens.

In Peru, even though the General Law of Fisheries and its Regulations, as well as the Law of Conservation and Sustainable Use of Biological Diversity, include concepts, concerns and management instrument directly related to sustainable use of the environment and biological diversity, no direct mention is made about introduced marine pests their potential effects and management. Presently, there is no authority or institution officially identified as responsible for the management of introduced marine pests. Nonetheless, due to their stated mission, objectives and conceptual approaches, the Ministry of Fisheries and its National Directorate of the Environment, along with the Port Authorities and the National Environmental Council (CONAM) may become the depositories of this responsibility in the future. Peru is a member of IMO but, they have not yet subscribed, nor implemented the IMO Guidelines for the control and management of ship's ballast water to minimise the transfer of harmful aquatic organisms and pathogens -Resolution A.868(20)-.

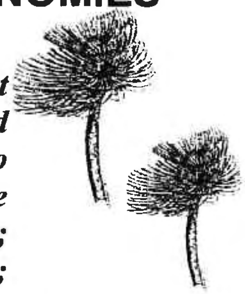
2.3.4 SUMMARY

Finally, while information on the approaches adopted in different economies is beneficial for potential 'lesson drawing' it is important to note that even when there are management arrangements in place, action to tackle introduced marine pests may be affected by a range of factors. These factors include, *inter alia*, the level of inter-agency coordination and cooperation, jurisdiction and available resources. It is important to note that such diversity in institutional structures and legislation provides considerable scope for developing appropriate responses suitable for each economy and supporting the effective development and implementation of risk management frameworks to address introduced marine pests.

The survey of institutional arrangements indicates that while few economies have specific legislation in place directed at management of introduced marine pests, such management can be effected under existing legislation or administrative arrangements. A key question becomes the choice of legislation and concomitant administrative agency to take responsibility for a management program that involves scientific research and monitoring as well as administration of maritime areas, activities and resources.

It is clear that effective institutional arrangements, regardless of whether the economy has a centralised or decentralised system of governance, need some degree of devolved or delegated authority to local administrators to effect appropriate risk management arrangements. This does raise the question of local capacity and resources to be able to undertake such activities, with these questions equally relevant for all economies.

SECTION 3
PRIORITIES AND HAZARDS FOR APEC ECONOMIES



Biological introduction, the process of species movement across natural barriers into new environments and habitats by the agency of human activity, is considered to be one of the top five main threats to the marine environment and biodiversity (Hatcher et al. 1989; Heywood 1989; Lubchenco et al. 1991; Norse [Ed] 1993; Suchanek 1994).

Marine species introductions are either accidental or intentional, and arise from a wide range of commercial and private practices. To direct available resources for maximum effect in reducing the overall risk of introduced pests, it is important to know the relative threat posed by each vector and whether the threat is increasing, decreasing or is stable. Hazard analysis and risk assessments are useful methods for evaluating this threat.

Box 8. Tools for assessing hazards and risks

A hazard is a situation that in particular circumstances could lead to harm. Risk, the measure of a hazard, is the likelihood of an undesired event occurring as a result of some behaviour or action (including no action). The level of risk can be measured through a risk assessment where the frequency and consequences of such events are be determined. Tools and methodologies such as hazard or risk assessments and analyses can be used for assessing potential invasions and managing hazardous activities. The likelihood of an introduction to occur involves three central components: (1) vector, (2) pathway (identified by trade routes and can be affected by various factors) and (3) species. Hazard analyses assess the likelihood of an introduced species becoming established, hazards associated with each central component and qualitatively evaluate the likely risks posed to an environment on the basis of past activities (Hewitt and Hayes, in press).

Ideally hazard analyses are conducted interactively identifying data gaps at each stage and updating the analysis, as more data become available. As is commonly the case, a comprehensive hazard analysis cannot be performed for the APEC region, due to lack of comprehensive information on past and present trends in international and domestic shipping, as well as aquaculture, fisheries and other maritime practices for each economy and the region. Instead, this section presents a hazard evaluation, the first step in identifying the hazards for a comprehensive hazard analysis or risk assessment.

This hazard evaluation establishes (1) impacts and management priorities, (2) vector hazards, (3) factors that affect pathways, and (4) taxonomic hazards. Case studies and historical information are included to substantiate identified hazards. The priorities, pathways and vectors were identified during the APEC Introduced Marine Pest Workshop, 2001, using a preliminary questionnaire. This questionnaire was revised following comments at the workshop and an electronic questionnaire sent to contacts in each APEC economy. Eleven economies evaluated these hazards using simplistic ranking. The eleven respondents were from Australia (AUS), Brunei Darussalam (BD), Canada (CDA), Chile (CHL), New Zealand (NZ), Peru (PE), Philippines (RP), Singapore (SIN), Thailand (THA), USA and Vietnam (VN).

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3.1 IMPACTS AND MANAGEMENT PRIORITIES

Introduced marine pests impact negatively on many economic marine and coastal uses and social and customary values. During the APEC Introduced Marine Pest Workshop, participants identified the following marine uses and values as potentially impacted (refer to Table 3.1).

Table 3.1. Marine uses and values potentially impacted on by introduced marine pests identified at the APEC MRC Workshop, 2001

Marine infrastructure	Artisanal fisheries
Coastal tourism	Social values
Aquarium trade	Aquaculture
Recreational fisheries	Fish trade
Customary fisheries	International shipping
Biodiversity	Human health
Commercial fisheries	Domestic shipping

3.1.1 POTENTIAL IMPACT ON MARINE USES AND VALUES IN APEC

Economies were asked to rank the current or potential impact of introduced marine pests on fourteen identified marine uses and values within the APEC region and domestically using high (1), medium (2) and low (3). Note that in some cases these rankings were provided by government officials rather than professionals working directly with marine pests. The results are therefore indicative only.

APEC impacts:

Figure 1 shows an aggregate of the eleven economies' ranked impacts.

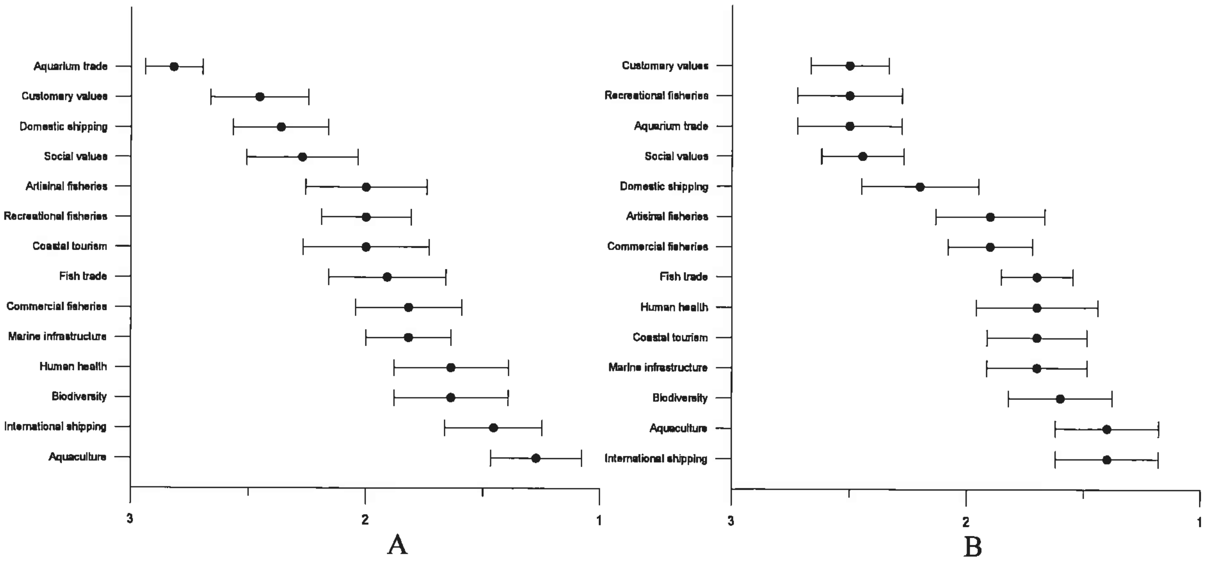

Figure.1 Means and standard error of ranked scores for each impact for (A) regional impacts and (B) domestic impacts. Each marine use and value was ranked as a having high (1), medium (2) or low (3) impact.

International shipping, aquaculture and biodiversity are considered as being impacted on greater than the other marine uses and values at both the regional and domestic level. Human health is also seen as being greatly impacted on by introduced marine pests at the regional level, however not so at the domestic level. Aside from the first three identified marine uses and values, the ranked current and potential impact for regional and domestic activities do differ. The marine uses and values are perceived to be impacted on at higher levels for the domestic activities than the regional activities.

Individual economy impacts:

The level of impact from introduced marine pests will vary between economies due to the intensity that the identified marine uses are conducted or values are held to the population or indigenous people. The following charts present the individual economies' ranking (high, medium or low) for impacts on regional and domestic marine uses and values.

Regional marine uses and values:

high							
International shipping	AUS	CDA	CHL	RP	SIN	THA	USA
Aquaculture	AUS	CDA	NZ	PE	RP	USA	VN
Human health	AUS	CDA	CHL	NZ	RP		
Biodiversity	CDA	CHL	NZ	PE	USA		
Marine infrastructure	AUS	CDA	CHL	SIN			
Coastal tourism	CDA	RP	SIN	THA			
Fish trade	AUS	CDA	CHL				
Artisinal fisheries	CDA	CHL	SIN				
Commercial fisheries	AUS	CDA					
Domestic shipping	AUS	SIN					
Aquarium trade	CDA						
Recreational fisheries	CDA						
medium							
Commercial fisheries	CHL	NZ	PE	SIN	THA	USA	VN
Fish trade	NZ	PE	RP	SIN	THA	USA	VN
Marine infrastructure	NZ	PE	RP	THA	VN		
Coastal tourism	AUS	CHL	NZ	USA	VN		
Customary values	AUS	CHL	NZ	PE	VN		
Artisinal fisheries	NZ	PE	RP	USA	VN		
Social values	AUS	NZ	PE	RP	VN		
Domestic shipping	CHL	NZ	USA	VN			
Biodiversity	AUS	RP	SIN	VN			
Aquarium trade	AUS	CHL	THA				
Recreational fisheries	CHL	NZ	VN				
Human health	PE	USA	VN				
International shipping	NZ	PE					
Aquaculture	SIN	THA					
low							
Aquarium trade	NZ	PE	RP	SIN	USA	VN	
Recreational fisheries	AUS	PE	RP	SIN	THA	USA	
Customary values	CDA	RP	SIN	THA	USA		
Social values	CHL	SIN	THA	USA			
Domestic shipping	CDA	PE	RP	THA			
Human health	SIN	THA					
Artisinal fisheries	AUS	THA					
International shipping	VN						
Aquaculture	CHL						
Biodiversity	THA						
Commercial fisheries	RP						
Marine infrastructure	USA						

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Domestic marine uses and values:

high									
Aquaculture	AUS	BD	CDA	CHL	NZ	PE	RP	USA	VN
International shipping	AUS	BD	CDA	CHL	SIN	THA	USA		
Biodiversity	BD	CDA	CHL	NZ	PE	USA			
Human health	AUS	BD	CDA	NZ	RP	VN			
Coastal tourism	BD	CDA	CHL	RP					
Commercial fisheries	BD	CDA	CHL	NZ					
Fish trade	BD	CHL	NZ	RP					
Marine infrastructure	CHL	RP	SIN						
Artisinal fisheries	BD	CDA	RP						
Recreational fisheries	BD	CDA							
Social values	CDA	NZ							
Customary values	NZ								
Domestic shipping	AUS								
medium									
Marine infrastructure	AUS	BD	CDA	NZ	PE	THA	VN		
Recreational fisheries	AUS	CHL	NZ	RP	THA	USA	VN		
Commercial fisheries	AUS	PE	THA	USA	VN				
Domestic shipping	CHL	NZ	RP	USA	VN				
Customary values	CDA	CHL	PE	VN					
Fish trade	PE	SIN	USA	VN					
Artisinal fisheries	CHL	NZ	PE	VN					
Social values	AUS	BD	PE	VN					
Human health	CHL	PE	USA						
Biodiversity	AUS	RP	VN						
Coastal tourism	AUS	NZ	VN						
International shipping	NZ	PE	RP						
Aquarium trade	BD	RP							
Aquaculture	THA								
low									
Aquarium trade	AUS	CDA	CHL	NZ	PE	SIN	THA	USA	VN
Customary values	AUS	BD	RP	SIN	THA	USA			
Social values	CHL	RP	SIN	THA	USA				
Domestic shipping	BD	CDA	PE	SIN	THA				
Coastal tourism	PE	SIN	THA	USA					
Fish trade	AUS	CDA	THA						
Artisinal fisheries	AUS	THA	USA						
Biodiversity	SIN	THA							
Commercial fisheries	RP	SIN							
Human health	SIN	THA							
Recreational fisheries	PE	SIN							
International shipping	VN								
Aquaculture	SIN								
Marine infrastructure	USA								

3.1.2 MANAGEMENT PRIORITY RANKING

Each economy was asked to rank (from 1 to 14, with 1 being the most significant to 14 being the least significant) the relative importance placed on protecting the identified marine uses and values from introduced marine pests. This priority ranking is considered principally from the viewpoint of current management values, with priorities typically set in the hope of minimising the long term operational input and costs.

APEC priorities:

Figure 2 presents an aggregate of the responses from the eleven economies.

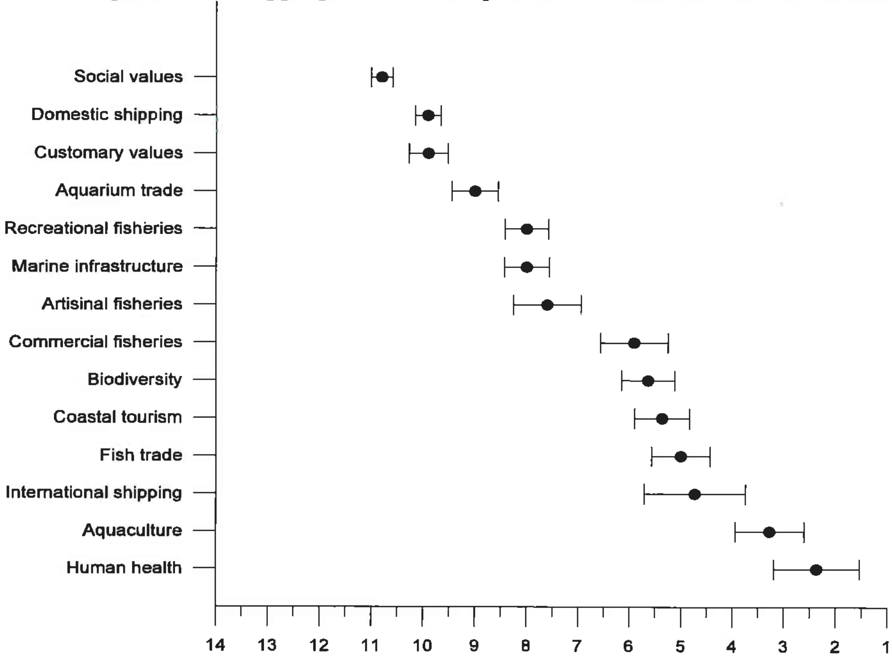

Figure 2. Means and standard error of ranked significance for protecting marine uses and values from a management perspective, with (1) being the most significant to (14) being the least significant.

Within APEC, human health has the highest management priority for protection against introduced marine pests. The protection of aquaculture from introduced marine pests is also considered of high priority, while international shipping, fish trade, commercial tourism, biodiversity and commercial fisheries are a moderate priority. Social values are considered the least significant priority.

Individual economy priorities:

Individual economy priorities are not addressed in this section. Please refer to Appendix 4 for specific details.

3.2 VECTOR HAZARDS

The vectors for marine invaders are diverse. Carlton (2001) listed 15 broad categories of mechanisms available for transoceanic transport, ranging from ballast water to deliberate introductions (refer to Table 1.2). These 15 categories were used as the basis for developing the list of potential vectors in the APEC region. Identifying the invasive route for any particular species is often difficult – even within a category such as international shipping a species can be transported via hull fouling, sea chests or ballast. Individual management actions may prove ineffective against many marine invaders, unless it is clear that a single vector poses the major risk of introduction.

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Table 3.2. Vectors for introducing marine species identified at the APEC MRC Workshop, 2001.

Pathway	Vector
Commercial Shipping	Ballast water Hull fouling Solid ballast Sea chests Cargo Anchors/anchor chains
Aquaculture Fisheries	Intentional release Accidental release Gear or stock movement Discarded nets, floats, traps Discarded packaging materials (feeds, stock) Release of transgenic species
Wild Fisheries	Processing of fresh and frozen product Live bait movement Discarded fishing gear Hull fouling of fishing vessels Live fish trade-consumption
Aquarium Industry	Live fish trade Intentional release Accidental release
Military Activities	Military vessels
Marine Tourism	Recreational boating: hull fouling Diving: dive gear
Oil, Gas and Mining	Drilling platforms: hull fouling Drilling platforms: ballast water Dredging spoil
Other	Canals: movement through locks

3.2.1 IDENTIFICATION OF MAJOR VECTORS IN APEC REGION

During the APEC workshop, twenty-seven vectors associated with commercial shipping, aquaculture fisheries, wild fisheries, the aquarium industry, oil, gas and mining, marine tourism and others were identified. Each APEC economy was asked to rank, using high (1) medium (2) or low (3), the potential of these vectors to introduce marine pests through their international activities, and their domestic activities, based on current practices, activities and laws. This subsection presents the results from the 11 responding economies and the data aggregated to provide a summary of hazards affecting the APEC region as a whole. Economies were asked to rank each vector on its potential to (a) introduce marine pests internationally from outside the economy or region and (b) distribute marine pests domestically within individual economies.

APEC vector hazards:

Figure 3 shows the combined ranking of vectors by the 11 economies.

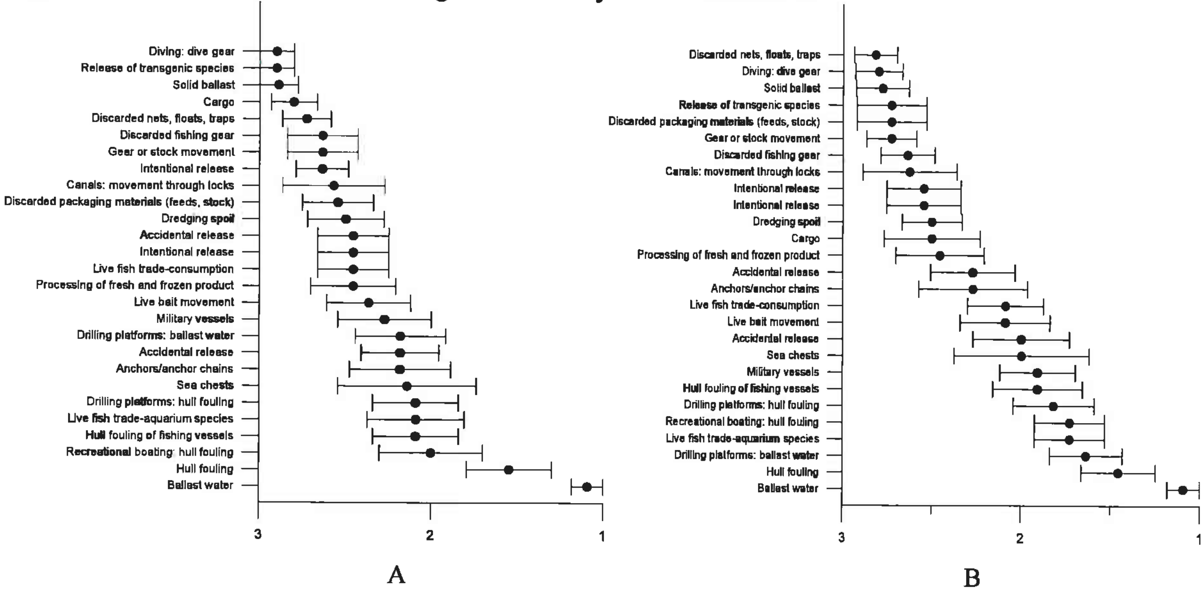

Figure.3 Means and standard error of ranked scores for each hazard for (A) international vectors and (B) domestic vectors. Each vector was ranked as a high (1), medium (2) or low (3) risk.

Shipping related vectors are considered to have the highest associated risk. Of the shipping vectors, ballast water has the highest risk for both international and domestic activities. The small standard error associated with the rank indicates its almost unanimous ranking as a high risk. Hull fouling is ranked similarly high. These two vectors are ranked distinctly higher than all other identified vectors for introducing marine pests through international activities. While vectors are ranked in a similar order for domestic activities, more vectors, there is less distinction between ballast water and hull fouling and the remaining vectors. Additional vectors – drilling platforms (ballast water and hull fouling) and the live fish trade of aquarium species are also seen as high-risk vectors. This indicates that there are a greater variety of high-risk vectors at the domestic level.

Individual economy hazards:

Economies identified different levels of risk for each vector according to their individual marine activities and administration. It is important that economies focus management responses on hazards that *they* have assigned a high risk to – once they have reviewed their results in the light of the experiences of other APEC economies. For example, there is little point for a country with a relatively small aquarium industry that is restricted and closely monitored, to focus on this vector just because other economies are. The following charts present the individual economies' ranking for each vector (high, medium or low) for international and domestic activities.

International activities (S-commercial shipping; OGM-oil, gas and mining; AF-aquaculture fisheries; AI-aquarium industry; WF-wild fisheries; MT-marine tourism; MA-military activities; OT-other):

High

Pathway	Vector										
S	Ballast water	AUS	BD	CDA	CHL	NZ	PE	RP	SIN	THA	USA
S	Hull fouling	AUS	BD	CDA	CHL	NZ	THL	USA			
OGM	Drilling platforms: ballast water	BD	CDA	NZ	PE	SIN					
S	Anchors/anchor chains	AUS	CDA	CHL	NZ						
AF	Accidental release	CDA	RP	SIN	VN						
OGM	Drilling platforms: hull fouling	BD	CDA	NZ	USA						
AI	Live fish trade-aquarium species	BD	CDA	CHL	PE						
WF	Hull fouling of fishing vessels	BD	CDA	RP	THL						
MT	Recreational boating: hull fouling	AUS	CDA	NZ	THL						
MA	Military vessels	BD	CDA	CHL							
WF	Live bait movement	CDA	PE	SIN							
S	Sea chests	AUS	BD	NZ							
WF	Processing of fresh and frozen product	BD	PE								
AF	Accidental release	NZ	PE								
S	Cargo	RP	SIN								
WF	Live fish trade-consumption	BD	SIN								
AF	Discarded packaging materials	RP									
AF	Release of transgenic species	PE									
AI	Intentional release	PE									
OT	Canals: movement through locks	CDA									
AF	Intentional release	SIN									

Medium

Pathway	Vector						
WF	Live fish trade-consumption	CDA	CHL	PE	THL	USA	VN
MT	Recreational boating: hull fouling	BD	CHL	PE	SIN	USA	VN
AI	Live fish trade-aquarium species	AUS	RP	SIN	THL	USA	VN
MA	Military vessels	AUS	PE	SIN	THL	USA	VN
OGM	Drilling platforms: hull fouling	AUS	CHL	PE	THL	VN	
OGM	Drilling platforms: ballast water	AUS	CHL	THL	USA	VN	
OGM	Dredging spoil	BD	CHL	SIN	THL	VN	
AI	Accidental release	BD	RP	SIN	VN		
WF	Live bait movement	CHL	NZ	USA	VN		
WF	Discarded fishing gear	CHL	NZ	THL	VN		
WF	Hull fouling of fishing vessels	CHL	NZ	PE	SIN		
AI	Intentional release	NZ	SIN	VN			
S	Hull fouling	PE	RP	SIN			
AF	Intentional release	PE	RP	VN			
AF	Accidental release	PE	THL	USA			
AF	Gear or stock movement	NZ	SIN	VN			
AF	Discarded nets, floats, traps	NZ	VN				
S	Solid ballast	CHL	THL				
WF	Processing of fresh and frozen product	USA	VN				
MT	Diving: dive gear	CHL	NZ				
S	Sea chests	USA					
S	Cargo	CDA					
S	Ballast water	VN					
AF	Discarded packaging materials	VN					
AF	Release of transgenic species	VN					
OT	Canals: movement through locks	VN					

Low Pathway	Vector									
AF	Discarded nets, floats, traps	AUS	BD	CDA	CHL	PE	RP	SIN	THL	USA
AF	Discarded packaging materials	AUS	BD	CDA	CHL	NZ	PE	SIN	THL	USA
AF	Release of transgenic species	AUS	BD	CDA	CHL	NZ	RP	SIN	THL	USA
MT	Diving: dive gear	AUS	BD	CDA	RP	SIN	THL	USA	VN	
AI	Intentional release	AUS	BD	CDA	CHL	RP	THL	USA		
S	Solid ballast	AUS	BD	CDA	NZ	SIN	USA	VN		
WF	Processing of fresh and frozen product	AUS	CDA	CHL	NZ	RP	SIN	THL		
WF	Discarded fishing gear	AUS	BD	CDA	PE	RP	SIN	USA		
S	Cargo	AUS	BD	CHL	NZ	THL	USA	VN		
S	Anchors/anchor chains	BD	PE	RP	SIN	THL	USA	VN		
AF	Intentional release	AUS	BD	CDA	CHL	NZ	THL	USA		
OT	Canals: movement through locks	AUS	BD	CHL	NZ	SIN	USA			
AI	Accidental release	AUS	CDA	CHL	THL	USA				
OGM	Dredging spoil	AUS	CDA	NZ	RP	USA				
AF	Accidental release	AUS	BD	CHL	NZ					
WF	Live bait movement	AUS	BD	RP	THL					
S	Sea chests	RP	SIN	THL						
WF	Hull fouling of fishing vessels	AUS	USA	VN						
WF	Live fish trade-consumption	AUS	NZ	RP						
OGM	Drilling platforms: hull fouling	RP	SIN							
MA	Military vessels	NZ	RP							
AI	Live fish trade-aquarium species	NZ								
OGM	Drilling platforms: ballast water	RP								
MT	Recreational boating: hull fouling	RP								
S	Hull fouling	VN								

Domestic activities:

High Pathway	Vector										
S	Ballast water	AUS	BD	CDA	CHL	NZ	PE	RP	SIN	THA	USA
S	Hull fouling	AUS	BD	CDA	CHL	NZ	THA	USA			
MT	Recreational boating: hull fouling	AUS	CDA	NZ	THA	USA					
AI	Live fish trade-aquarium species	AUS	BD	CDA	CHL						
S	Anchors/anchor chains	AUS	CDA	CHL	NZ						
MA	Military vessels	BD	CDA	CHL							
OGM	Drilling platforms: hull fouling	BD	CDA	THA							
OGM	Drilling platforms: ballast water	BD	CDA	THA							
S	Sea chests	AUS	BD	NZ							
WF	Hull fouling of fishing vessels	BD	RP	THA							
AF	Accidental release	CDA	VN								
WF	Processing of fresh and frozen product	BD	PE								
WF	Live bait movement	CDA	USA								
AF	Gear or stock movement	NZ									
AF	Discarded packaging materials	RP									
WF	Discarded fishing gear	BD									
WF	Live fish trade-consumption	BD									
AI	Intentional release	AUS									
AI	Accidental release	NZ									
OGM	Dredging spoil	THA									
OT	Canals: movement through locks	USA									

Medium

Pathways	Vectors	Economies
AF	Accidental release	AUS CHL RP SIN VN
WF	Hull fouling of fishing vessels	AUS CDA NZ PE
S	Hull fouling	PE SIN USA
AI	Accidental release	AUS BD CHL
WF	Live bait movement	AUS NZ USA
S	Cargo	RP SIN
AF	Intentional release	RP SIN
AF	Discarded nets, floats, traps	AUS NZ
AF	Discarded packaging materials (feeds, stock)	AUS BD
WF	Live fish trade-consumption	CDA SIN
AI	Intentional release	CHL NZ
OGM	Drilling platforms: hull fouling	AUS NZ
OGM	Drilling platforms: ballast water	AUS NZ
OGM	Dredging spoil	BD NZ
WF	Discarded fishing gear	NZ
AF	Gear or stock movement	AUS
MT	Diving: dive gear	NZ
MT	Recreational boating: hull fouling	USA
MA	Military vessels	AUS
OT	Canals: movement through locks	USA
S	Ballast water	USA
S	Solid ballast	THA
S	Anchors/anchor chains	BD
AF	Intentional release	RP

Low

Pathways	Vectors	Economies
AF	Release of transgenic species	AUS CDA CHL NZ PE RP SIN THA USA
WF	Discarded fishing gear	AUS CDA CHL PE RP SIN THA USA VN
MT	Diving: dive gear	AUS BD CDA CHL RP SIN THA USA VN
AF	Gear or stock movement	BD CDA CHL PE RP SIN THA USA
AF	Discarded nets, floats, traps	BD CDA CHL PE RP SIN THA USA
OGM	Dredging spoil	AUS CDA CHL RP SIN SIN SIN USA
S	Cargo	AUS BD CDA CHL NZ THA USA VN
S	Solid ballast	AUS BD CDA CHL NZ SIN USA
AF	Discarded packaging materials	CDA CHL NZ PE SIN THA USA
WF	Processing of fresh and frozen product	AUS CDA CHL NZ RP SIN THA
AF	Intentional release	AUS BD CDA CHL NZ PE THA
WF	Live bait movement	BD CHL PE RP SIN THA
WF	Live fish trade-consumption	AUS CHL NZ PE RP THA
AI	Intentional release	BD CDA PE RP SIN THA
AI	Accidental release	CDA PE RP SIN THA USA
MA	Military vessels	NZ PE RP SIN THA USA
S	Sea chests	RP SIN THA USA VN
S	Anchors/anchor chains	PE RP SIN THA USA
AI	Live fish trade-aquarium species	NZ PE RP SIN THA
OGM	Drilling platforms: ballast water	CHL PE RP SIN USA
OT	Canals: movement through locks	AUS CDA CHL NZ SIN
MT	Recreational boating: hull fouling	BD CHL PE RP SIN
AF	Accidental release	BD NZ PE THA
OGM	Drilling platforms: hull fouling	CHL PE RP SIN
WF	Hull fouling of fishing vessels	CHL SIN USA
S	Hull fouling	RP VN
S	Ballast water	VN

3.2.2 THE SCOPE OF VECTORS IN THE APEC REGION

Evaluating the importance of vectors using qualitative methods is an effective first step for determining areas or activities of high risk for management to focus on. To supplement the results from the vector ranking, a summary of the history and relevant cases for each vector follows:

3.2.2.1 Ballast water

World patterns of ballast water movement over the past 100 years have paralleled the changing patterns of world shipping routes since the late nineteenth century. These patterns are complex, and

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reflect the changing world distribution of resources, population, location of industries, the characteristics of markets, economic growth rates, political and military factors. Although the intensity, number, and direction of trade routes have changed many times, a clear pattern of marine invasions emerges when compared to the growth in maritime trade and changes in shipping activities as new technologies were introduced (e.g., Carlton 1985; Campbell and Hewitt 1999).

Prior to the 1840's vessels used primarily dry (or semi-dry) ballast. By the 1850s, water ballast became more common but dry ballast was not phased out until the 1950s. Most ships carry some ballast water, even those carrying cargo. Ballast water is pumped into ballast tanks at the donor port to stabilise the vessel during unloading (or exchanged at sea) and is typically released at the recipient port when more cargo is taken on. Ballast water transport results in the transport of holoplankton (species that spend their entire life in the water column), meroplankton (species that spend a portion of their life in the water column, e.g. species with planktonic larval stages), or tychoplankton (benthic species that have been accidentally swept into the water column). It was assumed that only species with long-lived larvae could survive in ballast water, but as ships became faster the likelihood that marine fauna and flora in ballast water would survive the journey increased. Ballast water transfer has been implicated in the introductions of damaging marine pests world-wide including the zebra mussel (*Dreissena polymorpha*) and the Asian clam *(Potamocorbula amurensis*) in the US; the comb jelly (*Mnemiopsis leidyi*) in the Black and Azov Seas; and the toxic dinoflagellate (*Gymnodinium catenatum)* and northern Pacific seastar (*Asterias amurensis*) in Australia. Ballast water is also capable of transporting viral and bacterial pathogens, including the bacteria that cause cholera (Ruiz *et al.* 2000). At any given moment some 10,000 different species are being transported between bio-geographic regions in ballast tanks alone (Carlton 1999).

3.2.2.2 Hull fouling

Historically, coastal movements of humans have attributed to the transport and establishment of encrusting and wood boring species. Our ability to detect and identify these organisms however is severely limited. Since European expansion in the 1500s, wooden hulled vessels have transported many fouling species attached to (hull fouling) and boring into (hull boring) ship hulls. Older, well-fouled vessels carrying mixed sand and rock ballast could easily have transported 150 or more species around the world's oceans (Carlton 1999). Not only did wooden ships transport numerous species in the early days of shipping, but wooden ships could also end up permanently moored or sunk in the new port at the end of a voyage. This often resulted in the introduction of whole fouling communities where they were able to adapt, reproduce and establish. Today, the cosmopolitan nature of many wood-boring species (e.g. limnorid isopods and teredinid bivalves) suggests that many species were transported by hull boring. This makes the identification of native distributions difficult – many of the species that we now regard as cosmopolitan may have been introduced in the early days of human coastal movement.

Since the mid 1800s, international shipping vessels have increasingly been made with steel hulls reducing hull boring as a vector. Wooden-hulled vessels however, continue to operate in many coastal situations (e.g., coastal transport, fishing vessels) and have been identified as carrying invasive marine species (Bax *et al.* in press).. It is often assumed that the widespread use of anti-fouling paints (including the introduction of TBT) and the increased speeds of modern vessels have eliminated hull fouling as a vector. However, recent research demonstrates international and domestic merchant vessels continue to have many encrusting species attached to hulls suggesting that marine fauna and flora are still transported by this vector (Rainer 1996; Coutts 2000; Hewitt and Campbell, 2002; Hewitt unpub data). The consequences of the international phasing out of TBT on hull fouling communities and the rate of transport of marine species is as yet unknown.

3.2.2.3 Dry ballast

Ballast is used to stabilize vessels. Prior to the 1840s vessels used primarily dry ballast – rocks, shingle, cobble, or sand – often loaded from the nearest beach complete with attached fauna and flora. Because ballast holds accumulated water, the ballast became semi-dry (sometimes referred to semi-dry ballast) allowing intertidal and subtidal marine organisms present in the hold to survive the voyage. The conditions resembled inter-tidal habitats and consequently favoured transport of inter-tidal and

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meiofaunal species.. Dry ballast was typically off-loaded in or near a harbour and this vector is thought to have been responsible for transport of a large number of species, however, because of a lack of baseline surveys, many of the species thought to be dry-ballast introductions are classified as cryptogenic.

3.2.2.4 Drilling platforms

Movement of drilling platforms, used for oil exploration and extraction has resulted in several species introductions in New Zealand and the USA (Cranfield *et al.* 1998; Carlton 2001). Both the fouling organisms attached to the platforms, and plankton and nekton in the ballast can be introduced via this vector. Oil rigs in the Gulf of Mexico have been implicated in providing a novel habitat for juvenile jellyfish that are believed to be severely impacting the recruitment of local fish stocks.

3.2.2.5 Fishing operations: Floating debris

Floating debris, including fishing nets and plastics can carry a variety of fouling species. This is thought to be particularly important in the Pacific Ocean where fishing nets have been washed ashore covered with many marine organisms (Cranfield *et al.* 1998; Carlton 2001).

3.2.2.6 Fishing and aquaculture operations: movement of gear

Moving aquaculture and fishing equipment (buoys, nets, etc.) is another vector for species introductions. *Caulerpa taxifolia* in the Mediterranean is spread by fishing vessels and their gear (Relini *et al.* 2000).

3.2.2.7 Fisheries intentional

The introduction of species to enhance stocks is a vector for introducing marine pests. (Carlton, 2001).

3.2.2.8 Fisheries unintentional

Product (frozen or live) used for fish food can also result in species introductions. Frozen prawn imported to Australia for human consumption, from an area known to have the white spot syndrome virus (WSSV), was reclassified as bait and thus reintroduced to the marine environment, though it may not have established. . White spot syndrome virus is highly virulent with a wide range of potential hosts. It was first reported in Chinese Taipei in 1991-1992 and is now widely spread throughout SE Asia. It was introduced to the Americas in 1995 via imported prawns from Thailand.

3.2.2.9 Aquaculture intentional

A large number of species have been introduced intentionally for aquaculture and to enhance or create new fisheries. These species may become established and impact on the aquatic environment. The Pacific oyster (*Crassostrea gigas*) has been transported throughout much of the Pacific for aquaculture, including Australia, New Zealand, North and South Pacific Islands, and the west coast of North America (Carlton 1987, 1999). Other species released for aquaculture in the Pacific include bivalves (giant clams, oysters, mussels), gastropods (trochus, turbo), fish, crustaceans (penaeid shrimps) and seaweed (Eldredge 1994). Attempts to reduce the risk of introduced species spreading outside the culture site by using sterile organisms, e.g., triploid oysters in Chesapeake Bay, have not always met with success (Allen *et al.* 1999).

3.2.2.10 Aquaculture unintentional

There are numerous vectors associated with aquaculture that can lead to unintentional species introductions. Parasites and pathogens of aquaculture species can be introduced unintentionally in association with stock movement. The mud blister worm, *Polydora websteri*, a polychaete that bores into oyster shells, is thought to have been introduced to Hawaii in oyster spat imported from hatcheries on the west coast of America (Eldredge 1994). In the 1880s, large volumes of half-grown American oysters *Crassostrea virginica* from Long-Island Sound were imported in wooden barrels to Europe. Associated individuals included the hard-shelled clam *Mercenaria mercenaria* which became briefly established in Liverpool Bay, the American tingle *Urosalpinx cinerea* a predator of oysters, and the slipper limpet *Crepidula fornicata* that resulted in significant economic damages (Minchin *et al.* 1995, Minchin 1996). Similarly, the South African polydorid polychaete that infects abalone was introduced to California through aquaculture movements (Culver and Kuris 2000).

Globally almost 10% of aquaculture production is derived from non-indigenous species (FAO 2000). Not surprisingly it is common for species introduced for aquaculture to establish populations outside farms and become part of the established introduced fauna. Reared Atlantic salmon on North America's Pacific and Atlantic coasts and in Norway regularly escape their net pens, following seal and storm damage or operator error. Escaped fish are recorded breeding in areas they have not bred in before and altering the genetic composition of local populations (Gausen and Moen 1991). Given the history of escapes of reared salmon, concern has been expressed at the potential impacts of reared transgenic salmon escaping (Sutterlin *et al.* 1996).

3.2.2.11 Aquarium industry

In 1999, the world exports of ornamental fish exceeded US$240 million (FAO 2001). This live trade in fish can result in the intentional or accidental released of species that can establish populations in the donor region. The popular aquarium plant *Caulerpa taxifolia* has been introduced via the aquarium industry to the west coast of North America and the Mediterranean. Australia's aquarium industry is believed to be the cause of domestic *Caulerpa* strains spreading outside their natural range. A broad range of marine flora and fauna including *Caulerpa* species are still available to order over the internet.

3.2.2.12 Dive operations

Within the Asia-Pacific region, diving and snorkeling is a major source of tourism. Divers taking personal dive equipment with them on their travels may accidentally transport marine fauna and flora.

3.2.2.13 Canal development

Species introductions can be facilitated by movement of marine fauna and flora through locks in man made canals. For example, several fish and invertebrate species have been transported through the Panama Canal (Hildebrand 1939). Nearly 300 species of Red Sea and Indo-West Pacific origin invaded and settled in the Mediterranean, where they now represent 4% of the species diversity (10% of the Levantine basin diversity), following the opening of the Suez Canal in 1869 (Boudouresque 1999).

3.3 FACTORS AFFECTING PATHWAY STRENGTH

Pathways for marine pests follow trading routes, the geographical corridor between point A and point B (Carlton 2001). This involves determining the trading partners and routes used for the flows of fishery and aquaculture products and bulk commodities[14]. Hewitt and Hayes (in press) evaluated hazards associated with pathways (specifically, identified trade routes) based on two factors:

1. Frequency or pathway strength, and
2. The likelihood that transported species can survive in the recipient environment.

Pathway strength

The frequency, or strength of a trade route can be measured by the total number of ship visits (for hull fouling) or type of vessels and ballast water activities (for ballast water). To perform these assessments correctly, required data include:

1. The traffic density of the ports (total number of vessels, annually);
2. The frequency of visits from specific ports/economies either as last port of call (LPOC) or previous ports from which ballast water might be retained;

[14] Trade in this context includes the international tourism and recreational trade.

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3. The activities and characteristics (type of vessel, deadweight tonnage, unloading, loading) of the vessels during each port call;
4. Seasonal patterns in the traffic from each port; and
5. Details of any ballast water treatment taken on route.

Likelihood of survival

The likelihood of a species surviving in the recipient environment is estimated from species specific tolerances matched between the donor and receiving ports, or environmental ranges (maximum and minimum salinity and temperature) for the bioprovinces of the extant range and the receiving bioprovince.[15] The likelihood of survival is not examined further in this report but it is a major component of the risk assessment of marine pest pathways (Hayes, Hewitt and Hayes).

3.3.1 IDENTIFICATION OF FACTORS THAT AFFECT PATHWAY STRENGTH IN APEC

This subsection presents the factors influencing the strength of marine pest pathways throughout the APEC region and at the level of the individual economies. The risk associated with each factor would ideally be established through comprehensive hazard analysis techniques looking at trade patterns and routes.

Table 3.3. Factors that affect pathway strength for introducing marine species into APEC economies identified at the APEC MRC Workshop, 2001.

Commercial shipping
New vessels (larger, faster)
Number of trading partners
Domestic port extension/ construction
Aquaculture fisheries
New aquaculture species
Genetically modified aquaculture species
Wild fisheries
Aquarium trade
Oil, gas and mining
Marine tourism (including diving)
Recreational boating

Eleven factors influencing pathways for marine pest introduction were identified during the APEC workshop. Each economy was asked to rank the importance of these factors as high (1) medium (2) or low (3), for both their international and domestic activities.

[15] Bioprovinces represent regions with significant and cohesive faunal and floral assemblages with 60-70% turnover at the edges (Hewitt and Hayes in press).

APEC pathways hazards:

Results for the APEC region as a whole are shown in Figure 4.

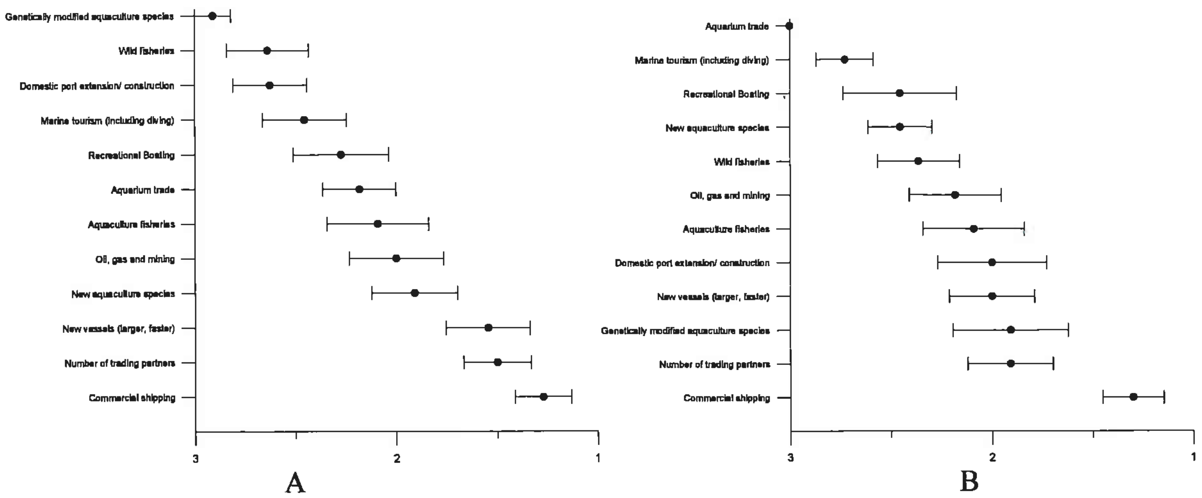

Figure. 4 Means and standard error of ranked scores for each factor influencing marine pest introductions for (A) international and (B) domestic pathways. Each factor was ranked as of high (1), medium (2) or low (3) importance.

Commercial shipping is ranked an important factor for both international and domestic operations throughout the APEC region. The number of trading partners and the impact of new larger and faster ships were also ranked highly for international introductions of marine pests. A large number of trading partners increases the number of potential pathways for marine species to travel; larger vessels increase the number of individual marine organisms that can be carried; faster vessels increases the probability that they will arrive in good condition. Oil, gas, mining, aquaculture and fisheries are seen as factors of medium importance in both international and domestic activities. Genetically modified species are seen as an important domestic factor, but not an important international factor, while the aquarium trade and new aquaculture species are seen as relatively important factors internationally but not domestically. Marine tourism was seen as a factor of relatively low importance both domestically and internationally.

Individual economy hazards:

As with vector hazards, pathway hazards vary between economies based upon the levels of activities and types of activities undertaken within each economy. The following charts present the economy rankings of the levels of international and domestic activities (high, medium and low), in place within each economy, which affect pathways for introducing marine pests.

International activities (note: Chile may be better classified as recognising new aquaculture species as a high rather than a low hazard in the following table – eds):

High

Commercial shipping	AUS	BD	CDA	CHL	NZ	RP	SIN	USA	
New vessels (larger, faster)	AUS	BD	CDA	PE	SIN	USA			
ballast water management	AUS	BD	NZ	RP	SIN	USA			
Number of trading partners	AUS	CDA	CHL	SIN	USA				
New aquaculture species	AUS	RP	USA						
Genetically modified aquaculture species	PE	RP	SIN						
Marine tourism (including diving)	BD	PE	SIN						
Domestic port extension/ construction	CDA	NZ							
Aquarium trade	PE								
Oil, gas and mining	CHL								
Recreational boating	AUS								

Medium

Oil, gas and mining	AUS	CDA	NZ	RP	SIN	USA	VN		
Genetically modified aquaculture species	AUS	BD	CDA	CHL	THA	USA			
Marine tourism (including diving)	AUS	CHL	THA	USA	VN				
Number of trading partners	BD	NZ	RP	THA	VN				
Domestic port extension/ construction	CHL	PE	SIN	THA					
New vessels (larger, faster)	CHL	NZ	RP	THA					
New aquaculture species	CDA	PE	SIN	VN					
Recreational boating	CDA	NZ	SIN	VN					
Aquaculture fisheries	BD	NZ	VN						
Commercial shipping	PE	THA	VN						
Aquarium trade	CDA	NZ							
Wild fisheries	THA								

Low

Wild fisheries	AUS	BD	CDA	CHL	NZ	PE	RP	SIN	USA	VN
Aquarium trade	AUS	BD	CHL	RP	SIN	THA	USA	VN		
Recreational boating	BD	CHL	PE	RP	THA	USA				
Aquaculture fisheries	CHL	PE	RP	SIN	THA					
Domestic port extension/ construction	AUS	BD	RP	USA	VN					
New aquaculture species	BD	CHL	NZ	THA						
Oil, gas and mining	BD	PE	THA							
Marine tourism (including diving)	CDA	NZ	RP							
Genetically modified aquaculture species	NZ	VN								
New vessels (larger, faster)	VN									

Domestic activities:

High										
Commercial shipping	AUS	CDA	CHL	NZ	RP	SIN	USA			
Recreational boating	AUS	NZ	SIN	THA	USA					
Oil, gas and mining	AUS	CDA	CHL	PE						
New vessels (larger, faster)	AUS	SIN	THA							
New aquaculture species	BD	RP	SIN							
Wild fisheries	AUS	BD	PE							
Number of trading partners	CDA	SIN								
Aquaculture fisheries	NZ	RP								
Marine tourism (including diving)	AUS									
Medium										
Domestic port extension/ construction	AUS	CDA	NZ	RP	SIN	VN				
New vessels (larger, faster)	BD	CDA	CHL	NZ	PE	USA				
Number of trading partners	AUS	BD	CHL	NZ	THA	VN				
Aquaculture fisheries	AUS	CDA	CHL	USA	VN					
Marine tourism (including diving)	CDA	NZ	RP	THA	VN					
New aquaculture species	AUS	CHL	THA	USA						
Aquarium trade	AUS	USA	VN							
Oil, gas and mining	BD	THA	VN							
Commercial shipping	BD	PE	VN							
Recreational boating	CDA	PE								
Low										
Wild fisheries	AUS	BD	CDA	CHL	NZ	PE	RP	SIN	THA	USA	VN
Aquarium trade	CDA	CHL	NZ	RP	SIN	THA	USA	VN		
Oil, gas and mining	BD	CDA	CHL	NZ	PE	RP	SIN	THA		
Aquaculture fisheries	BD	CHL	PE	THA	USA					
Recreational boating	BD	CHL	PE	SIN	USA					
Domestic port extension/ construction	BD	CHL	RP	VN						
Marine tourism (including diving)	NZ	RP	SIN	USA						
New aquaculture species	BD	PE	SIN	THA						
Genetically modified aquaculture species	CDA	NZ	PE	VN						
New vessels (larger, faster)	RP	VN								
Number of trading partners	RP	USA								

3.3.2 THE SCOPE OF FACTORS AFFECTING PATHWAY HAZARDS

Relevant information is unavailable, or unattainable in the timeframe of this project, thus this subsection will only scope the role of commercial shipping's' effects on pathways in the APEC region.

3.3.2.1 Shipping in the APEC region

Shipping related pathways were identified as a high risk pathway in the APEC region. This subsection provides an overview of shipping activities and hazards within the APEC region. Within the Pacific the maritime transport network is extremely complex, comprising of both hub-centres of varying capacity that filter out through small coastal feeder vessels to regional ports, and traditional port structures (Rimmer 1997). The most recent major changes to the Pacific maritime transport network were from 1985 to 1994 when China entered the global economy, adding a significant new trading partner for many APEC economies. (Rimmer 1997). Historically, the Panama Canal facilitated trade from the Atlantic and European regions and decreased ships' transit times, thus increasing both the strength of the pathway and the likelihood of an organism surviving the voyage. An idea of the complexity of shipping and, more specifically, shipping related marine pest introductions in APEC is evident from mapping the routes that shipping vessels take in the Pacific Ocean (refer to Figure. 5).

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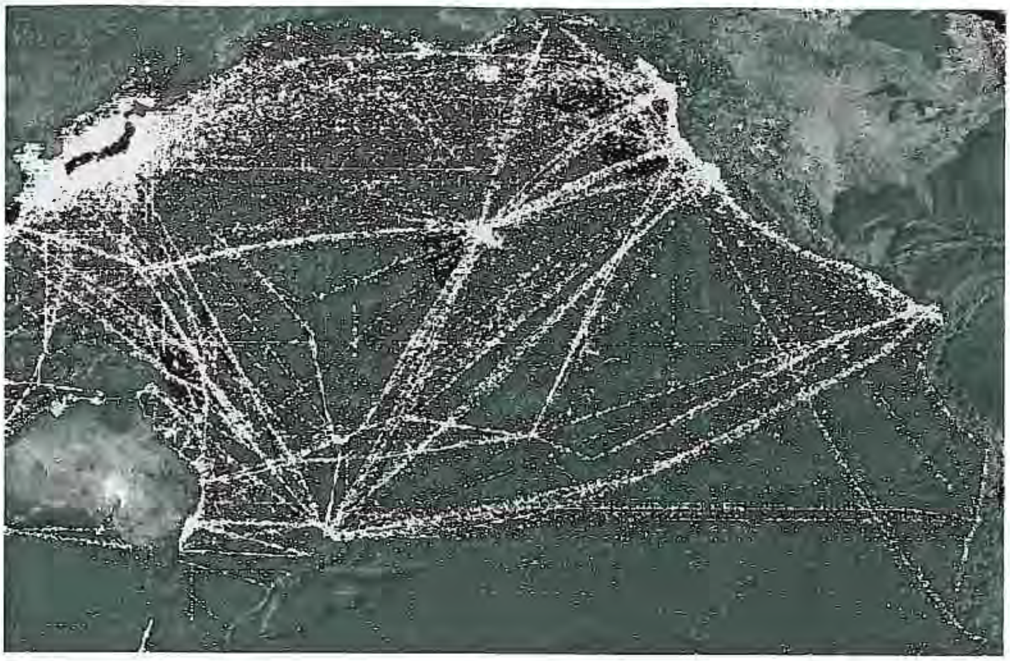

Figure 5. The shipping routes in the Pacific Ocean 2000 – 2001 (Source: Trevor Gilbert, AMSA).

3.3.2.1.1 Commercial shipping

Commercial vessels transport marine organisms ranging from microscopic viruses and plankton to macroalgae and fish across the seas in a multitude of habitats: hulls, anchors, anchor chains, ballast tanks and sea chests. With more than 35 000 vessels at sea on any given day, and assuming that only 10% of these are carrying a full load of ballast water with only 2 unique species per vessel, then 7 000 species may be being transported around the world each day in ballast water alone (Carlton 1999). When other vectors carrying ballast water are included – e.g. military vessels (including submarines), ocean-going tugs and barges, self-propelled exploration platforms, ballastable yachts, etc. – a more realistic estimate would be over 10 000 unique species being transported daily in ballast water around the globe (Carlton 1999). Of course this does not include species being carried on the hull, in the seachest, on the anchor (chain) and other exposed surfaces and crevices.

The actual hazards associated with shipping are influenced by: cargo type, vessel types, deadweight (dwt), loading activities, vessel movement history, ballast tank capacity, vessel trim and stability and trading characteristics (e.g. international trading, coastal shipping) (Walters 1996). Shipping studies have investigated ballast water practices and calculated ballast water imports (Jones 1991; Carlton *et al.* 1993; Kerr 1994; Walters 1996). The major trading products for APEC economies and their ports can be identified from statistics. This assists in determining the role of the economy as an exporter or importer of specific commodities and the resultant shipping characteristics. It is the ship type and its activities with the trading partners that influence the potential risk, with these being determined by who is exporting and who is importing. Kerr (1994) identified the following vessel types as heavily ballasted:

1. Bulk carriers
2. Ore carriers
3. Woodchip carriers
4. Oil tankers
5. Chemical tankers

These vessels have a high ballast capacity that must be discharged to onload cargo. Australia and New Zealand are major exporters of dry bulk commodities (UNCTAD 2001). This trade results in bulk carriers, ore carriers and woodchip carriers arriving in port fully loaded with ballast and then discharging it to load on the cargo (Kerr 1994; Walters 1996). Furthermore, Australia and New Zealand import chemicals and crude oil, so ballast water is taken up in Australian and New Zealand ports and distributed elsewhere. Bulk loading ports are a main risk for introductions from ballast water.

The frequency of ship visits is one determinant of the risks introducing marine species via ballast water or hull fouling. A map of routes and density for the Southern Pacific Ocean in 2000 was constructed through amalgamating an AMSA ship reporting GIS and the SPREP Pacific Ocean Pollution Prevention Programme (PACPOL) GIS (Trevor Gilbert, 2002; Figure. 6).

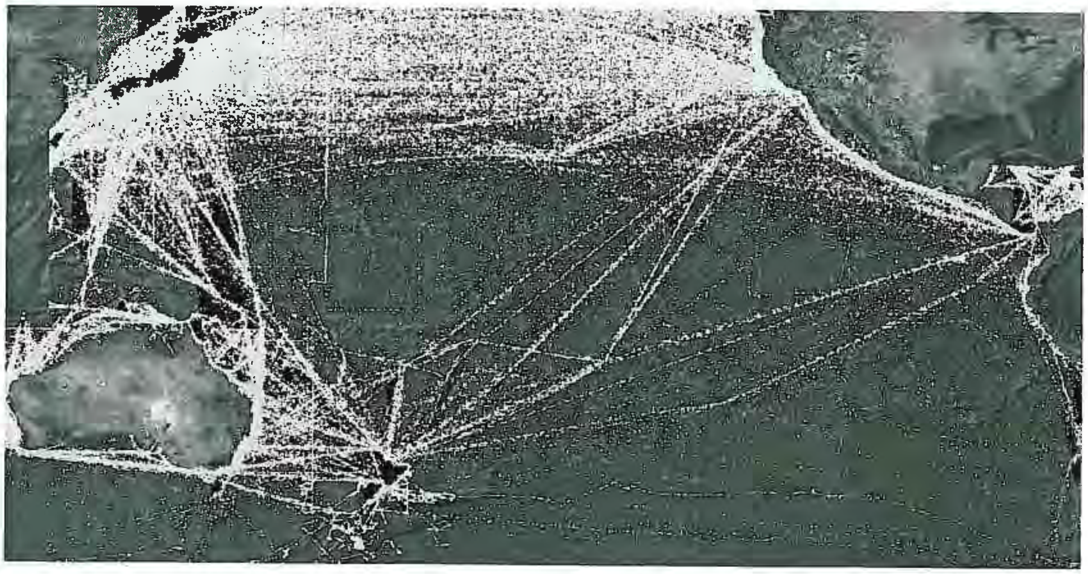

Figure 6. Shipping routes and vessel densities (Source: Trevor Gilbert, AMSA).

Though some APEC economies are absent from Figure 2, as it focuses on the Southern Pacific, it is evident that a considerable amount of ship traffic exists within the APEC region. A more complete way of looking at the level of international shipping in the APEC region is to examine the number of ships (preferably of each type) arriving at each port. This is beyond the scope of this report – there are 998 recognised ports within APEC's Pacific borders. However, Table 3.4 lists the number of ports and number of vessel visits for one example port in each APEC economy

Table 3.4. APEC economies and port statistics where available (Source: Port numbers: Fairplay Ports Guide 2001-2002; Traffic density: Informa seasearcher.com, 2001).[16]

Economy	Number of Ports	Example Port	Traffic density 2001-2002**
Australia	78	Port Phillip Bay	2834
Brunei Darussalam	5	Seria	180*
Canada ***	52	Vancouver	3625
Chile	40	Valparaiso	1074
China	44	Shanghai	3600*
Hong Kong China	2	Hong Kong	42000*
Indonesia	99	Tanjung Priok	15135
Korea	20	Busan	19674
Japan	180	Tokyo	56000*
Malaysia	49	Penang	7071*
Mexico	6	Manzanillo	1084
New Zealand	39	Auckland	1362
Papua New Guinea	15	Port Moresby	719
Peru	18	Callao	1117
Philippines	60	Manila	*
Russian Federation ***	63	Vladivostok	2888
Singapore	6	Singapore	42708
Chinese Taipei	5	Kaosiung	14421
Thailand	11	Bangkok	2655
USA ***	123	San Francisco	971
Vietnam	13	Ho Chi Min	1192

*Estimates according to Fairplay Guide 2001-2002
** Annual numbers (Dec 2001-Dec 2002)
*** Only includes ports adjacent to the Pacific Ocean (Source: Informa, 2001).

3.3.2.1.2 Domestic Shipping: Translocation

Domestic shipping is an important pathway for transporting introduced species around an economy. Domestic shipping within Australian waters is the most likely vector to have translocated the introduced pest *Asterias amurensis* from Hobart (the site of initial establishment) to Port Phillip Bay. In 1998-1999 commercial domestic shipping in Australia moved more than 97 million tonnes of cargo (Anon 2001). The relative importance of domestic shipping in spreading introduced marine pests is illustrated by the number of domestic ports compared to international ports (c.f. Indonesia with 131 international ports and 3647 domestic ports)

Domestic shipping (for trade, fishing and transport) is also an important vector in extending the range of introduced marine species once established. Hull fouling and the accidental transport of species in seachests of domestic vessels (both commercial and recreational), in particular those that spend long periods in infected ports, are likely to be important mechanisms for the translocation of introduced species away from ports of first entry. Fishing vessels that dredge the seabed (e.g. for scallops) can pick up and transport introduced species from one area to another.

3.3.2.1.3 Recreational boating

Ocean going recreational vessels can also transport marine flora and fauna via hull fouling. The recent incursion of the black striped mussel (*Mytilopsis sallei*) into northern Australia was probably via recreational vessels travelling between Darwin and other areas in SE Asia where the mussel is also introduced, or on a round the world yacht passing through the Panama Canal (Willan *et al.* 2000). The black striped mussel was successfully eradicated from Northern Territory waters (Bax 1999; Willan *et al.* 2000; Bax *et al.* in press). In the two years following the eradication, 437 vessels including 364 yachts, 38 commercial fishing trawlers and 35 apprehended illegal vessels were inspected by Darwin authorities. The 35 apprehended vessels were identified as a high-risk category of vessels following

[16] The numbers of vessel visits by receiving port and by ship type is available and would be invaluable to determining the frequency of visits from all last ports of call and previous ports of call to assist in a hazard analysis.

the finding of significant black striped mussel fouling. Four undesirable taxa have been detected– a variety of bryozoans (not identified to species), and three mollusks: *Musculista senhousia, Perna viridis* and *Mytilopsis* sp. Recreational vessels also pose a threat of translocating introduced species domestically. The movement of zebra mussels throughout the Great Lakes and adjacent waterways is largely due to transport via recreational vessels which transport the mussels long distances over land to new waters they would otherwise be unable to reach (Buchan and Padilla 1999). The pathways of recreational vessels vary considerably as there are no set courses that must be taken. This complicates evaluating recreational vessels pathways.

3.4 TAXONOMIC HAZARDS

For APEC economies to respond and control these incursions most effectively and efficiently, a species specific approach is necessary (Hayes and Hewitt 1998; Hewitt and Hayes. *in press* (a, b). Knowing species life history characteristics is important for identifying potential pests as well as for the management of existing introduced marine pests. This subsection reviews considerations for the detection of introduced marine pest, and profiles introduced marine species that have been identified by various APEC member economies in the Asia Pacific region.[17].

3.4.1 IDENTIFICATION OF INTRODUCED MARINE PESTS

The accurate identification of a species as an introduced marine pest or pathogen is essential for any form of rapid response to the incursion. Several key attributes make an introduced marine species a pest. A widely accepted definition of an introduced marine pest is a non-indigenous species that threatens human health, economic or environmental values (Williamson, 1996). In order to determine if a species is a pest, it is essential to review the biology and ecology of that species. Briefly, it requires an identification of the species as non-indigenous to an economy and recognition of the species as either being invasive or having an invasive history. The next step is to look at: the species physiological tolerances; whether it is known to cause impacts on human health, economic activities and/or ecological processes; specifically, whether this impact can occur in a particular economy; and what are likely vectors for the species and whether they still exist (Hayes and Sliwa *in review*).

Determining the native or introduced status of a species can be problematic and requires a rigorous examination of the taxonomy, phylogeny, ecology and biogeography of the species. Certain well-known fouling organisms have been widely dispersed by human activities, however many other invasions remain cryptic until researched. Carlton (1996) has called these species whose origins cannot be determined "cryptogenic".

One method that has been used to determine whether species are native or introduced is the ten-point criteria of Chapman and Carlton (1991). These criteria comprise questions relating to both local/provincial and global distribution and ecology. This method will not be completely accurate, but will aid in the identification of likely introduced species. The Chapman and Carlton (1991) criteria allow for assigning probability values to the combination of the assessed attributes for the species in question (refer to Table 3.5). These criteria can be used to provide testable hypotheses that can be disproved and ranked dichotomously with negative evidence indicating the species is native and positive evidence suggesting the species is introduced (Chapman and Carlton, 1991).

[17] It should be noted that other introduced marine pests do occur within some of these economies though they are not associated with the Asia Pacific region.

Table 3.5. The ten criteria for determining whether a species is native or introduced as described in Chapman and Carlton (1991).

LOCAL/PROVINCIAL	Criterion 1	Appearance in local regions where not found previously	This criterion can be assessed if the regions in question have been sufficiently sampled previous to the introduction
	Criterion 2	Initial expansion of local range subsequent to introduction	This criterion is applicable if there are sufficient historical surveys soon after the introduction
	Criterion 3	Association with human mechanism(s) of dispersal	Individuals of introduced species populations commonly remain associated with the dispersal mechanisms on which they arrived
	Criterion 4	Association with or dependency on other introduced species	Introduced species commonly occur predominantly with, or prey predominantly upon, other taxa that are known to be introduced
	Criterion 5	Prevalence on or restriction to new or artificial environments(s)	Introduced species often predominate on or are restricted to human-created substrates, such as floats, piers, pilings, rock jetties, or vessel bottoms
	Criterion 6	Relatively restricted distribution on a continent compared to distributions of native species	Introduced species often have northern and southern range limits along a continuous continental margin that are unrelated to classical biogeographical boundaries of native species
			Introduced species may occur in some locations such as a port or harbour, but not in adjacent apparently suitable bays, ports and harbours that are inhabited by ecologically similar native species
GLOBAL	Criterion 7	Isolated populations on different continents or in isolated oceans	Few shallow-water temperate marine invertebrates of the northern hemisphere which have well defined distributions and which are well known taxonomically, have been demonstrated to have naturally isolated intercontinental or interoceanic populations
	Criterion 8	Insufficient active dispersal capabilities to account for the observed distribution of the species	Introduced species do not have larval or adult life stage histories that are capable of recruiting to their entire present-day distributions
	Criterion 9	Insufficient passive dispersal capabilities that account for the observed distribution of the species	Introduced species do not have adaptations for dispersing by passive mechanisms, such as on drifting wood or carried on migrating birds, to their entire present distributions
	Criterion 10	Exotic evolutionary origin	Most introduced species populations have the closest morphologic and genetic affinities to species groups occurring elsewhere in the world

Determining whether an introduced marine species will become a pest is much more difficult. Some methods attempt to define characters that make for an 'ideal' invader. More recent and successful methods contain criteria associated with the species biological history and specific vectors, known impacts and recipient environment factors. Hayes and Sliwa (in review) constructed the following selection criteria to identify potential marine pests that have been introduced via ballast water and hull fouling for Australia:

1. It has been reported in a shipping vector or has a ship-mediated invasion history; and,
2. The vector still exists; and,
3. It has been responsible for environmental and/or economic harm; and,
4. It is exotic to Australia or present in Australia but subject to official control (i.e. listed, restricted or otherwise legislated by an authorised national authority).

Only a limited number of APEC member economies have identified introduced marine species, alone introduced marine pests and put them under some form of regulation or legislation. In Australia, a target pest list has been developed by the Australian Ballast Water Management Advisory Council (ABWMAC) that includes 12 pest species identified in Australian waters. This list includes one feral species grown in aquaculture and the bacterium *Vibrio cholera*. Two additional target pest species that had not been identified in Australian waters were also highlighted by ABWMAC. An interim trigger-list of 16 species applicable to all vectors was also put in place by the Standing Committee for Conservation/Standing Committee of Fisheries and Agriculture (SCC/SCFA 1999). A recent CRIMP study identified a further 33 potential "next pest" species (Hayes and Sliwa *in review*). New Zealand identified 7 unwanted marine species, of which only one has been introduced (C. Cox NZ MFish *pers. comm.*). No other APEC economies have attempted to list and prioritise potential or actual introduced marine pests. Some economies have introduced legislation against individual species (e.g., *Caulerpa taxifolia* in the US, fish pathogens in several economies).

3.4.2 DETECTION ABILITIES AND METHODOLOGIES

The present detection abilities of APEC member economies will differ due to the awareness, accessibility of information and expertise of personnel. This report is intended to assist APEC member economies in increasing their detection abilities by reviewing detection methodologies that are currently in use.

Understanding the invasion patterns of marine species is seen as critical to developing management strategies (Hewitt and Martin, 1996, 2001). Hewitt and Martin (2001) state that there are two primary methods to understand the invasion patterns of marine species.

1. Review of literature records and specimens
2. Field surveys

Baseline port surveys are conducted to provide an accurate assessment of the introduced species in a locale likely to be impacted by species introduced via shipping related activities. These involve qualitative and quantitative surveys in high risk environments (such as ports, marinas and fishing boat harbours) of the marine flora and fauna (Hewitt and Martin, 2001). Baseline port surveys have been conducted in Australia, USA and New Zealand. Furthermore, the International Maritime Organisation (IMO), in conjunction with the Global Environmental Facility (GEF) and the United Nations Development Program (UNDP) have jointly established a Global Ballast Water Management Program[18] that has as part of its brief, to undertake port surveys in six demonstration sites, including one APEC economy, China. Despite these recent developments, the current state of knowledge is severely limited and there is a lack of baseline data on marine introductions worldwide, and in the APEC region.

In light of the international focus on ship borne marine introductions and specifically the role of ballast water, research and industry have been focusing on methods to quantify the risks associated with ballast water discharge and uptake. Numerous ballast water sampling programs have been conducted by international institutions to determine: species present; survival rates during transit; etc.[19] A ballast water sampling program is an essential component for management based on a Decision Support System (DSS) providing a means to validate and improve the underlying risk estimates. Sutton *et al.* (1998) found through a review and evaluation of several ballast water sampling programs, that there is no single appropriate method for sampling ballast water. They recommended that a better understanding of the sampling methods and of the survival and ecology of individual species would enhance the effectiveness of sampling and its ability to be used as a risk validation tool.

Introduced marine pests that are entering through non-shipping related means may be detected through general customs and quarantine procedures. If a species is listed as an illegal import by legislation then its presence may be recognised by trained staff. Within the APEC region, varied forms of customs and

[18] Refer to Globallast website http://globallast.imo.org
[19] Refer to Sutton *et al*, (1998) for a review of international ballast water sampling protocols.

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quarantine are in place from a 'quarantine like' tool used for shipping (such as the DSS is in Australia) to the unrestricted import of marine species in some Asian economies.

Baseline port surveys can pick up species that are introduced by other vectors than shipping and species distributed within the economy, depending on survey coverage. Detection abilities may be increased with community participation that can be encouraged with educational awareness materials and programs. Regular monitoring of aquaculture facilities and their effluent assists in the detection of exotic species and pathogens that may have been introduced with new broodstock or fry.

Despite increasing awareness of the introduced marine pests problem, the number of species transported around the globe and establishing outside their native range is increasing exponentially with increased globalisation of world trade (Cohen and Carlton, 1998; Hewitt *et al*, 1999; Ruiz *et al*, 2001). It is important to develop a risk assessment framework that can cater for regional economies regardless of their current data holdings. Assessed risks can be updated as new information becomes available. This approach is used in the Australian ballast water DSS, where the risk of a particular species or event is considered to be 100 per cent until scientific data are available that reduce that risk estimate.

3.4.3 INTRODUCED MARINE SPECIES PROFILES

There is starting to be a proliferation of lists of marine pests, the majority of which have no formal basis for defining which introduced marine species will actually reach pest status (although see Hayes and Sliwa in review for a formal process that identifies species likely to become pests if they establish in Australian waters). Not wishing to add to this proliferation of marine pest lists, we present the following list as species of concern. It will be up to each economy or the APEC region as a whole to develop a process for determining which of these (and other) species are likely to become pests if they establish in the APEC marine environment.

Tables 3.6 and 3.7 list 103 marine species and pathogens of concern that have been introduced within the Asia Pacific region. These species and pathogens have been profiled to provide species specific information, including information on the distribution and linkage with vectors as well as observed and potential impacts. Where known, details on management approaches have been included. This list is not comprehensive as not all economies have information sufficient to determine the introduced marine pests in their region, but merely represents those species recognised with various APEC economies as potentially presenting a threat. Sources for this information are tabulated in Appendix 2

Table 3.6. Introduced marine species in the APEC region: distribution, origins and vectors.

Species name	Common name	APEC Invasion distribution	Presumed origins	Vector (class)	Vector (detailed)
Acanthogobius flavimanus	Yellowfin goby	USA (California), Australia	East Asia; Japan, China or Korea	Shipping	Ballast water
Acanthophora spicifera	Macroalgae	USA (Hawaii)	Guam	Shipping	Hull fouling
Acartia omorrii	Japanese copepod	Chile	Japan	Shipping	Ballast water
Alexandrium catenella	Toxic dinoflagellate	Australia, Japan, Korea, Russia (east coast), China, Hong Kong, Chinese Taipei, Chile, Peru, Mexico, USA, Canada	Unknown native range, thus invasion distributions are in fact cryptogenic	Shipping	Ballast water
Alexandrium minutum	Toxic dinoflagellate	Australia, China, Malaysia, Thailand, Vietnam, Philippines, Chinese Taipei, Hong Kong, Indonesia	Unknown native range, thus invasion distributions are in fact cryptogenic	Shipping	Ballast water
Alexandrium tamarense	Toxic dinoflagellate	Australia, New Zealand, Indonesia, Malaysia, Thailand, Vietnam, China, Hong Kong, Chinese Taipei, Philippines, Japan, Korea, Russia (east coast), USA (Alaska), Canada	Unknown native range, thus invasion distributions are in fact cryptogenic	Shipping	Ballast water
Ascidiella aspersa	Solitary ascidian	Australia, New Zealand, USA	Unknown	Shipping	Hull fouling
Asterias amurensis	Northern Pacific sea star	Australia	North West Pacific, Japan	Shipping	Ballast water Hull fouling
Astrostole scabra	Sea star	Australia	New Zealand	Fisheries	Accidental with oyster shipments
Arcuatula demissa	Atlantic mussel	USA	Unknown	Fisheries	Accidental with oyster shipments
Balanus amphitrite	Barnacle	Japan, USA (Hawaii and west coast), New Zealand, Australia	Unknown	Shipping	Ballast water, ship fouling
Balanus eburneus	Ivory barnacle	Japan	Unknown	Shipping	Ballast water, ship fouling
Balanus improvisus	Barnacle	Australia, Japan, USA, Singapore, New Zealand	Northwest Atlantic	Shipping	Ship fouling, oil platform fouling, accidental with oyster farming
Balanus reticulatus	Barnacle	New Zealand	Unknown	Shipping	Ship fouling, oil platform fouling
Batillariaa attramentaria	Japanese false cerith	USA	Japan	Fisheries	Accidental with oyster shipments for aquaculture
Blackfordia virginica	Black Sea jelly fish	USA	Unknown	Shipping	Ballast water, hull fouling

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Table 3.6. Introduced marine species in the APEC region: distribution, origins and vectors….continued.

Species name	Common name	APEC Invasion distribution	Presumed origins	Vector (class)	Vector (detailed)
Boonea bisuturalis	Two-groove odostome	USA	Unknown	Shipping	Ballast water
				Fisheries	Accidental with oyster farming
Botrylloides leachi	Colonial ascidian	Australia, New Zealand, Indonesia	Unknown	Shipping	Hull fouling
Buscytopus canaliculatus	Conch	USA	Unknown	Fisheries	Aquarium, accidental with oyster farming
Callinectes sapidus	Blue crab	Japan	Canada, Europe	Shipping	Ballast water, hull fouling
				Fisheries	Intentional release
Capitella capitella	Polychaete worm	Australia, Brunei Darussalam	Unknown	Unknown	Unknown
Carcinus maenas	Green crab, European shore crab	Australia, USA Canada	Europe, Greenland and waters above Canada	Shipping	Ballast water
				Fisheries	Bait (seaweed with bait)
				Natural	Range extension
Caulerpa taxifolia	Green seaweed	Southern Australia, USA	Native in Asia, Northern Australia, Western Africa, India	Ornamental	Aquatic plant shipments
				Fisheries	Gear
Centropages abdominalis	Japanese copepod	Chile	Japan	Shipping	Ballast water
Chelura terebrans	Amphipod	USA, New Zealand	Unknown	Shipping	Hull fouling
Ciona intestinalis	Sea vase	Australia, Chile (II-IV Regions), China Sea, NE Pacific, New Zealand, Peru	N Atlantic, Europe	Shipping	Ballast water, ship fouling
Cirolana harfordi	Speckled pill bug	Australia	East Asia	Shipping	Ship fouling
Corbula gibba	European clam	Australia	Europe/Mediterranean, North East Africa	Shipping	Ballast water
Crassostrea gigas	Pacific oyster	Australia, New Zealand, Canada, USA, Mexico, Peru, Chile	Native region encompasses NW Pacific	Fishery	Intentional introduction for aquaculture purposes
Crepidula fornicata	Slipper limpet	USA, Japan		Shipping	Ballast water, ship fouling
				Fisheries	Accidental with oyster farming
Cryptosula pallasiana	Bryozoan	Japan, New Zealand, Australia, USA	Unknown	Shipping	Ship fouling
				Fisheries	Accidental with oyster farming
Dinophysis spp. (*D. acuta, D, acuminata, D. rotunda*)	Toxic dinoflagellate	Chile	Unknown	Shipping	Ballast water

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Table 3.6. Introduced marine species in the APEC region: distribution, origins and vectors....continued.

Species name	Common name	APEC Invasion distribution	Presumed origins	Vector (class)	Vector (detailed)
Diadumene lineata	Orange striped green anemone	New Zealand, USA		Shipping	Ballast water, hull fouling
				Fisheries	Accidental with oyster farming
Eriocheir sinensis	Chinese mitten crab	USA	China, Korea, Yellow Sea	Fisheries	Intentional introduction
				Shipping	Ballast water, ship fouling
Enerocytozoon salmonis cofactor with the retrovirus PL		Chile	Unknown	Fisheries	Accidental with aquaculture imports
Exopalaemon carinicauda	Asian shrimp	USA	China, Korea	Unknown	Unknown
Gymnodinium catenatum	Toxic dinoflagellate	Australia, New Zealand, Mexico, Malaysia, China, Thailand, Indonesia, Philippines	Unknown native range, thus invasion distributions are in fact cryptogenic	Shipping	Ballast water
Gonodactylaceus mutata	Mantis shrimp	USA (Hawaii), Australia		Shipping	Ship fouling
Hydroides elegans	Serpulid polychaete	New Zealand, Australia, USA (Hawaii)	Cryptogenic in Japan, China, SE Asia and Australia	Shipping	Ship fouling
Hydroides sanctaecrucis	Serpulid polychaete	Australia, USA (Hawaii)	Caribbean, North –Eastern South America	Shipping	Ballast water and ship fouling
Hypnea musciformis	Brown macroalgae	USA (Hawaii)		Fisheries	Intentional introduction
Infectious Pancreatic Necrosis Virus (IPNV)	Chile, Japan, Mexico	Unknown	Unknown	Fisheries	Accidental with aquaculture imports
Kappaphycus alverezeii	Red macroalgae	USA (Hawaii)		Fisheries	Intentional introduction
Kappaphycus striatum	Red macroalgae	USA (Hawaii)	Unknown	Fisheries	Intentional introduction
Lates calcarifer	Giant perch	Brunei Darussalam	Thailand, Malaysia	Fisheries	Intentional introduction
Limnoithona sinensis	Cyclopoid copepod	USA	Native in Australia	Shipping	Ballast water
Limnoperna fortunei	Golden mussel	Hong Kong, Japan, Chinese Taipei	Native in South East Asia	Shipping	Ballast water, potable water
Limnoria quadripunctata	Wood boring isopod	USA , Australia, New Zealand, Chile	Native in Australia	Shipping	Ship fouling
Limnoria tripunctata	Wood boring isopod	New Zealand, NE Pacific	Native in Australia	Shipping	Ship fouling
Littorina saxatlis		USA	Unknown	Accidental	Bait packaging
Lumbricillus lineatus		Canada	Unknown	Shipping	Ballast water, ship fouling
Maeotias marginata	Sarmatic hydroid	USA	Unknown	Shipping	Ballast water
Maoricolpus roseus	New Zealand screw shell	Australia	New Zealand	Fisheries	Accidental with oyster farming

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Table 3.6. Introduced marine species in the APEC region: distribution, origins and vectors....continued.

Species name	Common name	APEC Invasion distribution	Presumed origins	Vector (class)	Vector (detailed)
Marenzelleria viridis	Red gilled mud worm	USA (west coast)	Native in east coast of USA	Shipping	Ballast water, ship fouling
Membranipora membranacea	Bryozoan	Australia	North Pacific	Unknown	unknown
Monodon baculovirus (MBV)		Indonesia, China, Chinese Taipei	Unknown	Fisheries	Accidental with aquaculture imports
Mugilogobius parvus	Least mullet goby	USA (Hawaii)	Philippines, Chinese Taipei	Shipping	Ballast water
Musculista senhousia	Asian clam/mussel	NE Pacific, Canada, Mexico, New Zealand, Australia	Native in East Asia, cryptogenic in South East Asia	Fisheries	Accidental with oyster farming
				Shipping	Hull fouling, ballast water
Mya arenaria	Atlantic clam	NE Pacific, USA (Alaska)	North Atlantic	Fisheries	Accidental with oyster farming
				Shipping	Hull fouling, ballast water
Mytilopsis sallei	Black striped mussel	Australia, Indonesia, Singapore, Thailand, Malaysia, China, Chinese Taipei, Vietnam	Gulf of Mexico, Caribbean	Shipping	Hull fouling
				Fisheries	Fishing gear fouling, mariculture gear fouling
Mytilus galloprovincialis	Mediterranean mussel	Australia, NE Pacific, Japan, China, Hong Kong,	Mediterranean, Eastern Atlantic	Shipping	Ballast water, ship fouling
Neanthes succinea	Pileworm	USA (west coast and Hawaii), Australia, Japan, Vietnam, South China Sea	Europe	Shipping	Ballast water, ship fouling
Nuttallia obscurata	Japanese mahogany clam	USA(west coast), Canada	Korea and Japan	Shipping	Ballast water
Oithona davisae	Asian copepod	Chile, USA (San Francisco Bay)	Unknown	Shipping	Ballast water
Okenia plana	Dorid nudibranch	Australia, New Zealand, USA (California)	Unknown	Fisheries	Accidental with oyster farming
				Shipping	Hull fouling, ballast water
Oncorhynchus kisutch	Coho salmon	Chile	Unknown	Fisheries	Deliberate introduction for aquaculture- escapees
Oncorhynchus tshawytscha	Chinook salmon	Chile	Unknown	Fisheries	Deliberate introduction for aquaculture- escapees
Paracerceis sculpta	Isopod	Australia	Mexico (west coast)	Shipping	Hull fouling
Patiriella regularis	Sea star	Australia	New Zealand	Fisheries	Accidental with oyster farming
Penaeus stylirostris	Blue shrimp	Brunei Darussalam, Mexico	Unknown	Fisheries	Deliberate introduction for aquaculture
				Unknown	Unknown

Table 3.6. Introduced marine species in the APEC region: distribution, origins and vectors….continued.

Species name	Common name	APEC Invasion distribution	Presumed origins	Vector (class)	Vector (detailed)
Phyllorhiza punctata	Spotted jelly fish	USA	Indo Pacific region	Shipping	Ballast water
Porichthys notatus	Plainfin frogfish	USA		Accidental	Unknown
Potamocorbula amurensis	Asian clam	USA (California)	East Asia (Korea, China, Japan)	Shipping	Ballast water
Procambarus clarkii	Red swamp crayfish	USA	Unknown	Deliberate introduction	Unknown
Pseudodiaptomus forbesi	Chinese copepod	USA (Hawaii)	Unknown	Shipping	Ballast water
Pseudodiaptomus marinus	Asian copepod	USA (Hawaii, west coast)	Unknown	Fisheries	Accidental with oyster farming
				Shipping	Hull fouling, ballast water
Pseudopolydora paucibranchiata	Spionid polychaete	Australia, NE Pacific, New Zealand	Unknown	Fisheries	Accidental with oyster farming
				Shipping	Hull fouling
Pyrodinium bahamense	Toxic dinoflagellate	Brunei Darussalam	Unknown	Unknown	Unknown
Renibacterium salmoninarium		Chile	Unknown	Fisheries	Accidental with aquaculture imports
RV-PJ (virus of *Penaeus japonica*)		Japan	Unknown	Fisheries	Unknown
Sabella spallanzanii	Mediterranean fanworm	Australia, Indonesia	Mediterranean, Eastern Atlantic	Shipping	Hull fouling
Salmo salar	Atlantic salmon	Chile, USA , Canada , Australia	Unknown	Fisheries	Deliberate introduction for aquaculture, escapees
Salmoneus gracilipes	Asian shrimp	USA	Unknown	Shipping	Ballast water
Schizoporella unicornis	Lace coral	Australia, USA	Asia, Japan	Shipping	Ship fouling
				Fisheries	Accidental with oyster farming
Spartina alterniflora	Saltmarsh cordgrass	USA, Canada	Unknown	Natural dispersal	Range extension
				Accidental	Unknown
Spartina anglica	Rice grass	Australia, New Zealand, USA,	Hybrid species	Agriculture	Deliberate out planting
Sphaeroma quoyanum	Marine pillbug	USA	Australia	Accidental	Unknown
Styela clava	Sea squirt	Australia, NE Pacific,	NW Pacific	Shipping	Ballast water, hull fouling
				Fisheries	Accidental with oyster farming
Taura Syndrome Virus (TSV)		USA (Hawaii), Mexico, Chinese Taipei	Unknown	Fisheries	Accidental with aquaculture imports
Teneridrilis mastix	Chinese worm	USA	Unknown	Shipping	Ballast water

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Table 3.6. Introduced marine species in the APEC region: distribution, origins and vectors....continued.

Species name	Common name	APEC Invasion distribution	Presumed origins	Vector (class)	Vector (detailed)
Terebrasabella heterouncinata	Sabellid polychaete	USA	South Africa	Fisheries	Abalone shipments for mariculture
Teredo navalis	Naval shipworm	Canada (British Columbia)	Atlantic Ocean	Accidental	Unknown
				Natural dispersal	Range extension
Theora fragilis		USA	Unknown	Shipping	Ballast water
Tilapia zilli	Red belly tilapia	NW Pacific, NE Pacific	Unknown	Ornamental	Aquarium release
Undaria pinnatifida	Wakame	Australia, New Zealand, USA	Japan, Korea, China	Shipping	Ballast water, hull fouling
Urosalpinx cinerea	American whelk tingle	USA , Canada	Unknown	Natural dispersal	Range extension
Vibrio cholera 01 stereotype Inaba, biotype El Tor		Peru, USA (Gulf coast) Mexico, Chile, Asia	Asia for the Peru epidemic and Latin America for the USA (Gulf coast) epidemic	Water	Water systems, ballast water, ship nonpotable waters
					Consumption of raw seafood
White spot syndrome virus (WSSV)		Japan, China, Chinese Taipei, Mexico, Philippines, Thailand, Peru	Unknown	Fisheries	Imported bait used for sport fishing (Chinese Taipei, Japan), direct import of infected broodstock and post larvae for shrimp culture (Mexico)
Yellowhead virus (YHV)		Thailand, Indonesia	Unknown	Fisheries	Imported shrimp
Zostera japonica	Japanese eel grass	USA	Unknown	Fisheries	Accidental with oyster farming
Non-specified	Red algae	China	Europe	Shipping	Ship fouling
				Fisheries	Aquaculture imports
Non-specified	Shrimp	China	Japan	Unknown	Unknown
Non-specified	Bivalve	China	USA	Unknown	Unknown
Non-specified	Fish	China	Unknown	Unknown	Unknown

Table 3.7. Introduced marine species in the APEC region: Observed and potential impacts.

Species name	Common name	Species specific traits	Impacts on ecology	Impacts on human health	Impacts on economic activity	Existing management approaches
Acanthogobius flavimanus	Yellowfin goby	Competes for space and food with native species	Habitat change, food/prey	None	Unknown	None in place
Acanthophora spicifera	Macroalgae	Competes for space with native species	Habitat change	None	Probable, aesthetic	None in place
Acartia omorrii	Japanese copepod	Opportunistic	Probable, Food/prey, habitat change	None	Probable	None in place
Alexandrium catenella	Toxic dinoflagellate	Toxins are bioaccumulated in fish, molluscs, crustaceans, polychaetes and some echinoderms	Toxic	PSP – sickness and mortality	Health, artisanal fisheries, tourism, mariculture,	Farm, and wild harvesting closures Action plans Research and monitoring
Alexandrium minutum	Toxic dinoflagellate	Toxins are bioaccumulated in zooplankton, shellfish and crabs	Toxic	PSP – sickness and mortality	Fisheries, mariculture, health	Farm, and wild harvesting closures Research and monitoring
Alexandrium tamarense	Toxic dinoflagellate	Toxins are bioaccumulated in zooplankton and shellfish	Toxic	PSP – sickness and mortality	Fisheries, mariculture, health	Farm, and wild harvesting closures
Ascidiella aspersa	Solitary ascidian	Nuisance fouling species	Habitat change	None	Shipping, fisheries, recreational boating	None in place
Asterias amurensis	Northern Pacific sea star	Prey on a wide range of native animals, effect recruitment of native shellfish population	Habitat change, food/prey	None	Mariculture production	Physical removal
Astrostole scabra	Sea star	Prey on scallops and oysters	Habitat change, food/prey	None	Mariculture production, fisheries	None in place
Arcuatula demissa	Atlantic mussel	Dominant competitor, harmful to bird life	Habitat change, toxic	None		None in place
Balanus amphitrite	Barnacle	Nuisance fouling species	Habitat change	None	Shipping, fisheries, recreational boating	None in place
Balanus eburneus	Ivory barnacle	Nuisance fouling species, harmful	Habitat change	None	Shipping, fisheries, recreational boating	None in place
Balanus improvisus	Barnacle	Nuisance fouling species	Habitat change	None	Shipping, fisheries, recreational boating	None in place
Balanus reticulatus	Barnacle	Nuisance fouling species	Habitat change	None	Shipping , fisheries, recreational boating	None in place

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Table 3.7. Introduced marine species in the APEC region: Observed and potential impacts…continued.

Species name	Common name	Species specific traits	Impacts on ecology	Impacts on human health	Impacts on economic activity	Existing management approaches
Batillaria attramentaria	Japanese false cerith	Dominant competitor	Habitat change	None	Probable, fisheries	None in place
Blackfordia virginica	Black Sea jelly fish	Opportunistic	Habitat change, food/ prey	None	Probable	None in place
Boonea bisuturalis	Two-groove odostome	Ectoparasite of oysters, bivalves and gastropods	Parasitism	None	Probable, mariculture and fisheries	Unknown
Botrylloides leachi	Colonial ascidian	Competitor, nuisance fouling species	Habitat change, food/prey	None	Shipping , fisheries, recreational boating	None in place
Buscytopus canaliculatus	Conch	Possible competitor, fouling species	Habitat change, food/prey	None	Shipping , fisheries, recreational boating	None in place
Callinectes sapidus	Blue crab	Known predator, competitor and host for *Loxothylacus texanus*	Habitat change, food prey	None	Possible fishery being considered	None in place
Capitella capitella	Polychaete worm	Unknown	Probable	None	Probable	None in place
Carcinus maenas	Green crab, European shore crab	Voracious predator of a wide range of species, including native shellfish	Predation	None	Mariculture and fisheries	Manual removal
Caulerpa taxifolia	Green seaweed	Smoothers other plant life in area it invades, reduces available habitat for fish and other species	Habitat change	None	Fisheries, tourism	Physical removal, chemical removal, prevention, eradication, education, legislation
Centropages adbominalis	Japan copepod	Opportunistic species	Habitat change	None	Probable	None in place
Chelura terebrans	Amphipod	Burrows into wooden structures. Feeds on wood boring isopods fecal pellets.	Unknown	None	Life of wooden structures decreased	Unknown
Ciona intestinalis	Sea vase	Aquaculture nuisance	Probable	None	Mariculture nuisance	Unknown
Cirolana harfordi	Speckled pill bug	Can reach high population densities	Habitat change	None	Mariculture, fisheries	None in place
Corbula gibba	European clam	Can reach high population densities, competitor, affects native species recruitment (e.g., scallops)	Habitat change, food/prey	None	Mariculture, fisheries	None in place
Crassostrea gigas	Pacific oyster	Forms dense aggregations, resulting in the exclusion of other species	Habitat change, food/prey	None	Mariculture, fisheries	None mentioned
Crepidula fornicata	Slipper limpet	Competitor, reduces growth in mariculture productions, benthic modifier	Habitat change, food/prey	None	Mariculture	Unknown

Table 3.7. Introduced marine species in the APEC region: Observed and potential impacts.....continued.

Species name	Common name	Species specific traits	Impacts on ecology	Impacts on human health	Impacts on economic activity	Existing management approaches
Cryptosula pallasiana	Bryozoan	Competitively excludes slower growing natives	Habitat change	None	Probable	None in place
Dinophysis spp.	Toxic dinoflagellate	Bloom forming species	Toxic	DSP- illness	Health, artisanal fisheries, tourism, mariculture,	Farm and wild harvesting closures
Diadumene lineata	Orange striped green anemone	Harmful, potential to dominate the biota	Habitat change	None	Probable, fisheries	Unknown
Enerocytozoon salmonis cofactor with the retrovirus PL		Causes high mortalities on both salmonoids and native fishes	Mortality	None	Mariculture losses	Action plans, monitoring, prevention
Eriocheir sinensis	Chinese mitten crab	Alter marine communities, erode shorelines	Habitat change	Lung fluke vector	Fisheries, health, water schemes	Ban on importation, physical removal
Exopalaemon carinicauda	Asian shrimp	Opportunistic	Habitat change, food/prey	None	Possible	Unknown
Gymnodinium catenatum	Toxic dinoflagellate	Toxins are bioaccumulated in shellfish	Toxic	PSP – sickness and mortality	Fisheries, mariculture, health	Farm and wild harvesting closures
Gonodactylaceus mutata	Mantis shrimp	Competitor with native species	Habitat change, food/prey	None	Unknown	Unknown
Hydroides elegans	Serpulid polychaete	Nuisance fouling species	Habitat change	None	Shipping , fisheries, recreational boating	Unknown
Hydroides sanctaecrucis	Serpulid polychaete	Nuisance fouling species	Habitat change	None	Shipping , fisheries, recreational boating	Unknown
Hypnea musciformis	Brown macroalgae	Competitor	Habitat change	None	Tourism, fisheries	Unknown
Infectious Pancreatic Necrosis Virus (IPNV)		A highly contagious viral disease for salmonoids and native fishes	Mortality	None	Mariculture losses	Action plans, monitoring, prevention
Kappaphycus alverezeii	Red macroalgae	Competitor	Habitat change	None	Tourism, fisheries	Unknown
Kappaphycus striatum	Red macroalgae	Competitor	Habitat change	None	Tourism, fisheries	Unknown
Lates calcarifer	Giant perch	Competitor	Habitat change, food/prey	None	Fisheries	None in place
Limnoithona sinensis	Cyclopoid copepod	Opportunistic	Habitat change, food/prey	None	Tourism	Unknown
Limnoperna fortunei	Golden mussel		Significant impacts	None	Probable	Unknown
Limnoria quadripunctata	Wood boring isopod	Damages wooden structures	Unknown	None	Tourism, port infrastructure	Unknown

Table 3.7. Introduced marine species in the APEC region: Observed and potential impacts.....continued.

Species name	Common name	Species specific traits	Impacts on ecology	Impacts on human health	Impacts on economic activity	Existing management approaches
Limnoria tripunctata	Wood boring isopod	Damages wooden structures	Unknown	None	Tourism, port infrastructure	Unknown
Littorina saxatilis			Significant impacts	None	Probable	Unknown
Lumbricillus lineatus		Unknown	Unknown	Unknown	Unknown	Unknown
Maeotias marginata	Sarmatic hydroid	A predator and competitor, predates on native eggs and larvae	Habitat change, food/prey, Predation	None	Probable, fisheries, tourism	Unknown
Maoricolpus roseus	New Zealand screw shell	Can form dense populations,	Habitat change	None	Possible, fisheries	None in place
Marenzelleria viridis	Red gilled mud worm	A competitor, causes displacement on native species, a benthic modifier	Habitat change, food/prey	None	Probable, fisheries	Unknown
Membranipora membranacea	Bryozoan	Increase potential for surge damage	Significant ecological damages	None	Probable, fisheries, tourism,	Unknown
Monodon baculovirus (MBV)		Cause of mass mortalities of prawns	Mortality	None	Mariculture losses	Action plans, monitoring, prevention
Mugilogobius parvus	Least mullet goby	Space competitor	Habitat change	None	Unknown	None in place
Musculista senhousia	Asian clam/mussel	Can form dense populations, dominator species and can exclude native species	Habitat change	None	Fisheries, mariculture, is consumed in China and used as bait in Japan	Unknown
Mya arenaria	Atlantic clam	Tourism nuisance		None	Tourism	None in place
Mytilopsis sallei	Black striped mussel	Forms dense monospecific groups that exclude other species	Habitat change, food/prey	None	Fouling of port infrastructure, fishing gear, mariculture, boats	None in place
Mytilus galloprovincialis	Mediterranean mussel	Competitor	Habitat change, food/prey	None	Harmful to aquaculture	None in place
Neanthes succinea	Pileworm		Habitat change, food/prey	None	Probable	None in place
Nuttallia obscurata	Japanese mahogany clam	Unknown	Habitat change, food/prey	None	Probable	None in place
Oithona davisae	Asian copepod		Habitat change, food/prey	None	probable	None in place
Okenia plana	Dorid nudibranch	Unknown	Habitat change, food/prey	None	Unknown	None in place

Table 3.7. Introduced marine species in the APEC region: Observed and potential impacts.....continued.

Species name	Common name	Species specific traits	Impacts on ecology	Impacts on human health	Impacts on economic activity	Existing management approaches
Oncorhynchus kisutch	Coho salmon	Competitor with native species for food and space	Habitat change, food/prey	None	Yes, no details	None in place
Oncorhynchus tshawytscha	Chinook salmon	Competitor with native species for food and space	Habitat change, food/prey	None	Yes, no details	None in place
Paracerceis sculpta	Isopod	Competitor with native species for food and space	Habitat change, food/prey	None	Unknown	None in place
Patiriella regularis	Sea star	Competitor with native species for food and space	Habitat change, food/prey	None	Unknown	None in place
Penaeus stylirostris	Blue shrimp	In Mexico, it has brought pathogens with it	Introduced pathogens	None	Fisheries, mariculture	Research and monitoring, Effluent controls,
Phyllorhiza punctata	Spotted jelly fish	Predates on native species eggs and larvae	Food/prey, predation	None	Fisheries, mariculture	None in place
Porichthys notatus	Plainfin frogfish			None		None in place
Potamocorbula amurensis	Asian clam	Can reach high densities and displace native species	Habitat change	None	Impacts on all activities within the invaded estuaries	None in place
Procambarus clarkii	Red swamp crayfish	Habitat modifier, predator and an economic pest	Habitat change, predation	None	Industries	None in place
Pseudodiaptomus forbesi	Chinese copepod	Associated with a decline in native species	Habitat change	None	Fisheries	None in place
Pseudodiaptomus marinus	Asian copepod	Opportunistic	Habitat change, food/prey	None	Fisheries	None in place
Pseudo-nitzschia spp.	diatom	Toxins are bioaccumulated in shellfish	Toxic	ASP, illness and mortality	Fisheries, mariculture, health	Unknown
Pseudopolydora paucibranchiata	Spionid polychaete	Competitor	Habitat change, food/prey	None	Fisheries	None in place
Pyrodinium bahamense	Toxic dinoflagellate	Toxins are bioaccumulated in shellfish	Toxic	PSP- illness and mortality	Fisheries, mariculture, health	Research and monitoring
Renibacterium salmoninarium		Absent in native fishes, bacterial kidney disease, affects salmonoids	Mortality	None	Mariculture losses	Action plans, monitoring, prevention
RV-PJ (virus of *Penaeus japonica*)		Cause of mass mortalities of kuruma prawns	Mortality	None	Mariculture losses	Unknown

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Table 3.7. Introduced marine species in the APEC region: Observed and potential impacts.....continued.

Species name	Common name	Species specific traits	Impacts on ecology	Impacts on human health	Impacts on economic activity	Existing management approaches
Sabella spallanzanii	Mediterranean fanworm	Can disrupt the nutrient cycle by interfering with the settling of organic material,	Habitat change,	None	Mariculture and boat owners	Unknown
Salmo salar	Atlantic salmon	Competitor with native species for food and space	Habitat change, food/prey	None	Fisheries	None in place
Schizoporella unicornis	Lace coral	Unknown	Unknown	Unknown	Unknown	None in place
Salmoneus gracilipes	Asian shrimp	Opportunistic	Habitat change, food/prey	None	Unknown	None in place
Spartina alterniflora	Saltmarsh cordgrass	Competitor, faster growth than natives, alter mudflat habitats, effect juvenile invertebrates and seabirds and higher animals	Habitat change (major)	None	Fisheries	Physical removal, education, chemical removal, prevention
Spartina anglica	Rice grass	Competitor, faster growing than natives, effects juvenile fish	Habitat change (major)	None	Fisheries, port infrastructure	Physical removal
Sphaeroma quoyanum	Marine pillbug/ isopod	Erodes shorelines, in Coos bay (USA) it has burrowed into polystyrene, releasing tiny particles into the water	Habitat change	None	Port infrastructure	Unknown
Styela clava	Sea squirt	Unknown	Unknown	Asthmatic effects	Health, mariculture	None in place
Taura Syndrome Virus (TSV)		Mass mortality of prawns	Mortality		Mariculture losses	Unknown
Teneridrilis mastix	Chinese worm	Opportunistic	Habitat change, food/prey	None	None	None in place
Terebrasabella heterouncinata	Sabellid polychaete	Retards growth of host and causes deformation, also has rapid growth into dense populations	Habitat change,	None	Mariculture	Eradication program
Teredo navalis	Naval shipworm	Unknown	Unknown	None	Longevity of port infrastructure	Unknown
Theora fragilis		Opportunistic	Food/prey	None	None	None in place
Tilapia zilli	Red belly tilapia	Negative effects on other cichlids	Predation, food/prey	None	None	None in place
Undaria pinnatifida	Wakame	Highly invasive causes displacement of native species	Habitat change	None	Fisheries, mariculture, shipping, boating	Physical removal, farming

Table 3.7. Introduced marine species in the APEC region: Observed and potential impacts.....continued.

Species name	Common name	Species specific traits	Impacts on ecology	Impacts on human health	Impacts on economic activity	Existing management approaches
Urosalpinx cinerea	American whelk tingle	Oyster drill		None	Mariculture, fisheries	Unknown
Vibrio cholera 01 stereotype Inaba, biotype El Tor		Spreads rapidly	Unknown	Illness, diarrhoea, death	Human health, tourism losses, mariculture losses	Mariculture closures, quarantine, sanitary regulations, surveillance
White spot syndrome virus (WSSV)		High shrimp mortality and disease	Mortality	None	Mariculture losses	Action plans, monitoring, prevention
Yellowhead virus (YHV)		Mass mortality and disease of prawns	Mortality	None	Mariculture losses	Action plans, monitoring, prevention
Zostera japonica	Japanese eel grass	Habitat modifier	Habitat change	None	Fisheries	Prevention, eradication programs
Non-specified	Red algae	No details provided	Yes	yes	yes	None in place
Non-specified	Shrimp	No details provided	Yes	None	None	None in place
Non-specified	Fish	No details provided	None	None	None	None in place

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3.5 REGIONAL PRIORITIES AND HAZARDS SUMMARY

3.5.1 IMPACTS AND MANAGEMENT PRIORITIES

Participants at the APEC Introduced Marine Pest Workshop identified fourteen marine uses and values that were potentially impacted by introduced marine pests. Identified uses were: fisheries (commercial, customary, artisinal, recreational and the fish trade), aquaculture, shipping (international and domestic), marine infrastructure and coastal tourism. Identified values were: biodiversity, social values and human health. Subsequent ranking by eleven APEC economies indicated international shipping, aquaculture and biodiversity to be the most impacted at the domestic and regional level. Human health is seen as being greatly impacted at the regional level but not at the domestic level.

From a management perspective, human health was considered the highest priority for protecting against introduced marine pests of the fourteen marine uses and values. Aquaculture was assigned the second highest priority, with international shipping; fish trade, coastal tourism, biodiversity and commercial fisheries were all assigned a moderate priority. The priorities for protecting marine uses and values did cover the highest impacted marine uses and values, though they were not consistent. This inconsistency between priorities and highest impacted marine uses and values ultimately leaves the region vulnerable to severe destruction and pressures.

3.5.2 VECTORS AND FACTORS AFFECTING MAJOR PATHWAYS

Marine pests are introduced by a diverse array of vectors along an intricate network of pathways. Questionnaires were used to gain an understanding of how the APEC economies ranked the different vectors and pathways. Eleven of the APEC economies ranked the importance of different vectors identified by APEC workshop participants. Shipping related vectors – ballast water and hull fouling – were ranked the highest risk vectors for both international and domestic introductions. Drilling platforms and the live fish trade of aquarium species were seen as additional high risk vectors for domestic introductions. This shows that a greater variety of vectors would need to be managed to control the spread of an introduced species, once it has entered an economy's waters – the initial prevention of an introduced species arriving is easier than its subsequent management.

The frequency or strength of a trade (or recreational) route, or pathway strength, is a major determinant of the hazard associated with a pathway. APEC economies ranked commercial shipping as the most important factor affecting the strength of pathways transporting introduced marine pests. Trading partners and newer (larger and faster) vessels were important factors influencing the strength of international pathways, while oil, gas, mining, aquaculture and fisheries are seen as factors of medium importance affecting both international and domestic pathways. The importance of different pathways changes continuously with the introduction of new trading partners (e.g. China in the 1980s), or changes in technology such as the phasing out of the effective antifoulant TBT.

The differences between individual economies ranking of vectors reflects differences in their maritime trade and transport and illustrates the need for a flexible approach to managing marine pests at the level of individual economies. On the other hand, the commonalities between economies, the importance of a relatively limited number of international vectors, and the different importance placed on the different pathways for domestic vs. international introductions indicates that there is a significant role for a regional response to the marine pest problem in the APEC region.

The questionnaire responses presented in this section provide a valuable first step in identifying the significant vectors and factors influencing the major pathways, however a more detailed and comprehensive assessment will be needed before appropriate and cost-effective management responses are introduced. **The construction of a comprehensive hazard analysis and assessment of APEC member economies and APEC as a whole, using standardised set of analysis** tools is recommended to form a comprehensive tool for future management purposes. Accepting this issue crosses mandates of several APEC working groups, **we recommend that the Marine Resource Conservation Working Group should coordinate activities with relevant working groups.**

3.5.3 DISTRIBUTION OF INTRODUCED MARINE SPECIES

The regional distribution of introduced marine species is analysed in terms of seven groups of marine organisms: (i) Micro algae, (ii) Macro algae, (iii) Sea grass, (iv) Molluscs, (v) Arthropods, (vi) Other Invertebrates and (vii) Fish. Other invertebrates is comprised of all species different from crustaceans and molluscs. Table 3.8 summarises the distribution of the introductions of these seven types of organisms in the APEC region, considering the five sub-regions defined.

From Table 3.8 it is possible to state that the most frequent type of organisms introduced in the APEC region are invertebrates, mainly arthropods and molluscs as well as other invertebrates. Micro algae follow in importance and, fish and macro algae are third in importance. By subregion, North America presents the largest number of identifications, followed by Oceania. The three countries contributing the most to these identifications are USA, Australia and New Zealand. Identifications in North America and Oceania are mainly molluscs, arthropods and other Invertebrates, even though the remaining groups are also represented. Asia and South East Asia present an intermediate number of identifications, mainly Micro algae. South America presents the lowest number of identifications and fairly distributed among all categories/groups with the exception of Macro algae and Sea grass.

Table 3.8. Occurrence of introduced marine species in the APEC region according to their subregion of destination and type

Subregion of Destination	Micro Algae	Macro Algae	Sea grass	Molluscs	Arthropods	Other Invertebrates	Fish	Total
Oceania	6	3	2	10	13	23	2	59
South East Asia	15			5	2	4	1	27
Asia	13	1		9	2	3	1	29
North America	5	6	4	16	14	19	5	69
South America	3			2	4	2	3	14
Total	42	10	6	42	35	51	12	198

A second useful perspective to analyse the distribution of introduced marine species in the APEC region is from the point of view of their presumed origin. Table 3.9 summarises the distribution of introduced marine pests according to their presumed origin by type of organism and subregion.

Table 3.9. Occurrence of introduced marine species in the APEC region according to their subregion of presumed origin and type.

Subregion of Origin	Micro Algae	Macro Algae	Sea grass	Molluscs	Arthropods	Other Invertebrates	Fish	Total
Oceania	Unknown	1		1	4	3		9
South East Asia	Unknown			14		7	3	24
Asia	Unknown	8		11	7	12	4	42
North America	Unknown			1	3	2		6
South America	Unknown							
Total	Unknown	9		27	14	24	7	81

Table 3.9 shows that only five out of the seven groups considered have a defined presumed Subregion of Origin, these are: Macro algae, Molluscs, Arthropods, Other Invertebrates and Fish. Also, it is clear that Micro algae have an unclear origin, as they are mostly seen as having an “unknown native range”, thus increasingly becoming cryptic organisms in the region.

Table 3.9 also shows that Asia and South East Asia seem to be the presumed origin for most of the marine organisms identified, with Molluscs and Other Invertebrates as the most common identifications. Oceania and North America are other relevant presumed origins but with less relative importance than Asia and South East Asia. The groups of more importance, as origin, for Oceania and North America are Arthropods and Other Invertebrates. South America has not been identified as presumed origin for any of the seven groups considered.

The above information suggests that there are sub regions with tendency to contribute with introduced marine species and others to receive them. Asia and South East Asia may be simultaneously contributors and recipients. Oceania and North America show to be more recipients than contributors, even though they do appear contributing introduced marine pests to the region. South America shows to be a recipient rather than a contributor.

The recipient or contributing nature of the subregions may be directly related to the economic activities conducted and their relationship to the marine environment. A general and preliminary analysis of distributions of introduced marine species by vector of introduction may show some common threads on this respect. Table 3.10 summarises the occurrence of introduced marine species by subregion of destination, vector of introduction and type of organisms.

Table 3.10. Occurrence of introduced marine species in the APEC region according to their subregion of destination, vector of introduction and type.

Subregion of Destination	Micro Algae	Macro Algae	Sea grass	Molluscs	Arthropods	Other Invertebrates	Fish	Total
Oceania								
Shipping	5	4		12	16	25	1	63
Fisheries & Aquaculture Imports		2	2	9	2	8	1	24
Ornamental Imports								
Natural Dispersal								
Unknown						2		2
South East Asia								
Shipping	17			5	6	2		30
Fisheries & Aquaculture Imports				8	4	1	1	14
Ornamental Imports								
Natural Dispersal								
Unknown	1				1	1		3
Asia								
Shipping	13	1		10	7	7		38
Fisheries & Aquaculture Imports		1		5	2	1		9
Ornamental Imports								
Natural Dispersal								
Unknown				1	1	1		3
North America								
Shipping	6			13	11	15	2	47
Fisheries & Aquaculture Imports		2	2	11	5	6	2	28
Ornamental Imports				1				1
Natural Dispersal			2	2	2	1		7
Unknown			2		5	1	1	9
South America								
Shipping	3				4	4		11
Fisheries & Aquaculture Imports				2			3	5
Ornamental Imports								
Natural Dispersal								

The highest number of occurrences observed in Table 3.10 is due to the fact that any specific marine organism may be introduced in one destination economy via one or more vectors.

At a first glance the two most important vectors of introduction of introduced marine species in the APEC region are shipping and fisheries and aquaculture Imports. Shipping, including ballast water or a fouling, is by far the most significant vector in all five subregions. Fisheries and aquaculture imports are the second most important vector of introduction with equal relative importance in Oceania, South East Asia, North America and South America. Ornamental imports and natural dispersal are also relevant vectors in North America.

This information reflects the importance of the commercial shipping in the international trade activity conducted among the different APEC economies. It also shows that fisheries and aquaculture are very important economic activities in the APEC region.

Identifications of introduced marine pathogens are common to all subregions, except for Oceania. Asia is the subregion with the largest number of introductions, closely followed in importance by South America, South East Asia and North America. Presumed origin for marine pathogens it is not very clear and varies with specific pathogen specie, with bi-directional reported origins for some of them such as WSSV. In some cases as the TSV and INPV the origins may be traced from outside the APEC economies.

By far, the largest type of marine pathogens identified are those directly related to and affecting aquaculture activities, with fisheries and aquaculture imports being the most important vector of introduction. Some marine pathogens affecting human health have been identified in South America, North America and Asia. The only presumed vector of introduction identified is shipping (via ballast water).

3.5.4 ECONOMIC AND SOCIAL IMPACTS

The main economic and social implications of introduced marine pests are related to their negative or positive impacts on the coastal environments of the economies where they are introduced and actually established. Negative impacts are related to effects on human health, loss of habitats and natural resources and, to decreases in production of economic activities based on marine environments or natural resources such as fisheries, aquaculture and tourism. Impacts on economic activities may be measured by the change (usually decrease) in net social benefits generated by the introduced marine pests effect of the resource base and the added costs of introduced marine pest management. Impacts on human health may be measured by the reduction in working time (therefore in lost revenues) and by additional medical treatment costs. Nonetheless, if the end result is human mortality, the valuation of this impact may be a very difficult task, since it becomes a question of moral values and ethics.

Additional negative impacts may be related to increased maintenance costs of coastal infrastructure (ports, marinas and other) and productive equipment in fisheries, aquaculture or tourism activities. All these have related social impacts through decreases in employment levels in economic activities directly affected by introduced marine pests but also to decreases in people's welfare due to negative changes in the quality of their environments and natural surroundings.

Other sources of negative impacts refer to the need to divert financial resources, labour and scientific and technical capacities from other activities to the management of introduced marine pests. These may be measured in terms of the opportunity cost to economies and societies due to foregone benefits of the use of these resources and people in other activities.

In addition, introduced marine species may have positive impacts in terms of their aesthetic values (Carlton 2001) or to the creation of new activities (fisheries and aquaculture for example) and in terms of increased employment in introduced marine pest management projects and programs, including prevention, control and related research. Knowledge gained on ecosystems and resource dynamics and interactions may also be seen as a positive impact.

In this context, the level of financial resources, labour, technical and scientific capacities and other, assigned to the prevention, control and management of introduced marine pests and their negative

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impacts, may become a major issue in the diverse context of the APEC region. Chiefly because developing economies have restricted levels of resources availability (see Section 2.2).

The final, net outcome of the introduction and establishment of exotic marine organisms will depend on the net result of the subtraction of inter-temporal benefits and costs (negative impacts and additional costs of prevention, control and management) generated. Nonetheless, it is important to recognise that even after introduced marine pests have been managed and controlled, there is still a negative impact on local economies through changes (mostly decreases) in their level of expected socio economic inter–temporal net benefits (see Section 4.2). This, at least from a theoretical point of view, raises the question of changes in welfare equilibrium among economies in the APEC system, and the need for compensations. That is, recipient economies of introduced marine pests will have decreased levels of utility (in a strict economic sense) and they will need a compensation to recover it. This is directly related to the issue of property rights in the sense of defining whether the recipient economy is entitled to a "clean introduced marine pest-free coastal marine environment" or the contributing economy or economies are entitled the right to contribute introduced marine pests, as technical externalities of their main activities. In other environmental issues, such as clean water and clean air, the right has been entitled to the recipients of the negative impacts and the contributor or polluter are required, at least in theory, to compensate the recipient, so they recover their initial level of utility and welfare. Again, this is a moral question that politicians and decision makers will have to resolve.

In the context of economies search for social and economic development and the need to reach higher and sustainable levels of social and economic wellbeing (i.e. sustainable development), introduced marine pest issues and their impacts on the environment, human health and the economy may have are very relevant role in preventing the attainment of desired sustainable development. Thus, social and economic impacts of introduced marine pests and the benefits and costs of their prevention control and management are very important issues to be considered by decision-makers. Therefore, the valuation and evaluation of those impacts and their alternative management strategies may become of central importance when planning and implementing policies and strategies for the APEC economies' sustainable development.

Finally, a preliminary review of observed and presumed impacts of introduced marine species in APEC economies by type of organisms is presented in Table 3.11. Here it is seen that Micro algae (mainly dinoflagellates) are generating impacts on human health through diseases (DSP and ASP) and even mortality (PSP) and these have been observed in all five subregions considered. In addition, and directly related to the human health problems, as these micro algae act through fish and shellfish consumption, fisheries, aquaculture and tourism activities have also been negatively affected through decreases in demand for their products and services. Macro algae have generated negative effects on fisheries and aquaculture activities causing decreases in their productions due to habitat changes. Maintenance costs of shipping and boating have also been increased and demand for tourism services have decreased due to aesthetic values decrease. Subregions with observed occurrences are Oceania and North America. Sea grass has had negative effects on fisheries production and on increased costs of maintenance of ports. Only Oceania has observed occurrences of these effects.

Introduction of exotic Molluscs have caused a variety of effects. Negative effects on fisheries and aquaculture production due to habitat changes have been observed in Oceania, Asia and North America. Increased maintenance costs of fisheries, aquaculture and tourism infrastructure and equipment due to fouling problems have been observed in Oceania, South East Asia and North America. Increase costs of port and marinas wooden structures have also been observed in Oceania, South East Asia and North America. Creation of new fisheries or aquaculture activities (oysters for example), have been observed in Oceania, North America and South America. Arthropods have also caused a variety of effects. Increased maintenance costs in: shipping, recreational boating, fisheries, aquaculture, ports and marinas infrastructure and equipment have been observed in Oceania, South East Asia and North America. Decreased fisheries and aquaculture production due to habitat changes have been observed in Asia and North America.

Table 3.11. Observed and presumed impacts of introduced marine species in the APEC region according to subregion of destination and type.

Subregion of Destination	Micro Algae	Macro Algae	Sea grass	Molluscs	Arthropods	Other Invertebrates	Fish
Oceania	Human Health (PSP, DSP, ASP). Health costs increased Fisheries, Aquaculture & Tourism decreased	Fisheries Aquaculture decreased Shipping & boating costs increased Decreased tourism	Fisheries decreased Port maintenance costs increased	Fisheries of native species decreased New Aquaculture or Fisheries Increased costs in Fisheries & Aquaculture (fouling) Increased costs of port infrastructure and marinas	Shipping & boating costs increased Increased gear maintenance costs in Fisheries & Aquaculture (fouling) Increased maintenance costs of port infrastructure and marinas	Decreased fisheries and aquaculture production Increased maintenance costs in ports, marinas, shipping recreational boating, fisheries and aquaculture	
South East Asia	Human Health (PSP, DSP, ASP). Health costs increased Fisheries, Aquaculture and Tourism decreased			Increased gear maintenance costs in Fisheries & Aquaculture (fouling) Increased costs of port infrastructure & marinas	New Aquaculture Shipping & boating costs increased Increased maintenance costs of port infrastructure and marinas	Increased maintenance costs in ports, marinas, shipping recreational boating, fisheries and aquaculture	New fisheries
Asia	Human Health (PSP, DSP, ASP). Health costs increased Fisheries, Aquaculture and Tourism decreased			Decreased Fisheries & Aquaculture production (oyster)	Fisheries decreased		
North America	Human Health (PSP, DSP, ASP). Health costs increased Fisheries, Aquaculture and Tourism decreased	Fisheries & Aquaculture decreased Shipping & boating costs increased Decreased Tourism		Local Fisheries or Aquaculture decreased New Aquaculture or Fisheries Increased gear maintenance costs in Fisheries & Aquaculture (fouling) Increased maintenance costs of port infrastructure and marinas Increased maintenance costs of coastal private industrial facilities	Shipping & boating costs increased Increased gear maintenance costs in Fisheries & Aquaculture (fouling) Increased maintenance costs of port infrastructure and marinas Decreased Fisheries & Aquaculture Productions	Health (skin irritation) Decreased tourism, fisheries, aquaculture (abalone, oyster) Increased maintenance costs in aquaculture (fouling)	Decreased fisheries production for native species New fisheries
South America	Human Health (PSP, DSP, ASP). Health costs increased Fisheries, Aquaculture and Tourism decreased			New Aquaculture or Fisheries		Increased maintenance costs in aquaculture (fouling)	Decreased fisheries production for native species New fisheries (commercial & sport fishing)

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Other Invertebrates have caused increases in maintenance costs of fisheries, aquaculture, shipping recreational boating, ports and marinas infrastructure and equipment in Oceania, South East Asia, North America and South America. Decreases in fisheries and aquaculture productions have been observed in Oceania and North America. Human health problems and decreased tourism demand have been caused in North America.

Introduction of exotic fish species have caused decreased native fisheries production in North America and South America but have also created new commercial fisheries in South East Asia and South America. Sport fisheries are been created in South America.

Finally, all of the fish pathogens have been introduced through fisheries and aquaculture operations. The primary vector is the direct import of infected broodstock, post larvae, fry etc for aquaculture. The pathogens have a wide distribution throughout the economies that have intensive aquaculture operations. The introductions resulted from economies participating in the international trade of brood, fry and post larval stocks for aquaculture operations. All of the profiled pathogens cause disease and mortality to the cultured marine species. In some cases the pathogens, such as *Infectious Pancreatic Necrosis Virus (IPNV)* also affect native species of fish in addition to the cultured salmonids that they were introduced with. The economic impact of fish pathogens was estimated at US$1 400 million in the developing countries of Asia alone (Subasinghe 1997). Farm operators are financially affected through high stock mortalities. This can lead to retrenchment of workers and severe social implications. Occurrences of these negative impacts have been observed in Asia, South America, South East Asia and North America.

Box 9. *Vibrio Cholera*

***Vibrio cholera* is a significant pathogen that can cause severe human health problems. It is transported via waterways and has been associated with consuming raw seafood and drinking from contaminated water sources (De Paola 1981). It can spread rapidly through areas with poor sanitation and hygiene and was associated with many human deaths. The toxogenic *V. cholera* 01 stereotype, biotype El Tor was introduced into Peru in the early 1990s. It is considered that this may have been associated with ballast water from Asia (where this strain has become endemic) (Kumate *et al.* 1998). The epidemic in Peru 1991 infected 659,731 people, which lead to 4,631 deaths. There were 152 cases and 3 deaths in Chile and 45,497 cases and 524 deaths in Mexico after the cholera epidemic spread throughout Latin America (Kumate *et al.* 1998). This strain was then identified in the USA from ballast water and other water reservoirs in five vessels with a last port of call in Latin America (Kumate *et al.* 1998). The epidemiological evidence loosely associates the spread of cholera with travel and trade routes.**

3.5.5 SUMMARY

The threat of introduced marine pests is real. Marine species are impacting the environment, economic activities and human health. The tables in this section do not contain a comprehensive list of introduced marine species but merely a list of examples of species that have been introduced to new locations and survived, reproduced and had direct impacts on the economic activities, environment or human health. More information needs to be collected on introduced species as well as pathogens. One area that this report lacks is the introduction of marine mammal pathogens. Though this area was not investigated in this report it is recommended that further studies should also include pathogens that affect marine mammals. The potential introduction of cholera should be further investigated, particularly as it has been identified in the APEC region. **We recommend the development of a complete list of introduced marine pests in the APEC region.**

To obtain more information, baseline surveys are needed. A general lack of search effort for introduced marine pests within the APEC region is apparent with only three economies having conducted baseline surveys and one other participating in the Globallast program which performed a baseline survey. **We recommend the undertaking of baseline port surveys of all major trading ports in the APEC region using consistent protocols.**

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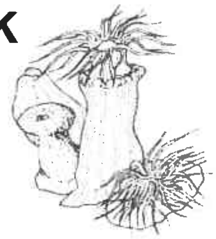
SECTION 4
CONSIDERATIONS FOR A RISK MANAGEMENT FRAMEWORK



Global transfers and introductions of non-indigenous species by human activities are fundamentally altering the earth's biota (Elton 1958; Carlton 1989; Lodge 1993; Norse 1993).

At the November 2001 workshop, APEC economies produced a document: "Elements for a Risk Management Framework" (Appendix 2). Workshop participants emphasised that **Risk Assessment** needed to consider environmental aspects, institutional frameworks, human activities as vectors, and costs to marine related industries. This section presents the elements of a risk management framework for potential use in introduced marine pest management.

4.1 RISK MANAGEMENT FRAMEWORK

There was considerable discussion at the APEC workshop on what constituted a Risk Management Framework. One definition is that of the AS/NZS 4360:1999 Risk Management Standard, which defines a risk management framework as "the culture, processes and structures that are directed towards the effective management of potential opportunities and adverse effects".

Participants of the workshop recognised that in the short term **Risk Management** would be achieved by economies working collectively, to an agreed timeframe, on the common requirements, protocols and procedures for the reduction of the spread and further introduction of introduced marine pests, including micro-organisms and pathogens, across national boundaries. It was recommended that existing frameworks be considered as a basis to manage particular risks. Potentially useful frameworks included: the UN Convention on the Law of the Sea; the IMO Guidelines for the Control and Management of Ships' Ballast Water; the FAO Code of Conduct for Responsible Fisheries, and in particular the Guidelines on a Precautionary Approach to Capture Fisheries and Species Introduction; and the Guiding Principles for the Prevention, Introduction and Mitigation of Impacts of Alien Species from the Convention on Biological Diversity. Participants noted the importance of developing **Cooperative Projects** and **Regional Communication**, and suggested that a regional taskforce and technology and extension centre be established to develop, disseminate, and advise on the use of prevention and control options. It was further recognised that introduced marine pests are also a global issue that require inter-regional cooperation.

As an immediate priority, it was recommended that each economy undertake an analysis to prioritise those aspects of the introduced marine pest problem that should be addressed. A comprehensive analysis for the APEC region should also be carried out in order to identify regional priorities for cooperation that may be additional to economies' most immediate priorities.

To assist the prioritisation, we provide in this section an overview of the invasion process, identify the factors that are increasing the risks of marine pest introductions, and further opportunities for management intervention. Finally, we provide a list of available instruments that address specific intervention opportunities.

4.1.1 OVERVIEW OF THE INVASION PROCESS

The invasion process can be broken down into discrete phases: the pre-border, border and post-border phases (Figure 7, and Table 4.1). Once inside a border, local mechanisms can further spread the invader; these are referred to as secondary, or even tertiary introductions. The border can be the border of a region, an economy or a local jurisdiction i.e. any place on the transport pathway where jurisdiction exists or could be developed to protect areas inside the border. The first border from an APEC perspective would be that of the Pacific Ocean; the second border that of an individual economy or biogeographic province, the third that of a province, port or island.

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In the pre-border phase, the potential introduced species must be available to be taken up in a suitable transport pathway that will move it from its native (or existing introduced) range to a new area. The vectors available to transport potential marine pests were detailed earlier; a summary is given in Table 4.2. The risk posed by a vector is theoretically a function of its frequency, the density of the threatening species at the time and place of contact, the likelihood that the species will be taken up by the vector, and the likelihood that the species will survive the journey. Consequently, any action that reduces the availability (abundance, likelihood of being taken up) or its survival rate in transit, or restricting the transport pathway, will reduce the risk of the potential introduced species arriving at the border. Effective intervention at the pre-border level requires the culture, processes and structures of risk management be functional at the regional level.

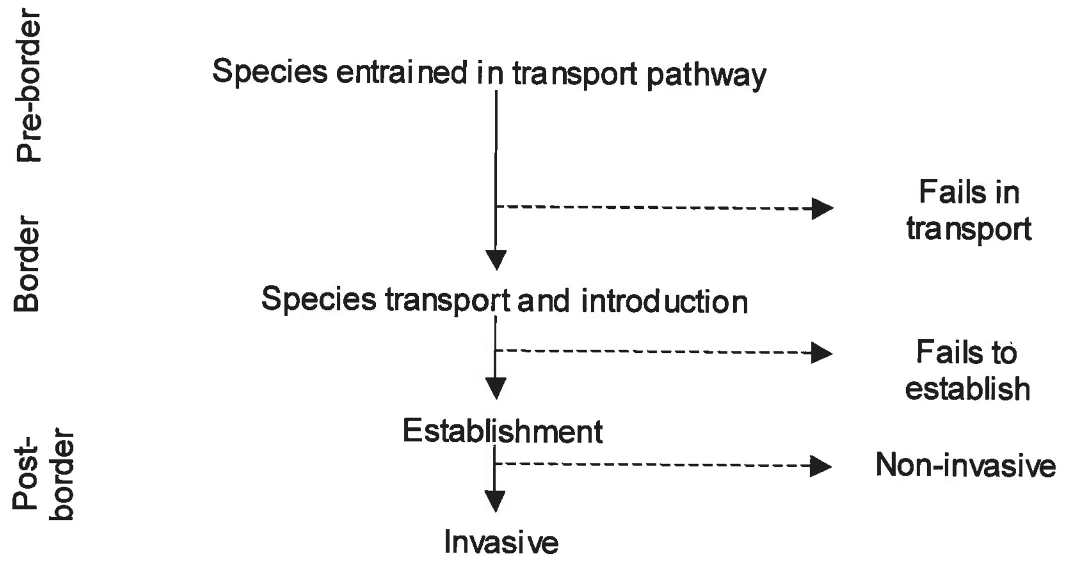

Figure 7. Schematic of invasion process showing steps necessary for an alien species to become invasive. (after Kolar and Lodge 2001).

At the border, the transport vector must be permitted to cross the border and the potential introduced species discharged healthy enough to establish itself. Ballast water containing the species must be discharged, or a fouling organism dislodged, discarded with the medium, drop off, divide or spawn and release gametes or offspring. There are a variety of mechanisms available, and more being developed, to reduce the possibility of a species being discharged. In most cases, they are expensive to implement and manage and they are cost-effective only when applied to transport vectors of known risk. Ideally, a species-specific risk assessment would be in place to estimate the risk posed by an individual vector arriving from a given overseas destination, in a particular season after journey of known duration, and to a particular location. Once the risk level has been estimated, appropriate management actions can be implemented.

Once a viable species has been released into a new environment, it must still establish a viable, reproducing population. To become an introduced pest, it must not only establish, but also reach high population densities. The likelihood of this happening is a function of the species' physiological tolerance, biotic and abiotic variables, environmental resistance and stochastic events. The post-border phase is the first phase at which there are costs of not managing the risks. Managing risk at this, local level will typically require that a framework for risk management be effective at the port or community level, though it may be necessary to call on resources at the economy or regional level for assistance in specific management interventions, such as efforts to quickly eradicate a new invader.

Once an introduced marine species has established in a new region, it is available to be transported by new and probably a more diverse set of local vectors within the economy's border. Once established, it may well adapt physiologically, ecologically or genetically to the local environment, increasing the risk of spread. Increasing spread increases the risk that habitats of high conservation and/or economic value (marine parks, aquaculture sites) will be impacted. These sensitive habitats are typically not directly impacted by international shipping and so are relatively immune from introduced marine species until introduction occurs via local vectors (Wasson *et al.* 2001). Managing the risk at this level is complicated by the diversity of local vectors and may on occasion be reduced to the protection of particularly sensitive or valuable habitats.

Given that at any one time there is estimated to be 10,000 organisms moving around the world in the ballast water of ships (Carlton 1999), it might be expected that the rate of species introductions would be extremely high and that by now all suitable species would have been distributed rapidly around the globe. That this is not the case (a new species establishes in busy ports like San Francisco and Port Phillip Bay on average every 3-6 months; Cohen and Carlton 1995; Hewitt *et al.* 1999), shows how common it is that an organism taken up in ballast water fails to complete the set of steps to become introduced, let alone invasive. This is encouraging and emphasizes the point that managing the risk of introduced species does not have to be about preventing the entry of a new species, but is more usefully directed at reducing the risk of entry and establishment by increasing the already high failure rate at each step. Kolar and Lodge (2001), in a metanalysis of published studies on pest invasions, found the strongest result was that the probability of bird establishment increases with number of individuals released and the number of release events. They extrapolated this result to suggest that therefore even if impossible to halt ballast water releases completely, "reducing the number of individuals released and the frequency of releases will, however, reduce the probability of establishment."

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Table 4.1. The invasion process for unintentional marine introductions

	Pre-border	Border	Post-border	2nd …tertiary introductions
EVENT	Infection (many vectors)	Discharge Spawning Dislodgement Discard	a) Survival b) Establishment (spread, impact)	Invasive characters expressed
RELATIONSHIP	Function of: vector frequency inoculum density vector type vector medium pest density journey duration	Function of: vector frequency inoculum density journey duration vector treatment	a) Function of: physiological tolerance biotic and abiotic variables b) Given survival, Establishment function of: vector frequency inoculum density environmental resistance (and variability) stochastic events	Function of: 2nd transport connectivity infection discharge survival establishment natural spread
CONSEQUENCES			Introduced species present and adapted to local conditions. Regional inoculation rate increased due to decreased journey length, increased variety of suitable vectors, improved match in environmental conditions.	Increased regional adaptation Increased regional inoculation Increased likelihood that sensitive habitats inoculated and damaged
	Regional ⟶	**Economy** ⟶	**Provincial**	

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Table 4.2. Summary of vectors available for transporting introduced marine species.

Source	Vector
Commercial shipping	Ballast water Hull fouling Solid ballast (rocks, sand, etc)
Aquaculture and fisheries	Intentional release for stock enhancement Gear, stock or food movement Discarded nets, floats, traps, trawls, etc. Discarded live packaging materials Release of transgenic species
Drilling platforms	Ballast water Hull fouling
Canals	Movement of species through locks
Aquarium Industry	Accidental or intentional release
Recreational boating	Hull fouling
Dive practices	Snorkelling and dive gear
Floating Debris	Discarded plastic debris

4.1.2 FACTORS CONTRIBUTING TO THE INVASION PROCESS

To offer insights into invasion process, this section integrates information from the hazard analysis as well as introducing new examples and relevant information sources.

4.1.2.1 Change in supply

As the volume of world shipping increases, so does the number and diversity of vectors available to bring introduced marine species to an economy's border (Table 4.3). Shipping carries more than 80 percent of the world trade and in the process, 12 billion tones of ballast water per year. Over the last 30 years, world seaborne trade has more than doubled, from 2490 million tonnes in 1970 to 5 330 million tonnes in 2000 (UNCTAD 2001). Larger vessels with larger ballast tanks and larger surfaces available to carry more fouling organisms are being developed – the currently largest vessels of 7 500 TEU (twenty foot equivalents – i.e. a shipping container), will soon be surpassed by the 9 200 TEU vessels on the drawing board, while 12 500 TEU vessels are planned. The registered merchant fleet now consists of more than 45 000 vessels. New building contracts over the last 5 years will provide an additional 6 000 ships of 300grt and over (UNCTAD 2000 a,b, Lloyd's Register of Shipping cited in Carlton 2001). As the merchant fleet grows, the number of ship visits can be expected to increase (unless a prevalence of larger vessels leads to fewer visits) and the number of species given the opportunity to invade increases with it. For example, it is estimated that more than 10 000 vessels from 300 overseas ports visit Australia's 64 international ports each year (Hayes, *CSIRO unpublished ms*).

While the frequency and strength of traditional vectors, such as shipping, are increasing, new vectors are also developing. The number of recreational yachts moving between economies, regions or around the world is increasing and the routes travelled are diversifying as marine infrastructure in developing economies expands to attract the recreational trade. A recreational yacht is held responsible for the 1999 *Mytilopsis* sp. invasion of Darwin marinas that cost over AUS$2 million to eradicate (Bax 1999; Willan *et al.* 2000; Bax *et al.* in press).

Drilling platforms, used for oil exploration and extraction have introduced fouling and ballast water species in New Zealand and USA (Cranfield *et al.* 1998; Carlton 2001). As oil exploration extends to new areas, further introductions are to be expected.

Many species have been intentionally introduced for aquaculture - a response to the increasing globalisation of the world fish trade. Species released for aquaculture in the Pacific include bivalves (giant clams, oysters, mussels), gastropods (trochus, turbo), fish, crustaceans (penaeid shrimps) and seaweed (Eldredge 1994). Parasites and pathogens of aquaculture species can be introduced unintentionally in association with stock movement (Minchin *et al.* 1995, Minchin 1996). The mud blister worm, *Polydora websteri*, a polychaete that bores into oyster shells, is thought to have been introduced to Hawaii in oyster spat imported from hatcheries on the west coast of America (Eldredge 1994). Similarly, the South African polydorid polychaete that infects abalone was introduced to California through aquaculture movements (Culver and Kuris 2000).

The increasing globalisation of the world fish trade includes the movement of product. Frozen prawn imported to Australia for human consumption, from an area known to have the white spot syndrome virus, was reclassified as bait and thus reintroduced to the marine environment – a case of successful border controls being circumvented by post-border actions. Reintroduction to the marine environment led to the introduction of the highly virulent white spot syndrome virus to Australia. White spot syndrome virus was first reported in Chinese Taipei in 1991-1992 and is now widely spread throughout SE Asia and was introduced via a fish processor to the Americas in 1995. Moving aquaculture and fishing equipment (buoys, nets, etc.) is another vector for species introductions -- *Caulerpa taxifolia* in the Mediterranean Sea is spread by fishing gear (Relini and Trochia 2000).

The speed of conventional shipping is gradually increasing, reducing the time that an organism has to survive in ballast water or on the hull and thereby increasing the chances that it will reach the recipient port in good condition for colonisation. Perhaps the fastest route today is the internet – invasive species such as *Caulerpa taxifolia* can be bought on the internet.

In addition to traffic volume and diversity, the supply of potentially invasive marine species arriving at the borders of APEC economies is increasing because the supply is increasing as new donor ports develop. Every time an invasive species establishes in the port of a trading partner, it increases the risk of that species eventually penetrating borders. This is especially the case when, as with the North Pacific Seastar (*Asterias amurensis*) in Australia, the species enters a new hemisphere and synchronises with the austral or boreal seasons, making it increasingly likely that it will be discharged into neighbouring economies waters at times when its physiological requirements match local conditions. It is for this reason that a coordinated regional approach will enhance effective management of the risk of introduced marine species in the APEC.

4.1.2.2 Change in media

As waters in ports around the globe are becoming cleaner, they are also likely to harbour viable populations of native species ripe for translocation. In addition, these cleaner waters will provide improved living conditions for the long voyage in the ballast tanks of visiting ships.

Reduced use of harmful 'organotins' for anti-fouling paints will occur as a result of the ratification of the International Convention on the Control of Harmful Anti-fouling Systems on Ships on 5 October 2001. Application and re-application of organotin compounds will be phased out by 1 January 2003, and by 1 January 2008 ships will either not have such compounds on their hulls or will have a coating that forms a barrier to the leaching of such compounds. The extent to which this ban increases the level of fouling organisms being carried on ships' hulls will depend on the development of effective and economic alternative antifouling systems.

Larger vessels will provide larger surfaces and larger ballast tanks as temporary habitat for marine invasive species in transit.

4.1.2.3 Change in discharge patterns

As world trade changes so does the pattern of imports and exports. As trade with economies such as China increases, so will the diversity of potentially invasive species carried on ship hulls and in their ballast.

The increasing size of commercial ships will increase their draft and restrict the number of ports that they can enter. Particular ports in a region may end up catering for these larger ships, offloading cargo to smaller vessels for more local transport and in the process changing the patterns of transport of potentially invasive species around the region. Ideally, a regional risk management framework would operate to capitalise on regional patterns in shipping activity concentrating management resources in the areas where it would have the greatest long-term effect, which might not be at the level of the individual economy.

Increasing development of marinas for smaller vessels (recreational, fishing and other commercial activities) and aquaculture sites will increase the contact between international vessels potentially releasing invasive species and local vessels or gear that can either provide suitable habitat or transport the species to a diversity of suitable habitats. One approach that could be considered as part of a risk management is isolating, to the extent possible, vessels that could be bringing introduced marine species into a region, economy or province, from vessels that move around that region, economy or province.

The live fish trade continues to increase both for the culinary and aquarium trades. The transport of live fish, their attendant water, and packing materials has the potential to introduce a new suite of invasive species. Furthermore, the recipient environment is likely to be well outside international ports. This increases the number of vectors and environments that need to be addressed in a risk management framework.

4.1.2.4 Increased survival

Comparatively little research effort has been directed at the factors contributing to the post-border success of introduced marine pests. Once a potential marine pest has entered a new environment through whatever means, it still has to establish. Furthermore, to become a problem the species must become invasive in its new environment. Williamson (1996) proposed the "rule of 10s": 1 in 10 of every species introduced would become established; 1 in 10 of every species established would develop invasive properties – however this does not seem to hold in practice for marine species. Of the more than 250 alien marine species found in Australian waters, only a few have the characteristics of pests (Hewitt *et al.* 1999

Very little is known about the process of establishment and the development of invasive characters in marine species. However, it seems reasonable to assume that since most instances of marine introductions do not result in establishment, that conditions in the receiving environment are important (table 4.3). Additionally, since invasive characteristics may take a long time to develop, it seems reasonable to assume that environmental conditions are important for the development of invasive characters.

The black striped mussel, *Mytilopsis* sp., spawned at least twice in its ~9 month invasion of 2 Darwin marinas in 1999 (Bax *et al.* in press). Gametes and larvae undoubtedly would have been carried out of the marinas by the substantial outflow of water from the marinas during the tropical wet season and as vessels passed through the marina locks. However no mussels were found outside the marinas, suggesting that the marinas provided a unique habitat in an area that was otherwise unsuitable for this mussel. The marinas are freed from the large local tides (up to 8m) and thus provide a novel environment in this area; they are degraded following accidental sewage releases and chemical pollution from customary marina practices; they provide new habitat due to marina structures and the development of seasonal stratification that kills marine species in the surface layers. Any of these factors could have contributed to the successful establishment and development of invasive characters inside, but not outside, the marinas. Novel physical habitats – e.g. piers, breakwaters, seawalls, eutrophied and polluted areas, docks and marinas, boat hulls and ballast tanks – often support assemblages that are distinct from neighbouring communities (Glasby 1999).

The potential for a delay between the establishment of a non-native organism and its development into a pest indicates the importance of a appropriate environmental conditions, either natural fluctuations or as a result of changes in the man-made component. The Chinese mitten crab (*Eriocheir sinensis*) arrived in England in the early part of the 20th Century but did not reach pest proportions until the droughts from 1989 to 1992; the small soft-sediment dwelling bivalve *Musculista senhousia* first appeared in San Diego in the mid-1960s, but it was not until the early 1980s that it could be found in densities of 10,000 m^{-2}, and not until 1995 that densities of 170,000 m^{-2} were recorded in Mission Bay; the wood-boring gribble *Limnoria tripunctata* was introduced into the Long Beach–Los Angeles Harbour area at least one hundred years ago, but it was not until the pollution abatement program in the 1960s that it underwent a population explosion (Crooks and Soulé 1999 and references therein). Zebra mussels (*Dreissena polymorpha*) should have been able to establish in the Great Lakes since the 1920s as it would have been a frequent inoculation in ships' ballast water, but it did not do so until the water quality in the lakes improved (Enserink 1999).

The role of disturbance and the removal or reduction of higher predators (that could control new species entering a community) is an active field of research in invasion biology, but little consensus has been reached. Disturbance by trawling has been shown to be associated with the invasion of particular bays by the introduced gastropod *Crepidula fornicata* (de Mantaudouin *et al.* 2001). Removal of suitable hosts was used as a technique to stop the spread and probably eliminate the abalone mudworm from outside an abalone culture facility in California (Culver and Kuris 1998).

While it has been difficult to link species reduction with invasion success in the marine environment, it has been suggested that introduced species provide new habitat or change existing habitat, creating opportunities for additional new species to establish (Simberloff and von Holle 1999). The New Zealand screwshell *Maoricolpus roseus* which has spread up Australia's east coast since its arrival in Tasmania in the 1920s, provides a long-lasting shell that is home to a particular hermit crab, the presumed increase of which may have at least as much ecological impact as the invader itself, changing the habitat and community composition again, and potentially increasing its invasibility further.

While there is little consensus on what specific factors are the most important in increasing the post-border success of potential introduced marine species, it does seem clear that the changing conditions (environmental, infrastructure, biological) in the marine environment can only increase the opportunities for the establishment of new species and the expression of their invasive characteristics.

4.1.2.5 Lack of action

Once a species has established inside the borders of a region, economy or province, the threat to other areas inside the border is increased. The type and frequency of available potential vectors increase as the travel distance between invaded and non-invaded sites decreases. Areas not visited directly by the international vector become vulnerable to species that could not have reached them directly (Wasson *et al.* 2001). This can occur because of a non-detection of the primary establishment, for example the black striped mussel was only found in Darwin after it had spread to one other marina and then only because of a fortitudinous decision to have a second (wet season) survey of those ports only 6 months after a dry season survey had found no sign of the mussel. The North Pacific seastar (*Asterias amurensis*) was detected in the Derwent estuary, Tasmania but misidentified as a native species for at least 5 years.

Even when an invasive species is detected or known about, scientists and authorities can fail to understand the consequences. This has occurred with the international introduction of aquaculture species that have invasive characteristics (e.g. the Pacific oyster, *Crassostrea gigas* in many areas or the Japanese seaweed *Undaria pinnatifida* in France).

Lack of processes to inform or act on information of newly established invasive marine pests remains a serious impediment to reducing their spread. Although the North Pacific seastar was in plague proportions in the Derwent estuary, no action has been taken to reduce the risk of its spread to other Australian estuaries; New Zealand has imposed ballast water restrictions on vessels carrying ballast water from invaded Australian ports. The seastar has since spread to Port Phillip Bay where its biomass now outweighs that of all fished species. To date, no actions have been taken to reduce the risk of its spread to ports outside Victoria. The case of *Caulerpa taxifolia* in the Mediterranean is an astounding example of inability to act on what may be the worlds most environmentally damaging marine pest invasion (see box 10).

One reason for the repeated failure to understand the consequence or to respond to marine pest invasions, is that true costs of these invasions to the environment, the economy and human health are not well documented; neither are the benefits of responding. Cost-benefit analysis can be used to assess the advantages and disadvantages of a proposed public policy from a broad societal perspective (Dasgupta and Pearce, 1978). It can be especially useful as a tool when there are unmarketed, or unpriced costs and benefits including alterations in environmental services and ecosystem function (Field 1994). However, although there is a variety of techniques for valuing environmental effects that have no direct economic value (e.g. Costanza *et al.* 1997), there are ecosystem services integral to the sustainable functioning of marine systems that are currently beyond the realm of economic valuation techniques; these ecosystem services must also be considered if cost-benefit analysis is to represent broad societal values in valuing the management response to the threat of introduced marine pests (Hite and Gutrich 1999, Bax *et al.* 2001).

Box 10. The history of the invasive marine algae, *Caulerpa taxifolia*, in the Mediterranean

1984	**first discovered (1 site ~ 1m²)**
1989	**authorities informed verbally (1 Ha)**
1990	**authorities informed in writing**
1991	**scientific and media controversy**
1992	**four commissions created (430 Ha)**
1994	***Caulerpa* declared a major threat (1,500 Ha)**
1996	**1996 38 sites (3,052 Ha)**
1997	**control recommended by French Academy (4,630 Ha)**
1998	**UN law recommending all necessary measures to battle invader quickly**
1999	**Covers 97% of suitable surfaces between Toulon and Genes (France, Monaco and Italy)**

(Source: Alex Meinesz 1999)

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Table 4.3. Factors contributing to the invasion process – hazard identification

Pre-border	Border	Post-border	2nd …tertiary introductions
→ **Change in supply** traffic volume traffic diversity traffic speed new trade routes new fisheries new recreation routes new donor ports esp. synchrony **Change in media** reduced antifouling cleaner ballast water larger vessels **Results from** Globalisation mining oil &gas aquaculture aquarium recreation	**Change in discharge patterns** import/export marinas live fish trade	**Increased survival** Changing receiving environment degradation/clean up micro-habitats natural fluctuations (floods) climate change. New (novel) habitat marinas, wharves marine farms oil rigs, etc. Reduced predator control fishing, etc. Increased nutrients Invasional meltdown symbiotic parasitic successional	**Lack of action** Non-detection of primary establishment Lack of recognition of consequences of primary establishment Lack of process to inform regional partners of primary establishment Lack of process to inform national partners of primary establishment Fear of economic consequences of informing trading partners Lack of institutional structures to deal with problem Lack of resources to deal with problem Increased traffic between marine vectors at different scales (region, economy, province)
Regional ——→ **Economy** ————→ **Provincial**			

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4.1.3 INTERVENTION OPTIONS TO SLOW THE INVASION PROCESS

Managing the threat of introduced marine species can be done effectively through a hierarchical approach similar to that used to manage infectious diseases. There are 6 essential elements to this hierarchy: prevention, detection, quarantine, eradication, control, and mitigation (Table 4.4). Ideally managing the threat should occur at the earliest possible time in this hierarchy – interventions generally become more costly and less effective down the hierarchy.

Risk assessment and cost-benefit analysis should play a key role in any control action proposed for marine pests. The risks and benefits of a proposed control action need to be weighed against the risks and costs of doing nothing. It is worth noting that ecological damage is extremely difficult to quantify, and that resorting to a cost-benefit approach without properly costing out such damages could lead to; 1) drawn out discussions as how to cost them, or 2) gross under or overestimations of ecological costs, most likely with little justification. There are clear dangers in going down this path, as opposed to automatically trying to eradicate anything exotic, on the basis that it will always have at least some negative impact, and hence is always an undesirable addition to the local biota. This point is worth discussing] When there is still an opportunity for cost-effective local eradication, this should be seriously considered, almost regardless of current impacts, because it is difficult to predict what future impacts might be (Crooks and Soulé 1999). It is important that the risk assessment is conducted openly – it provides a good opportunity to gain the public and legislative support that will be necessary for most significant control attempts (Bax *et al.* 2001). It will also help establish an acceptable level of indirect ecological damage.

4.1.3.1 Prevention

Most effort to date in managing the risk of introduced marine species has been spent on reducing the amount or frequency of introductions arriving at and passing through the border -- "reducing the number of individuals released and the frequency of releases will, however, reduce the probability of establishment." (Kolar and Lodge 2001). Reducing the rate of introduction is being achieved by managing the vectors (primarily ballast water) and border quarantine for fisheries products, aquarium supplies, etc. Mandatory and voluntary programs to limit the introduction of species in ballast water are in place in the USA, Australia, Canada, Chile, Israel, and New Zealand.

The Australian mandatory ballast water management system is based on a species and vessel visit quantitative risk assessment (Hayes 1998, Hayes and Hewitt 1998, 1999), where the risk of a species being introduced is:

$$\text{Risk}_{\text{species}} = p(\omega).p(\phi).p(\psi).p(\nu)$$

where:

- $p(\omega)$ = probability donor port infected
- $p(\phi)$ = probability vessel infected
- $p(\psi)$ = probability species survives the journey
- $p(\nu)$ = probability species will survive in recipient port

and the risk from a specific vessel is:

$$\text{Risk}_{\text{vessel}} = 1 - \prod_{i=1}^{n} \left[1 - Risk_{\text{species i}}\right]$$

A decision support system implemented by the Australian Quarantine and Inspection Service uses IMMARSAT C communications to contact ships before arrival, requesting a ballast history and other relevant data. The risk assessment decision is automated and the result communicated to the vessel prior to arrival in Australia. The decision support system began operation on 1st July 2001 and has proven effective in defining low risk ships that are not required to exchange ballast water at sea. Continuing refinements will improve the discrimination between low and high-risk vessels.

The GloBallast program of IMO is directed at developing the infrastructure for global management of this vector through surveys of pest populations in demonstration ports and development of risk assessment techniques for ballast water on incoming vessels.

Despite this progress, many nations have little or no regulation of ballast water exchange. This is only anticipated to be 95% effective in removing marine organisms (actual effectiveness will vary highly between taxa, with some such as cyst forming toxic dinoflagellates that form cysts in sediment in the tanks possibly having much less than a 95% reduction). New technologies are required to increase the effectiveness of ballast water management measures; considerable research is being conducted in this area, especially in the USA.

Ballast water is but one of many vectors (see Vector Hazard Identification) and comparatively little is being done to manage vectors other than ballast water. What is urgently needed is a systematic risk analysis of the threat of introduced marine species to the APEC region that includes all vectors. A systematic risk analysis would provide the rationale for directing limited resources for management intervention to those vectors posing the greatest risk and with the greatest potential for effective intervention.

Until a systematic risk analysis is available, preventative measures such as requiring recent hull inspections and adequate antifouling, spatial and seasonal quarantine, and restricting imports of fishery products to areas known to be free of particular diseases, can be implemented. APEC economies' border and quarantine procedures are well established in most instances, although they may need refocusing to ensure that marine pests are dealt with sufficiently. For some trades that are difficult to effectively control – e.g. the aquarium trade and live fish trades – public education may provide one way to reduce the risk of individuals releasing potential pests into the marine environment from their aquaria, bait bucket, or food container. Similarly, where local vessels are responsible for distributing marine pests that have established (e.g. fishing vessels spreading *Caulerpa taxifolia* in the Ligurian Sea, Relini *et al.* 2000) education of the skippers to maintain clean vessels and gear may be one of the few economic methods to reduce the spread.

Post-border preventative actions include restricting the amount of available habitat around international ports, increasing the resistance of native communities and spatial and/or seasonal quarantine. Comparatively simple ways to achieve this may be by locating aquaculture areas, marinas or fishing ports away from international trading ports. Aquaculture areas, marinas and fishing ports all provide increased novel habitats through marine infrastructure, would tend to spread a new pest locally through increased local marine traffic, and may increase nutrient loading that has been implicated in increasing susceptibility to invasion (*Stohlgren et al.* 1999). In areas without the infrastructure to separate international and domestic vessels, visiting international vessels that are identified as high risk may be restricted to offshore high energy environments that would restrict the establishment success of coastal and estuarine invertebrates. The Cocos Keeling Islands used this approach to reduce the risk from recreational yachts that were at high risk of carrying the black striped mussel.

4.1.3.2 Detection

Early detection of established introduced marine pests is vital if management options are to remain open. Ideally, potential marine pests would have been identified before they arrived at a border as part of the risk assessment described above. Early detection requires that major trading partners (for each vector) have regular port surveys to determine the status of introduced marine pests in their waters and inform the international community of their presence. While Australia has undertaken systematic port surveys, few other countries have, although the GloBallast program has started capacity building for this eventuality. A shortage of appropriate taxonomic expertise will complicate species identification in countries without an established marine research infrastructure and regional cooperation will be needed. The soon to be released National Introduced Marine Pests Information System (NIMPIS) and the complementary Smithsonian Environmental Research Centre database are a first step in providing some of the necessary information in a format that can be accessed readily over the internet. Local taxonomic expertise will still be needed.

However, no risk assessment is foolproof and early detection of potential pests that have crossed the border is essential. Routine sampling of all ballast water and ships hulls is technically impractical at present, although technologies (e.g. genetic probes for particular pests in ballast water) are developing. Routine monitoring of ships' hulls can detect those with hulls that are particularly heavily fouled and require that they be cleaned before entering sensitive areas.

Following the expensive eradication of the black striped mussel from Darwin marinas in 1999 (Bax 1999, Whelan et al 1999), the four Darwin marinas were recognised as high-risk areas, and visiting international vessels as high-risk vectors. Since the eradication, all international vessels wishing to enter Darwin marinas are inspected and treated prior to being issued clearance certificates. Entry to the marinas is prohibited without a clearance certificate. Between May 1999 and June 2001, a total of 437 vessels, including 364 yachts, 38 commercial fishing trawlers and 35 apprehended illegal vessels, were inspected. At least four undesirable taxa were detected: a variety of bryozoans (not identified to species), and three molluscs: *Musculista senhousia*, *Perna viridis* and *Mytilopsis* sp. (Bax *et al.* in press).

Once a potential introduced marine pest species has crossed the border and established, early detection is still essential if management options such as eradication or quarantine are to be successful. Early detection of the black striped mussel in Darwin marinas was critical in its eventual eradication there. In many other instances pests have not been detected until it is too late to effectively eradicate them using available technologies; in some cases where initial settlement is widespread in an open area even early detection of establishment is inadequate given available technologies. Early detection of establishment can be part of routine port monitoring program. It can also be part of community monitoring and sampling techniques are being developed to assist communities in this effort. Increased public awareness and participation requires education of the interested public and a system to report likely sightings. The NIMPIS has been developed to facilitate public report in Australia.

4.1.3.3 Quarantine

Quarantine actions can be preventative or responsive. International notification of the presence of pests in an economy's port can assist other economies to anticipate future risks and protect their borders accordingly. New Zealand, for example, has placed restrictions on ships carrying ballast water from areas in Australia where *Asterias amurensis* is rife. These restrictions only apply during the winter and spring when larvae are likely to be present in the water column and susceptible to being picked up in ballast water. Preventative quarantine of international introductions is currently limited by the lack of information on which pests are present at ports around the world. This lack of information can impact the recipient port by reducing their opportunity to manage the risk. It can also impact the donor port if, as has happened at least once, an economy or port is assumed to have a pest, without a survey that confirms the pest's presence.

Preventative quarantine can also be part of regional marine planning, by separating vectors or areas at high risk of containing introduced marine pests from favourable habitat or vectors that would assist its establishment and spread.

Once a marine pest has established, responsive quarantine can be used to restrict (preferably prevent) its spread on vessels or in water currents. Within 3 days of discovering the black striped mussel in 3 Darwin marinas, the Northern Territory government had quarantined the marinas and chlorine was added to the canal between the lock gates, ensuring no larvae could escape. At the same time no vessels were allowed to leave the marinas. One hundred and ninety seven vessels that had been in the marinas and exposed to the mussel, but had since left were tracked, surveyed and treated or hauled out where necessary (Bax *et al.* in press). Prompt effective quarantine was essential in the success of the black striped mussel, reducing the risk of the mussel spreading to open waters, and buying time to determine effective eradication chemicals and protocols.

4.1.3.4 Eradication

Eradication can be successful when the potential pest species is restricted to a small area or habitat. At the border, hulls can be cleaned and ballast water can be treated (although perhaps not as effectively as

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would be desired). Eradication becomes more difficult as the area occupied by the potential species increases – it is expensive to remove large vessels from the water for hull cleaning and this requires special facilities.

Once a marine pest species has established within a border, eradication can be very difficult. There are few documented examples of short-term control of invasive marine pests and they are all relatively recent. Several common factors distinguish the successful from the unsuccessful control attempts for invasive marine pests.

Early detection of the pest is essential. In the successful control programs, the pest was detected at an early stage while its distribution was still limited. The black striped mussel in Darwin was detected within 6 months of its establishment (Bax 1999; Willan *et al.* 2000). The escape of a sabellid polychaete from a southern Californian abalone facility was documented (by a mark and recapture study) in October 1996 and the eradication started in July 1997 while its distribution was still restricted (Culver and Kuris 1998). *Caulerpa taxifolia* was discovered in the Cap D'Or anchorage while there was only 200 m^2 of plants distributed over 1 hectare. Concerted efforts by divers, repeated annually for 3 years, eradicated *Caulerpa* from Cap D'Or, but then it was surrounded by the larger, uncontrolled Mediterranean population (Meinesz 1999).

Conversely, when *Sargassum muticum* was detected on the English coast it was already widely spread and in quite open areas (Critchley *et al.* 1986). Eradication was started but never made significant gains. The original invasive strain of *Caulerpa* was also detected at an early stage, and there appeared to have been at least a 5-year period (1984–1989), when it grew from 1 m^2 to hectare, in which it could have been controlled. However scientific advice was neither consistent nor entirely based on the best available data. Meinesz (1999) characterises the "scientific" discussion taking place in the media as a polemic. This brings us to the second point – managers require well reasoned and impartial advice based on the best available information if they are to mobilise the necessary response in appropriate situations. The rapid response toolbox in the NIMPIS database provides information on all available control and eradication attempts for selected marine species.

Once it has been decided that containment and/or eradication is warranted, a rapid and vigorous response is called for to control the pest while containment is possible and chemical and physical controls can still be effective. Depending on the biology and rate of spread of the organism this will require pre-existing legislative powers. In the example of the black striped mussel eradication in Darwin, Northern Territory fishery officers already had the powers to trespass, seize and, if necessary destroy private property under the Fisheries Act. Existing legislation enabled the Northern Territory government to declare the infected marina a National Disaster area 2 days after being informed of the problem. Quarantine officers at the national level had similar powers once the organism was listed (although due to vagaries of the legislation, it had to be listed as a plant). The legislative powers enabling early quarantine were essential to the success of the eradication.

There must also be a willingness to act at all levels. There will always be reasons advanced for not acting or waiting for further information. At some times this will be appropriate, but as the decision to take action is delayed, the probability of successful quarantine and/or eradication are reduced. It must be established at an early date that the cost of doing nothing is greater then the cost of doing something.

In the two of the three successful documented eradications, there were clear economic risks in allowing the invasion to spread unchecked. In the third successful documented eradication there was a mixture of political, environmental and economic considerations. The black striped mussel in Darwin threatened the Au$250 million dollar pearl oyster fishery, as well as the operation of shoreline infrastructure. The sabellid polychaete in southern California threatened the valuable wild and aquaculture abalone industry. *Caulerpa taxifolia* at Cal D'Or was seen to threaten important tourist opportunities and was also in the domain of a pro-active mayor (Meinesz 1999). Where the risks have been seen as primarily ecological (at least initially) – *Sargassum muticum* on the English coast; *Caulerpa taxifolia* in the Mediterranean – responses have been slower and lacked the committed resources to achieve quarantine or eradication.

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The willingness to act will always depend on the perceived threat balanced against the costs of eradication. In many cases it will be seen as simply too difficult. To increase the capacity to respond to marine pests we must decrease the costs of eradication. Eradication technologies that can be targeted at specific taxa or whose impact can be restricted to localised areas are needed to decrease costs and decrease attendant environmental damage.

4.1.3.5 Control

It is hypothesized that degraded habitats present a greater opportunity for colonisation by exotics. Similar logic suggests that restoring degraded habitats may reduce the prevalence of pest species. While it appears unlikely that restoring degraded habitats would return the original community composition (once a new species has become established, the community has been fundamentally changed), there is support for specific actions to restore habitats that would either reduce a pest's food supply or increase the opportunities for native competitors or predators. It has been shown, for example, that *Asterias amurensis* in the Derwent estuary has increased fecundity in areas of high anthropogenic impacts (Morris 2001). It has been hypothesized that removing this food source could have a significant effect on the egg production of the *Asterias amurensis* population.

Fishing and harvesting are often suggested as potential control mechanisms for introduced marine pests. However, results from marine and other areas are not promising. Either the fishery is not economic and has little detectable impact (e.g. a targeted bounty fishery for *Cancer maenas* on the east coast of the USA, Walton 1997), or it is feared that the fishery will become economically important and the successful fishers will assist the spread of the species or resist its eradication.

Biological control using natural enemies has been proposed as an option for controlling marine invasions (Lafferty and Kuris 1996) and several parasitic castrators have been identified that have the potential to control the European shore crab (*Cancer maenas*) that infests the shores of eastern and western USA, Australia, South Africa, and has recently reached Canada's western shores. A parasitic castrator of the Northern Pacific seastar has also been identified (Goggin and Bouland 1997). The US National Academy of Scientists recommended that "biological control can and should become the primary [pest control] method in the United States" (NAS 1987) and stressed that "the development of biological control as the foundation of pest control in the United States is the most important challenge we face in making safe and efficient use of our managed ecosystems." However, given public skepticism on the success of terrestrial biological control (see Center *et al.* 1998 for review of the successes and failures of biological control), marine biological control will be required to meet the highest standards of scientific rigour and safety.

control using introduced grazers has also been suggested for controlling particularly destructive marine pests. The two most prominent examples are the suggested use of a Caribbean seaslug *Elysia subornata*, to control *Caulerpa taxifolia* in the Mediterranean (Thibaut *et al.* 1998) and the use of the West Atlantic butterfish (*Peprilus triacanthus*) or other gelatinous feeders to control the American comb jelly *Mnemiopsis leidyi*, that was implicated in the crash of anchovy fisheries in the Black and Azov seas (GESAMP 1997). *Elysia subornata* would also consume native *Caulerpa* in the Mediterranean, but as these will probably soon be overwhelmed by the invasive *Caulerpa taxifolia*, there may be little that can be done to protect them in their present environment. Although the butterfish could be a useful control agent of the *Mnemiopsis leidyi* in the Azov and Black Seas it does not prey exclusively on ctenophores (Horn, 1970), so that other, non-target native species also could be affected. The potential impacts of this butterfish on the native zooplankton communities of the Black and Azov seas and of the adjoining seas it would presumably migrate to are strong arguments against its introduction.

Development of biological control in the marine environment is potentially more complicated than in terrestrial or freshwater environments because of the difficulty in conducting restricted field trials in an open physically energetic environment. There are several ways to circumvent this problem and provide a risk averse approach to developing marine biological control options. In the first instance, some parasites, like the parasitic castrator *Sacculina carcinae*, have life histories that require the release and establishment of a female population of the parasite, taking a year or more, before fertilisation by male individuals can occur and produce a second generation. This suggests that the host specificity and impact of this parasitic castrator could be tested before a self-perpetuating population is developed. *Elysia subornata*, proposed as a herbivore control of *Caulerpa taxifolia* should, based on its characteristics in its home range, not survive the cold Mediterranean winters. Its introduction could therefore be potentially reversible, although the history of alien introduction is rife with examples of organisms that have changed their environmental tolerance to suit their new environment.

A second option for developing marine biological control, is the augmentation of naturally occurring parasites in the receiving environment. A recent candidate for this approach is the dinoflagellate parasite, *Parvilucifera infectans*, that infects many species of dinoflagellates including toxic species (Noren *et al.* 1999), but no other plankton species that have been tested. It occurs from Norway to the Mediterranean (and probably elsewhere). Augmentative use of this parasite may be able to shift harmful algal blooms from one species complex to another and as long as it used in an environment where it naturally occurs may have minimal long-term impact. A possible complication with its use is that a close relative, *Perkensis* sp., is an important parasite of shellfish. Other possible candidates for augmentative control exist in *Carcinus maenas*. Augmentative control provides the opportunity for learning about marine biological control in a risk averse manner.

Augmentative control does not just include parasites. Augmentation of naturally occurring grazers, predators and competitors all provide potential opportunities for local control, although it may be difficult to make such progammes cost-effective, unless the proposed control agent has commercial value. Environmental engineering or rehabilitation potentially provides a more economic approach to long-term pest control, although it is worth noting that in some cases, for example the wood-boring gribble *Limnoria tripunctata* in the Long Beach–Los Angeles Harbour, environmental rehabilitation may facilitate the emergence of latent pests (Crooks and Soulé 1999). However there are particular environmental modifications (e.g. concentrated food supplies, closed marinas, elevated temperatures, removal of top predators) that create novel environments. These disturbed or novel environments are likely to be more susceptible to invasion from alien organisms than the undisturbed natural habitat (Rejmánek 1999), but the costs of future invasions have yet to be factored into the cost-benefit analyses of their development or continuation.

Genetic methods offer one of the most promising technologies for the control of destructive marine pests. It is possibly the only approach with the (theoretical) potential to eradicate an established, widely dispersed marine pest. When classical biological control is impractical because of lack of host specificity, or if parasitic castrators cannot reduce population fecundity sufficiently to impact future generations, genetic methods may provide one of the few options for long-term control. Such methods, if feasible, are risk-averse because genetic techniques can be made species-specific. Several genetic approaches have been suggested, including introducing a fatal weakness into a pest population (e.g. *Asterias amurensis*) or engineering baits that inhibit its reproduction.

Terminator genes, while controversial for commercial protection of particular crop strains, may provide a valuable mechanism for controlling populations of otherwise uncontrolled marine pests. Considerable control can be exerted over the time that a terminator gene is expressed by making its expression dependent on the presence of a particular compound – an inducible fatality gene (IFG) (Grewe 1996). However, introgression of a selectively neutral gene into a "wild" population is slow and would require substantial and sustained additions of organisms carrying the IFG (Davis *et al.* 1999). Recent modeling studies have identified genetic constructs that would introgress into a population without being linked to a gene offering selective advantage (Davis *et al.* 2001). Genetic methods require considerable technical development before their feasibility can be realistically determined. There are also major issues regarding their safety and social acceptability that would need to be addressed before any field trials could be undertaken.

4.1.3.6 Mitigation

When eradication of an introduced marine pest species is no longer practical, and when there are no resources or will to develop control techniques, then mitigation of the impacts of the pest is all that remains. Mitigation for impacts of marine pests has been primarily targeted at the protection of local facilities or areas. New Zealand has a program to reduce or eradicate *Undaria pinnatifida* (that infests ports on its eastern seaboard) from its southernmost and westernmost extensions in an attempt to prevent it reaching important marine reserves, and the sub-Antarctic islands (Mike Stuart, Department of Conservation, New Zealand; pers. comm). Some important marine reserves in the Mediterranean are now protected (hand-weeding) against *Caulerpa taxifolia.*

4.1.4 INFORMATION SOURCES AND EXAMPLES OF INTERVENTION PROCESSES

Throughout this report various examples of the different stages of the intervention process have been presented. Table 4.5 categorises these as well as information sources according to their roles within the intervention process. This table provides a guide to different options that may be developed by management at the economy level. It also highlights the absence of responses taken within the APEC region for particular intervention steps. The presences of these gaps indicate potential introduced marine pest introduction or translocation. These information sources, examples and links should be provided via the Internet at a central web page. This would provide and easy and quick way to a catalogue of risk management progress in the region and at the same time provide the full text or links to these.

Other methods for increasing the access to available information sources and examples are through training and exchange programs. Capacity building through joint cooperative projects would enhance the level of awareness and capabilities of each economy. Various international instruments that directly concern introduced marine pest management for specific vectors already offer protocols/frameworks/guidelines for response. After recognising specific risks at the regional and economy level, the adoption and implementation of appropriate existing international conventions at the level of the individual economy should be encouraged.

4.1.5 SUMMARY

This regional risk management framework offers a guide for APEC member economies to follow with their individual management responses to introduced marine pests. The framework also offers an insight into attempts and actions facilitated by select economies. The usefulness of this framework will depend on the whether economies implement or modify existing legislation, regulation and management procedures. In many cases, legislative and regulatory frameworks existing for other identified threats (e.g. Prevention of animal and human disease) could with slight modification, be adapted to manage the risk of introduced marine pests. As APEC has 21 member economies with varying management capabilities, approaches and international obligations, APEC will need to encourage and complement the risk management framework with technical support and capacity building exercises. Documenting the realized and potential costs of introduced marine pests to the environment, economies and health of APEC member economies would emphasize the need to formulate appropriate management responses.

We recommend that APEC economies consider cooperative projects to develop a strategy for managing introduced marine pests in each individual economy and in the APEC region as a whole as the first step in developing a regional response to introduced marine pests. A regional response will provide APEC economies most effective risk reduction, in the absence of a comprehensive global response to this problem. As a first step in developing regional communication and collaboration **we recommend that a central information server be established on the internet to provide information on: potential marine pests, their distributions and vectors; management strategies in place and being developed; response strategies in place and being developed**. This central information server should be a distributed system with nodes in each APEC economy linking to the central server.

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Table 4.4. Intervention options to slow the invasion process

	Pre-border	Border	Post-border	2nd …tertiary introductions
Prevention	Risk Assessment Identify future pests Reduce supply Ballast water treatment Ballast water exchange Hull cleaning Anti-fouling Import restrictions		Reduce available habitat Increase resistance stable communities natural predator load reduce nutrients	Spatial and/or seasonal quarantine
Detection	International reporting	Ballast water sampling Diver inspections Dry-docking Haul out Quarantine inspections	Early detection Port surveys/resurvey Settlement monitoring Community monitoring Public awareness	Regional (national) monitoring program
Quarantine	Area free status	Separate vectors from suitable habitat	Restrict vector movement Enclose area Remove contaminated vessels Destroy contaminated stock	Reduce contact between contaminated and uncontaminated areas, vectors and vector types
Eradication		On shore BW treatment Hull cleaning	Rapid response physical, chemical drain, smother, cook	
Control			Environmental rehab Fishing/harvesting Enhance native predators	Biological control Genetic biological control
Mitigation			Protection and treatment of local facilities	Quarantine and protect vulnerable areas

Table 4.5. Information sources and examples of intervention processes.

	Pre-border	Border	Post-border	2nd …tertiary introductions
Prevention	IMO Resolution A. 868 (20) 1997 IMO new convention (draft) NSW Waterways – Olympics (AUS) Australian ballast water DSS Globallast program NZ Mandatory ballast water reporting and management procedures NZ Ballast water and hull fouling strategy ANZECC Antifouling Code IUCN Guidelines CITES WTO SPS agreement FAO/NACA Guidelines and Beijing Consensus	NZ Import Health Standards ICES Code of Practice LOSC WTO SPS agreement	WTO SPS agreement	DNRE Public education (AUS) QDPI Public education (AUS) Guidebook on Toxic Red Tide Management (PHL) IUCN Guidelines WTO SPS agreement
Detection	International databases NIMPIS/SERC (AUS/USA)	NT Aquatic Pest Management Unit (AUS) CRIMP Port Survey Protocol (AUS) International Health Regulations	NHT Community detection toolkit (AUS) NZ Incursion Response Protocol	Guidebook on Toxic Red Tide Management (PHL)
Quarantine	NZ Import Health Standard for Ships' Ballast Water	NT marinas (AUS)	NT *Mytilopsis* eradication (AUS) NZ Incursion Response Protocol	Code of Practise for Sustainable Shrimp farming (PHL) National action plan for whites spot syndrome virus (PHL) Guidebook on Toxic Red Tide Management (PHL)
Eradication			NT *Mytilopsis* eradication (AUS) CCIMPE Manual (AUS) EMPPLAN (AUS) Rapid Response Toolbox (AUS) NZ Incursion Response Protocol IUCN Guidelines CBD International Health Regulations	CSIRO sterile ferals (AUS)
Control			CBD International Health Regulations	Biological control (AUS) CSIRO sterile ferals (AUS) IUCN Guidelines CBD

Contents

Mitigation			International Health Regulations National Framework for managing *Undaria* (NZ)	

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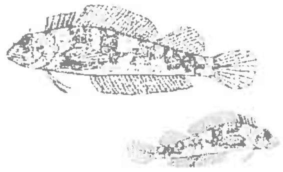
SECTION 5.
CONCLUSION AND RECOMMENDATIONS

The response of society to the problem of invading aquatic nuisance species should improve as we learn from experience, from our successes and our mistakes (Busiahn, 1997).



5.1 THE THREAT OF INTRODUCED MARINE PESTS

Introduced marine pests are one of the top five main threats to the marine environment. The introductions are often accompanied by the devastation of wild fisheries, aquaculture, marine infrastructure, marine ecosystems and human health. There are numerous recorded cases of introduced marine species out-competing or eating native species – reducing the numbers of native species and altering native habitat. Such cases follow a familiar pattern long since recognised in the terrestrial environment, and in light of the severity of these impacts, a number of international initiatives are focusing on alien invasive species, terrestrial and otherwise. These instruments have identified alien invasive species as a major challenge for decision-makers at provincial, economy and regional levels. Introduced marine species and pests are increasingly being recognised through the work of IUCN, IMO, FAO and specific individual economy actions. International instruments and policies designed for the control and prevention of introduced marine pests provide suitable guidelines to be implemented by member parties. The implementation of these at a local level varies throughout the APEC region from significant advances in management practices to a lack of response all together.

Recommendation: ***Introduced marine pests become a standing item for the Marine Resource Conservation Working Group (MRC-WG).***

APEC provides a suitable forum for effectively managing the risks to each economy through a regionally devised response. The Marine Resource Conservation - Working Group needs to accord this problem a high priority by recognising the threat of introduced marine pests and making it a standing item – *act quickly, urgently and together.*

Recommendation: ***APEC (MRC-WG) should liase with relevant international and regional for a, including IMO, FAO, NACA and SPREP, to enhance the effectiveness of regional approaches and of relevant international instruments and their implementation.***

The APEC region encompasses a vast area of the world and economies of varying levels of economic development and political organisation. Using its coverage, APEC should take the opportunity to influence global action regarding introduced marine pests and facilitate the implementation of relevant and useful international instruments into its member economies.

5.2 CURRENT MANAGEMENT OF INTRODUCED MARINE PESTS

The management of introduced marine pests varies considerably throughout the APEC region. The diverse responses are fragmented across the Pacific Ocean; some economies at the forefront of management actions, whereas others barely even recognise that there is a problem.

Recommendation. ***Each economy should dedicate authority to an existing or establishing a new agency, to manage introduced marine pests and to provide reports to the MRC-WG.***

It is clear that effective institutional arrangements, regardless of whether the economy has a centralised or decentralised system of governance, need some degree of devolved or delegated authority to local administrators to effect appropriate risk management arrangements. This raises the question of local capacity and resources to be able to undertake such activities, with these questions equally relevant for all economies. The survey of APEC economies indicates the importance of local authorities in management of maritime areas and activities.

Recommendation. ***Cooperative projects be established to develop a strategy for managing introduced marine pests in each individual economy and in the APEC region as a whole, as a first step in developing a regional response to introduced marine pests.***

5.3 PRIORITIES AND HAZARDS FOR APEC ECONOMIES

The perceived risk associated with different pathways and vectors was measured in this project using simple ranking methods. In reviewing responses by economies, it is evident that the level of risk associated with identified hazards is diverse. This variation is due to the characteristics of the economies' markets and industries and their location. Recognising this variation is imperative in any form of regional management approach. Nonetheless several hazards stood out as high-risk vectors. These concerned commercial shipping and were chiefly ballast water and to a lesser degree hull fouling. Commercial shipping and the number of trading partners were also seen as having the most important affect on pathway strength. It was also identified that international shipping, aquaculture and biodiversity are likely to be impacted to a greater extent than other marine uses and values by introduced marine pests.

Recommendation: ***This issue (introduced marine pests) crosses the mandates of several APEC working group. It should be coordinated by the Marine Resource Conservation Working Group.***

The vectors for introducing marine species and the impact of such introductions are diverse and wide spread. APEC has several working groups that are potentially affected by introduced marine pests. Coordinating activities by the relevant groups will complement the effectiveness of any action taken by the Marine Resource Conservation Working Group.

Recommendation: ***Construction of a comprehensive hazard analysis and assessment of all APEC member economies and APEC as a whole, using a standardised set of analysis tools.***

Hazard analyses are an essential component of the risk management framework. They need to be performed for each APEC member economy and APEC as a whole to provide the most comprehensive coverage. Conformity of the hazard analyses is essential and methods defined by recent studies, e.g. Hayes and Sliwa (*in review)* are useful guides.

5.4 DISTRIBUTION OF INTRODUCED MARINE PESTS

The detection abilities, methodologies and identification of introduced marine species vary considerably within the APEC region. This hinders any accurate estimate of the distribution of introduced marine species of concern. Australia and the USA have initiated several baseline port surveys to investigate the native and introduced biodiversity of high risk areas, such as Port Phillip Bay (Aus), San Francisco Bay (USA) and Pearl Harbour (USA). From these surveys 165, 212 and 96 species of introduced and cryptogenic species have been identified, respectively. A large proportion of the world's oceans occur within the APEC region, however the biodiversity of this area, both native and introduced, is not well known.

Recommendation: ***The undertaking of baseline port surveys of all major trading ports in the region using consistent protocols***

Biodiversity surveys investigating both native and exotic species within each economy need to be conducted. A focus on high-risk areas, such as major trading ports, is essential for detecting introduced species. These studies should follow established baseline port survey protocols (e.g. Hewitt and Martin 2001). Furthermore, the Globallast programme should be encouraged by APEC to stage its second phase of port surveys in the APEC region.

Management and research efforts focus on a species-specific approach. To complement this approach, comprehensive data requirements for increasing the effectiveness of management responses are needed. These requirements involve determining tolerance limits, known distributions and life history characteristics. At present, comprehensive datasets are limited to a small number of species, though through projects such as the Australian National Introduced Marine Pests Information System (NIMPIS) and CRIMP 'next pest database', these datasets are increasing.

Recommendation: ***The development of a complete list of introduced marine species in the APEC region.***

A comprehensive list of introduced marine species in the APEC region should be developed by an appropriate facility, in close cooperation with scientific bodies in the economies, and supported through dedicated funding. This list is a critical component of hazard analyses for each economy.

5.5 A RISK MANAGEMENT FRAMEWORK

Risk Management, "the culture, processes and structures that are directed towards the effective management of potential opportunities and adverse effects", is an important tool in reducing the risk of new introductions and responding to existing introductions. Risk Management can be achieved by economies working collectively, to an agreed timeframe, on the common requirements, protocols and procedures for the reduction of the spread and further introduction of introduced marine pests (including micro-organisms and pathogens) across local boundaries. Analysing past trends in the species numbers introduced by major vectors may provide some indication of future trends. The changing risk environment means that effective risk management of marine pests will not be a single intervention. Instead it requires developing an awareness of the problem in the APEC economies, the development of appropriate information systems and tools to react to the problem, and the development or adaptation of institutional structures at the level of individual economies and the region to monitor, report and implement the necessary response. APEC should support the following regional tools or initiatives for reducing problems posed by introduced marine pests:

Recommendation: ***APEC should develop an effective regional system for information sharing, capacity building, tool development and reporting procedures. The development should be led by a small representative task group working by correspondence and reporting through a central information server system established on the Internet.***

The development of this system would lead to increases in regional communication, technical support and create assistance in the decision-making process for managing and responding to introduced marine pests. The taskforce would be able to have a comprehensive view of the situation within the whole APEC region and act accordingly.

Recommendation: ***The establishment of a central server on the internet that provides easy accessible information on: potential marine pests; their distributions and vectors; their impacts; management strategies in place; response strategies in place and being developed.***

Australia has developed a similar information system: the National Introduced Marine Pest Information System (NIMPIS). This could be extended into a regional tool that provides species-specific information for detection, education and management decision making.

Recommendation: ***Each economy should encourage participation in capacity building exercises and cooperative projects to enhance awareness, monitoring and response.***

A general lack of awareness for introduced marine pests exists within the APEC region. This can be improved through capacity building exercises and cooperative projects. These projects should be initiated at the levels of the economies and establish, to the extent possible the costs and benefits of management responses to the threat of introduced marine pests.

Recommendation: ***APEC should provide, or facilitate, assistance for developing economies through training and exchange programs.***

The lack of capabilities by some APEC economies to develop the necessary awareness and ability to monitor and respond to introduced marine pests, ultimately leaves the whole APEC region vulnerable. APEC's assistance would greatly improve the capabilities of developing economies.

Recommendation: ***Each economy should facilitate APEC and other responses at local levels.***

There are numerous international and regional initiatives that have not been implemented by APEC economies at local levels. For these initiatives and APECs response to be most effective, economies need to facilitate these at the local level.

Recommendation: ***A reporting procedure should be developed for all economies.***

The development of a reporting procedure can allow neighbouring economies to prepare responses and act accordingly. Reporting should follow a standard protocol.

5.6 SOCIAL AND ECONOMIC CONSIDERATIONS FOR INTRODUCED MARINE PEST MANAGEMENT

Managing introduced marine pests requires determining the risk of marine pest introduction, establishment and spread in different economies and regions, their impacts on the ecosystem, on human health and on economic activities due to the changes they cause in coastal environments and resources. Hazard analysis and risk assessments can be used to determine high-risk areas and vectors and identify the environmental, economic and social impacts, but are not designed to evaluate the costs and benefits of alternative management strategies, approaches and mechanisms. Documenting the realized and potential costs of introduced marine pests to the environment, economies and health of APEC member economies would emphasize the need to formulate appropriate management responses.

Recommendation: ***Valuation of the environmental, social and economic impacts of introduced marine pests and the potential management strategies, policies and measures that can be applied to them, as a basis for sound decision-making.***

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Do Van Khuong	Director of Research Institute for Marine Products Department of International Cooperation, Ministry of Fisheries, Hanoi, Vietnam	Ph: 84 4 831 7693	Htqt@hn.vnn.vn
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John Waugh	Senior Multilateral Relations Officer IUCN-The World Conservation Union	WD.C. Ph. (1 202) 518-2057 Fx: (1 202) 478-0051	jwaugh@iucnus.org
ISSG-IUCN			
Maj De Poorter	ISSG coordinator		Maj-De-Poorter@xtra.co.nz
Carola Warner	Invasive Species Specialist Group, University of Auckland, Tamaki Campus, Private Bag 92019, Auckland, New Zealand	Phone: #64 9 37 37 599 x5210 Fax: #64 9 37 37 042	issg@auckland.ac.nz
NACA			
Melba Reantaso	Aquatic Animal Health Specialist Network of Aquaculture Centres in Asia - Pacific (NACA)	Bangkok Ph: (662) 561-1728-9 Ext 116 Fx: (662) 561-1727	melbar99@yahoo.com
IMO			
Chua Thia-Eng	Regional Programme Director, GEF/UNDP/IMO Regional Programme on Partnerships in Environmental Management for the Seas of East Asia, Quezon City 1165, Philippines	Tel/Fax : (632) 426-3849 / 926-9712	chuate@imo.org.ph
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APPENDIX 2
SPECIES INFORMATION SOURCES

The following references were used to construct the species tables in Section 3 (tables 3.6 and 3.7). This is not an exhaustive list of relevant references.

Table 7.2. Key references for species.

Acanthogobius flavimanus	Cohen, A. and Carlton, J. (1995), Biological study - Nonindigenous aquatic species in a United States Estuary: A case study of the biological invasions of the San Francisco Bay and Delta, United States Fish and Wildlife Service and the National Sea Grant College Program, Washington D.C., USA Walford L. and Wicklund R. (1973), Contribution to a World Wide Inventory of Exotic Marine and Anadromous Organisms, Fisheries Technical Paper No. 121, Food and Agricultural Organisation, Rome .
Acanthophora spicifera	Ribera M. A. and Boudouresque C. F. (1995), Introduced marine plants with special reference to macroalgae: mechanisms and impact, *Progress in Phycological Research,* **11**:187-268.
Acartia omorrii	Carlton, J.T., Geller, J.B. (1993), Ecological roulette: the global transport of nonindigenous marine organisms, *Science,* **261**:78-82.
Alexandrium catenella	NIMPIS 2002: http://crimp.marine.csiro.au/nimpis/. FIP (1997). Monitoreo de la Marea Roja an las aguas interiores de la XII Region. FIP-U. De Magallanes. FIP –IT 95-23 A: 204 p.
Alexandrium minutum	NIMPIS 2002: http://crimp.marine.csiro.au/nimpis/.
Alexandrium tamarense	NIMPIS 2002: http://crimp.marine.csiro.au/nimpis/.
Ascidiella aspersa	Ruiz, G.M., Fofonoff, P.W., Carlton, J.T., Wonham, M.J. and Hines, A.H. (2000), Invasion of Coastal Marine Communities in North America: Apparent Patterns, Processes, and Biases, *Ann. Rev. Ecol. Syst.,* **31**:481-531.
Asterias amurensis	NIMPIS 2002: http://crimp.marine.csiro.au/nimpis/.
Astrostole scabra	Walford L. and Wicklund R. (1973), Contribution to a World Wide Inventory of Exotic Marine and Anadromous Organisms, Fisheries Technical Paper No. 121, Food and Agricultural Organisation, Rome .
Arcuatula demissa	Walford L. and Wicklund R. (1973), Contribution to a World Wide Inventory of Exotic Marine and Anadromous Organisms, Fisheries Technical Paper No. 121, Food and Agricultural Organisation, Rome .
Balanus amphitrite	Ruiz, G.M., Fofonoff, P.W., Carlton, J.T., Wonham, M.J. and Hines, A.H. (2000), Invasion of Coastal Marine Communities in North America: Apparent Patterns, Processes, and Biases, *Ann. Rev. Ecol. Syst.,* **31**:481-531.
Balanus eburneus	
Balanus improvisus	Ruiz, G.M., Fofonoff, P.W., Carlton, J.T., Wonham, M.J. and Hines, A.H. (2000), Invasion of Coastal Marine Communities in North America: Apparent Patterns, Processes, and Biases, *Ann. Rev. Ecol. Syst.,* **31**:481-531.
Balanus reticulatus	
Batillaria attramentaria	Ruiz, G.M., Fofonoff, P.W., Carlton, J.T., Wonham, M.J. and Hines, A.H. (2000), Invasion of Coastal Marine Communities in North America:

	Apparent Patterns, Processes, and Biases, *Ann. Rev. Ecol. Syst.*, **31**:481-531.
Blackfordia virginica	GESAMP (Group of Experts on the Scientific Aspects of Marine Environmental Protection, United Nations). (1997). Opportunistic settlers and the problem of the ctenophore *Mnemiopsis leidyi* invasion in the Black Sea. Reports and Studies no. 58, 83 pp. Ruiz, G.M., Fofonoff, P.W., Carlton, J.T., Wonham, M.J. and Hines, A.H. (2000), Invasion of Coastal Marine Communities in North America: Apparent Patterns, Processes, and Biases, *Ann. Rev. Ecol. Syst.*, **31**:481-531.
Boonea bisuturalis	Ruiz, G.M., Fofonoff, P.W., Carlton, J.T., Wonham, M.J. and Hines, A.H. (2000), Invasion of Coastal Marine Communities in North America: Apparent Patterns, Processes, and Biases, *Ann. Rev. Ecol. Syst.*, **31**:481-531.
Botrylloides leachi	Ruiz, G.M., Fofonoff, P.W., Carlton, J.T., Wonham, M.J. and Hines, A.H. (2000), Invasion of Coastal Marine Communities in North America: Apparent Patterns, Processes, and Biases, *Ann. Rev. Ecol. Syst.*, **31**:481-531.
Buscytopus canaliculatus	Ruiz, G.M., Fofonoff, P.W., Carlton, J.T., Wonham, M.J. and Hines, A.H. (2000), Invasion of Coastal Marine Communities in North America: Apparent Patterns, Processes, and Biases, *Ann. Rev. Ecol. Syst.*, **31**:481-531.
Callinectes sapidus	Carlton J. T. (1985), Transoceanic and interoceanic dispersal of coastal marine organisms: the biology of ballast water, *Oceanography and Marine Biology. An Annual Review*, **23**:313-371. Gollasch S. and Leppakoski E. (1999), Initial risk assessment of alien species in Nordic coastal waters, Nord 1999:8, Nordic Council of Ministers, Copenhagen, Denmark .
Capitella capitella	Hajah Laila Abd Hamid pers. comm.
Carcinus maenas	Carlton, J. T. (2001). Introduced Species in U.S. Coastal Waters: Environmental Impacts and Management Priorities. Pew Oceans Commission, Arlington, Virginia.
Caulerpa taxifolia	Carlton, J. T. (2001). Introduced Species in U.S. Coastal Waters: Environmental Impacts and Management Priorities. Pew Oceans Commission, Arlington, Virginia. Jousson, O., Pawlowski, J., Zaninetti, L., Meinesz, A., Boudouresque, C. F. (1998), Molecular evidence for the aquarium origin of the green alga Caulerpa taxifolia introduced to the Mediterranean Sea, *Marine Ecology Progress Series*, **172**:275-280.
Centropages adbominalis	GESAMP (Group of Experts on the Scientific Aspects of Marine Environmental Protection, United Nations). (1997). Opportunistic settlers and the problem of the ctenophore *Mnemiopsis leidyi* invasion in the Black Sea. Reports and Studies no. 58, 83 pp. Carlton, J.T., Geller, J.B. (1993), Ecological roulette: the global transport of nonindigenous marine organisms, *Science*, **261**:78-82.
Chelura terebrans	Carlton, J.T., Geller, J.B. (1993), Ecological roulette: the global transport of nonindigenous marine organisms, *Science*, **261**:78-82.
Ciona intestinalis	Ruiz, G.M., Fofonoff, P.W., Carlton, J.T., Wonham, M.J. and Hines, A.H. (2000), Invasion of Coastal Marine Communities in North America: Apparent Patterns, Processes, and Biases, *Ann. Rev. Ecol. Syst.*, **31**:481-531.

Cirolana harfordi	Ruiz, G.M., Fofonoff, P.W., Carlton, J.T., Wonham, M.J. and Hines, A.H. (2000), Invasion of Coastal Marine Communities in North America: Apparent Patterns, Processes, and Biases, *Ann. Rev. Ecol. Syst.*, **31**:481-531.
Corbula gibba	NIMPIS 2002: http://crimp.marine.csiro.au/nimpis/.
Crassostrea gigas	NIMPIS 2002: http://crimp.marine.csiro.au/nimpis/.
Crepidula fornicata	Ruiz, G.M., Fofonoff, P.W., Carlton, J.T., Wonham, M.J. and Hines, A.H. (2000), Invasion of Coastal Marine Communities in North America: Apparent Patterns, Processes, and Biases, *Ann. Rev. Ecol. Syst.*, **31**:481-531.
Cryptosula pallasiana	Ruiz, G.M., Fofonoff, P.W., Carlton, J.T., Wonham, M.J. and Hines, A.H. (2000), Invasion of Coastal Marine Communities in North America: Apparent Patterns, Processes, and Biases, *Ann. Rev. Ecol. Syst.*, **31**:481-531.
Dinophysis spp.	FIP (1997). Monitoreo de la Marea Roja an las aguas interiores de la XII Region. FIP-U. De Magallanes. FIP –IT 95-23 A: 204 p.
Diadumene lineata	Ruiz, G.M., Fofonoff, P.W., Carlton, J.T., Wonham, M.J. and Hines, A.H. (2000), Invasion of Coastal Marine Communities in North America: Apparent Patterns, Processes, and Biases, *Ann. Rev. Ecol. Syst.*, **31**:481-531. Cohen, A. and Carlton, J. (1995), Biological study - Nonindigenous aquatic species in a United States Estuary: A case study of the biological invasions of the San Francisco Bay and Delta, United States Fish and Wildlife Service and the National Sea Grant College Program, Washington D.C., USA
Enerocytozoon salmonis cofactor with the retrovirus PL	FIP (1997). Monitoreo de la Marea Roja an las aguas interiores de la XII Region. FIP-U. De Magallanes. FIP –IT 95-23 A: 204 p.
Eriocheir sinensis	Carlton, J. T. (2001). Introduced Species in U.S. Coastal Waters: Environmental Impacts and Management Priorities. Pew Oceans Commission, Arlington, Virginia.
Exopalaemon carinicauda	GESAMP (Group of Experts on the Scientific Aspects of Marine Environmental Protection, United Nations). (1997). Opportunistic settlers and the problem of the ctenophore *Mnemiopsis leidyi* invasion in the Black Sea. Reports and Studies no. 58, 83 pp.
Gymnodinium catenatum	NIMPIS 2002: http://crimp.marine.csiro.au/nimpis/.
Gonodactylaceus mutata	Walford L. and Wicklund R. (1973), Contribution to a World Wide Inventory of Exotic Marine and Anadromous Organisms, Fisheries Technical Paper No. 121, Food and Agricultural Organisation, Rome . R. Caldwell pers. comm.
Hydroides elegans	Ruiz, G.M., Fofonoff, P.W., Carlton, J.T., Wonham, M.J. and Hines, A.H. (2000), Invasion of Coastal Marine Communities in North America: Apparent Patterns, Processes, and Biases, *Ann. Rev. Ecol. Syst.*, **31**:481-531.
Hydroides sanctaecrucis	Hayes, in prep.
Hypnea musciformis	Ribera M. A. and Boudouresque C. F. (1995), Introduced marine plants with special reference to macroalgae: mechanisms and impact, *Progress in Phycological Research,* **11**:187-268.
Infectious Pancreatic Necrosis Virus (IPNV)	FIP (1997). Monitoreo de la Marea Roja an las aguas interiores de la XII Region. FIP-U. De Magallanes. FIP –IT 95-23 A: 204 p.
Kappaphycus alverezeii	Carlton, J. T. (2001). Introduced Species in U.S. Coastal Waters: Environmental Impacts and Management Priorities. Pew Oceans

	Commission, Arlington, Virginia.
Kappaphycus striatum	Carlton, J. T. (2001). Introduced Species in U.S. Coastal Waters: Environmental Impacts and Management Priorities. Pew Oceans Commission, Arlington, Virginia.
Lates calcarifer	Hajah Laila Abd Hamid pers. comm.
Limnoithona sinensis	GESAMP (Group of Experts on the Scientific Aspects of Marine Environmental Protection, United Nations). (1997). Opportunistic settlers and the problem of the ctenophore *Mnemiopsis leidyi* invasion in the Black Sea. Reports and Studies no. 58, 83 pp
Limnoperna fortunei	Morton, B. (1996), The nature of the aquatic nuisance species problem: A global perspective, IN: *Abstracts from the Eighth International Zebra Mussel and Other Nuisance Species Conference, Sacramento, California, March 16-19 1998.*
Limnoria quadripunctata	Ruiz, G.M., Fofonoff, P.W., Carlton, J.T., Wonham, M.J. and Hines, A.H. (2000), Invasion of Coastal Marine Communities in North America: Apparent Patterns, Processes, and Biases, *Ann. Rev. Ecol. Syst.,* **31**:481-531.
Limnoria tripunctata	Ruiz, G.M., Fofonoff, P.W., Carlton, J.T., Wonham, M.J. and Hines, A.H. (2000), Invasion of Coastal Marine Communities in North America: Apparent Patterns, Processes, and Biases, *Ann. Rev. Ecol. Syst.,* **31**:481-531.
Littorina saxatilis	Carlton, J.T., Geller, J.B. (1993), Ecological roulette: the global transport of nonindigenous marine organisms, *Science,* **261**:78-82.
Lumbricillus lineatus	Cohen, A. and Carlton, J. (1995), Biological study - Nonindigenous aquatic species in a United States Estuary: A case study of the biological invasions of the San Francisco Bay and Delta, United States Fish and Wildlife Service and the National Sea Grant College Program, Washington D.C., USA
Maeotias marginata	Ruiz, G.M., Fofonoff, P.W., Carlton, J.T., Wonham, M.J. and Hines, A.H. (2000), Invasion of Coastal Marine Communities in North America: Apparent Patterns, Processes, and Biases, *Ann. Rev. Ecol. Syst.,* **31**:481-531.
Maoricolpus roseus	Walford L. and Wicklund R. (1973), Contribution to a World Wide Inventory of Exotic Marine and Anadromous Organisms, Fisheries Technical Paper No. 121, Food and Agricultural Organisation, Rome .
Marenzelleria viridis	Carlton, J.T., Geller, J.B. (1993), Ecological roulette: the global transport of nonindigenous marine organisms, *Science,* **261**:78-82. Ruiz, G.M., Fofonoff, P.W., Carlton, J.T., Wonham, M.J. and Hines, A.H. (2000), Invasion of Coastal Marine Communities in North America: Apparent Patterns, Processes, and Biases, *Ann. Rev. Ecol. Syst.,* **31**:481-531. Cohen, A. and Carlton, J. (1995), Biological study - Nonindigenous aquatic species in a United States Estuary: A case study of the biological invasions of the San Francisco Bay and Delta, United States Fish and Wildlife Service and the National Sea Grant College Program, Washington D.C., USA
Membranipora membranacea	Ruiz, G.M., Carlton, J.T., Grosholz, E.D., Hines, A.H. (1997), Global invasions of marine and estuarine habitats by non-indigenous species: Mechanisms, extent and consequences, *American Zoologist,* **37**:621-632. Ruiz, G.M., Fofonoff, P.W., Carlton, J.T., Wonham, M.J. and Hines, A.H.

	(2000), Invasion of Coastal Marine Communities in North America: Apparent Patterns, Processes, and Biases, *Ann. Rev. Ecol. Syst.*, **31**:481-531.
Monodon baculovirus (MBV)	Subasinghe, R.P, J.R. Arthur & M. Shariff. (1996). Health management in Asian aquaculture. Proceedings of the regional Expert Consultation on Aquaculture Health Management in Asia and the Pacific. Serdang, Malaysia, 22-24 May 1995. *FAO Technical Paper*. No. 360. Rome, FAO. 142 p.
Mugilogobius parvus	GESAMP (Group of Experts on the Scientific Aspects of Marine Environmental Protection, United Nations). (1997). Opportunistic settlers and the problem of the ctenophore *Mnemiopsis leidyi* invasion in the Black Sea. Reports and Studies no. 58, 83 pp. Carlton, J.T., Geller, J.B. (1993), Ecological roulette: the global transport of nonindigenous marine organisms, *Science,* **261**:78-82.
Musculista senhousia	Carlton, J. T. (2001). Introduced Species in U.S. Coastal Waters: Environmental Impacts and Management Priorities. Pew Oceans Commission, Arlington, Virginia. Ruiz, G.M., Fofonoff, P.W., Carlton, J.T., Wonham, M.J. and Hines, A.H. (2000), Invasion of Coastal Marine Communities in North America: Apparent Patterns, Processes, and Biases, *Ann. Rev. Ecol. Syst.*, **31**:481-531.
Mya arenaria	Carlton, J. T. (2001). Introduced Species in U.S. Coastal Waters: Environmental Impacts and Management Priorities. Pew Oceans Commission, Arlington, Virginia. Cohen, A. and Carlton, J. (1995), Biological study - Nonindigenous aquatic species in a United States Estuary: A case study of the biological invasions of the San Francisco Bay and Delta, United States Fish and Wildlife Service and the National Sea Grant College Program, Washington D.C., USA
Mytilopsis sallei	NIMPIS 2002: http://crimp.marine.csiro.au/nimpis/.
Mytilus galloprovincialis	Ruiz, G.M., Fofonoff, P.W., Carlton, J.T., Wonham, M.J. and Hines, A.H. (2000), Invasion of Coastal Marine Communities in North America: Apparent Patterns, Processes, and Biases, *Ann. Rev. Ecol. Syst.*, **31**:481-531. Cohen, A. and Carlton, J. (1995), Biological study - Nonindigenous aquatic species in a United States Estuary: A case study of the biological invasions of the San Francisco Bay and Delta, United States Fish and Wildlife Service and the National Sea Grant College Program, Washington D.C., USA
Neanthes succinea	GESAMP (Group of Experts on the Scientific Aspects of Marine Environmental Protection, United Nations). (1997). Opportunistic settlers and the problem of the ctenophore *Mnemiopsis leidyi* invasion in the Black Sea. Reports and Studies no. 58, 83 pp. Ruiz, G.M., Fofonoff, P.W., Carlton, J.T., Wonham, M.J. and Hines, A.H. (2000), Invasion of Coastal Marine Communities in North America: Apparent Patterns, Processes, and Biases, *Ann. Rev. Ecol. Syst.*, **31**:481-531. Cohen, A. and Carlton, J. (1995), Biological study - Nonindigenous aquatic species in a United States Estuary: A case study of the biological invasions of the San Francisco Bay and Delta, United States Fish and Wildlife Service and the National Sea Grant College Program, Washington D.C., USA
Nuttallia obscurata	Carlton, J. T. (2001). Introduced Species in U.S. Coastal Waters: Environmental Impacts and Management Priorities. Pew Oceans Commission, Arlington, Virginia.

Oithona davisae	Carlton, J.T., Geller, J.B. (1993), Ecological roulette: the global transport of nonindigenous marine organisms, *Science,* **261**:78-82. Ruiz, G.M., Fofonoff, P.W., Carlton, J.T., Wonham, M.J. and Hines, A.H. (2000), Invasion of Coastal Marine Communities in North America: Apparent Patterns, Processes, and Biases, *Ann. Rev. Ecol. Syst.,* **31**:481-531. Cohen, A. and Carlton, J. (1995), Biological study - Nonindigenous aquatic species in a United States Estuary: A case study of the biological invasions of the San Francisco Bay and Delta, United States Fish and Wildlife Service and the National Sea Grant College Program, Washington D.C., USA
Okenia plana	Ruiz, G.M., Fofonoff, P.W., Carlton, J.T., Wonham, M.J. and Hines, A.H. (2000), Invasion of Coastal Marine Communities in North America: Apparent Patterns, Processes, and Biases, *Ann. Rev. Ecol. Syst.,* **31**:481-531. Cohen, A. and Carlton, J. (1995), Biological study - Nonindigenous aquatic species in a United States Estuary: A case study of the biological invasions of the San Francisco Bay and Delta, United States Fish and Wildlife Service and the National Sea Grant College Program, Washington D.C., USA
Oncorhynchus kisutch	Soto and Jara (1995).
Oncorhynchus tshawytscha	Soto and Jara (1995).
Patiriella regularis	Walford L. and Wicklund R. (1973), Contribution to a World Wide Inventory of Exotic Marine and Anadromous Organisms, Fisheries Technical Paper No. 121, Food and Agricultural Organisation, Rome .
Penaeus stylirostris	Dr. Hajah Laila Haji Abd Hamid, pers.comm.
Phyllorhiza punctata	Ruiz, G.M., Fofonoff, P.W., Carlton, J.T., Wonham, M.J. and Hines, A.H. (2000), Invasion of Coastal Marine Communities in North America: Apparent Patterns, Processes, and Biases, *Ann. Rev. Ecol. Syst.,* **31**:481-531.
Porichthys notatus	Arthington A. H., Kailola P. J., Woodland D. J. and Zalucki J. M. (1999), Baseline environmental data relevant to an evaluation of quarantine risk potentially associated with the importation to Australia of ornamental finfish, Report to the Australian Quarantine and Inspection Service, Agriculture, Fisheries and Forestry, Canberra, Australia.
Potamocorbula amurensis	GESAMP (Group of Experts on the Scientific Aspects of Marine Environmental Protection, United Nations). (1997). Opportunistic settlers and the problem of the ctenophore *Mnemiopsis leidyi* invasion in the Black Sea. Reports and Studies no. 58, 83 pp. Ruiz, G.M., Fofonoff, P.W., Carlton, J.T., Wonham, M.J. and Hines, A.H. (2000), Invasion of Coastal Marine Communities in North America: Apparent Patterns, Processes, and Biases, *Ann. Rev. Ecol. Syst.,* **31**:481-531.
Procambarus clarkii	Ruiz, G.M., Fofonoff, P.W., Carlton, J.T., Wonham, M.J. and Hines, A.H. (2000), Invasion of Coastal Marine Communities in North America: Apparent Patterns, Processes, and Biases, *Ann. Rev. Ecol. Syst.,* **31**:481-531. Cohen, A. and Carlton, J. (1995), Biological study - Nonindigenous aquatic species in a United States Estuary: A case study of the biological invasions of the San Francisco Bay and Delta, United States Fish and Wildlife Service and the National Sea Grant College Program, Washington D.C., USA
Pseudodiaptomus forbesi	GESAMP (Group of Experts on the Scientific Aspects of Marine Environmental Protection, United Nations). (1997). Opportunistic settlers and the problem of the ctenophore *Mnemiopsis leidyi* invasion in the Black

	Sea. Reports and Studies no. 58, 83 pp. Carlton, J.T., Geller, J.B. (1993), Ecological roulette: the global transport of nonindigenous marine organisms, *Science,* **261**:78-82. Ruiz, G.M., Fofonoff, P.W., Carlton, J.T., Wonham, M.J. and Hines, A.H. (2000), Invasion of Coastal Marine Communities in North America: Apparent Patterns, Processes, and Biases, *Ann. Rev. Ecol. Syst.,* **31**:481-531. Cohen, A. and Carlton, J. (1995), Biological study - Nonindigenous aquatic species in a United States Estuary: A case study of the biological invasions of the San Francisco Bay and Delta, United States Fish and Wildlife Service and the National Sea Grant College Program, Washington D.C., USA
Pseudodiaptomus marinus	Ruiz, G.M., Fofonoff, P.W., Carlton, J.T., Wonham, M.J. and Hines, A.H. (2000), Invasion of Coastal Marine Communities in North America: Apparent Patterns, Processes, and Biases, *Ann. Rev. Ecol. Syst.,* **31**:481-531. Cohen, A. and Carlton, J. (1995), Biological study - Nonindigenous aquatic species in a United States Estuary: A case study of the biological invasions of the San Francisco Bay and Delta, United States Fish and Wildlife Service and the National Sea Grant College Program, Washington D.C., USA
Pseudo-nitzschia spp.	FIP (1997). Monitoreo de la Marea Roja an las aguas interiores de la XII Region. FIP-U. De Magallanes. FIP –IT 95-23 A: 204 p.
Pseudopolydora paucibranchiata	Cohen, A. and Carlton, J. (1995), Biological study - Nonindigenous aquatic species in a United States Estuary: A case study of the biological invasions of the San Francisco Bay and Delta, United States Fish and Wildlife Service and the National Sea Grant College Program, Washington D.C., USA . Ruiz, G.M., Fofonoff, P.W., Carlton, J.T., Wonham, M.J. and Hines, A.H. (2000), Invasion of Coastal Marine Communities in North America: Apparent Patterns, Processes, and Biases, *Ann. Rev. Ecol. Syst.,* **31**:481-531
Pyrodinium bahamense	G. Hallegraef, pers.com. Hajah Laila Abd Hamid pers. comm.
Renibacterium salmoninarium	Sanders and Barros, (1986).
RV-PJ (virus of *Penaeus japonica)*	Subasinghe, R.P, J.R. Arthur & M. Shariff. (1996). Health management in Asian aquaculture. Proceedings of the regional Expert Consultation on Aquaculture Health Management in Asia and the Pacific. Serdang, Malaysia, 22-24 May 1995. *FAO Technical Paper*. No. 360. Rome, FAO. 142 p.
Sabella spallanzanii	NIMPIS 2002: http://crimp.marine.csiro.au/nimpis/.
Salmo salar	Carlton, J. T. (2001). Introduced Species in U.S. Coastal Waters: Environmental Impacts and Management Priorities. Pew Oceans Commission, Arlington, Virginia. Dr John Pringle, pers. comm.
Schizoporella unicornis	Cohen, A. and Carlton, J. (1995), Biological study - Nonindigenous aquatic species in a United States Estuary: A case study of the biological invasions of the San Francisco Bay and Delta, United States Fish and Wildlife Service and the National Sea Grant College Program, Washington D.C., USA.
Salmoneus gracilipes	Carlton, J.T., Geller, J.B. (1993), Ecological roulette: the global transport of nonindigenous marine organisms, *Science,* **261**:78-82.
Spartina alterniflora	Carlton, J. T. (2001). Introduced Species in U.S. Coastal Waters: Environmental Impacts and Management Priorities. Pew Oceans

	Commission, Arlington, Virginia.
Spartina anglica	Ruiz, G.M., Carlton, J.T., Grosholz, E.D., Hines, A.H. (1997), Global invasions of marine and estuarine habitats by non-indigenous species: Mechanisms, extent and consequences, *American Zoologist,* **37**:621-632. Andrew Sullivan, pers. comm
Sphaeroma quoyanum	Carlton, J. T. (2001). Introduced Species in U.S. Coastal Waters: Environmental Impacts and Management Priorities. Pew Oceans Commission, Arlington, Virginia. Cohen, A. and Carlton, J. (1995), Biological study - Nonindigenous aquatic species in a United States Estuary: A case study of the biological invasions of the San Francisco Bay and Delta, United States Fish and Wildlife Service and the National Sea Grant College Program, Washington D.C., USA.
Styela clava	Ruiz, G.M., Fofonoff, P.W., Carlton, J.T., Wonham, M.J. and Hines, A.H. (2000), Invasion of Coastal Marine Communities in North America: Apparent Patterns, Processes, and Biases, *Ann. Rev. Ecol. Syst.,* **31**:481-531.
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Non-specified	Yubo Liang pers.comm.

APPENDIX 3
WORKSHOP OUTCOMES

The following documents were constructed during the APEC MRC-WG Workshop.

3.1 Summary Record

ASIA PACIFIC ECONOMIC COOPERATION
Summary Record of Marine Resource Conservation Working Group (MRCWG) Workshop on Introduced Marine Pests

12-15 November 2001, Hobart, Australia

A workshop to develop a Draft Risk Management Framework for Introduced Marine Pests (IMP) in APEC Economies was held from 12-15 November 2001 in Hobart, Australia. The workshop was attended by delegates from Australia, Brunei Darussalam, Canada, Chile, Chinese Taipei, People's Republic of China, Indonesia, Korea, New Zealand, the Philippines, Peru, Russia, Thailand, the United States of America, and Viet Nam, the International Maritime Organisation (IMO), the South Pacific Regional Environment Programme (SPREP), the shipping, port management and aquaculture industries, and representatives from the APEC Fisheries and Transport Working Groups.

Mr Philip Burgess, Environment Australia and Dr Alex Brown, Undersecretariat of Fisheries, Chile, were Joint Chairs of the workshop. Mr Warren Geeves and Mr Andrew Brooke (Australia) were appointed rapporteurs.

The list of participants is attached as Annex 1.

Opening Remarks and Introduction to the Workshop

Mr Burgess, Australia, welcomed delegates and thanked the workshop sponsors, noting that this workshop provides a valuable opportunity to raise the profile of the IMP issue throughout APEC and globally. The workshop sponsors were APEC; Environment Australia; the Natural Heritage Trust (Australia); Agriculture Fisheries and Forestry - Australia; AusAid; National Oceans Office (Australia); the Association of Australian Ports and Marine Authorities (AAPMA), and the Department of Natural Resources and the Environment, Victoria.

Dr Brown, Chile, welcomed delegates and expressed his hope that the sharing of information and ideas would lead to a productive workshop. It was noted that the development of a proposal useful for reducing the threats posed by marine pests to the environment should also protect and enhance human well being and long term economic sustainability in our region.

Agenda

The Workshop Agenda is attached.

Workshop Synopsis

Keynote Address

Mr. Steve Raaymakers (IMO) gave the keynote address summarising the threats posed by marine pests to environmental quality, human health and economic growth. It was noted that many resources have been spent on combating oil pollution and a relatively small amount on combating IMP. IMP are one of the four major threats to the world's oceans, and also have human health implications. Mr Raaymakers also reported on progress on the International Maritime Organisation's GloBallast Programme and the development of an international convention on ballast water. The value of the GloBallast Programme demonstration sites for raising awareness of ballast water management issues was also highlighted.

It was noted that IMP management is at different stages in different economies, and it is difficult to identify focal contact points for the issue in some economies.

Lead Shepherd

Ms Alison Russell French, Lead Shepherd, Marine Resource Conservation Working Group, thanked Chile for co-hosting the workshop and welcomed all participants to Hobart, noting that fifteen economies were represented. Ms Russell French reiterated the importance of IMP as an international problem, and noted the opportunities the issue offers for joint action from the APEC Marine Conservation Working Group, the Fisheries Working Group and the Transport Working Group.

Case studies on the management of IMP

Case studies on current management of IMP were given by Mr Don Hough (Australia), Dr Alex Brown (Chile), Ms Melissa Haltuch (USA), Ms Camilla Cox (New Zealand) and Mr Jhin Kyoo Chae (Korea).

The development of Australia's approach to IMP management accelerated following at least two recent, damaging marine pest incursions (the Black Striped Mussel and the Northern Pacific Seastar) and while much progress remains to be made, Australia's approach can offer some positive learning experiences for other economies. In particular the advantages of preventing incursions, rather than waiting until outbreaks have occurred, were emphasised.

The Chilean approach focuses on aquaculture pests and pathogens and uses quarantine instruments and formal environmental impact assessments to regulate introductions based on sanitary and environmental criteria and certification.

The US emphasised the value of regional and international approaches to addressing IMP issues, and commended APEC for developing the concept of a regional framework. The US shares characteristics with many APEC economies in identifying national cohesion and funding as areas that require improvement in order for effective progress to be made.

New Zealand is in the process of developing a risk management framework for marine biosecurity. This risk management framework is seen as a particularly valuable tool for making decisions when risk-minimising actions must be prioritised notwithstanding limited resources and information.

Korea emphasised that APEC economies need to develop a system to identify and classify risks from marine pests and that collating and sharing any available information is a high priority. APEC and its specific ocean related working groups could be more involved to protect indigenous species and protect each economy's socio-economic welfare. The opportunity to advance IMP management issues at the First APEC Ocean Related Ministerial meeting in Seoul, April 2002, was also noted.

Industry and research perspectives

Industry and research perspectives on IMP management issues were presented by Mr John Hirst (Association of Australian Ports and Marine Authorities, Australia); Mr Ross Finlay (Australian Shipping Federation); Mr. Sefania Nawadra - SPREP (PACPOL - shipping programme); and Dr. Ron Thresher (CSIRO Centre for Research on Introduced Marine Pests (CRIMP), Australia).

Mr Hirst offered the expertise gained by Australian ports management authorities to assist other economies in implementing policies to control and manage marine incursions from ballast water. Mr Hirst emphasised that port management authorities are only one of several parties responsible for ballast water management, and that a uniform multilateral approach was needed in planning such management.

It was noted that there are potential economic costs associated with a lack of knowledge of marine pest incursions, such as when it is perceived internationally that a particular economy harbours marine pests in its ports. Research to establish which species are present in port waters can help overcome this risk.

Mr Finlay noted that ballast water was only one of several IMP vectors, and encouraged all APEC member economies to work with the IMO towards the completion and early ratification of the international convention on ballast water. He recommended a unified, international approach as the best method of ensuring safe and efficient protection from IMP.

Mr Nawadra spoke on SPREP's PACPOL programme to maintain, protect and enhance the quality of coastal and marine environments in the Pacific Islands region by minimising ship-related marine pollution, including introduced marine pests. Current plans to address IMPs in the region include an IMP Risk Assessment of the Pacific Islands Region, and surveys for IMP in Pacific Island Ports. SPREP was also concerned with the potential impact of mid-ocean ballast water exchange on Pacific island economies.

Consultant's reports - synopsis of management operations across APEC

Dr. Exequiel González - APEC Group A (Brunei Darussalam, Canada, Chile, Chinese Taipei, People's Republic of China, Japan, Mexico, Peru, Russia, USA) – Report on approaches to IMP management. A Draft Report is at Annex 3.

Dr. Nic Bax - APEC Group B (Australia, Indonesia, Republic of Korea, Malaysia, New Zealand, Papua New Guinea, Philippines, Singapore, Thailand, Viet Nam) – Report on approaches to IMP management. A Draft Report is at Annex 4.

An updated final consultants' report will be made available early in 2002. It will consolidate all economies' contributions.

Practical approaches and other issues on management of IMP

Reports were given on:

- Regional Marine Planning under an Oceans Policy - Mr Campbell Davies, National Oceans Office, Australia;
- Marine pest management protocols - Mr Michael Drynan, Department of Agriculture Fisheries and Forestry, Australia;
- Technical fixes and issues (ballast water/hull fouling) - Mr Steve Raaymakers, IMO;
- Best practice - conservation/aquaculture - Dr Gustav Haellegraff, University of Tasmania, Australia;
- Institutional arrangements - Dr Marcus Haward, University of Tasmania, Australia;
- Trade in live or frozen products - Dr Vicki Wadley, Tasmanian Salmonid Growers Association, Australia.

Mr Davies urged a regional approach to marine management and shared some lessons from the Australian experience of coordinating a range of government and stakeholder interests into development of a regional marine plan.

Mr Drynan reported on Australia's mandatory Ballast Water Management Scheme, commended the IMO's efforts to develop an international convention on ballast water, and urged APEC member economies to include input from industry, science, regulatory bodies and government when developing their own domestic ballast water arrangements.

Mr Raaymakers outlined a number of technical issues relating to ballast water, and also noted the need for a global system of port surveys linked to a global database. Mr Raaymakers emphasised that APEC includes some of the world's largest economies, encompasses the world's largest ocean, and has the potential to act as an effective lobby in fora such as the IMO.

Dr Gustav Haellegraaf spoke on toxic dinoflagellates and recommended that global standards for permissible dinoflagellate levels in discharged ballast water be developed, along with options for higher level treatment of ballast water to further reduce dinoflagellate levels in vulnerable areas.

Dr Marcus Haward emphasised that developing appropriate institutional arrangements is required for effective management of introduced marine pests. Effectiveness will be enhanced by arrangements that provide strong 'vertical' governance and that link national objectives to local responses. At the same time attention needs to be given to maximising 'horizontal' governance and links in order to increase policy capacity and harness all appropriate resources.

Dr Vicki Wadley outlined the value of pest-free aquaculture and fisheries industries to member economies. Dr Wadley recommended the adoption of a uniform, transparent risk assessment approach to IMP management, including good levels of stakeholder involvement, communication and participation.

Introduction of a Draft IMP Management Framework

Working Groups were formed to discuss the risks and elements to be included in a draft risk management framework for IMP in the APEC region. Dr Nic Bax introduced the session.

Each Working Group was composed of delegates from a range of economies and industries in order to enhance broad information-sharing and to build a common understanding and appreciation of the issues faced by different economies.

Working Group Exercise 1 - Ranking of hazards

Groups worked on a questionnaire prepared by CRIMP researchers on IMP hazards. Working Group Facilitators reported to the plenary session that:

- the key vectors were perceived to be ship ballast water, hull fouling, and aquaculture;
- additional vectors for potential IMP transport were identified, including military vessels, mobile drilling platforms, dredging equipment and spoils, and accidental escapes from aquaculture;
- additional impacts from IMP incursions were identified, including impacts on sport fisheries, subsistence or indigenous fisheries, the fish trade, intrinsic environmental and aesthetic values, customary social values associated with coasts and oceans, and human health;
- a distinction was also drawn between commercial near-shore and ocean fisheries. Sport fisheries and subsistence fisheries were distinguished from commercial or industrial fisheries;
- clarification of terminology is required through an agreed IMP glossary;
- baseline data is lacking in some economies and addressing this issue should be a crucial element of a regional approach to IMP management.

Working Group Exercise 2 – IMP management

Groups discussed a range of issues including
- existing IMP management arrangements;
- existing institutions for hazard identification and data collection;

- practical IMP management options;
- what should be in an APEC IMP management framework?

Working groups reported that necessary aspects to a regional approach should include urgent, unified action on IMP - facilitated by

- coordinated research, information sharing, training and education within the region;
- a regional stocktake of marine biodiversity, including the establishment of the necessary capacity within economies;
- sharing of research and databases on native biodiversity and introduced pests, including the potential development of a regional equivalent of the Australian NIMPIS database;
- cooperating to develop capacity building mechanisms, including methods for developed economies to assist developing economies;
- clear identification of focal contact points for IMP issues within each member economy;
- advice from APEC on the applicability to member economies and the APEC region in general, of existing guidelines on IMP and related issues;
- research and cost/benefit analysis of intentional introduction of species, particularly in aquaculture;
- effective institutional arrangements within member economies on both a scientific / technical level, and an administrative level;
- high levels of communication and education between economies, within communities and within governments in order to raise the profile and develop a culture of IMP awareness;
- common procedures for industries to achieve cooperation on measures to manage IMP;
- APEC support for international Conventions on Ships' Anti-Fouling Systems and Ballast Water;
- a strong APEC statement at the First APEC Ocean Related Ministerial Meeting in Korea encouraging the adoption of the recommendations of the Workshop Statement of this IMP Workshop;
- establishment of an IMP Taskforce within APEC;
- development of a regional risk assessment for IMP in APEC economies;
- a regional replication of the IMO GloBallast programme;
- an IMP web page within the APEC website structure, listing resources, documents, existing legislation and contacts for IMP information;
- the need for guidelines on mid-ocean ballast water exchange sites;
- a role for APEC in regional, protocols and standards throughout the region;
- engagement of private sector interests including the shipping, aquaculture and bulk commodity arbitration on IMP issues;
- a study of measures to combat existing IMP incursions;
- a study and evaluation of introductions of transgenic or genetically modified organisms as potential threats similar to introductions of IMP;
- a strong call to action from APEC for member economies to address the above recommendations urgently and together; and
- the opportunity for economies to commit to timeframes for collective action.

Discussion of outcomes and development of a workshop statement
The Draft Workshop Statement is attached as Annex 5.

Summary of Plenary Discussions

(See also Draft Workshop Statement)

- The meeting reiterated the concern within APEC economies over the threats to economic growth, expansion of regional trade, human health, aquatic organism health and environmental quality posed by introduced marine pests. The meeting affirmed the need to adopt a regional approach to combat marine pests in the APEC region.

- The meeting agreed that it is crucial to encourage marine pest information sharing and links on a regional scale. An openly available, science-based database of marine pest information is essential to controlling known marine pests, preventing further incursions and enabling any new introductions to be managed. Australia's National Introduced Marine Pests Information System (NIMPIS) provides an example of a national database that may be suitable for expansion to the regional level. The meeting agreed that a glossary of IMP terminology is necessary to achieve common understanding between economies both on a scientific and a policy level.

- Capacity building and the establishment of effective institutional arrangements were noted as crucial preconditions to effective IMP management.

- Clear identification of focal contact points for IMP issues within each member economy is necessary.

- It was further agreed that awareness raising at senior levels of government is required to accelerate progress on the IMP issue. It was pointed out that risk assessment and cost/benefit analysis can provide the basis for such awareness raising.

- The meeting recommended the elements for a draft APEC Risk Management Framework to address IMP (at Annex 6), and urged all member economies to cooperate within APEC to pursue expansion and finalisation of a draft Framework. The meeting recommended that the APEC Marine Resource Conservation Working Group lead the establishment of the Risk Management Framework, and urged the Fisheries Working Group and Transport Working Group to engage on the issue. It was noted that introduced marine pests is a priority issue for a joint agenda, especially given the attention that it was paid in the last joint meeting of the Fisheries and Marine Resource Conservation Working Groups.

- The meeting emphasised that successful risk management operates as a culture rather than merely a document. APEC's efforts to address the issue of Introduced Marine Pests must therefore be continuous, persistent and must raise awareness and educate on all levels in order to be effective.

- The meeting agreed that the issue of IMP should be pursued at subsequent APEC and international fora including the First APEC Ocean Related Ministerial Meeting (Seoul, April 2002), Oceans and Coasts at Rio +10 (Paris, December 2001) and the World Summit on Sustainable Development (Johannesburg, 2002).

- The meeting encouraged member economies to participate with the IMO to finalise the draft Convention for the Control and Management of Ships' Ballast Water and Sediments, and to consider domestic arrangements for early ratification and adoption of the Convention.

- The meeting encouraged close coordination with other relevant international instruments and processes, such as the Guidelines on a Precautionary Approach to Capture Fisheries and Species Introduction, from the FAO Code of Conduct for Responsible Fisheries; the Guiding Principles for the Prevention, Introduction and Mitigation of Impacts of Alien Species, from the Convention on Biological Diversity; and the prevention of introduction of aquatic animal pathogens and the spread of diseases, from the FAO / Network of Aquaculture Centres in the Asia-Pacific's Regional Guidelines on Responsible Movement of Live Aquatic Animals.

- The meeting noted the recent IMO Convention on the Control of Harmful Anti-Fouling Systems on Ships, 2001 as a positive step towards the environmentally benign control of the spread of marine pests through hull fouling, and encouraged member economies to consider its signature, ratification and early entry into force.

Conclusion
The workshop Joint Chairs thanked delegates for their contributions during the meeting, stressed that this workshop represents the beginning rather than the end of APEC efforts to address IMP issues, and they also emphasised the need to translate these discussions and meetings into practical action.

Delegates thanked the Joint Chairs for their efforts, and thanked Australia, Chile and the Lead Shepherd of the Marine Resource Conservation Working Group for hosting the workshop. They also thanked workshop sponsors for their generous assistance.

The workshop recommends the results of this meeting be considered by economies, senior officials and APEC Leaders prior to the next Leaders' meeting.

3.2 Elements for a Draft Risk Management Framework

APEC economies recognise that the impacts of Introduced Marine Pests (IMP) are a serious threat to their economic growth, expansion of regional trade, aquaculture, fisheries, human health and environmental quality. They agreed that a regional risk management framework will be an effective instrument to address the threat by encouraging the development of appropriate action, processes and structures to respond to the IMP threat.

APEC economies should reduce and control the impacts of IMP, using science–based analysis and decision making, recognising that:

- the risks of adverse impacts could be substantially reduced;
- human and financial resources for prevention and control of IMP should be used effectively, since they are limited and subject to conflicting demands;
- there is a need to increase scientific knowledge and improve its use and availability;
- there is sufficient scientific knowledge to establish that action on IMP is a high priority.

Risk Assessment and Cost Benefit Analysis

Risk assessment of the threats of IMP in the APEC region needs to consider:

A. environmental aspects (for example dominant marine currents, geographical location, native and endemic biodiversity) at the species and ecosystem levels;
B. institutional frameworks (for example regulatory regimes and capacity building);
C. human activities as vectors (for example commercial shipping, recreational shipping and boating, commercial fishing, aquaculture and marine ranching, oil drilling and mining, the aquarium trade, and trade in live and processed food products);
D. costs to the marine related industries and activities (for example shipping, the ports industry, fishing, aquaculture and marine ranching).

Merging of risk assessment and cost benefit analysis can provide valuable information for timely and efficient decision making in a context of uncertainty and scarce economic resources.

Risk Management

In the short term, economies should work collectively in the design of common requirements, protocols and procedures for the reduction of the spread and further introduction of IMP, including microorganisms and pathogens, across national boundaries. In view of the urgent need to act quickly and jointly, economies should be encouraged to establish and apply an agreed timeframe for the implementation of these requirements.

There is also a need for appropriate management frameworks for specific risks. It is recommended that existing frameworks are considered, for example the UN Convention on the Law of the Sea; the IMO Guidelines for the Control and Management of Ships' Ballast Water; the FAO Code of Conduct for Responsible Fisheries, in particular the Guidelines on a Precautionary Approach to Capture Fisheries and Species Introduction; and the Guiding Principles for the Prevention, Introduction and Mitigation of Impacts of Alien Species from the Convention on Biological Diversity.

As an immediate priority, each economy should undertake an analysis to prioritise those aspects of the IMP problem that should be addressed. A comprehensive analysis for the APEC region should also be carried out in order to identify regional priorities for cooperation which may be additional to economies' most immediate priorities.

Economies should establish an information centre, including an APEC database containing the most up to date information on threats posed by marine pests from all vectors and options for their prevention and control.

A regional task force should be created to work with economies in capacity building and to advise economies on the development and implementation of prevention and control options.

Consideration needs to be given to establishment of a regional technology and extension centre to develop and disseminate prevention and control options, noting that current technologies are in many cases inadequate.

Development of Cooperative Projects

Co-operative joint projects should be established to enhance:

- the level of awareness of IMP among the policy-makers, relevant government agencies, scientists, marine industries and general populations of economies;
- the capacity of government, scientists and industries to address the threat of IMP, including training and exchange programs;
- the extent of shared information on IMP, including data bases on species identification, vectors, impacts, prevention options, treatment options, etc;
- the level of information on marine biodiversity in APEC, particularly in ports, making use of rapid assessment protocols;
- the development of marine biological diversity inventories;
- methodologies and techniques for the application of risk assessment and cost benefit analysis.

Developing economies in APEC should be assisted scientifically, technologically and financially in the formulation and implementation of this framework.

Regional Communication

Introduced marine pests are a problem for the region that requires improved regional communication. To assist with this communication there is a need to identify a focal point in each economy to facilitate information exchange.

Options for establishing an electronic communications network utilising the World Wide Web should be considered. The purpose of the network could be to provide:

- warning of all known IMP outbreaks in any APEC economy to all other APEC economies;
- rapid dissemination of information on development of scientific knowledge that is useful for IMP prevention and management, including current information on the state of development of relevant data bases;
- information on developments within economies of legislation, policy and practices related to IMP.

International

It should be recognised that IMP are also a global issue that require inter-regional cooperation. APEC economies should be encouraged to adopt and implement relevant international conventions and develop implementing legislation and other measures to the extent each considers appropriate.

3.3 Final workshop statement

APEC Workshop on Introduced Marine Pests
12-15 November 2001, Hobart, Australia
Workshop Statement

A workshop to develop a Draft Risk Management Framework for Introduced Marine Pests (IMP) in APEC Economies was held from 12-15 November 2001 in Hobart, Australia. The workshop was attended by representatives from 15 economies, the International Maritime Organisation, the South Pacific Regional Environment Program, the shipping, port management and aquaculture industries and representatives from the APEC Marine Resource Conservation Working Group, Fisheries Working Group and Transport Working Group.

Introduced Marine Pests are a shared problem and require shared solutions. The meeting noted that the translocation of marine organisms and micro-organisms beyond their natural environment is a serious and escalating problem in the region, particularly given the environmental, economic, cultural and social impacts of marine pest species and the reliance of many APEC economies on their marine and coastal resources. Once a marine pest is established remediation is often not possible or extremely costly. Given the rapid spread of marine pests, urgent action is essential.

There are substantial regional differences in the environmental vulnerability and in the capacity to react to and manage pest organisms. Once a marine pest becomes established in the region it increases the risk to other economies. Accordingly, there is an urgent need to build capacity within many economies to enable effective management of this problem. The workshop suggested APEC consider the establishment of a task force, comprising members of the Marine Resource Conservation, Fisheries and Transport Working Groups to develop and promote integrated approaches on the IMP issue.

This will need to include, but not be limited to, project development to assist with training and education, development of common regional standards consistent with other international processes, awareness raising including the general community, improved scientific capacity, sharing information and experiences, and identification of tools for control. Risk assessment and cost benefit analysis are tools that can assist decision makers to apportion limited resources and information. The elements for a Draft Risk Management Framework developed by this Workshop outline such integrated approaches and priority actions for addressing the IMP issue.

Mindful of the forthcoming APEC Ocean Related Ministerial Meeting in Korea in 2002, participants requested that APEC Ministers place the issue of IMP on their agenda. We strongly recommend a presentation be given to Ministers on the urgency of addressing this issue. A strong statement from that meeting on the importance of dealing with this issue at the regional level and the need for a common and cooperative approach would assist raising awareness within economies and across the region. It is also potentially a matter for the region to raise in the processes leading up to, and at, the World Summit on Sustainable Development in Johannesburg in 2002.

There is already a range of actions underway nationally, regionally and internationally which economies should use to develop their own responses. Effective implementation of existing regulations is a priority. The workshop stressed the need not to duplicate current efforts. APEC economies are also well placed to encourage the early entry into force of the IMO International Convention on the Control of Harmful Anti-fouling Systems on Ships, 2001.

Implementation and regional replication of the IMO GloBallast programme should be actively supported in order to assist APEC economies to adopt the IMO Guidelines for the Control and Management of Ships' Ballast Water, and to prepare for the rapid adoption and entry into force of the draft Convention for the Control and Management of Ships' Ballast Water and Sediments. There should be close co-ordination with other relevant international instruments and processes such as the UN Convention on the Law of the Sea; the Guidelines on a Precautionary Approach to Capture Fisheries and Species Introduction from the FAO Code of Conduct for Responsible Fisheries; the Guiding Principles for the Prevention, Introduction and Mitigation of Impacts of Alien Species from the Convention on Biological Diversity; and the Network of Aquaculture Centres in the Asia-Pacific.

Noting the many different government and industry interests relevant to harmful aquatic organisms and pathogens, there is a need for economies to identify focal points for communication and information exchange, both internally and with their trading partners and regional neighbours. Engagement of industry and local communities is essential.

APPENDIX 4
QUESTIONNAIRE AND RESPONSES

4.1 APEC INTRODUCED MARINE PEST WORKSHOP QUESTIONNAIRE

Thank you for taking the time to complete the APEC Introduced Marine Pest Workshop Questionnaire. The questionnaire has been developed by Australia's Centre for Research on Introduced Marine Pests (CRIMP) in conjunction with Chile's Inter-American Centre for Sustainable Ecosystems Development (ICSED). Summary results from the questionnaire will be included in the final report for the APEC workshop.

The intention of this questionnaire is to obtain specific information for each APEC economy so that the current status of Introduced Marine Pest management in the overall APEC region can be assessed. Responses will be used to finalise the risk management section in the consultancy report and will be available for future APEC initiatives on Introduced Marine Pests. The questionnaire is nine pages long. Please complete all segments.

1. A revised hazard assessment

2. A review of management arrangements
   2.1. Institutional structure
   2.2. General marine environment management
   2.3. International involvement
   2.4. Specific management related to introduced marine pests

An introduced marine pest glossary has been attached to this Email. The definitions are collated from relevant information materials, international instruments and scientific literature.

Answering instructions

1. Please enter your name and the economy you represent in the table below:

Name	Institution	Position	Economy

2. Read each question carefully. Refer to the attached glossary and contact CRIMP[20] if needed. Remember that there is no right or wrong answer so please answer as accurately as possible.

3. Answer in the spaces provided. As this is a word document the answering space is unlimited.

4. Please return the questionnaire by E-mail to: Angela.Williamson@csiro.au by no latter than the 29th of December 2001.

[20] E-mail addresses of CRIMP contacts; angela.williamson@csiro.au; nic.bax@csiro.au;

1. REVISED HAZARD ASSESSMENT

The purpose of this hazard assessment is to evaluate the identified hazards at the level of the individual economy. This will:

1. Provide an overview of the concerns and hazards with regard to introduced marine pests in APEC economies
2. Provide a basis to identify suitable management interventions
3. Provide a gap analysis to identify significant missing elements for APEC economies
4. Provide a basis to identify future initiatives that APEC may wish to consider.

1.1 Impacts of introduced marine pests

Introduced marine pests ultimately impact upon economic activities in addition to the marine and coastal environments. Workshop participants identified the following marine uses as potentially impacted.

Please rank (High, Medium and Low), according to your knowledge, the magnitude of impact that introduced marine pests may have on the following 14 'marine uses and values' both generally within the APEC region and specifically domestically (within your economy).

In the column titled "Protection value", rank to your best knowledge (this time from 1 to 14; with 1 being the most significant to 14 being the least significant) the relative importance your economy places, from a management perspective, on protecting the listed marine uses and values from introduced marine pests.

Marine uses and values	Ranking		
	Regional	Domestic	Protection value
	H,M,L	H,M,L	1 to 14
Marine infrastructure			
Coastal tourism			
Aquarium trade			
Recreational fisheries			
Customary values			
Biodiversity			
Commercial fisheries			
Human health			
Domestic shipping			
Fish trade			
Artisinal fisheries			
Social values			
International shipping			
Aquaculture			

1.2 Marine pest pathways

Marine pests are introduced via particular **pathways.** Continuing increases in global trade and changing technology has modified and added pathways. This has ultimately affected the numbers and species types being introduced. The following table lists activities that have the potential to introduce and spread marine pests to and around your economy.

We are summarising the major activities that could introduce marine pests to APEC economies. Please indicate, according to your best estimate, the current level of the following activities (High, Medium and Low) in your **international (pre-border)** and your **domestic (post-border)** operations.

Furthermore place an asterisk (*) next to the factors that you think will increase in magnitude for your economy over the next ten years.

Factors that affect introduced marine pest pathways	**Levels**	
	International activities	**Domestic activities**
Commercial shipping		
New vessels (larger, faster)		
Number of trading partners		
Oil, gas and mining		
Wild fisheries		
Aquaculture fisheries		
New aquaculture species		
Genetically modified aquaculture species		
Recreational boating		
Aquarium trade		
Marine tourism (including diving)		
Domestic port extension/ construction		
Reduced antifouling		
New trade laws		
ballast water management		

Please enter any specific information that you may have for each of the above factors within your economy:

For example, identify new trading partners and recreational routes, estimate increase in shipping volume if any, and identify new ports.

1.3 Vectors for introducing marine pests

There are many pathways for a marine pest to be introduced, however a **vector** is needed for the physical transportation of the species. Please rank (High, Medium and Low), according to your best estimate, the potential of each vector to introduce marine pests into your economy international activities **(pre-border)** and spread it within your economy domestic activities **(post-border)** based on current practices, activities and laws within your economy.

Vectors	**Ranking**	
	International activities	**Domestic activities**
Commercial shipping		
Ballast water		
Hull fouling		
Solid ballast		
Sea chests		
Cargo		
Anchors/anchor chains		
Aquaculture		
Intentional release		
Accidental release		
Gear or stock movement		
Discarded nets, floats, traps		
Discarded packaging materials (feeds, stock)		
Release of transgenic species		
Fisheries		
Processing of fresh and frozen product		
Live bait movement		
Discarded fishing gear		
Hull fouling of fishing vessels		
Live fish trade-consumption		
Aquarium industry		
Live fish trade-aquarium species		
Intentional release		
Accidental release		
Others		
Military vessels		
Canals: movement through locks		
Drilling platforms: hull fouling		
Drilling platforms: ballast water		
Dredging spoil		
Diving: dive gear		
Recreational boating: hull fouling		

Any additional comments:

2. REVIEW OF MANAGEMENT ARRANGEMENTS

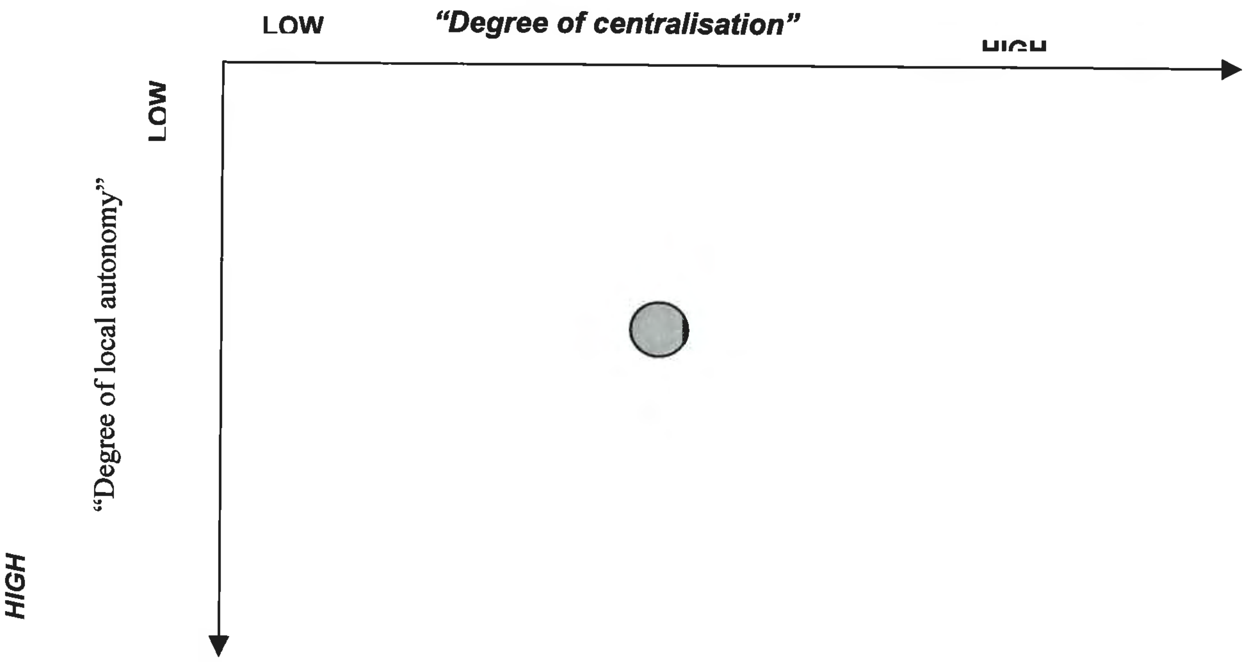
The purpose of this review is to identify the institutional structure of marine environment management and assess the current management responses to general marine issues and specifically the issue of introduced marine pests within the individual APEC economies. This will:

1. Provide an overview of the management measures in place regarding introduced marine pests
2. Provide an overview of the management measures in place regarding general marine environment issues
3. Provide an overview of the institutional arrangements regarding the formal jurisdiction and policy responsibilities of the economies
4. Form a basis for assessing individual economies current and future introduced marine pest management abilities
5. Provide a gap analysis

2.1 Institutional structure

The following diagram is a chart representing the formal jurisdiction and policy responsibilities of the APEC economies.

Please move the 'purple spot' to the position on the diagram that you feel your economy should be.



2.3 General marine environment management

Please enter the relevant ministries, departments and agencies/councils that are involved in managing the marine environment within your economy and a brief description of their role.

Ministry				
Departments				
Agencies/ councils				

Ministry				
Departments				
Agencies/ councils				

Ministry				
Departments				
Agencies/ councils				

2.4 International involvement

Please enter details on guidelines, regulations, legislation, strategies your economy has implemented regarding to **introduced** marine species after adopting the following international and regional instruments and agreements or enter <none> when there has been no action and <unknown> if not sure:

Instruments/agreements	National actions
Convention on Biological Diversity (CBD)	
WTO Agreement on Application of Sanitary and Phytosanitary Measures (SPS Agreement)	
Law of the Sea Convention (LOSC)	
Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)	
International Health Regulations	
International Plant Protection Convention (IPPC)	
Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar)	
Convention on the conservation of Migratory Species of Wild Animals (Bonn)	
IMO Resolution A.868 (20) 1997 (Guidelines for Control and Management of Ships' Ballast Water to minimise the transfer of harmful Aquatic Organisms and Pathogens)	
ICES Code of Practice on the Introductions and Transfers of Marine Organisms	
The IUCN Guidelines for the Prevention of Biodiversity Loss Caused by Alien Species	
FAO Code of Conduct for Responsible Fisheries	
FAO Asia Regional Technical Guidelines on Health Management for the Responsible Movement of Live Aquatic Animals (FAO Fisheries Technical Paper 402)	

Please note that this list is not exhaustive and if you wish to add information regarding other international/regional instruments and agreements, please enter this in the blank boxes above.

2.5 Specific introduced marine pests management

- **Has your economy identified any introduced marine pests as subject to specific legislation?**

<enter answer here>

- **What is the current and historical search effort for introduced marine pests that your economy has performed? (e.g. port surveys, aquaculture disease monitoring, etc.)**

<enter answer here>

- **Has your economy taken any actions on introduced marine pests? If so please specify.**

<enter answer here>

- **Has your economy developed legislation and regulatory measures specific to introduced marine pests at the level of the economy or provinces within the economy? If so please specify.**

<enter answer here>

4.2 QUESTIONNAIRE RESPONSES

Table 7.3. Rankings of potential impacts on domestic and regional marine uses and values by individual APEC economies.

IMPACTS	DOMESTIC ACTIVITIES											REGIONAL ACTIVITIES										
	AUS	BD	CDA	CHL	NZ	PE	RP	SIN	THA	USA	VN	AUS	BD	CDA	CHL	NZ	PE	RP	SIN	THA	USA	VN
Marine infrastructure	M	M	M	H	M	M	H	H	M	L	M	H		H	H	M	M	M	H	M	L	M
Coastal tourism	M	H	H	H	M	L	H	L	L	L	M	M		H	M	M	L	H	H	H	M	M
Aquarium trade	L	M	L	L	L	L	M	L	L	L	L	M		H	M	L	L	L	L	M	L	L
Recreational fisheries	M	H	H	M	M	L	M	L	M	M	M	L		H	M	M	L	L	L	L	L	M
Customary values	L	L	M	M	H	M	L	L	L	L	M	M		L	M	M	M	L	L	L	L	M
Biodiversity	M	H	H	H	H	H	M	L	L	H	M	M		H	H	H	H	M	M	L	H	M
Commercial fisheries	M	H	H	H	H	M	L	L	M	M	M	H		H	M	M	M	L	M	M	M	M
Human health	H	H	H	M	H	M	H	L	L	M	H	H		H	H	H	M	H	L	L	M	M
Domestic shipping	H	L	L	M	M	L	M	L	L	M	M	H		L	M	M	L	L	H	L	M	M
Fish trade	L	H	L	H	H	M	H	M	L	M	M	H		H	H	M	M	M	M	M	M	M
Artisinal fisheries	L	H	H	M	M	M	H		L	L	M	L		H	H	M	M	M	H	L	M	M
Social values	M	M	H	L	H	M	L	L	L	L	M	M			L	M	M	M	L	L	L	M
International shipping	H	H	H	H	M	M	M	H	H	H	L	H		H	H	M	M	H	H	H	H	L
Aquaculture	H	H	H	H	H	H	H	L	M	H	H	H		H	L	H	H	H	M	M	H	H

Table 7.4. Rankings of importance of factors that affect pathways by individual APEC economies for domestic and international activities.

Factors that affect introduced marine pest pathways	DOMESTIC ACTIVITIES											INTERNATIONAL ACTIVITIES										
	AUS	BD	CDA	CHL	NZ	PE	RP	SIN	THA	USA	VN	AUS	BD	CDA	CHL	NZ	PE	RP	SIN	THA	USA	VN
Commercial shipping	H	M	H	H	H	M	H	H		H	M	H	H	H	H	H	M	H	H	M	H	M
New vessels (larger, faster)	H	M	M	M	M	M	L	H	H	M	L	H	H	H	M	M	H	M	H	M	H	L
Number of trading partners	M	M	H	M	M		L	H	M	L	M	H	M	H	H	M		M	H	M	H	M
Domestic port extension/ construction	M	L	M	L	M	L	M	M	L	L	M		M		L	M	L	L	L	L		M
Aquaculture fisheries	M	L	M	M	H	L	H	L	L	M	M	H	L	M	L	L	M	H	M	L	H	M
New aquaculture species	M	H	L	M	L	L	H	H	M	M	L	M	M	M	M	L	H	H	H	M	M	L
Genetically modified aquaculture species	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	M	L	L
Wild fisheries	H	H	L	L	L	H	L	L	L	L	L	L	L	M	L	M	H	L	L	L	L	L
Aquarium trade	M	L	L	L	L	L	L	L	L	M	M	M	L	M	H	M	L	M	M	L	M	M
Oil, gas and mining	H	M	H	H	L	H	L	L	M	L	M	M	H	L	M	L	H	L	H	M	M	M
Marine tourism (including diving)	H	L	M	L	M	L	M	L	M	L	M	H	L	M	L	M	L	L	M	L	L	M
Recreational boating	H	L	M	L	H	M	L	H	H	H	L	L	L	H	M	H	M	L	M	M	L	L
Reduced antifouling	H	L	M	M	M	L	M	L	L	M	M	H	L	M	M	M		M	L	L	M	M
New trade laws	M	L		H	L	L	L	L	L		L	M	L		M	L		L	L	L	M	L
ballast water management	H	L	L	M	L	L	H	H	L	H	M	H	H	L	M	H	L	H	H	L	H	M

Table 7.5. Priority ranking for protection by individual APEC economies based on current management.

PROTECTION PRIORITY	DOMESTIC										
	AUS	BD	CDA	CHL	NZ	PE	RP	SIN	THA	USA	VN
Marine infrastructure	7	3	10	9	13	13	5	3	3	10	8
Coastal tourism	3	1	7	10	8	7	3	5	1	8	8
Aquarium trade	11	3	5	14	14	8	12	6	1		10
Recreational fisheries	6	2	3	12	3	11	8	12	7	5	8
Customary values	13	7	7	14	4	10	14	11	3		10
Biodiversity	8	1	3	7	7	1	7	8	5	6	8
Commercial fisheries	9	1	2	10	2	2	11	10	5	3	8
Human health	5	1	1	4	1	6	1	1	3	4	1
Domestic shipping	10	13	10	10	12	12	9	9	9	7	6
Fish trade	2	1	11	9	6	4	4	4	3	9	5
Artisinal fisheries	14	1	2	9	10	3	6	14	10		8
Social values	12	3	7	11	9	9	13	13	14		10
International shipping	4	1	2	5	11	14	10	2	1	1	4
Aquaculture	1	1	1	5	5	5	2	7	3	2	6

Table 7.6. Vector ranking associated with domestic and international activities by individual APEC economies.

Vectors	DOMESTIC ACTIVITIES										
	AUS	BD	CDA	CHL	NZ	PE	RP	SIN	THA	USA	VN
Commercial shipping											
Ballast water	H	H	H	H	H	H	H	H	H	H	M
Hull fouling	H	H	H	H	H	M	L	M	H	H	L
Solid ballast	L	L	L	L	L			L	M	L	L
Sea chests	H	H			H		L	L	L	L	
Cargo	L	L	L	L	L		M	M	L	L	L
Anchors/anchor chains	H	M	H	H	H	L	L	L	L	L	L
Aquaculture fisheries											
Intentional release	L	L	L	L	L	L	M	M	L	M	M
Accidental release	M	L	H	M	L	L	M	M	L	M	H
Gear or stock movement	M	L	L	L	H	L	L	L	L	L	M
Discarded nets, floats, traps	M	L	L	L	M	L	L	L	L	L	M
Discarded packaging materials (feeds, stock)	M	M	L	L	L	L	H	L	L	L	M
Release of transgenic species	L		L	L	L	L	L	L	L	L	M
Wild fisheries											
Processing of fresh and frozen product	L	H	L	L	L	H	L	L	L	M	M
Live bait movement	M	L	H	L	M	L	L	L	L	H	M
Discarded fishing gear	L	H	L	L	M	L	L	L	L	L	M
Hull fouling of fishing vessels	M	H	M	L	M	M	H	L	H	L	L
Live fish trade-consumption	L	H	M	L	L	L	L	M	L	M	M
Aquarium industry											
Live fish trade-aquarium species	H	H	H	H	L	L	L	L	L	M	M
Intentional release	H	L	L	M	M	L	L	L	L	M	M
Accidental release	M	M	L	M	H	L	L	L	L	L	M
Oil, gas and mining											
Drilling platforms: hull fouling	M	H	H	L	M	L	L	L	H	M	M
Drilling platforms: ballast water	M	H	H	L	M	L	L	L	H	L	M
Dredging spoil	L	M	L	L	M		L	L	H	L	M
Marine tourism											
Diving: dive gear	L	L	L	L	M		L	L	L	L	L
Recreational boating: hull fouling	H	L	H	L	H	L	L	L	H	H	M
Millatary activities											
Military vessels	M	H	H	H	L	L	L	L	L	L	M
Other											
Canals: movement through locks	L		L	L	L			L		H	M

Vectors	INTERNATIONAL ACTIVITIES										
	AUS	BD	CAN	CHL	NZ	PEF	PHL	SINK	THL	USA	VTN
Commercial shipping											
Ballast water	H	H	H	H	H	H	H	H	H	H	M
Hull fouling	H	H	H	H	H	M	M	M	H	H	L
Solid ballast	L	L	L	M	L			L	M	L	L
Sea chests	H	H			H		L	L	L	M	
Cargo	L	L	M	L	L		H	H	L	L	L
Anchors/anchor chains	H	L	H	H	H	L	L	L	L	L	L
Aquaculture fisheries											
Intentional release	L	L	L	L	L	M	M	H	L	L	M
Accidental release	L	L	H	L	L	M	H	H	M	M	H
Gear or stock movement	L	L	L	L	M	L	L	M	L	L	M
Discarded nets, floats, traps	L	L	L	L	M	L	L	L	L	L	M
Discarded packaging materials (feeds, stock)	L	L	L	L	L	L	H	L	L	L	M
Release of transgenic species	L	L	L	L	L	H	L	L	L	L	M
Wild fisheries											
Processing of fresh and frozen product	L	H	L	L	L	H	L	L	L	M	M
Live bait movement	L	L	H	M	M	H	L	H	L	M	M
Discarded fishing gear	L	L	L	M	M	L	L	L	M	L	M
Hull fouling of fishing vessels	L	H	H	M	M	M	H	M	H	L	L
Live fish trade-consumption	L	H	M	M	L	M	L	H	M	M	M
Aquarium industry											
Live fish trade-aquarium species	M	H	H	H	L	H	M	M	M	M	M
Intentional release	L	L	L	L	M	H	L	M	L	L	M
Accidental release	L	M	L	L	H	H	M	M	L	L	M
Oil, gas and mining											
Drilling platforms: hull fouling	M	H	H	M	H	M	L	L	M	H	M
Drilling platforms: ballast water	M	H	H	M	H	H	L	H	M	M	M
Dredging spoil	L	M	L	M	L		L	M	M	L	M
Marine tourism											
Diving: dive gear	L	L	L	M	M		L	L	L	L	L
Recreational boating: hull fouling	H	M	H	M	H	M	L	M	H	M	M
Millatary activities											
Military vessels	M	H	H	H	L	M	L	M	M	M	M
Other											
Canals: movement through locks	L	L	H	L	L			L		L	M

6

Fuel conservation through managing hull resistance

FUEL CONSERVATION THROUGH MANAGING HULL RESISTANCE

A PRESENTATION DELIVERED BY PROPULSION DUNAMICS INC. AT THE MOTORSHIP PROPULSION CONFERENCE, COPENHAGEN

26TH APRIL, 2006

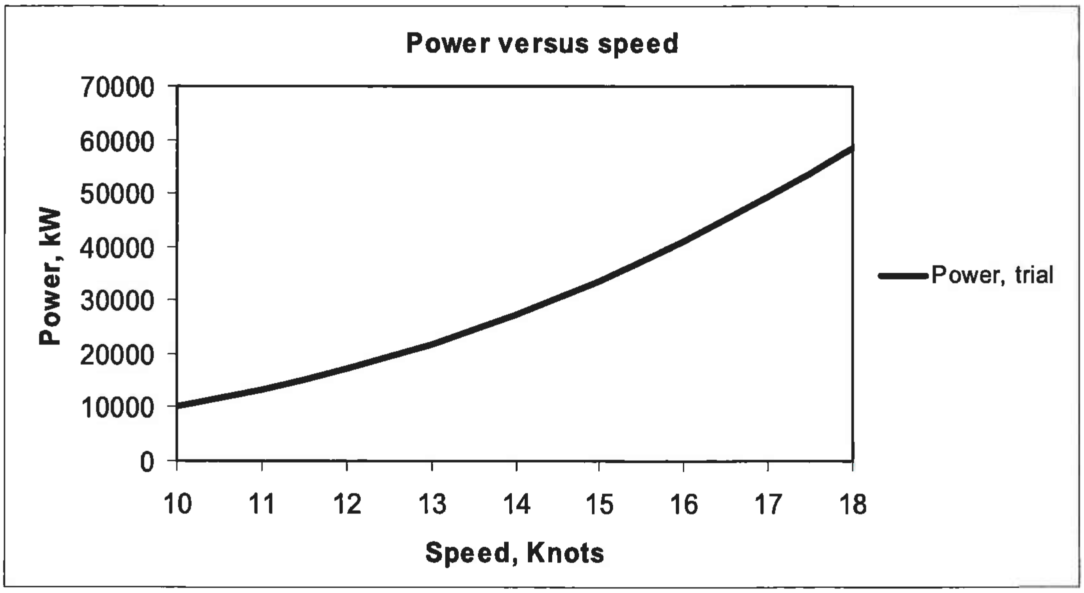
Fuel Conservation Through Managing Hull Resistance

Motorship Propulsion Conference, Copenhagen April 26th, 2006

By:Torben Munk, M.Sc., Propulsion Dynamics Inc. (PDI)

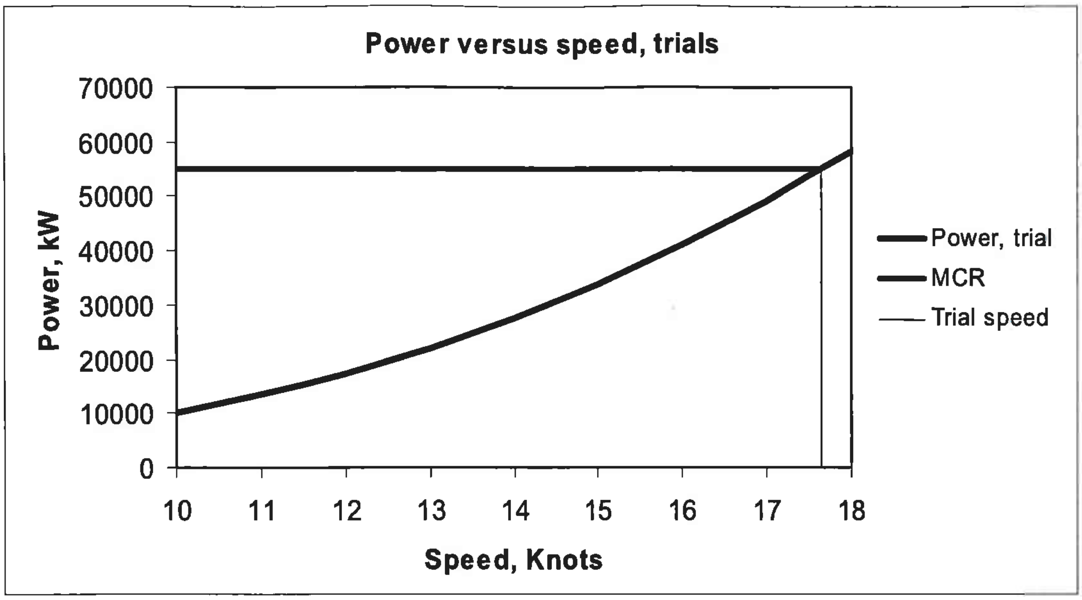
Abstract
There are many good reasons for reducing marine fuel oil consumption. First and foremost is that fuel prices are rising beyond what analysts have predicted as recently as a year ago. Furthermore, reduction in fuel consumption will have a corresponding positive impact in reducing airborne pollution and global warming. Ships are responsible for approximately 5 % of the global oil consumption, and a considerable part hereof could be saved, if the ships' underwater hull and propeller were cleaned at economically optimum intervals. Many ship owners are not aware of the true impact that fouling has on vessel performance, owing to the inherent limitations of performance monitoring systems. In the following, an unprecedented method for monitoring the performance of ships, based on the standard measuring equipment onboard will be described together with some examples of the results, which may be achieved. Also, some of the precautions, which may be taken to improve fuel conservation, mitigate performance losses and benchmark the performance of hull coating systems will be mentioned. Managing hull resistance may also contribute to mitigating invasive species attached to the hull.

Background on ship performance
For most ships delivered from a shipyard there is a diagram showing the relation between speed and required power for one or more loading conditions as shown below. This diagram has been prepared based on theoretical calculations and in most cases has been confirmed by model tests and by a speed trial immediately before delivery.

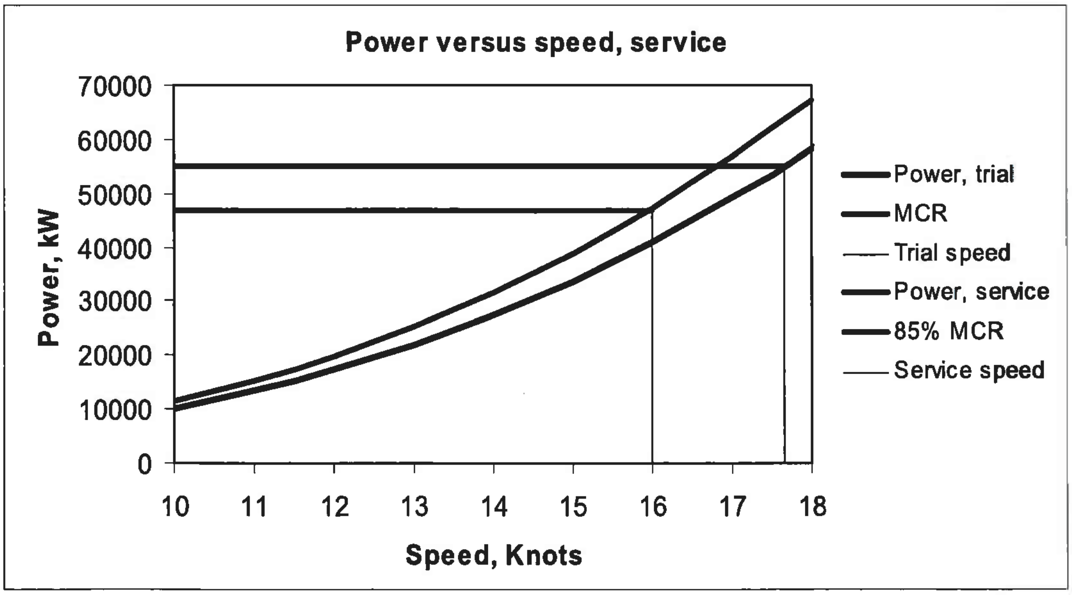


This speed trial is a complicated and time-consuming procedure. The ship must be loaded correctly, the weather needs to be reasonably good, and the trial has to take place in a test area with deep water at a time when there is no other immediate traffic. Time must be given to accelerate the ship up to a constant speed and, as a sea current may be present, each speed run has to be made twice, in opposite directions to compensate for this. Consequently, only a limited number of draft/speed combinations are tested, so the achieved speed/power results, properly adjusted for temperature, salinity, weather, and draft differences, are merely used to confirm or adjust the already existing diagram.

If the engine's maximum continuous rating (MCR) is plotted in this diagram, the maximum speed for the ship may be found as illustrated below.



Ship owners know that this is not the speed they can expect in daily operation, and for commercial consideration, they define a so-called 'service speed'. This service speed is traditionally found by adding 15% to the power curve and subtracting 15% from the engine power line as shown below. The 15% added power is expected to consist of 5% for weather losses and 10% for losses due to hull and propeller surface roughness caused by marine growth and corrosion. For a well-organized introduction to ship propulsion, see Ref. 1.



The actual situation with respect to marine fouling for any particular ship may be worse. This will only be discovered, if the fouling is significant, because it is very difficult in practice to get a reliable and reasonably accurate picture of the speed/power performance of a ship in service.

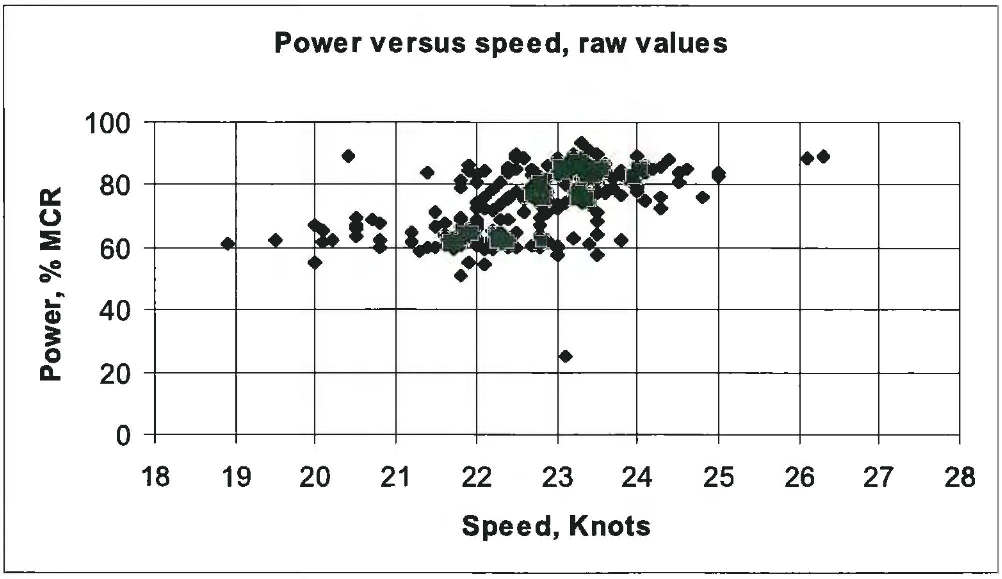
Degradation of the performance

The main reason for performance degradation is marine growth on the ship's hull. This subject is treated thoroughly in the technical literature, for instance in an excellent way in Ref. 2. Here it shall only be mentioned that ship owners are allocating a lot of time and money to prevent or mitigate the degradation. The main remedies are various types of coatings applied to the underwater part of the hull at regular intervals, and in some cases, in-water brushing of the hull and polishing of the propeller.

Altogether, the total costs of all ship owners' anti-fouling precautions are of the order of 1.5 billion USD per year or approximately 5% of the total marine fuel oil costs. Unfortunately, it is difficult to determine if this money is invested in the optimum way. There are many different types of hull treatments, and the price for the coatings varies greatly. In addition, each shipowner has his own way of handling coating selection and maintenance. Furthermore, it is difficult to evaluate and compare the effect of the different hull treatments, unless reliable methods of analysis are available.

Monitoring of ship performance

Most ship operators have established a procedure for speed/power monitoring, for instance by measuring the daily fuel consumption and the daily distance covered. In this way, the daily mean power and mean speed may be calculated, and the result may be plotted in the speed/power diagram for comparison with the trial trip results. Unfortunately, results achieved in this way usually scatter so much that it is impossible to conclude anything directly from such a diagram, as it may be seen from the following plot for a well-maintained container ship.



Procedures may also have been established for more precise measurements with longer intervals, for instance once a month. A day with nice weather may then be chosen. In such cases, and where the prime mover is a slow running diesel engine, the power may be measured more accurately by cylinder indication, and speed may be measured over a period of for instance two hours at constant power on a constant course. The result of such an exercise will be more accurate than one based on "noon data," however, even such monthly results may scatter to an extent that an accurate service speed prediction may be difficult or impossible.

Underwater inspections of the hull as a supplement to speed and power measurements are of course useful; however, they do not provide a meaningful metric between surface roughness and impact on vessel performance. For more information on the biological aspects of hull coatings, see Ref. 3.

Factors influencing the speed/power monitoring

There are many reasons why the directly obtained speed/power values are scattered as in the above illustration. The main factors, which need to be taken into account, are:

1. Drafts. Mean draft and trim has a great influence on the ship resistance. It is reasonably easy to adjust the results for differences in mean draft, but differences in trim are more difficult to deal with, especially when most ships today are equipped with a bulbous bow.

2. Weather. Wind and waves can seldom be totally ignored; therefore, the results will need to be corrected accordingly. It is not that difficult to measure and make corrections for the wind, but waves can neither be measured nor be easily corrected for.
3. Sea current. Today the speed over ground may be measured with great accuracy by means of the DGPS; however, this speed will not be the true speed due to the presence of sea current. The true speed, the speed through the water, is more difficult to deal with. The problem is that most speed logging devices are measuring the speed through water too close to the ship, so that the ship's boundary layer influences the result. Normally, it will not be possible to correct the speed for sea current, unless a reciprocal run is performed, and this is usually regarded as too time consuming to be done during commercial operation.
4. Temperature and salinity. These two factors do have some influence on the result, but they are seldom taken into account.
5. Degradation due to wear and tear of engine, bearings and propeller shaft. The specific fuel consumption of a well-maintained 2-stroke main engine will normally not change much during the lifetime. A possible engine degradation will not show itself in the same way as a hull degradation, but in a number of other ways; for example as a high residual resistance and a high exhaust gas temperature.
6. Potential damage of the hull and / propeller. In the unlikely event that there is damage to the hull or propeller, these can usually be identified since the wake fraction coefficients are not influenced by damage to the hull or propeller, whereas, the wake fraction coefficient is directly influenced by hull and propeller resistance (fouling).
7. Last but most important: The lack of method for interpretation of the results. Even if reliable speed/ power values, corrected for all the above-mentioned factors are obtained and plotted in the speed trial speed/power diagram it may be difficult to accurately describe the degradation of the performance. The reason is that the ship's resistance may be roughly divided into frictional resistance and wave-making resistance. The fouling only influences the frictional resistance, and as the frictional resistance fraction of the total resistance depends on the speed and the draft, the additional power demand, expressed as percentage of the total power requirement, will not be the same for different loading conditions and different speeds.

Proposed measure for performance degradation

The effect of hull resistance on propulsion performance is complicated and difficult to describe in an unambiguous way. The primary effect is that more water is dragged forward along with the ship, and this will of course increase the ship resistance. The increased forward velocity of the water in the ship's boundary layer will also cause the inflow velocity to the propeller to be reduced. This has several effects. On one hand the efficiency of the propeller will decrease, on the other hand some of the power lost in the boundary layer will be re-gained. Altogether, the required power will increase, however, not quite as much as the resistance. Since it is not possible to state a fixed relation between added resistance and added power, for simplicity it is proposed to use the added resistance as a measure for degradation and not the added power.

Even a description of the hull degradation in the form of the added resistance as a percentage of the total resistance is ambiguous, unless it is specifically designated, for which speed and which loading condition (draft) this percentage is valid. It is therefore further proposed to refer the added resistance to "the design speed and the design draft." This is not a precise reference, but it works in practice and is quite useful, not only for evaluation of the condition of a single ship, but also for comparison of several ships, which not need to be of the same shape and size. The implication here is that different coating systems may be compared, even if they are applied to ships of different size or hull form.

It should however always be kept in mind that the added resistance as defined here is *not* equal to the actual increase of power. Even at "design speed and draft" the increase of power will normally be a few per cent lower than the "added resistance". At deep draft and low speed the power increase will be more than the "added resistance", and in ballast condition at full speed it may be less than half of the "added resistance". It is however always possible to calculate the actual power increase for any draft/speed from the found "added resistance".

Collection of performance data
As mentioned above, performance data may be collected daily or, in a more detailed form, with an interval of a month or so. Some ships have an automatic data logging system, which files observations continuously. In principle, any of these methods may be relevant and useful, as long as the observations are made carefully. These different methods do have their advantages and disadvantages:
1. Continuous data logging excludes all human errors, but some data, for instance wave data, are normally not available in this way. Further, this method produces a lot of data, which means that some kind of data reduction and data selection has to be introduced together with the system. Still it is difficult to assure that only data for valid navigation conditions are further processed.
2. Daily observations, the so-called 'noon-data', are useful for some purposes, if carefully dealt with. Daily reports can however only be used for performance analysis, if all conditions have remained unchanged during the 24 noon-to-noon period, and this is seldom the case.
3. Monthly, detailed observations over a time interval of a couple of hours are normally as reliable as such observations can be and therefore quite useful. It will however be described later that these observations cannot "stand alone", but have to be treated together, and 12 sets of observations a year are therefore too few to establish a reliable "time history" for the development of the added resistance for a ship.
4. A reasonable solution seems to be a procedure, where observations are made once a week. This interval is so short that the routines are not forgotten, but on the other hand so long that the temptation of just repeating the latest data is avoided. In addition, it is usually possible to find a two hours period with constant navigation conditions within a time interval of a week, and +/- 50 observations per year is still enough for a detailed time history.

Processing of performance data
One way of processing the performance data is to compare the observed power and RPM values to those, which are found for similar weather and loading conditions from a mathematical model of the ship's propulsion performance. It can then be determined, at which speed through the water and with which added resistance the calculated values matches the measured values, and both speed through water and added resistance are then determined.

This method requires that such a mathematical model is available or can be established, however, this is not as easy as it sounds. There are complicated, theoretical methods for the calculation of resistance, propulsion system performance, weather resistance, and influence of hull roughness for a specific ship, but in practice a simple and robust general mathematical model, which can easily be adapted to any ship, is needed. Such a model may be established by means of a combination of theoretical considerations and approximation formulas with empirical constants.

The number of empirical constants in a model, which is developed in this way, is quite high, but fortunately, some of these values are valid for all ships or for large groups of similar ships. Other constants are specific for the individual ships. The value of some of these latter constants may be found by careful analysis of the tank test and/or trial trip results, whereas, other constants can only be found by statistical analysis of a large number of performance observations for the ship *in service*.

An example of a solution (called CASPER, Computerized Analysis of Ship PERformance)
CASPER® is based on a general mathematic model; a build up by well-known, state-of the art elements for the calculation of ship resistance, propeller performance, weather resistance, etc. The general model, based on the type and main dimensions of ship and propeller, may stand alone and may be used directly for comparison to actual performance data, but a more reliable model can easily be established by an adjustment of the general model, considering tank test/trial data. Even this model will not normally reflect all changes in the operational conditions, and the model is therefore not used for performance evaluation until it has been adjusted further by means of a statistical analysis of a number of performance observations. In general, 10 – 12 sets of observations are required for this purpose, and the model will then be used for performance analysis and predictions. The adjustment of the model continues, as more observation data are received. Normally, the basic constants of the model will remain

unchanged after 30 – 40 sets of observations, but the constants describing the condition of the hull and propeller resistance will be updated in real time as data from the ship is acquired.

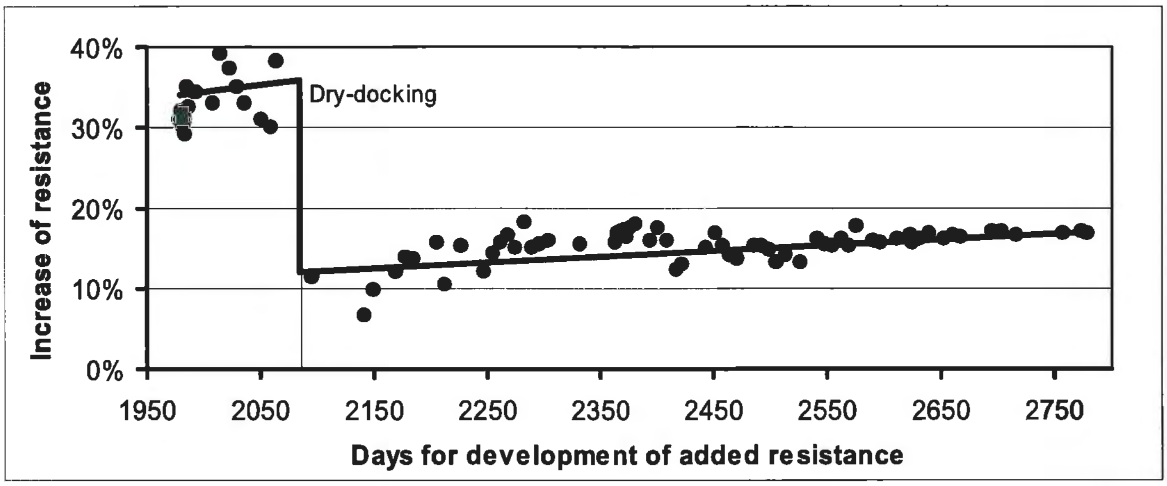
Accuracy of the analysis

In practice, the accuracy of the analysis results is more dependent on the accuracy of the observation data than of the mathematical model itself. Experience shows that the actual "added resistance" as earlier described may be found with an accuracy of approximately 1 %, and that the result from a single set of observations normally not will deviate more than 3% from the mean value. The actual speed/power diagrams, which may be produced from the adjusted mathematical model, are therefore fully valid for all practical purposes (transport cost calculations, cost-benefit decision for coating selection, maintenance intervals, total cost of ownership, etc).

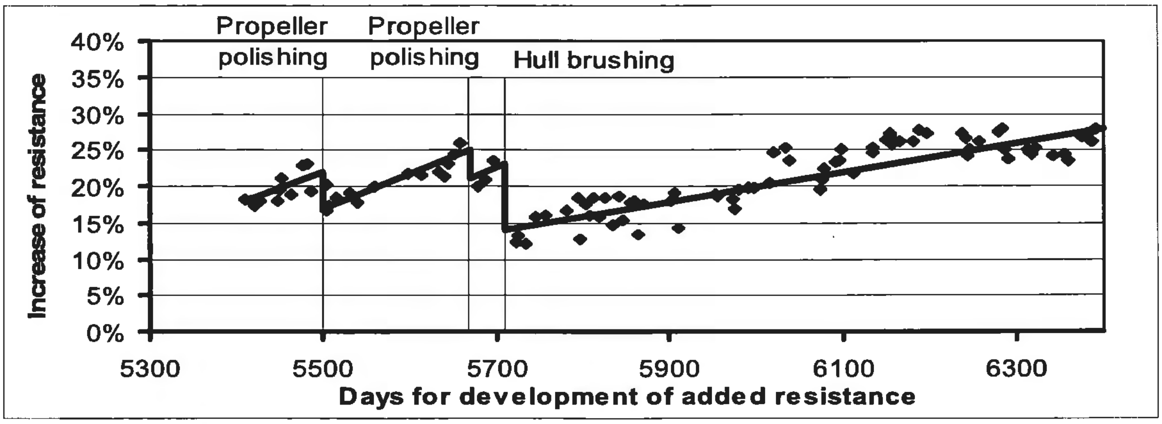
Examples of Added Resistance diagrams

In the following, a number of diagrams are shown in order to illustrate the described method. The individual analysis results are shown, and a 1st order curve (a straight line) is faired through the points in order to show the development.

1. Typical example (below) of development of added resistance. It is seen that the added resistance in this case develops very slowly, less than ½ % per month.



2. Example (below) of a more pronounced development of the added resistance. Here, the development of resistance is 0.7 – 1 % per month.



Use of the diagrams

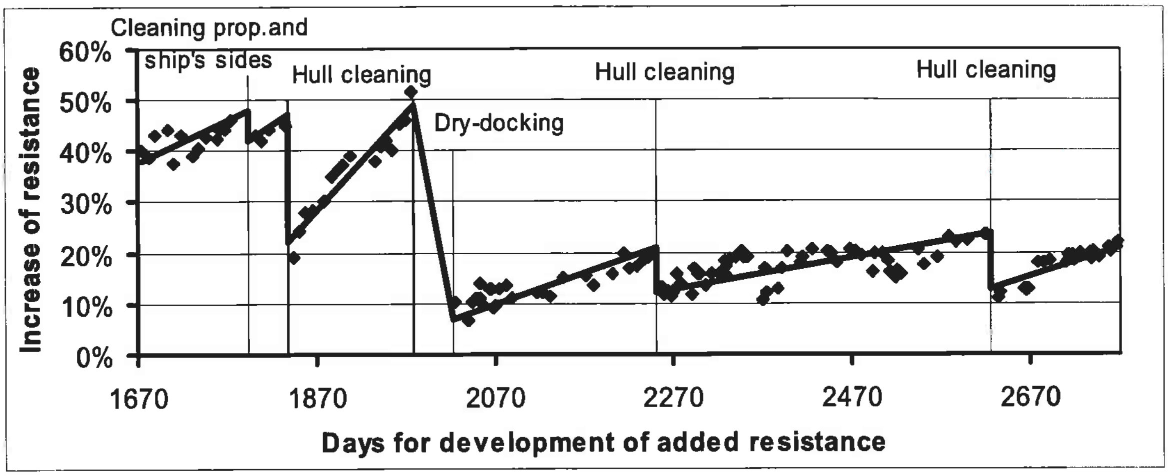
In the following, four examples of the use of the diagrams will be shown.

1. This ship (below) had initially a high added resistance, approximately 50 %. When this was discovered, the propeller was polished and the ship's sides were brushed. It is seen that the

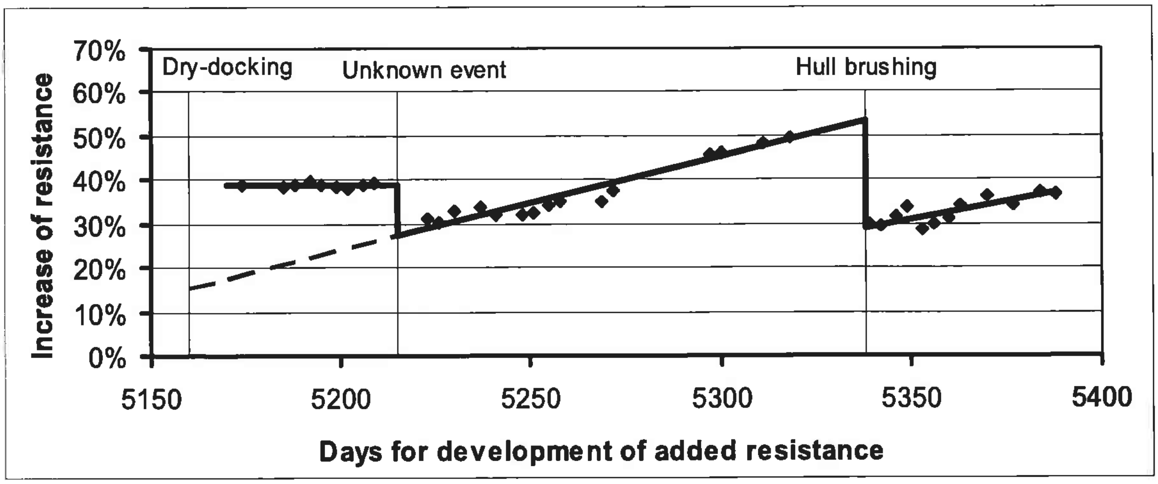
effect of this was marginal. The Operator was advised to have the ship dry-docked, but as this was inconvenient at that time he decided to brush the sides and bottom of the hull thoroughly a few weeks later.

The result of this brushing was remarkable, but as the anti fouling was apparently depleted, the result did not last long, and the ship was dry-docked on schedule.

Subsequent to the dry-docking, the hull was brushed, as soon as the added resistance exceeded 20%.



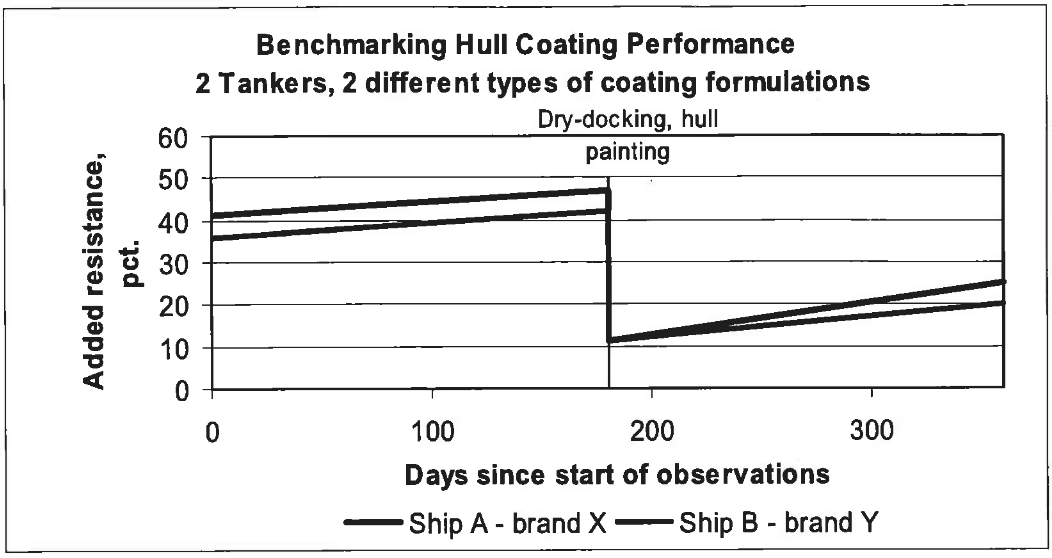
2. This ship (below) came out from the dry-dock with a remarkably high added resistance (40 %), and this resistance was constant for a period, until it suddenly dropped. After this the added resistance developed very fast (6 % per month). A hull brushing removed approximately half of the added resistance, but the resistance is developing fast again after the brushing. It is a clear example of a poor treatment in the dry-dock.



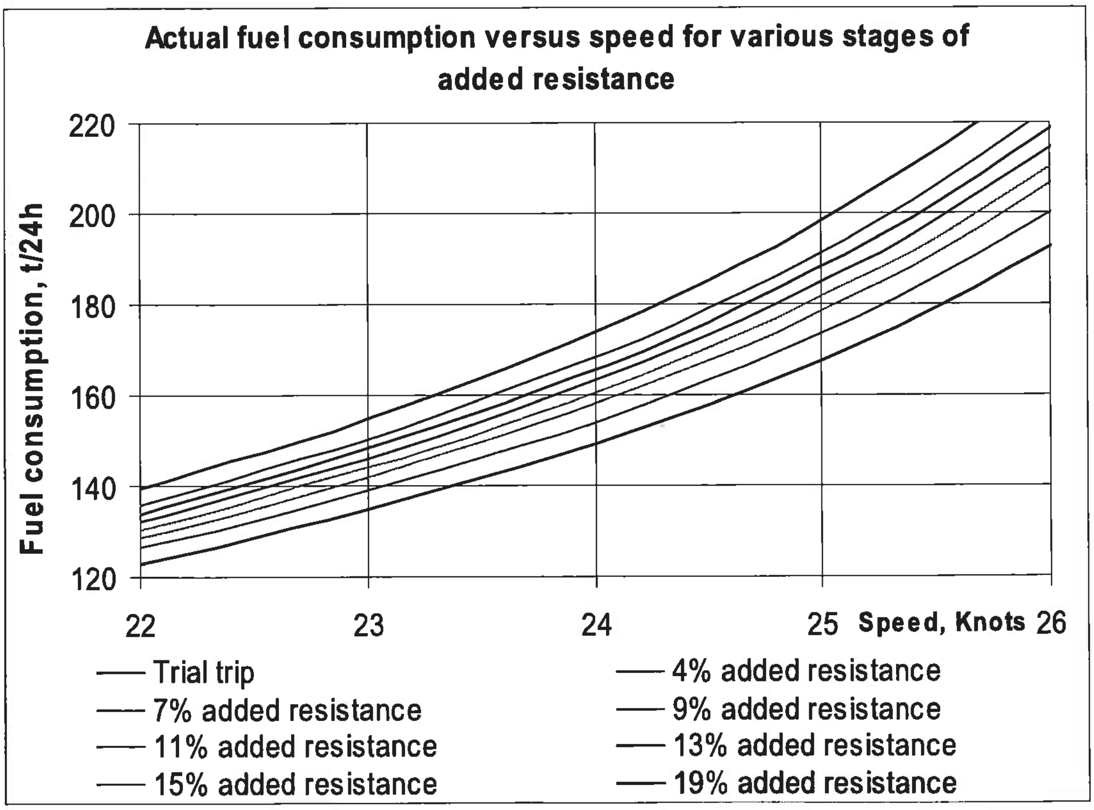
The explanation for the high, constant added resistance (above graph) after dry-docking can only be that something adhered to the hull. It could be keel blocks, plastic sheets or other objects, which may have been present under the bottom of the ship before docking out. Whatever it was, it disappeared suddenly, and the resistance dropped down to a usual development line. Assuming this was the case, the added resistance after dry-docking was as high as 16 %, which indicates that not much treatment had been done (in dry-dock) to make the hull smooth. Further, the fast development of the added resistance indicates a very inefficient anti fouling paint had been applied. It is seen that for this particular case a hull cleaning at least every half year will be advisable to mitigate what would otherwise be even higher fuel penalties.

3. These 2 ships (below) came out of dry-dock at different times. The effect of the coating performance before and after dry-dock is clearly shown, where ship A exhibited higher added

resistance before dry-dock. After dry-dock, the two different coating systems exhibit differing developments of resistance, hence greater fuel efficiency for Ship B than Ship A. (Individual data points removed for clarity and the drydock date was zero-adjusted).



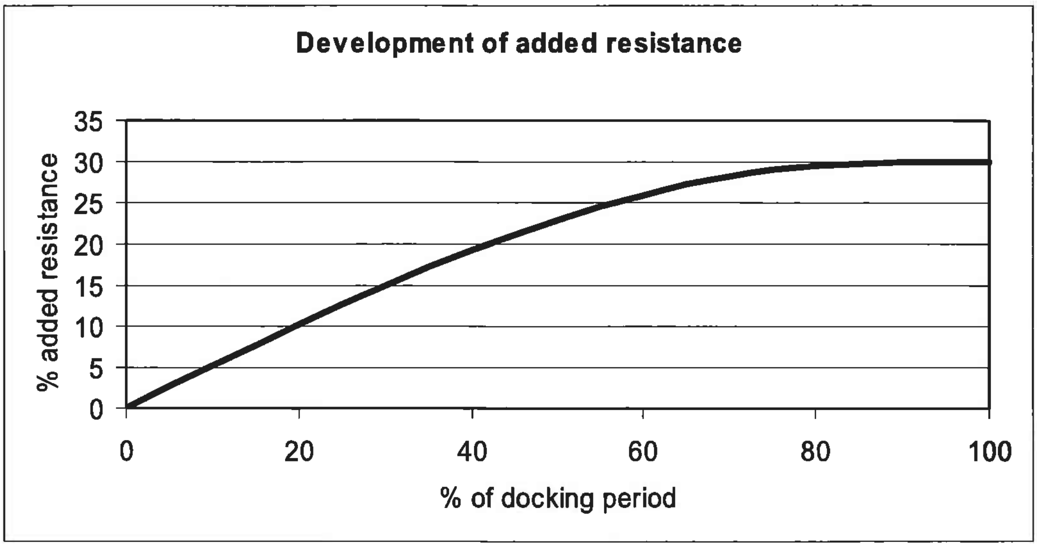
4. Fleet monitoring of hull efficiency. The graph (below) shows an array of 7 ships of similar design, plotting the actual performance due to present state of fouling. This also illustrates that performance losses due to fouling are seen as an increase in consumption to maintain a speed or as an incremental speed loss at a maintained power (no change in fuel consumption!).



Lessons learned
Since this technology has been utilized for more than 10 years, and on more than 100 ships (prior to commercialization in 2002 as CASPER®) it is possible to draw some general conclusions from the results.

1. The added resistance (due to fouling of the hull and propeller) varies from around 6 % and up to 80 % in the worst cases. *In average, the added resistance for a ship is approximately 30 %, if no special attention has been paid to the ship.*
a.) Roughly, one third of all ships are in a good condition with added resistance less than 20%;
b.) Half of all ships are in a reasonable condition, but in a condition, which easily could be improved, with an added resistance between 20% and 40%, but exhibit no unusual fouling pattern. For these ships, improvement in performance can be achieved by some standard maintenance procedures without interfering with the normal course of operations;
c.) The remainder of the world fleet (over 10,000 dwt) is in poor condition, where the added resistance is over 50%..

2. The development of the added resistance normally follows a curve like this:



The increase will normally be between 0.5 % and 2 % per month in the beginning of a dry-docking period. For some cases, 5% - 6% per month for a limited duration have been seen. Later in the period, when the added resistance has reached a certain level, the development may be more restricted. *The slope of the lines for development of resistance are a good business tool in determining future performance penalties due to fouling.*

3. The basic hull treatment in the dry-dock has a pronounced influence on the added resistance after the dry-docking. In the best cases, the base-line added resistance will only be 0 % to 4 %. A partial treatment in drydock has been seen to result in an added resistance of 5% - 20%, while in the worst cases there may be no effect at all from the dry-docking.

4. The type of coating has a pronounced influence on the development of the added resistance. It is not only a question of type of coating, it is also important that the coating is applied in correct thickness, and that the dissolution speed or, for self-polishing paint the polishing speed, is carefully adjusted to the service speed and operational patterns of the ship. Insofar as the performance of silicon coatings, the treatment in dry-dock is even more critical than with paint systems.

5. Hull brushing between dry-dockings may have a remarkable effect, especially if one of the less active types of antifoulants has been used. Hull brushing may to a certain degree compensate for low efficiency of the antifoulant.

It is advisable to clean the hull *before* the slimy layer of bacteria and algae has turned into a layer of seaweed. In that case, very soft brushes (for example - softer than the bristles of a toothbrush) can be used, and the anti fouling paint will not be damaged. This stage corresponds to approximately 12% of resistance added to the resistance after dry-docking. At a later stage, harder brushes are required, and though they easily can remove the seaweed they will most probably remove some of the anti fouling paint, and this may result in an increased development of the added resistance after the brushing.

Conclusion
Economically optimum precautions can only be taken, if the propulsion condition of the ship is well defined, and this requires not only a reliable performance monitoring system, but also rigorous methods of analysis. Any shipowner may establish such a system, however, it requires strong hydrodynamic and statistical expertise to develop and to extract actionable information for prudent business decisions.

When rigorous methods of analysis have been established and in use for some time, it will be possible:

- To evaluate dry-docking treatment (grit-blasting, water-blasting, robotic systems) and other emerging technologies;

- To follow the development of hull and propeller resistance for individual ships and to take action when economically justified on a ship-to-ship basis. This includes evaluating the before-an-after effect of hull cleanings, water pressure cleanings, propeller polishing, as well as the mitigation of invasive species introduced through the ship's hull.

- To benchmark the efficiency and true life cycle cost (Total Cost of Ownership) of any coating system by comparing ships with different coating systems applied to the hull and/or propeller. Ships need not be identical in hull form.

Experience has shown that at least 10% may be saved in average on the fuel costs. For a ship, which burns 100 t of fuel per day, at least 10 tons per day may be saved. This represents a value of approximately 3000 USD per day or approximately 800 000 USD per year.

Other advantages may follow, such as the ability to:

- Optimize trim characteristics for maximum propulsion efficiency;
- Correlate Average Hull Roughness to added resistance;
- Controlling invasive species from hull growth, by controlling the added resistance;

The aforementioned advantages are worthwhile, yet outside of the scope of this paper.

Looming on the horizon is a higher fuel prices (as of this writing, bunker fuel is $315 USD per ton), greater demand to reduce pollution and the need for defining true lifecycles of new coatings. It is in all parties' interest that ship operators do their utmost to establish accurate and reliable methods of analysis for maximizing fuel conservation and improving vessel performance.

This paper was slightly modified from it's original presentation and is for informational puposes only and cannot be construed as technical or financial advice whatsoever.

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Surface Ship Hull and Propeller Fouling Management

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Lt Cdr Ian Atkins, Fleet HQ, Royal Navy

SURFACE SHIP HULL AND PROPELLER FOULING MANAGMENT

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SUMMARY

In recent years, Royal Navy ships have increasingly suffered from hull fouling. This is due to a number of factors including the ban of TBT based anti-foulings, the move from three to 5-year docking cycles, and the shift in operations from following the Cold War from the North Atlantic to littoral theatres of operation in tropical waters such as the Arabian Gulf, where marine fouling is particularly prevalent.

In order to improve fuel efficiency across the fleet in an environment of increasing fuel costs, and more intense hull fouling, a system has been introduced to monitor the propulsive efficiency of the ships in order to highlight hull fouling before it reaches a severe state. This allows the hulls to receive a light in-water hull clean which will both remove the hull fouling, and re-activate the anti-fouling effectiveness of the paint.

Finally, a view will be given in respect of the suitability of different anti-fouling paint systems for applications in the Royal Navy and Royal Fleet Auxiliary.

1. INTRODUCTION

A warship is required to deliver military effect in order to meet the stated aims of the government of the day. This can take many forms from full scale war fighting operations to policing duties, embargo operations, anti slavery patrols, operational sea denial and operational sea control to name but a few. All of these tasks require a unit to be deployed, sustained on operations and then recovered at some point in time. It does not take too great an intellectual leap to work out that this needs to be done in the most cost effective manner possible as the nation is spending its taxpayers' money to do this. Hull and propeller fouling reduce the efficiency, and therefore, effectiveness of a unit with marked increases in fuel consumption and reductions in top speed. Not that this is new, ships have employed various methods for centuries to minimise hull fouling. However, the key has been to do this optimally.

A programme titled "Optimising Fleet Fuel usage to Maximise Effectiveness" has been initiated across the RN and RFA, which targets a number of fields for improving fuel efficiency including reducing ship hotel load, optimising ship trim and displacement for reduced resistance, and improving the management of marine fouling. This paper is limited to discussing the latter subject.

The extent to which a hull fouls is dependent on two factors:

- The marine environment surrounding the hull
- The effectiveness of the paint system in preventing the attachment of marine fouling to the hull surface.

The marine environment is not just dependant on location, but also water temperature, salinity, daylight hours, all of which may vary. The ship's speed and hull form shape will also influence the rate of fouling growth. All of these factors add together with the result that you will almost never find two ship's hulls fouled in an identical manner.

This makes quantification of the effects of fouling quite difficult in a visual respect, however, approximate relationships between fouling extents and their effect on resistance have been made, which are based on shaft power measurements taken from ships in service.

2. HULL FOULING IN THE CONTEXT OF NAVAL OPERATIONS - ENVIRONMENT

The extent to which a hull and/or propellers are susceptible to marine fouling are dictated by a number of primary factors. Unfortunately, the majority of these factors conspire against naval vessels, and result in an increased susceptibility to marine fouling on naval vessels compared with their commercial counterparts.

2.1 WATER TEMPERATURE

Little fouling will form in water temperatures below 13ºC. Ships are particularly susceptible to fouling in water temperatures above 20ºC, which tend to be found between the latitudes of 30ºN and 30ºS. The increase in operations in the Arabian Gulf region over the last decade has led to increasing demands on anti-fouling paints. Interestingly, tubeworm that had accumulated in the Black sea on one destroyer leading to over 20% increase in shaft power at 13 knots had almost entirely died off, and lost its adhesion with the hull after a month alongside in Portsmouth harbour over the winter. It was presumed this particular species could not survive in the winter water temperatures present in Portsmouth, but investigations are ongoing to assess whether any other influences had an effect.

2.2 LIGHT INTENSITY

Fouling organisms develop in areas where they can easily absorb daylight, as most rely on this to survive, or feed on plant organisms that rely on daylight to survive. Long daylight hours and increased strength of the sun will mean that fouling will grow most rapidly in summer and in the tropics. Where water clarity is poor, fouling will only tend to appear at or near the waterline, as light intensity will reduce with increased depth from the surface. In areas with high water clarity, fouling may develop over the full-immersed draught of the vessel. Hull surfaces facing the sun will be most vulnerable to fouling. Thus, the tops of sonar domes and the top faces of stabilisers/bilge keels will be most likely to foul. Following these, the vertical sides of the vessel will be next most susceptible, then the turn of bilge, and finally the least likely being the flat of keel, and under the stern in way of the propellers.

2.3 SHIP SPEED

Most forms of fouling can only attach to a surface at ship speeds below 4 knots. Thus, operations, as commonly undertaken by the RN and RFA, which involve loitering, continuous sprint and drift, or extended periods alongside will all encourage the formation of hull fouling. Once attached, most fouling will hold fast to the hull for the full range of ship speeds.

2.4 AGE OF PAINT COATING

When paint coatings near the end of life there is a notable reduction in the secretion of anti-fouling chemicals and the ability to inhibit the growth of fouling is lost. This typically occurs after three years of service for the paints applied to the vast majority of RN and RFA vessels, and five years for the more advanced self-polishing paints. The majority of RN platforms have now moved to 5/6 year docking cycles, thus paints are being pushed right to the limits of their life and often beyond.

2.5 PRESENCE OF OTHER FOULING

The existence of slime on a hull will reduce the effectiveness of the anti fouling by providing a barrier between the anti-fouling paint and other forms of hull fouling. Once there is a notable amount of fouling on the hull, there will be an 'Oasis Effect' [1] where secondary communities are attracted to and forage on, the weed and algae, which will lead to a dramatic increase in the rate of fouling accumulation on the hull.

2.6 SALINITY

Most forms of shell fouling cannot survive in fresh water, thus will not accumulate on the hull in these conditions. If already accumulated on the hull, barnacles cannot survive for more than a few days in fresh water; however, the calcareous shell will stay attached to the hull for months if not years after the death of the enclosed organism.

3. HULL FOULING IN THE CONTEXT OF NAVAL OPERATIONS – EFFECT

Most ships in the RN spend the majority of time at cruise speeds below 15 knots. A typical operating profile for a typical frigate is shown in figure 1 (split into 1 knot increments).

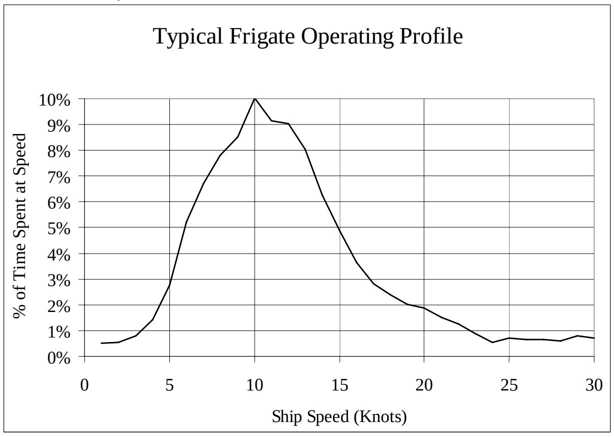

Figure 1: Typical operating profile for an RN Frigate

Naval vessels are unique in that the hulls are designed for high speed, but they spend the majority of their time at significantly lower speeds. Thus at cruise speeds, the wavemaking resistance plays a significantly smaller part than most commercial vessels. Typically, resistance due to friction forms 75-85% of total resistance for the range of cruise speeds, as shown in figure 2, below.

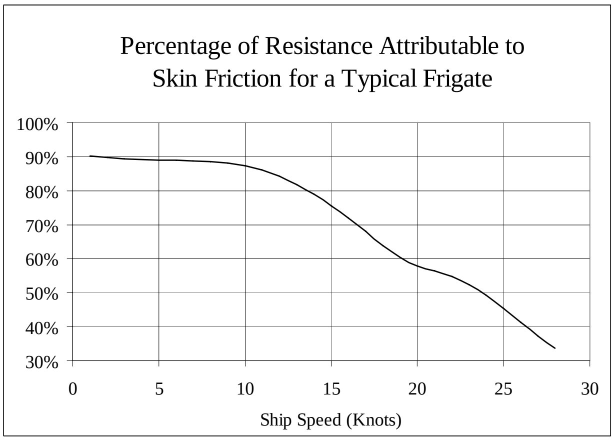

Figure 2: Percentage of Resistance attributable to Skin Friction for a Typical Frigate

When the operating profile as figure 1 is overlaid with the fuel consumption figures, which take into account the influence of switching different prime movers in and out of the propulsion train, the profile of total fuel burn (excluding hotel load) against speed transforms into a completely different shape, as figure 3. Now it becomes apparent that despite the fact that the majority of time is spent at speeds around 10 knots, due to the increases in fuel consumption with speed, the majority of fuel is consumed in the 17 to 22 knot region, with a second peak at the maximum speed.

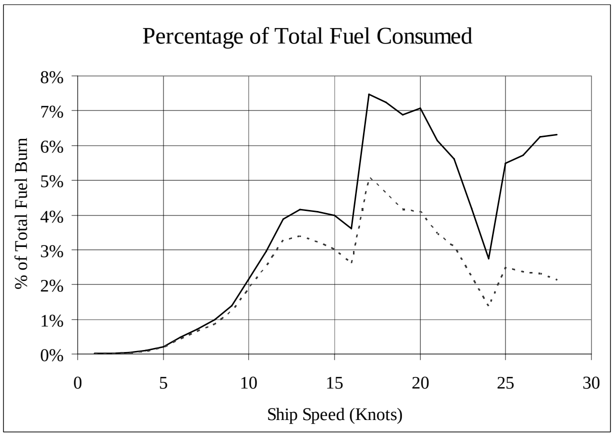

Figure 3: Proportion of fuel consumed (as a percentage of annual total) by speed increment for a typical frigate. The lower dotted line is a direct multiplication of the upper line with the distribution as figure 2, thus showing the proportion of fuel burned to overcome skin friction resistance.

From figure 3, it can be found that 61% of annual fuel burn is attributable to skin friction for a typical RN frigate. Due to the environmental effects as discussed in section 2, no two hulls will ever be subject to the same pattern of fouling, however, recent experience with fouled hulls has suggested that some approximate relationships can be made between fouling extent, and its associated resistance penalty in terms of increase in the friction coefficient, Cf.

Fouling Extent by area of wetted hull	Increase in Friction Coefficient (Cf)	Increase in Fuel Consumption based on figure 3
100% coverage of slime, occasional patches of weed	20%	12%
As above, plus additional 20% coverage of tubeworm less than 6mm in height	30%	18%
As above, plus additional 20% coverage with barnacles less than 5mm in height	40%	24%
80% Coverage with Barnacles less than 5mm in height	100%	61%
80% Coverage 10-15mm Barnacles	150%	92%

Table 1 – Approximate relationships between fouling extent and resultant increase in Friction Coefficient

4. A RECENT EXAMPLE OF SEVERE FOULING – TYPE 22 FRIGATE

4.1 BACKGROUND

A Type 22 Frigate was anti-fouled with a paint system with a manufacturer's stated life of 3 years in January 2003. Following 2½ years of operations, which included deployments to the Arabian Gulf, one to the Mediterranean, operations in UK waters, followed by another deployment to the Arabian Gulf, severe fouling was reported.

Shaft power readings were recorded in September 2005, which indicated that the ship was experiencing a 51% increase in shaft power at 13 knots (equivalent to 115% increase in Cf). Further shaft power readings were recorded exactly one month later in October, which indicated that this had increased to 76% (equivalent to 160% increase in Cf).

Some of this increase in shaft power will be attributable to increased roughness and fouling on the propeller. It is generally found that propeller roughness and fouling reaches a plateau if the ship is in operation, as fouling will be limited to the hub, and a small proportion of the propeller blades in the close vicinity. This is due to the high water turbulence preventing fouling on the outer portions of the propeller blades. Estimations on the effects of propeller roughness and fouling indicate that this plateaux is in the region of 8-10% on shaft power at 13 knots, and this would be equivalent to fouling growth and roughness accumulated on a propeller operating in the tropics that had not been cleaned for 18 months or more. Typically, shaft power will increase by 6% over a year due to fouling growth and roughness accumulation on the propeller.

4.2 HULL INSPECTION

The hull of the Type 22 Frigate was inspected when in water, and the following fouling was found:

Hull sides: 80% coverage with barnacles up to 30mm in height, with weed also present: similar to figure 4

Figure 4 – Fouling Equivalent to 80% coverage of barnacles interspersed with weed

Hull bottom: 80% coverage with barnacles 10-15mm in height

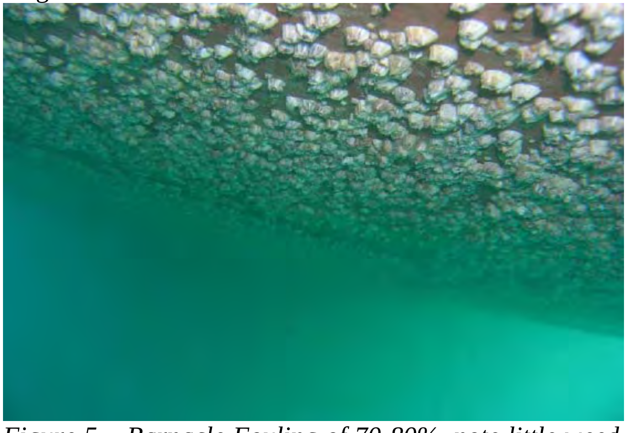

Figure 5 – Barnacle Fouling of 70-80%, note little weed present due to reduced light under the hull

Sonar Dome: 100% coverage with weed growth: figure 6

Figure 6 – Weed Fouling as can be found on upper faces of sonar domes

Propeller Shafts: 70% Coverage with barnacle growth

Figure 7 – Barnacle Fouling on a propeller shaft

As can be seen, fouling type and extent varies over the hull, and was primarily driven by the ambient light levels.

4.3 HULL CLEANING

The hull was cleaned in water, which required twisted wire brushes to remove the fouling, due to its severe nature. Following cleaning, the hull resistance led to shaft power returning to predicted clean hull levels.

Figure 8 – Typical condition of the hull following cleaning

Due to the requirement to have a highly abrasive clean in this instance, the anti-fouling was removed in places down to the epoxy anti-corrosive paint beneath. This occurred primarily where barnacles had bedded significantly into the paint, and upon removal took a 'footprint' of paint with them. Were the fouling less developed, the barnacles would not have bedded into the paint to such an extent. This would have meant that a lighter clean would have been sufficient, using plain wire or nylon brushes, which would have reduced the damage to the paint system.

This emphasises the need to detect fouling at an early stage, and tackle it before it matures to a level that is difficult to remove. This applies particularly to hard fouling such as barnacles.

However, despite the very abrasive clean required to remove the fouling, there were no areas of bare steel exposed when the hull was inspected at the time of next docking. This was assumed to be due to the epoxy anti-corrosive being significantly harder than the anti-fouling paint. An example of the condition of the hull following cleaning is shown in figure 8.

4.4 FOULING RE-GROWTH FOLLOWING HULL CLEANING

With commonly applied ablative paints, the biocide release process leaves a residue of salt leachate on the surface, which builds up over time, eventually forming a barrier between the biocide and the water, leading to the failure of the paint as an effective anti-fouling agent. The abrasive nature of in water cleaning has the effect of removing this layer, thereby re-activating the anti-fouling.

It is commonly quoted by paint manufacturers that the hull cleaning process releases a cloud of spores into the water, which settle on the hull surface, and lead to fouling re-establishing at a faster rate. However, this needs to be put into context:

- The rate of fouling accumulation on a fouled hull will be far greater than on a newly cleaned hull, due to the 'oasis effect' as described in 2.5.
- The abrasive nature of the hull clean will 're-activate' the anti fouling, which will lead to the majority of spores being killed before they have chance to mature into hull fouling. Note: cleaning in dock will not have the same effect, as a pressure hose will not abrade the paint surface in the same way.
- If the clean did remove paint down to the anti-corrosive, the rate of increase in shaft power over time will be significantly less for a cleaned hull with no effective anti-fouling, than for a fouled hull.
- A cleaned hull will always foul faster than a newly painted hull, as the newly painted hull has higher levels of biocide in the paint, and the surface has not been seeded with spores.

5. MONITORING SHIP PERFORMANCE FOR THE DETECTION OF FOULING

By periodically monitoring shaft power under controlled conditions, it is possible to detect the influence of an accumulation of fouling on the propeller and/or hull of a ship. The shaft power is measured using the shaft rpm and torque instrumentation already fitted across the fleet. By comparing the as-measured power with a known baseline, the increase in shaft power over the clean hull condition can be determined.

The baseline is derived either by measuring the shaft power characteristics of a ship of the class upon leaving refit, or other occasion where it is known that the hull and propellers are both completely free of fouling, or by calculation based on model resistance and propulsion and first of Class speed trial data held for the vessel.

By calculating the effect on fuel consumption as section 2.6, the economic impact of the hull fouling can be assessed and appropriate remedial action taken.

5.1 THE BUSINESS CASE FOR HULL CLEANING

The metric that has been used on whether or not a hull qualifies for a hull clean is: If the costs of the clean can be recouped within three months of operations, then the clean provides overall financial benefit, as it is assumed that all operations after three months are providing fuel savings. The shaft power level that meets this criterion has been termed the shaft-power trigger value.

Additionally, the hull clean provides further operational benefit in terms of higher top and cruise speeds.

The process to determine shaft power triggers takes into account the cost of fuel, the resistance and fuel consumption characteristics of each class in both clean and fouled condition, and the Fleet programme (i.e. each ships predicted fuel consumption) for each ship over the next 12 months (see figure 8).

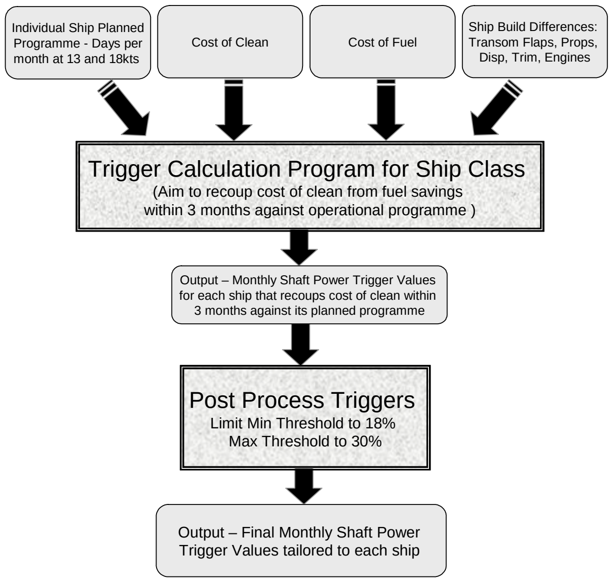

Figure 8- Calculation Process for Shaft Power Triggers

The output from the trigger calculation process tends to vary between from 2 to 50%, with the lower end being dominated by ships with all gas turbine propulsion, and high utilisation rate, such as the Aircraft Carriers, Type 22 frigates and Type 42 destroyers.

Because 2% is within the bounds of experimental error, due to instrument inaccuracies, environmental influences and ship build differences, a minimum threshold is required. In determining this threshold, practical considerations also need to be considered.

5.2 PRACTICAL LIMITS TO BE IMPOSED WHEN DETERMINING SHAFT POWER TRIGGER VALUES

Because the paint applied to RN warships has not been historically given a margin to allow for depletion arising from hull cleaning (typically assumed as 25-50 microns per clean), the process must not take place too frequently. An assumed lower threshold of 18% increase in shaft power at 13 knots has been applied, which coincides with the approximate initiation point for hard fouling.

An upper limit was also applied appropriate to the point before mature shell growth has developed and a heavy clean is required. This is estimated as 30% increase in shaft power at 13 knots. In-service ships should be cleaned when they reach this stage, irrespective of their rates of utilisation. To allow fouling to grow beyond this stage would lead to barnacles bedding into the paint surface. This will damage the coating directly, and indirectly due to the cleaning force required to later remove the barnacle.

The trigger values are published annually, based on fuel allocations for each individual ship, and provide a monthly value against which the ship is to check shaft power. Typical trigger values by percent increase on shaft power at 13 knots are shown in table 2.

	Month	1	2	3	4	5	6	7
T23	Trigger %	18	18	18	18	18	18	18
T22	Trigger %	18	18	18	18	18	18	18
T42 Batch 2	Trigger %	30	24	18	18	18	18	18
T42 Batch 3	Trigger %	30	24	25	25	18	18	18
CVS	Trigger %	18	18	18	18	18	18	18

Table 2 – Typical Trigger Values, by month

Trigger values are calculated based on typical trim and displacement for each class, and for RFA ships are calculated for a range of draughts.

5.3 MEASURING SHAFT POWER

The shaft power is measured under the following constraints:

- Wind speed less than 12 knots
- Sea State 3 or less
- Stabilisers set to zero incidence
- Minimum rudder to be used
- Ship to be at steady speed, no power adjustments to be made throughout the trial.
- Water deep enough to reduce shallow water effects to less than 1% of resistance, as below.

Ship Length	Required water depth (speed <16 kts)
0 – 90 m	20 m
90 – 160 m	35 m
160 m plus	43 m

Ship speed is set to 13.0 knots by GPS, as fouling will often affect the performance for the ship's log. Corrections are applied for tide, or reciprocal runs undertaken if required. Shaft power and speed is recorded on five occasions at two-minute intervals, in order to provide a data set from which to take a steady state average.

Every ship in the RN and RFA that is fitted with a torque meter is now required to undertake this task on a monthly basis. Results are centrally compiled for the fleet via the fuel usage returns system.

Where a ship has exceeded its trigger value, two further runs are undertaken at 8 and 18 knots, and the results returned along with the ship's draught readings, environmental conditions and water depth. These results are then analysed, and if they prove the ship has exceeded its trigger value, then a hull clean is considered, taking into account the operational implications of scheduling a hull clean, the condition of the hull, and the remaining service life of the coating.

6. IN WATER HULL CLEANING

A number of commercial companies offer an in-water hull cleaning service. Most commonly, fouling is removed from the hull surface using a diver driven machine with motorised brushes. This is an in-water operation, and it can be carried out in most locations at relatively low cost.

6.1 THE HULL CLEANING PROCESS AND ITS EFFECTS

The cleaning machines use suction to hold the machine against the hull, whilst multiple brushes clean the surface. The intensity of the cleaning can be controlled by varying brush height above the hull surface, and brush type. Available brush types include:

- **Light polyester brushes** – removal of light slime and weed
- **Medium Polyester brushes –** removal of medium slime and weed
- **Stainless Steel Wire Brush** – For removal of medium to heavy slime and weed, and infantile shell growth
- **Twisted wire brush** – For removal of medium to heavy shell growth
- **Carriage Bolt Brush –** For removal of very heavy shell growth

As can be seen, the heavier the fouling, the more intense the cleaning method has to be, thus the higher the likelihood of damage to paint coatings from the cleaning process. It is thus important to identify fouled ships before shell growth can mature, in order to preserve paint life.

For light to medium slime and weed, this has been estimated to be 25-50 microns per clean. For heavier fouling, this will be exceeded, though from experience it is unlikely that hull cleaning will damage the anti-corrosive paint beneath due to the hard nature of epoxy.

There are also additional benefits to hull cleaning in that the abrasive nature of the clean has the effect of reactivating the anti-fouling properties of the paint. This is because with the types of paint used in the RN, the biocide release process leaves a residue of salt leachate on the surface, which builds up over time. This eventually forms a barrier between the biocide and the water, leading to the failure of the paint as an effective anti-fouling agent. The abrasive nature of in water cleaning has the effect of removing this layer, thereby re-activating the anti-fouling.

6.2 THE HULL CLEANING PROCESS - ENVIRONMENTAL CONSIDERATIONS

The main environmental risks associated with underwater hull cleaning are attributable to accumulation of microscopic fragments of antifouling paint, containing copper and zinc, removed during the cleaning process, which settle on the seabed, and/or are dispersed in the water. Biological effects of copper and zinc are noted in several citations. For example, an EPA Technical Support Document (TSD) for Newport Bay, California points out that copper and zinc can bio-accumulate and are toxic to lower aquatic organisms (e.g. phytoplankton). Hull cleaning is considered such a risk that it is banned in a number of locations, including:

- Australia
- New Zealand
- The Netherlands
- Dubai
- Riga (Latvia)
- California (no other US states currently affected)
- Seychelles

It is likely that additional locations will be added to the above list in time, particularly if frequent cleaning occurs in a location resulting in high concentrations of copper accumulating in the water or on the seabed.

Thus, it is the opinion of the MoD fouling working group that hull cleaning can only be considered as a short-term solution to the legacy issue of ships being coated with paint systems that are unable to provide adequate protection from marine fouling. The longer-term solution is to move to improved paint schemes, which not only offer 5 years or more of effective service without the need for hull cleaning, but can also offer other benefits, both environmental and economic.

6. ANTI-FOULING PAINT OPTIONS

Due to the majority of RN ships now operating on a five–year docking cycle, the ‘traditional paints’, marketed under various titles such as ablative / eroding / controlled depletion / polishing paints have a very poor track record in providing effective protection to five years without hull cleaning. Hull cleaning is undesirable due to its impact both in terms of the interruption to operations, and the potential effect on the environment.

There are therefore two types of paint that will provide adequate protection over five years against the operational profile of RN and RFA ships:

- Second Generation Self-Polishing Paints
- Foul Release Type paints

The rate of biocide release of ‘traditional’ paints reduces rapidly over time, eventually (typically after 3 years) becoming ineffective due to the biocide release being prevented by the salt leachate residue building on the surface. Second generation self polishing paints do not generate the layer of salt leachate on the surface, and result in a near constant level of biocide release over 5 years, thus avoiding the rapid decline in performance in years 4 and 5 as seen with traditional paints. This makes them suitable for use on RN and RFA ships with 5 year docking cycles.

Foul release paint can offer at least five years service, and possibly 7-10 years service with a touch-up at the 5 year point. They do not contain copper as a biocide, but rely on an ultra smooth surface, which prevents fouling from attaching itself to the hull. At speeds between 10 and 15 knots (depending on paint type), any fouling that has accumulated whilst the ship was stationary is washed off. Not only does this paint system offer a long life, and a performance proven in the severe fouling environments of the Caribbean and the Arabian Gulf, but also due to its low surface roughness, there are additional fuel savings due to the ship’s hull having a lower coefficient of friction. Foul Release type paints have been variously claimed by paint manufacturers to reduce hull resistance by approximately 4 to 6%. These figures will soon be verified for naval vessels following trials on two RN frigates.

5. CONCLUSIONS

The shaft power trigger system has proven to be an effective tool for monitoring the in service condition of ships hulls, and providing advance warning of fouling growing on the hulls. Hull cleaning has been demonstrated to provide clear economic benefits.

This system however is only a short-term solution to the legacy issue of inadequate paint schemes, so in the longer term the MoD is looking to move to second generation self polishing paints, and foul release paints in order to provide effective fouling prevention in order to maximise the operability of the fleet as a whole.

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7

Heated water treatment – CSIRO

HEATED WATER TREATMENT

REPORTED BY

CSIRO

CRIMP + NIMPIS

Note: On line at http://www.marine.csiro.au/crimp/nimpis/control

Heated water treatment (baths, spray)

Application Method:

Seastars (Asterias forbesi) collected by trawled "mops" are killed by immersion in troughs of hot water (Lee 1948). While steam treatment (~100?C) of Spartina spp has been used in New Zealand with relative success. Heat treatment as an application to treat ships? ballast water was found effective in destroying Undaria pinnatifida zoospores and phytoplankton cells and cysts eg. Gymnodinium catenatum (Montani et al. 1995; Bolch and Hallegraeff 1993; Hallegraeff et al. 1997; Oemcke 1999; Rigby et al. 1999; Mountfort et al. 1999a). A short (30-90 second) heat treatment of dinoflagellate cysts at temperatures as low as 40-45?C may provide an effective, environmentally friendly solution to the global ballast water problem (Bolch and Hallegraeff 1993). Thermal shock (flushing with hot water) is used in some power plants. Power plant cooling water picks up heat from the condenser and is usually discharged. By recirculating the heated effluent through the precondser sections the water flowing through the conduits may maintain a sufficient temperature to kill the organisms growing inside (Rajagopal et al. 1994). Heat treatment has been used to control Mytilus edulis in temperate areas and Perna viridis in tropical areas (Fox and Coheren 1957; Rajagopal et al. 1994) and Dreissena polymorpha in freshwater (Morton 1977; Barrett-O?Leary 1995; Boelman et al. 1997; Harrington et al. 1997). Younger mussels are killed in less time period than adults. One practical aspect is that during peak settling periods young mussels can be easily killed by comparatively shorter exposure to elevated temperatures (Rajagopal et al. 1994). Usually twice a year, heated water is pumped through water-intakes to kill newly recruited zebra mussels. Some industrial plants also permanently heat flow-through water to temperatures greater than the thermal tolerance of the species (eg. Murray Station, Barrett-O?Leary 1995).

Side Effects:

Application Rate:

A combination of lower heat and chemicals can reduce costs. A combination of heat and chemical oxidants (chlorine or ozone) allows lower temperatures (30?C) to be used and reducing heating costs (Harrington et al. 1997).

Health and Safety Issues:

Constraints:

Heat treatment may be an effective method for controlling mussel fouling in power plants, provided that such treatment is compatible with plant design (Ricciardi 1998), but would prove difficult to implement in open marine conditions unless fouled habitats can be isolated eg. Wharf pylons. Heat treatment (baths, spray) is likely to be ineffective for thick-walled organisms such as oysters (Crassostrea gigas); exposure to 70?C water for 40 seconds did not raise the core temperature of the oysters above 24?C but killed associated boring spionid polychaetes (Nel et al. 1999). However, even though C. gigas has a high thermal tolerance, experiments by Rajagopal et al. (2005) showed that exposure to 42?C for more than one hour results in 100% mortality for C. gigas. Gametophytes of Undaria pinnatifida can survive temperatures of 30?C for up to 10-40 days (Kim and Nam 1997), and thus high temperature water treatment is needed for cleaning vessel hulls and this must penetrate into the crevices and other openings where gametophytes may otherwise survive (Wallentinus 1999a).

Legal Issues:

Direct contact with the relevant Commonwealth and State Authorities is necessary to determine the legality of a control option in that State and to obtain permits for the use of chemicals (eg Fusilade herbicide) or to perform physically destructive actions in the aquatic environment (eg dredging in Tasmania). While chemicals are registered for use at the Commonwealth level (NRA, NICNAS), there may be restrictions or prohibitions on their use in some States, particularly in the aquatic environment. Searching the NRA database may give some indication of registered products but not application methods of use or restrictions on usage.

Notes:

Heated water has been shown to kill seastars (Martin 1998 and citations therein), Dreissena polymorpha (Morton 1977; Claudi and Mackie 1994; Boelman et al. 1997) and Corbicula fluminea (Graney et al. 1980; Jenner and Janssen-Mommen 1993). During the cleanup of crude oil spilt by the Exxon Valdez in 1989 high pressure cleaning using hot (60?C+) and warm water (30-60?C) was used on intertidal and subtidal regions (Mearns 1996). Studies of the intertidal biota before and after treatment showed that as much as 90% of the marine life that survived the oiling could have been killed through thermal shock or displaced by high pressure-hot water washing (Driskell et al. 1996; Houghton et al. 1996; Lees et al. 1996). In addition, elevated temperatures has been shown to affect reproductive success of mussels (eg. Musculista senhousia and "Limnoperna fortunei kikuchi" (re-identified as Xenostrobus securis, native to Australia; Morton 1996) in Japan.

Taxon Specifics

Alexandrium

Alexandrium tamarense

Successful. The heating of ships' ballast water tank sediments containing Alexandrium tamarense cysts has successfully prevented germination by incubation at temperatures of 45?C (Bolch and Hallegraeff 1990; Hallegraeff and Bolch 1991; Bolch and Hallegraeff 1993).

Asterias forbesi

Successful. Seastars collected by dredging or mopping are killed by immersion in troughs of hot water (Lee 1948; Loosanoff 1961; Martin 1998; C. MacKenzie, NEFC, NMFS, US; pers. comm.).

Caulerpa taxifolia

Unsuccessful. Underwater application of hot water at or above 40?C at the plant surface resulted in destruction of C. taxifolia, however, recovery was observed after 3 weeks (Boudouresque et al. 1996).

Corbicula fluminea

Limited success. Freshwater. Heated water has been shown to kill Corbicula fluminea (Graney et al. 1980; Jenner and Janssen-Mommen 1993). In the Netherlands, C. fluminea is normally restricted to thermal plumes from power and chemical plants. In winter, populations experience high mortality due to low temperatures (Graney et al. 1980). When temperatures rise, clam populations can grow rapidly and these plume areas serve as reproductive sources for range extension during summer. The inability of this species to tolerate low temperature and the lack of suitable habitat in industrial areas suggest that C. fluminea is not likely to be a serious problem in the Netherlands (Jenner and Janssen-Mommen 1993).

Cordylophora caspia

Hydroids exposed to temperatures over 37.7?C did not survive (Folino-Rorem & Indelicato 2005). This species causes fouling problems in Europe and the United States, particularly clogging intake pipes and screens at power plants in freshwater habitats.

Crassostrea gigas

Unsuccessful. Heat treatment (baths, spray) is likely to be ineffective for thick-walled organisms such as oysters (Crassostrea gigas); exposure to 70?C water for 40 seconds did not raise the core temperature of the oysters above 24?C but killed associated boring spionid polychaetes (Nel et al. 1999).

Dreissena polymorpha

Limited success. Freshwater. Fouling control by heat treatment has been used at a number of power stations to control Dreissena polymorpha in freshwater (Nelson ?; Morton 1977; Jenner and Janssen-Mommen 1993; Barrett-O?Leary 1995; Boelman et al. 1997; Harrington et al. 1997). Water temperatures >33?C are rapidly lethal to zebra mussels and water temperatures 28-32?C are physiologically stressful and prolonged periods (months) at these temperatures (ie.

summer) can be lethal (Payne 1997). Water temperatures in excess of 40?C have been shown to kill D. polymorpha and at 55?C 70% are killed in one hour (Morton 1977; Barrett-O?Leary 1995; Boelman et al. 1997; Harrington et al. 1997), with its upper thermal limit about 31-34?C in the former Soviet Union and North America (Karatayev et al. 1998). Larvae appear to be less tolerant of high temperature than adults. D. bugensis appears to be less tolerant of high temperature surviving up to ~30.5?C (Karatayev et al. 1998).

Gymnodinium catenatum

Limited success. Heat treatment experiments using Gymnodinium catenatum (30-90seconds at 40-45?C) were effective in killing cysts and motile cells (Montani et al. 1995; Bolch and Hallegraeff 1993; Hallegraeff et al. 1997; Oemcke 1999; Rigby et al. 1999; Mountfort et al. 1999a). Germination of cysts was unaffected by temperatures up to 35?C, but no germination occurred after heating to 45?C or higher. Exposure to cysts for 150 seconds to temperatures 36-38?C reduced germination by 65-75% and inactivation of cysts occurred by exposures ranging from 120 seconds at 38-40?C to 30 seconds at temperatures of 44.5-46.3?C (Bolch and Hallegraeff 1993).

Limnoperna fortunei

? Heat treatment may be a successful method for controlling Limnoperna fortunei in Hong Kong water conduits and power plants (Riccardi 1998).

Musculista senhousia

Limited success. In addition, elevated temperatures have been shown to decrease reproductive success in Musculista senhousia in Japan.

Mytilopsis leucophaeata

Heat treatment is suggested as a control method by Jenner and Janssen-Mommen (1993).

Mytilus edulis

Limited success. Fouling control by heat treatment has been used at a number of power stations to control Mytilus edulis in temperate areas (Fox and Coheren 1957). In Scottish waters Ritche (1927) found that flushing the intake tunnel with condenser effluents at a maximum temperature of 43?C, once every four weeks during peak spat fall could control Mytilus edulis (Rajagopal et al. 1994).

Perna viridis

Limited success. Fouling control by heat treatment has been used at a number of power stations to control Perna viridis in tropical areas (Rajagopal et al. 1994, 1995). Studies of the tropical green mussel Perna viridis showed that a 100% kill occurred by maintaining the temperature at 43?C for 30 minutes, with juveniles affected in a shorter time period. The rate of production of byssus decreased with temperature and stopped between 35-37.5?C for all size groups tested (Rajagopal et al. 1994).

Polydora hoplura

Successful. Exposure to 70?C water for 40 seconds did not raise the core temperature of oysters (Crassostrea gigas) above 24?C but killed associated boring spionid polychaetes (Nel et al. 1999).

Spartina anglica

Limited success. Steam treatment (~100?C) of rice grass (Spartina spp) for 20-30 seconds per stand has been used in New Zealand with relative success. The method is non-selective and there are problems associated with accessibility and maintenance of high temperatures (Rash et al. 1995).

Spionidae

Styela clava

Dips in 70 and 60 degree Cilices seawater killed Styela after immersions of 10 and 15 seconds respectively (Minchin and Duggan 1988).

Terebrasabella heterouncinata

Control of a boring sabellid infestation in green and pink abalones Haliotis fulgens and H. corrufata by exposure to elevated water temperatures had some successful (Leighton (1998).

Undaria pinnatifida

Limited success. Heat treatment as an application to treat ships? ballast water was found effective in destroying Undaria pinnatifida zoospores (Mountfort et al. 1999a). Gametophytes of Undaria pinnatifida can survive temperatures of 30?C for up to 10-40 days (Kim and Nam 1997), and thus high temperature water treatment is needed for cleaning vessel hulls and this must penetrate into the crevices and other openings where gametophytes may otherwise survive (Wallentinus 1999a). Used in NZ to remove Undaria pinnatifida from the hull of a sunken trawler (Wotton et al. 2004)

Xenostrobus securis

Limited success. In addition, elevated temperatures have been shown to decrease reproductive success of mussels "Limnoperna fortunei kikuchi" (re-identified as Xenostrobus securis, native to Australia; Morton 1996) in Japan.

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The International Convention on the control of harmful anti-fouling systems on ships – tabled in March 2003

THE INTERNATIONAL CONVENTION ON THE CONTROL OF HARMFUL ANTI-FOULING SYSTEMS ON SHIPS TABLED IN MARCH 2003

INTERNATIONAL CONVENTION ON THE CONTROL OF HARMFUL ANTI-FOULING SYSTEMS ON SHIPS DONE AT LONDON ON 18 OCTOBER 2001

Documents tabled on 4 March 2003:

National Interest Analysis

Text of the Proposed treaty action

Regulation Impact Statement

Annexures for multilateral treaties:

Consultations

Current status list

NATIONAL INTEREST ANALYSIS: CATEGORY B TREATY
SUMMARY PAGE

International Convention on the Control of Harmful Anti-fouling Systems on Ships done at London on 18 October 2001

Date of Proposed Treaty Action

1. 4 March 2003

Nature and Timing of Proposed Treaty Action

2. Australia signed the Convention on 19 August 2002. The Government proposes to ratify the Convention in accordance with Article 17 of the Convention.

3. The Convention will enter into force internationally 12 months after the date on which not less than 25 States representing 25 per cent of the world's merchant shipping tonnage have become Parties to the Convention. As at 31 December 2002 no country has ratified the Convention, although several have signed subject to ratification and others have advised that they are actively considering the Convention. It is expected that Australia will ratify the Convention before it enters into force internationally in 2004/2005.

4. The exact date of treaty action is the date on which Australia ratifies the International Convention on the Control of Harmful Anti-fouling Systems on Ships (the Convention). Ratification is dependent on domestic legislation being passed by both Houses of Parliament. The Protection of the Sea (Harmful Anti-fouling Systems) Bill 2003 is expected to be introduced into Parliament in the Spring 2003 sittings.

Overview and National Interest Summary

5. The purpose of the Convention is to ban the use of organotin compounds which act as biocides in anti-fouling paints on ships, specifically tributyl tin (TBT) based anti-fouling paints. TBT acts as a biocide preventing the growth of algae, barnacles and other marine organisms on the ships' hull. This enables the ship to travel faster through the water and consume less fuel. For the last 20 years scientific investigations have shown that TBT-based paints pose a substantial risk of toxicity and other chronic impacts at both the species, habitat and ecosystem level. Effects of TBT-based paints have been reported on such ecologically and economically important marine organisms as oysters and molluscs as well as contaminating sediments in many port areas around the world. TBT is also highly toxic to a range of marine reef biota.

6. There are also concerns about the impact of TBT on human health, especially people who consume large quantities of seafood in their diet. A study recently completed in the United States showed that prolonged exposure to TBT can cause chronic disease in humans.

7. Without international action, there would be insufficient impetus for the shipping and marine coatings industries to restrict the use of harmful anti-fouling systems and develop replacement systems. The collective efforts of government and industry, working through the auspices of the IMO, have addressed this environmental concern. Cabinet agreed to the banning of organotin based antifouling paints through *Australia's Oceans Policy* in 1998.

Reasons for Australia to Take the Proposed Treaty Action

8. Australia has played an active role in developing the Convention and internationally, has been a strong supporter of its early entry into force. Additionally, this action is in accordance with Australia's general obligations as a signatory to the *United Nations Convention on the Law of the Sea* 1982 (UNCLOS), which provides for nations to adopt generally accepted international rules and standards when implementing laws and regulations to prevent, reduce and control pollution of the marine environment from vessels (Article 211 of UNCLOS).

9. Implementation of the Convention is in accordance with *Australia's Oceans Policy,* which commits Australia to banning the application of TBT-based paints to vessels being repainted in Australian docks from 1 January 2006, unless the IMO introduces an earlier date, in which case Australia would comply, noting Defence operational requirements. In addition, Cabinet specifically agreed to the phased withdrawal of the use of toxic organotin anti-fouling paint.

10. If Australia does not become a party to the Convention, the level of environmental protection in Australia will be lower than internationally adopted standards. Also, Australian ships trading to overseas ports would incur additional costs as a result of the need to have proper survey documentation confirming compliance with the Convention. Such documentation can only be issued by Administrations that have adopted the Convention.

11. Australia has demonstrated leadership in many areas of marine environment protection, as successive governments have recognised the importance of embracing internationally consistent measures in the maritime industry. Due to Australia's reliance on the international maritime industry to underpin our international trade, support and adoption of the Convention is essential to provide for adequate protection of Australia's marine environment.

12. By becoming a party to the Convention, Australia will be able to enforce the full range of controls on TBT-based anti-fouling paints on foreign and Australian flagged vessels.

13. Implementation of the Convention will establish a national approach to TBT-based paints by complementing current State and Territory regulations and policies, which already ban the use of TBT-based anti-fouling paints on vessels of less than 25 metres in length.

Obligations

14. The Convention applies to all Australian and foreign ships as defined in Articles 2(9) and 3 of the Convention. This includes fixed or floating platforms, floating storage units (FSUs), and floating production storage and offtake units (FPSOs) used by the oil production industry. The Convention does not apply to warships, naval auxiliary or other ships used only on government non-commercial service (Article 3, paragraph 2).

15. Article 4 sets out the controls on the use of anti-fouling systems listed in Annex 1. Annex 1 states that by an effective date of 1 January 2003, all ships shall not apply or re-apply organotin compounds that act as biocides in anti-fouling systems, namely TBT-based anti-fouling paints. By 1 January 2008 (effective date), ships either:

- shall not bear such compounds on their hulls or external parts or surfaces; or
- shall bear a coating that forms a barrier to such compounds leaching from the underlying non-compliant anti-fouling systems.

Waste material from the application or removal of TBT-based paints will be controlled in a safe and environmentally sound manner (Article 5). The Australian Paint Manufacturers' Federation

(APMF) will set up a web page outlining acceptable ways for disposal of surplus stocks of TBT-based paints.

16. Survey and certification of vessels will be required under the Convention (Article 10). The Australian Maritime Safety Authority (AMSA) and/or an authorised organisation will undertake this role as part of its flag State control function for Australian ships. Ships of 400 gross tonnage and above engaged in international voyages shall be subject to an initial survey before the ship is put into service and a survey when the anti-fouling systems are changed or replaced. This excludes fixed or floating platforms, FSUs, and FPSOs. Ships of 24 metres or more in length, but less than 400 gross tonnage engaged in international voyages are required to carry a declaration of anti-fouling system signed by the owner or owner's authorised agent.

17. Article 7 provides for the establishment of a technical group within the Marine Environment Protection Committee of the IMO to review proposals for amendments to controls on anti-fouling systems, specifically the addition of new anti-fouling systems. As and when required, appropriate Australian representatives will participate in the deliberations of the technical group.

18. The Convention provides for appropriate measures to promote and facilitate scientific and technical research on the effects of anti-fouling substances (Article 8), and provides for communication and exchange of information between parties to the Convention and the IMO (Article 9). Where permitted within relevant legislative confidentiality provisions, Commonwealth agencies will participate in the exchange of information between Parties to the Convention and the IMO.

19. The Convention provides for inspection of ships and detention for violations (Article 11). This will be undertaken by AMSA as part of their port and flag State control functions. Each Party to the Convention must also prohibit and enforce violations of the Convention under its domestic law (Article 12). Compensation may be provided for any loss or damage suffered if a ship is unduly detained or delayed while undergoing inspection for possible violations of the Convention (Article 13).

Implementation

20. The Convention will be implemented through the *Commonwealth Protection of the Sea (Harmful Anti-fouling Systems) Act*. The legislation will apply to all jurisdictions, with suitable roll-back and savings provisions to preserve any existing or future State/NT legislation.

21. AMSA will make appropriate subordinate legislation such as Marine Orders and will also develop Instructions to Surveyors and/or Class Societies, as necessary based on guidelines being developed by IMO.

22. Through a separate process, the Department of Agriculture, Fisheries and Forestry is working to facilitate the deregistration of the use of TBT-based anti-fouling paints for painting, re-painting or repairing any ship in Australian waters, ports or shipyards and associated infrastructure, whilst preserving the integrity of the National Registration Scheme.

Costs

23. The financial impact of compliance with the Convention is low. Alternative non-TBT-based anti-fouling paints are already available domestically and overseas. Also, as this requirement is based on an international convention, any additional costs to industry would be incurred for international trading vessels whether or not Australia adopts the new Convention.

24. Costs of enforcement of the Convention will be low as established inspection and certification procedures applied to other IMO environmental conventions are already in place. This primarily involves a system of port and flag State control functions undertaken by AMSA.

Consultation

25. Consultation with State/NT transport agencies has been undertaken through the Australian Transport Council (ATC) and subordinate committees, which recommended that Australia ratify the Convention at its meeting on 8 November 2002.

26. Australian and foreign shipping represented by the Australian Shipowners Association and Shipping Australia Limited, respectively, have been consulted at all stages in the development of the Convention and provided input and briefing on a number of issues for the IMO Marine Environment Protection Committee meetings. Additionally, the international shipping industry has consultative status at IMO and participates actively in deliberations.

27. Consultation was also undertaken with relevant Commonwealth agencies, Premiers/Chief Ministers Departments in all States/NT, CSIRO, Association of Australian Ports and Marine Authorities, Australian Paint Manufacturers' Federation, World Wide Fund for Nature and the Australian Marine Conservation Society.

28. In regard to paint manufacturers, the National Registration Authority for Agricultural and Veterinary Chemicals (NRA) has developed and circulated an information document outlining efficacy requirements for registration of anti-fouling paints, and conducted a seminar for registrants of anti-fouling paints at which the implications of the Convention and NRA risk-based registration requirements were fully described and discussed.

Regulation Impact Statement

29. A Regulation Impact Statement is attached.

Future Treaty Action

30. Article 16 outlines how amendments to the Convention can be made. Any Party can propose an amendment to an article or annex to the Convention. A proposed amendment to Annex 1 shall be subject to technical review before proceeding through the normal amendment process. Amendments shall be adopted by a two-thirds majority of the Parties present and voting in the Marine Environment Protection Committee of the IMO, on condition that at least one-third of the Parties are present at the time of voting.

31. Any adopted amendment is subject to a further acceptance procedure. An amendment will be accepted after two-thirds of the Parties have deposited a notification of acceptance (positive acceptance), or after the lapse of a specified period of time, as long as there have not been objections from more than one-third of the Parties (tacit acceptance). The amendment will enter into force, for those Parties accepting the amendment, six months after it has received positive or tacit acceptance.

32. All amendments would be subject to the Australian treaty process.

33. Any notification or declarations under Article 16 shall be made in writing to the Secretary-General of the IMO.

Withdrawal or Denunciation

34. Article 19 provides that Australia may denounce the Convention by written notification to the Secretary-General of the IMO at any time after two years from the date on which the Convention enters into force for that Party. Denunciation would take effect one year after receipt or longer if specified in the notification.

35. Denunciation would be subject to the Australian treaty process.

Contact details
Maritime Regulation Section
Transport Regulation Division
Department of Transport and Regional Services

International Convention on the Control of Harmful Anti-fouling Systems on Ships

Adoption: 5 October 2001

Entry into force: 17 September 2008

The International Convention on the Control of Harmful Anti-fouling Systems on Ships will prohibit the use of harmful organotins in anti-fouling paints used on ships and will establish a mechanism to prevent the potential future use of other harmful substances in anti-fouling systems.

Under the terms of the new Convention, Parties to the Convention are required to prohibit and/or restrict the use of harmful anti-fouling systems on ships flying their flag, as well as ships not entitled to fly their flag but which operate under their authority and all ships that enter a port, shipyard or offshore terminal of a Party.

Ships of above 400 gross tonnage and above engaged in international voyages (excluding fixed or floating platforms, FSUs and FPSOs) will be required to undergo an initial survey before the ship is put into service or before the International Anti-fouling System Certificate is issued for the first time; and a survey when the anti-fouling systems are changed or replaced.

Ships of 24 metres or more in length but less than 400 gross tonnage engaged in international voyages (excluding fixed or floating platforms, FSUs and FPSOs) will have to carry a Declaration on Anti-fouling Systems signed by the owner or authorized agent. The Declaration will have to be accompanied by appropriate documentation such as a paint receipt or contractor invoice.

Anti-fouling systems to be prohibited or controlled will be listed in an annex (Annex 1) to the Convention, which will be updated as and when necessary.

The harmful environmental effects of organotin compounds were recognized by IMO in 1989. In 1990 IMO's Marine Environment Protection Committee (MEPC) adopted a resolution which recommended that Governments adopt measures to eliminate the use of anti-fouling paint containing TBT on non-aluminium hulled vessels of less than 25 metres in length and eliminate the use of anti-fouling paints with a leaching rate of more than four microgrammes of TBT per day.

In November 1999, IMO adopted an Assembly resolution that called on the MEPC to develop an instrument, legally binding throughout the world, to address the harmful effects of anti-fouling systems used on ships. The resolution called for a global prohibition on the application of organotin compounds which act as biocides in anti-fouling systems on ships by 1 January 2003, and a complete prohibition by 1 January 2008.

Annex I attached to the Convention and adopted by the Conference states that by an effective date of 1 January 2003, all ships shall not apply or re-apply organotins compounds which act as biocides in anti-fouling systems.

Given that this date has already passed, IMO has been urging States to ratify the convention as soon as possible in order to achieve entry into force conditions. In November 2001, the IMO Assembly adopted Resolution A.928(22) *Resolution on early and effective application of the international convention on the control of harmful anti-fouling systems on ships.*

In the case of the reference to a requirement being effective on 1 January 2003, if the convention comes into force at a later date, then the legal effect is the requirements are moved forward to that date. In other words, the legal effect of the 1 January 2003 date is suspended until the entry into force date. During such time before the entry into force of the convention, port States cannot apply any requirements of the convention to foreign ships calling into your ports. HOwever, flag States may apply the requirements of the convention to their national fleet, depending on their national legal system and decisions of that country, but they may not expect the International Certificates to be recognized as effective until the date of entry into force.

By 1 January 2008 (effective date), ships either:

(a) shall not bear such compounds on their hulls or external parts or surfaces; or

(b) shall bear a coating that forms a barrier to such compounds leaching from the underlying non-compliant anti-fouling systems.

This applies to all ships (except fixed and floating platforms, floating storage units (FSUs), and floating production storage and off-loading units (FPSOs) that have been constructed prior to 1

January 2003 and that have not been in dry-dock on or after 1 January 2003.

The Convention includes a clause in Article 12 which states that a ship shall be entitled to compensation if it is unduly detained or delayed while undergoing inspection for possible violations of the Convention.

The Convention provides for the establishment of a "technical group", to include people with relevant expertise, to review proposals for other substances used in anti-fouling systems to be prohibited or restricted. Article 6 on Process for Proposing Amendments to controls on Anti-fouling systems sets out how the evaluation of an anti-fouling system should be carried out.

Resolutions adopted by the Conference

The Conference adopted four resolutions:

Resolution 1 Early and Effective Application of the Convention – The resolution invites Member States of the Organization to do its utmost to prepare for implementing the Convention as a matter of urgency. It also urges the relevant industries to refrain from marketing, sale and application of the substances controlled by the Convention.

Resolution 2 Future work of the Organization pertaining to the Convention – The resolution invites IMO to develop guidelines for brief sampling of anti-fouling systems; guidelines for inspection of ships; and guidelines for surveys of ships. The guidelines are needed in order to ensure global and uniform application of the articles of the Convention which require sampling, inspection and surveys.

The following have been developed and adopted:

- Guidelines for survey and certification of anti-fouling systems on ships - adopted by resolution MEPC.102(48);
- Guidelines for brief sampling of anti-fouling systems on ships - adopted by resolution MEPC.104(49); and
- Guidelines for inspection of anti-fouling systems on ships - adopted by resolution MEPC.105(49).

Resolution 3 Approval and Test Methodologies for Anti-Fouling Systems on Ships – This resolution invites States to approve, register or license anti-fouling systems applied in their territories. It also urges States to continue the work, in appropriate international fora, for the harmonization of test methods and performance standards for anti-fouling systems containing biocides.

Resolution 4 Promotion of Technical Co-operation – The resolution requests IMO Member States, in co-operation with IMO, other interested States, competent international or regional organizations and industry programmes, to promote and provide directly, or through IMO, support to States in particular developing States that request technical assistance for:

(a) the assessment of the implications of ratifying, accepting, approving, or acceding to and complying with the Convention;
(b) the development of national legislation to give effect to the Convention; and
(c) the introduction of other measures, including the training of personnel, for the effective implementation and enforcement of the Convention.

It also requests Member States, in co-operation with IMO, other interested States, competent international and regional organisation and industry programmes, to promote co-operation for scientific and technical research on the effects of anti-fouling systems as well as monitoring these effects.

Background

Anti-fouling paints are used to coat the bottoms of ships to prevent sealife such as algae and molluscs attaching themselves to the hull – thereby slowing down the ship and increasing fuel consumption.

The new Convention defines "anti-fouling systems" as "a coating, paint, surface treatment, surface or device that is used on a ship to control or prevent attachment of unwanted organisms".

In the early days of sailing ships, lime and later arsenic were used to coat ships' hulls, until the modern chemicals industry developed effective anti-fouling paints using metallic compounds.

These compounds slowly "leach" into the sea water, killing barnacles and other marine life that have attached to the ship. But the studies have shown that these compounds persist in the water, killing sealife, harming the environment and possibly entering the food chain. One of the most effective anti-fouling paints, developed in the 1960s, contains the organotin tributylin (TBT), which has been proven to cause deformations in oysters and sex changes in whelks.

9

Regulatory Impact Statement

INTERNATIONAL CONVENTION ON THE CONTROL OF HARMFUL ANTI-FOULING SYSTEMS ON SHIPS 2001

REGULATORY IMPACT STATEMENT

International Convention on the Control of Harmful Anti-Fouling Systems on Ships 2001

Regulatory Impact Statement

1. Problem

1.1. Organotin compounds are formed by combining tin with materials that contain carbon, and are used to make plastics, food packages, plastic pipes, pesticides, paints, and pest repellents. Organotin-based compounds, such as tributyltin (TBT), have been used in anti-fouling paints on vessel hulls and infrastructure since the 1970's. The toxicity of TBT prevents the growth of algae, barnacles and other marine organisms on the ship's hull for up to five years, meaning ships are able to travel faster through the water and consume less fuel. Research conducted by the US Navy in 2002 indicates that the speed loss of an aircraft carrier caused by heavy fouling was 1.5 knots, with a 40% increase in fuel required to maintain a speed of 20 knots. For a 250,000 ton oil tanker, if 5% of the underwater hull is fouled, fuel costs increase by 17%. Not only is energy conserved by effective anti-fouling systems, the improved efficiency of maritime transport reduces carbon dioxide emissions.

1.2. The harmful effects of such compounds were first recognised in oyster farms on the Atlantic coast of France in the early 1980s, and since that time a range of marine species have been contaminated and affected by organotins. Sediments in many port areas around the world have been contaminated, resulting in long-term impacts on benthic invertebrates, like molluscs and amphipods, which are living in close contact with the sediment. In Australia, research conducted in the late 1980's found evidence of TBT contamination in Sydney rock oysters. Research also indicates adverse affects such as inhibition of growth and reproduction on a range of invertebrate species in the vicinity of other ports and marinas around the Australian coastline.

1.3. While there have been few studies to quantify the cost of environmental damage caused by organotin compounds, a 1999 Victorian Environment Protection Authority Report considered that organotins threatened biodiversity and ecosystem health, eco-tourism and related activities valued at $96 million each year and aquaculture and fisheries, particularly mollusc production valued at $55 million each year.

1.4. Significant costs are incurred by port authorities in disposing of contaminated waste from shipyards and dredge spoil. In some circumstances, heavily contaminated spoil must be disposed of at approved land-based disposal sites at 2-3 times the cost of disposal at sea. There are also significant costs associated with removing TBT based paint from coral reefs after ship groundings. The removal of contaminated sediment and associated waste following a recent grounding at Sudbury Reef in the Great Barrier Reef Marine Park was completed in 70 days at a cost of some $1.5 million, with ongoing monitoring costs.

1.5. The threat to human health from organotins has not yet been studied in detail. However, there are concerns about the potential for impact on humans who consume large quantities of seafood in their normal diet, as organotins may disrupt the critical function of human immune cells, particularly those which fight infection. A study recently completed in the United States shows that shipyard workers exposed to TBT for just a few minutes developed breathing difficulties, skin irritation, dizziness, and flu-like symptoms. The report also states that prolonged exposure can cause chronic disease in humans.

1.6. In 1982, the French Government banned the use of TBT based anti-fouling paints on boats and ships less than 25m overall length, and the European Union introduced similar legislation in 1989. Legislation applying the same general requirements was progressively introduced by each Australian State and Territory, a process that was completed in 1991. Today the use of TBT in anti-foulings on boats less than 25m overall length is banned nearly worldwide. This approach has addressed concerns regarding smaller recreational vessels such as yachts and pleasure craft.

1.7. While there is evidence suggesting that the banning of the use of TBT based anti-fouling paints on small vessels has decreased levels of pollution in many localised areas, effects on invertebrates are still being detected in many species around the world. It is also emerging that marine mammals have been found contaminated with organotin compounds, indicating a more global distribution of organotins in the oceans. While some mammals can expel or degrade organotins from the body, others such as dolphins show increasing levels of organotins as they grow older.

1.8. Elements of TBT based antifouling paints are highly toxic to a range of marine reef biota. There are also strong indications that the presence of residual TBT based anti-foulants at ship grounding sites may present an ongoing impediment to coral reef recovery.

1.9. Consequently, it was recognised by many governments that, while domestic use of TBT based anti-fouling paints was generally strictly controlled, a mechanism was required to regulate the harmful effects of TBT used on international trading vessels. The implementation of an overall ban on the use of TBT based anti-fouling paint through international co-operation (with standard IMO treaty exemptions for Government vessels) was seen as the only way to avoid global and regional pollution by organotin compounds.

1.10. In response to these calls from the global community for international action, the International Maritime Organization (IMO) developed proposals for international regulations over a period of several years, leading to the successful conclusion of the International Convention on the Control of Harmful Anti-fouling Systems on Ships (the AFS Convention) at a Diplomatic Conference in October 2001.

1.11. The AFS Convention will provide for the protection of the marine environment and human health from adverse effects of anti-fouling systems on ships. The Convention will prohibit the application of harmful anti-fouling systems on ships by 1 January 2003. By 1 January 2008, all ships will be banned from having such compounds on their hulls or external surfaces, or will be required to have a coating that forms a barrier to such compounds leaching from the underlying non-compliant anti-fouling systems. The Convention also provides a risk assessment regime to identify and evaluate new antifouling systems.

1.12. The Convention applies to all ships either registered in a State Party or operating under the authority of a State Party, as well as any other ships that enter a port, shipyard or offshore terminal of a Party. Parties to the Convention will be required to prohibit and/or restrict the use of harmful anti-fouling systems on ships flying their flag, as well as ships not entitled to fly their flag but which operate under their authority and all ships that enter a port, shipyard or offshore terminal. The Convention also applies to ships such as fixed or floating platforms, floating storage units, and Floating Production Storage and Offtake units used by the oil production industry.

1.13. The Convention will not apply to any warship, naval auxiliary, or other ships owned or operated by the country and used only on government non-commercial service. However, Australia needs to ensure, by the adoption of appropriate measures not impairing the operational capabilities of such ships, that they act in a manner consistent, so far as is reasonable and practicable with the Convention.

1.14. A survey will be required for ships of 400 gross tons and above engaged in international voyages before they are put into service or before an International Anti-fouling System Certificate is issued for the first time. A survey will also be required when an anti-fouling system is changed or replaced. Ships of 24 metres or more in length but less than 400 gross tons engaged in international voyages will have to carry a Declaration on Anti-fouling Systems signed by the owner or authorised agent.

1.15. The Convention will enter into force 1 year after 25 States representing 25% of the world's merchant shipping tonnage have either signed it without reservation as to ratification, acceptance or approval or have deposited instruments of ratification, acceptance approval or accession with the IMO Secretary-General. At this time no countries have ratified the Convention, although several (including Australia) have signed subject to ratification, and others have advised they are actively considering the Convention. It is expected that the Convention will enter into force internationally in 2004/2005.

1.16. Australia signed the AFS Convention, subject to ratification, on 19 August 2002. If the Convention is to be ratified, Government action is required to develop legislation to give effect to the AFS Convention in Australia, and once legislation is in place, to ratify the Convention. In a letter dated 23 May 2002, the Office of International Law, Attorney-General's Department, confirmed that legislation will be required to implement the AFS Convention in Australia.

1.17. The need for government action is a consequence of market failure to address the problem within a suitable timeframe. Without the intervention of governments, working through the auspices of the IMO, there would have been little incentive for the shipping and marine coatings industries to restrict the use of harmful anti-fouling systems and develop replacement systems. Collective actions by governments, through the IMO, has now seen this market failure addressed.

1.18. Since the need for international action was first recognised by IMO in the late 1980's, governments, regional organisations and the marine coating industry have been working to ensure TBT-free anti-fouling products will be available in the marketplace. This work has gained momentum since the text of the AFS Convention was adopted in 2001.

1.19. The Convention is in accordance with Australia's Oceans Policy, which commits Australia to banning the application of TBT to vessels being repainted in Australian docks from 1 January 2006, unless the IMO introduces an earlier date, in which case Australia would follow suit. The Oceans Policy commitment recognises that, while IMO environmental conventions generally do not apply to naval vessels, Australian Defence Force vessels seek to comply with international environmental standards as far as practicable, taking into account that in some circumstances operation requirements may take precedence.

1.20. However, the Defence Science and Technology Organisation is particularly active in assessing alternatives, having begun trials in 1990, and all efforts will be made to avoid the need to use TBT. Should such products need to be used on naval vessels, the paint would be applied by private contractors and the Australian Defence Force would require compliance with all relevant OH&S and environmental regulations, including those relating to disposal of any TBT contaminated waste.

1.21. Additionally, in recognition of the OH&S risks already identified in the use of TBT antifouling paints, to continue the authorised use of the product under the relevant Agvet Code legislation, registration of the product will be contingent on satisfactorily addressing the risks involved and the conditions of its use.

2. <u>Objectives</u>

2.1 The objectives of developing legislation enabling Australia to adopt the AFS Convention are:

- to ensure, to the maximum extent available under international law, the best available protection for the Australian marine environment from the harmful effects of anti-fouling systems used on ships;
- to protect human health during the application or removal of anti-fouling systems; and
- to adopt uniform international rules and procedures for protecting the global environment from the harmful effects of anti-fouling systems used on ships.

2.2 It is proposed that legislation to give effect to the AFS Convention in Australia will be developed as part of the existing "Protection of the Sea" legislation package giving effect to IMO environmental conventions. The legislation will be developed in close consultation with Environment Australia, which has responsibility for several policy and administrative aspects of the Convention.

2.3 It is proposed that Australia consents to be bound by the AFS Convention through lodgement of an instrument of ratification with the Secretary-General of IMO as soon as practicable after Australia's domestic requirements for implementation have been met.

2.4 Regulations and policies currently in place in Australia are primarily those implemented in each State and Territory to ban the use of TBT based anti-fouling on vessels of less than 25 metres in length.

2.5 All anti-fouling substances used in Australia require registration with the Commonwealth National Registration Authority for Agriculture and Veterinary Chemicals (NRA) under pesticide laws. Once registered, the following restrictions are applicable:

- TBT Anti-foulings must not be applied to vessels less than 25 metres in length.
- TBT anti-fouling applied must have a release rate less than 5μg TBT/cm2/day.

3. Options

3.1 Having signed the AFS Convention subject to ratification, Australia's options are:

1. Not to ratify the AFS Convention and maintain the current situation, i.e. not implement the AFS Convention and continue to rely on the existing State/NT legislation and NRA registration relating to vessels of less than 25 metres in length; or

2. Develop legislation enabling Australia to ratify the AFS Convention; or

3. Limit the use of TBT anti-fouling through other regulatory measures such as an environmental tax on the sale of TBT based anti fouling paints.

4. Impact Analysis

4.1 Option (1) would mean no change to the current arrangements. This would result in additional costs to the community in that the level of environmental protection would be lower than internationally adopted standards. Costs associated with this option are discussed in the "Problem" section above, and include threats to biodiversity and aquaculture, and disposal of contaminated waste and dredge spoil.

4.2 Australia would not be in a position to take advantage of, and enforce the full range of controls on, anti-fouling systems against foreign flag and Australian vessels. Australia played an active role in developing the Convention, and internationally, has been a strong supporter of its early entry into force.

4.3 The lack of a national approach to the issue could result in States/NT implementing their own requirements for larger vessels, potentially resulting in different requirements around the Australian coast and applicable only to internal and coastal waters up to 3 nautical miles from the coast. Waters under Commonwealth control i.e. beyond 3 nautical miles to the limit of the 200 nautical mile exclusive economic zone would not be covered, resulting in inadequate protection from this type of pollution. This option would also not be in accordance with the Australia's general obligations as a signatory to the United Nations Convention on the Law of the Sea 1982, which provides for nations to adopt generally accepted international rules and standards when implementing laws and regulations to prevent, reduce and control pollution of the marine environment from vessels (Article 211).

4.4 Australian ships trading to overseas ports would incur additional costs as a result of the need to have proper documentation confirming compliance with the AFS Convention. Such documentation can only be issued by Administrations that have adopted the Convention.

4.5 Option (2) involves ratifying and, on international entry into force, applying the AFS Convention in Australian waters. Both domestic and international shipowners and the sector of the paint industry involved in the production of anti-fouling systems will be affected by this proposal.

4.6 An assessment of the overall effect of option (2) needs to take into account the international actions that have already been taken on a voluntary basis. A resolution adopted at the 2001 Diplomatic Conference, entitled "Early and Effective Application of the Convention", invites member States of the Organization to do their utmost to prepare for implementing the Convention as a matter of urgency. It also urges the relevant industries to refrain from marketing, sale and application of the substances controlled by the Convention. This resolution has had a noticeable impact in several areas:

- The International Chamber of Shipping has urged shipowners to assume that the dates included in the AFS Convention will be universally adopted, notwithstanding the fact that the Convention will not be in force by 1 January 2003. Due to this voluntary action, it might be expected that shipowners worldwide will no longer apply TBT based anti-fouling paints on their ships from that date.

- The European Commission has taken action to implement the dates for the banning of TBT as set out in the AFS Convention. Commission Directive 2002/62/EC of 9 July 2002 effectively bans the application of TBT anti-fouling paints to all ships in the EU countries from 1 January 2003. Japan and New Zealand have taken similar decisions.

- Indications are that all major manufacturers and suppliers of anti-foulings in Australia have recognised the development of the AFS Convention, as well as developments in Europe, and consequently will not supply TBT based anti-foulings from that date. Diminishing market supply of TBT based anti-fouling paint will impact on the ability of the navy to source the necessary levels of stock. Defence anticipates that a successful transition to alternative products will occur.

4.7 The short-term alternatives available are likely to be copper or silicone-based anti-fouling paints. In Australia, the NRA has registered a number of anti-fouling paint products that do not contain TBT. However, the majority of these formulations were developed for the pleasure craft market and are therefore unsuitable for commercial trading vessels. There are however 2 biocides registered by the NRA that are particularly effective for vessels with a 60 month docking cycle. Concerns have been raised by the Australian Shipowners Association over the small number of alternative TBT free anti-fouling paints currently available in Australia suitable for commercial trading vessels, and that this has resulted in premium costs for these products due to a lack of competition. However, higher costs in Australia are at least in part attributable to the relatively small market, which does not justify the use of cheaper automated manufacturing equipment. The costs in Australia are also not significantly higher – Singapore is widely recognized globally as one of the cheapest locations for anti-fouling systems, with prices typically 20% lower than Australia.

4.8 It is expected that competition from the availability of more paints will reduce these costs, although there are likely to be some cost implications for shipowners in the short term, depending on the particular vessel's dry docking cycle. For ships operating on the basis of a 2 - 2 ½ year dry docking cycle, the cost of TBT free anti-fouling paint is around 3% lower. Most Australian ships operate on this basis. However, ships operating on longer dry docking cycles of up to 5 years will initially incur higher costs. There are many more alternative TBT free anti-fouling paints available overseas, and discussions have been held with the National Registration Authority to streamline the Australian assessment and registration process.

4.9 In the longer term, research into new methods of fouling control is examining extracts of different marine plants and animals that are able to resist fouling pressure in their natural environment, as well as the possible development of new biocides.

4.10 It is also relevant that as the requirement is based on an international convention, provided Australian shipowners have the same level of access to non TBT based systems, any additional costs would be incurred for international trading vessels whether or not Australia adopts the new Convention.

4.11 The effect on the shipping industry of the certification requirement in the AFS Convention will be minimal. Consistent with international practice, Australian ships undergo regular survey by approved Classification Societies to verify compliance with a broad range of IMO conventions relating to safety and protection of the marine environment. Inspection of the anti-fouling system and issue of an additional certificate will become part of this process and may give rise to a slight increase in the cost of such surveys. However, these costs will also be borne by international trading vessels, so there will be no cost differential.

4.12 The effect on paint manufacturers will be minimal. Overall demand for anti-fouling paint will not be affected, and there may even be opportunities arising from the obligation that existing TBT based systems may be over-coated. In Australia, there are six main suppliers of anti-fouling paints. Two of these companies produce anti-fouling paint in Australia, with the remainder distributing paint manufactured overseas. The sale of anti-fouling paints is a small part of overall business – the largest Australian manufacturer estimates that anti-fouling paint represents 2% of total sales. Only one manufacturer expects to have any stock of TBT based paint after 31 December 2002. The Department of Defence intends to retain control of their stock of TBT based anti-fouling paint already in hand for use in the short-term for repairs to vessels that are yet to be transitioned to TBT-free coatings.

4.13 It is proposed that the Commonwealth implementing legislation will form part of the "Protection of the Sea" suite of acts which give effect to the IMO environmental conventions. As such, it will apply to all State/NT coastal and internal waters, with a "roll-back" provision preserving the operation of State/NT legislation. The existing State/NT legislation applicable to ships of less than 25 metres in length will need to be examined in detail to ensure there are no omissions, inconsistencies or duplication of requirements. It is not anticipated there will be any significant difficulties – the State/NT legislation has no certification or survey requirements, and the ban on TBT based anti-fouling systems is consistent with the AFS Convention.

4.14 Option (3) involves developing domestic regulatory measures to limit the use of TBT based anti fouling paint through regulatory measures such as an environmental tax on the sale or use of TBT based anti-fouling paints. This option would involve Australia taking unilateral action and would therefore be difficult to enforce in respect of foreign registered vessels visiting Australian ports. Given the vast majority of Australian trade is carried out in foreign registered vessels, this option would not address the main source of environmental threat.

4.15 As for option (1), option 3 would not contribute to the development of international law, would be inconsistent with the United Nations Convention on the Law of the Sea, and would result in additional costs being incurred by Australian ships traveling to overseas ports where the AFS Convention is applied.

5. <u>Consultation</u>

5.1 The Australian Shipowners Association and Shipping Australia have been consulted at all stages in the development of the Convention and provided input and briefing on a number of issues for the IMO Marine Environment Protection Committee meetings. Additionally, the international shipping industry has consultative status at IMO and participates actively in deliberations. The only concerns raised relates to the limited number of alternatives to TBT based anti-fouling systems currently available in Australia. As noted above in paragraph 4.7, this will be addressed as more alternatives are approved for use in Australia.

5.2 Consultation with State/NT transport agencies has been undertaken through the Australian Transport Council (ATC), which recommended Australian adoption of the AFS Convention at its meeting on 8 November 2002. The outcomes of the ATC meeting will be passed for information to the Environment Protection and Heritage Ministerial Council.

5.3 Consultation was also undertaken with relevant Commonwealth agencies, Premiers/Chief Ministers Departments in all States/NT, CSIRO, Association of Australian Ports and Marine Authorities, Australian Paint Manufacturers Federation, World Wide Fund for Nature, and the Australian Marine Conservation Society.

5.4 In respect of paint manufacturers, the NRA developed and circulated an information document dealing specifically with the efficacy requirements for anti-fouling paints and conducted a seminar for registrants of anti-fouling paints at which the requirements of the AFS Convention were fully described and discussed.

6. Conclusion and recommended option

6.1 The preferred option is Option 2, namely to develop legislation enabling Australia to adopt the AFS Convention. Option 2 would provide Australia with consistent national standards that can also effectively be applied to any foreign or domestic ships operating in Australian waters. Option 2 would also ensure that human health and Australia's marine environment is protected by applying the most up-to-date international environmental standards.

7. Implementation and review

7.1 While Environment Australia has led on the development and presentation of Australia's negotiating position at the IMO, Ministers have agreed that the Department of Transport and Regional Services will assume responsibility for the steps leading to ratification as the Convention will principally affect the maritime transport industry and compliance with the terms of the Convention will be administered by the Australian Maritime Safety Authority (AMSA).

7.2 This is consistent with AMSA's role in administering the Commonwealth's other environmental legislation associated with shipping. Environment Australia's role will be to assist the consultation process and development of legislation, by providing policy advice, and participate in the assessment of alternatives to tributyltin based paints. The latter role will be through the provision of advice to the National Registration Authority for Agricultural and Veterinary Chemicals which has a statutory role to assess and register chemical products such as anti-fouling systems.

7.3 Administration and enforcement of the AFS Convention will be by way of established procedures applied to other IMO environmental conventions. This involves primarily a system of port State control inspections undertaken by AMSA. AMSA produces reports setting out details of deficiencies found during port State control inspections.

7.4 Consultation with the shipping industry would be on-going in respect of any proposed changes to the AFS Convention or problems being experienced by industry that might need to be raised at IMO meetings. The AFS Convention provides a mechanism involving the establishment of a technical group to consider any proposals for listing additional harmful anti-fouling systems. The Convention also places an obligation on Parties to promote and facilitate scientific and technical research on the effects of anti-fouling systems as well as monitoring such effects.

7.5 It is proposed that penalties for non-compliance will be consistent with other IMO environmental conventions, i.e. up to $220,000 for an individual and $1.1 million for a corporation. Article 14 of the AFS Convention sets out procedures to be followed in the event of a dispute between parties.

10

Adoption of the Final Act

INTERNATIONAL CONVENTION ON THE CONTROL OF HARMFUL ANTI-FOULING SYSTEMS ON SHIPS 2001

ADOPTION OF THE FINAL ACT

INTERNATIONAL CONFERENCE ON THE CONTROL OF HARMFUL ANTI-FOULING SYSTEMS FOR SHIPS
Agenda item 8

AFS/CONF/26
18 October 2001
Original: ENGLISH

ADOPTION OF THE FINAL ACT OF THE CONFERENCE AND ANY INSTRUMENTS, RECOMMENDATIONS AND RESOLUTIONS RESULTING FROM THE WORK OF THE CONFERENCE

INTERNATIONAL CONVENTION ON THE CONTROL OF HARMFUL ANTI-FOULING SYSTEMS ON SHIPS, 2001

Text adopted by the Conference

1 As a result of its deliberations, as recorded in the Record of Decisions of the Plenary (AFS/CONF/RD/2) and in the Final Act of the Conference (AFS/CONF/25), the Conference adopted the International Convention on the Control of Harmful Anti-fouling Systems on Ships, 2001.

2 The above-mentioned Convention, as adopted by the Conference, is annexed hereto.

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ANNEX

INTERNATIONAL CONVENTION ON THE CONTROL OF HARMFUL ANTI-FOULING SYSTEMS ON SHIPS, 2001

THE PARTIES TO THIS CONVENTION,

NOTING that scientific studies and investigations by Governments and competent international organizations have shown that certain anti-fouling systems used on ships pose a substantial risk of toxicity and other chronic impacts to ecologically and economically important marine organisms and also that human health may be harmed as a result of the consumption of affected seafood,

NOTING IN PARTICULAR the serious concern regarding anti-fouling systems that use organotin compounds as biocides and being convinced that the introduction of such organotins into the environment must be phased-out,

RECALLING that Chapter 17 of Agenda 21 adopted by the United Nations Conference on Environment and Development, 1992, calls upon States to take measures to reduce pollution caused by organotin compounds used in anti-fouling systems,

RECALLING ALSO that resolution A.895(21), adopted by the Assembly of the International Maritime Organization on 25 November 1999, urges the Organization's Marine Environment Protection Committee (MEPC) to work towards the expeditious development of a global legally binding instrument to address the harmful effects of anti-fouling systems as a matter of urgency,

MINDFUL OF the precautionary approach set out in Principle 15 of the Rio Declaration on Environment and Development and referred to in resolution MEPC.67(37) adopted by MEPC on 15 September 1995,

RECOGNIZING the importance of protecting the marine environment and human health from adverse effects of anti-fouling systems,

RECOGNIZING ALSO that the use of anti-fouling systems to prevent the build-up of organisms on the surface of ships is of critical importance to efficient commerce, shipping and impeding the spread of harmful aquatic organisms and pathogens,

RECOGNIZING FURTHER the need to continue to develop anti-fouling systems which are effective and environmentally safe and to promote the substitution of harmful systems by less harmful systems or preferably harmless systems,

HAVE AGREED as follows:

ARTICLE 1
General Obligations

(1) Each Party to this Convention undertakes to give full and complete effect to its provisions in order to reduce or eliminate adverse effects on the marine environment and human health caused by anti-fouling systems.

(2) The Annexes form an integral part of this Convention. Unless expressly provided otherwise, a reference to this Convention constitutes at the same time a reference to its Annexes.

(3) No provision of this Convention shall be interpreted as preventing a State from taking, individually or jointly, more stringent measures with respect to the reduction or elimination of adverse effects of anti-fouling systems on the environment, consistent with international law.

(4) Parties shall endeavour to co-operate for the purpose of effective implementation, compliance and enforcement of this Convention.

(5) The Parties undertake to encourage the continued development of anti-fouling systems that are effective and environmentally safe.

ARTICLE 2
Definitions

For the purposes of this Convention, unless expressly provided otherwise:

(1) "Administration" means the Government of the State under whose authority the ship is operating. With respect to a ship entitled to fly a flag of a State, the Administration is the Government of that State. With respect to fixed or floating platforms engaged in exploration and exploitation of the sea-bed and subsoil thereof adjacent to the coast over which the coastal State exercises sovereign rights for the purposes of exploration and exploitation of their natural resources, the Administration is the Government of the coastal State concerned.

(2) "Anti-fouling system" means a coating, paint, surface treatment, surface, or device that is used on a ship to control or prevent attachment of unwanted organisms.

(3) "Committee" means the Marine Environment Protection Committee of the Organization.

(4) "Gross tonnage" means the gross tonnage calculated in accordance with the tonnage measurement regulations contained in Annex 1 to the International Convention on Tonnage Measurement of Ships, 1969, or any successor Convention.

(5) "International voyage" means a voyage by a ship entitled to fly the flag of one State to or from a port, shipyard, or offshore terminal under the jurisdiction of another State.

(6) "Length" means the length as defined in the International Convention on Load Lines, 1966, as modified by the Protocol of 1988 relating thereto, or any successor Convention.

(7) "Organization" means the International Maritime Organization.

(8) "Secretary-General" means the Secretary-General of the Organization.

(9) "Ship" means a vessel of any type whatsoever operating in the marine environment and includes hydrofoil boats, air-cushion vehicles, submersibles, floating craft, fixed or floating platforms, floating storage units (FSUs) and floating production storage and off-loading units (FPSOs).

(10) "Technical Group" is a body comprised of representatives of the Parties, Members of the Organization, the United Nations and its Specialized Agencies, intergovernmental organizations having agreements with the Organization, and non-governmental organizations in consultative status with the Organization, which should preferably include representatives of institutions and laboratories that engage in anti-fouling system analysis. These representatives shall have expertise in environmental fate and effects, toxicological effects, marine biology, human health, economic analysis, risk management, international shipping, anti-fouling systems coating technology, or other fields of expertise necessary to objectively review the technical merits of a comprehensive proposal.

ARTICLE 3
Application

(1) Unless otherwise specified in this Convention, this Convention shall apply to:

(a) ships entitled to fly the flag of a Party;

(b) ships not entitled to fly the flag of a Party, but which operate under the authority of a Party; and

(c) ships that enter a port, shipyard, or offshore terminal of a Party, but do not fall within subparagraph (a) or (b).

(2) This Convention shall not apply to any warships, naval auxiliary, or other ships owned or operated by a Party and used, for the time being, only on government non-commercial service. However, each Party shall ensure, by the adoption of appropriate measures not impairing operations or operational capabilities of such ships owned or operated by it, that such ships act in a manner consistent, so far as is reasonable and practicable, with this Convention.

(3) With respect to the ships of non-Parties to this Convention, Parties shall apply the requirements of this Convention as may be necessary to ensure that no more favourable treatment is given to such ships.

ARTICLE 4
Controls on Anti-Fouling Systems

(1) In accordance with the requirements specified in Annex 1, each Party shall prohibit and/or restrict:

(a) the application, re-application, installation, or use of harmful anti-fouling systems on ships referred to in article 3(1)(a) or (b); and

(b) the application, re-application, installation or use of such systems, whilst in a Party's port, shipyard, or offshore terminal, on ships referred to in article 3(1)(c),

and shall take effective measures to ensure that such ships comply with those requirements.

(2) Ships bearing an anti-fouling system which is controlled through an amendment to Annex 1 following entry into force of this Convention may retain that system until the next scheduled renewal of that system, but in no event for a period exceeding 60 months following application, unless the Committee decides that exceptional circumstances exist to warrant earlier implementation of the control.

ARTICLE 5
Controls of Annex 1 Waste Materials

Taking into account international rules, standards and requirements, a Party shall take appropriate measures in its territory to require that wastes from the application or removal of an anti-fouling system controlled in Annex 1 are collected, handled, treated and disposed of in a safe and environmentally sound manner to protect human health and the environment.

ARTICLE 6
Process for Proposing Amendments to Controls on Anti-Fouling Systems

(1) Any Party may propose an amendment to Annex 1 in accordance with this article.

(2) An initial proposal shall contain the information required in Annex 2, and shall be submitted to the Organization. When the Organization receives a proposal, it shall bring the proposal to the attention of the Parties, Members of the Organization, the United Nations and its Specialized Agencies, intergovernmental organizations having agreements with the Organization and non-governmental organizations in consultative status with the Organization and shall make it available to them.

(3) The Committee shall decide whether the anti-fouling system in question warrants a more in-depth review based on the initial proposal. If the Committee decides that further review is warranted, it shall require the proposing Party to submit to the Committee a comprehensive proposal containing the information required in Annex 3, except where the initial proposal also includes all the information required in Annex 3. Where the Committee is of the view that there is a threat of serious or irreversible damage, lack of full scientific certainty shall not be used as a

reason to prevent a decision to proceed with the evaluation of the proposal. The Committee shall establish a technical group in accordance with article 7.

(4) The technical group shall review the comprehensive proposal along with any additional data submitted by any interested entity and shall evaluate and report to the Committee whether the proposal has demonstrated a potential for unreasonable risk of adverse effects on non-target organisms or human health such that the amendment of Annex 1 is warranted. In this regard:

(a) The technical group's review shall include:

(i) an evaluation of the association between the anti-fouling system in question and the related adverse effects observed either in the environment or on human health, including, but not limited to, the consumption of affected seafood, or through controlled studies based on the data described in Annex 3 and any other relevant data which come to light;

(ii) an evaluation of the potential risk reduction attributable to the proposed control measures and any other control measures that may be considered by the technical group;

(iii) consideration of available information on the technical feasibility of control measures and the cost-effectiveness of the proposal;

(iv) consideration of available information on other effects from the introduction of such control measures relating to:

- the environment (including, but not limited to, the cost of inaction and the impact on air quality);

- shipyard health and safety concerns (i.e. effects on shipyard workers);

- the cost to international shipping and other relevant sectors; and

(v) consideration of the availability of suitable alternatives, including a consideration of the potential risks of alternatives.

(b) The technical group's report shall be in writing and shall take into account each of the evaluations and considerations referred to in subparagraph (a), except that the technical group may decide not to proceed with the evaluations and considerations described in subparagraph (a)(ii) through (a)(v) if it determines after the evaluation in subparagraph (a)(i) that the proposal does not warrant further consideration.

(c) The technical group's report shall include, *inter alia,* a recommendation on whether international controls pursuant to this Convention are warranted on the anti-fouling system in question, on the suitability of the specific control measures suggested in the comprehensive proposal, or on other control measures which it believes to be more suitable.

(5) The technical group's report shall be circulated to the Parties, Members of the Organization, the United Nations and its Specialized Agencies, intergovernmental organizations having agreements with the Organization and non-governmental organizations in consultative status with the Organization, prior to its consideration by the Committee. The Committee shall decide whether to approve any proposal to amend Annex 1, and any modifications thereto, if appropriate, taking into account the technical group's report. If the report finds a threat of serious or irreversible damage, lack of full scientific certainty shall not, itself, be used as a reason to prevent a decision from being taken to list an anti-fouling system in Annex 1. The proposed amendments to Annex 1, if approved by the Committee, shall be circulated in accordance with article 16(2)(a). A decision not to approve the proposal shall not preclude future submission of a new proposal with respect to a particular anti-fouling system if new information comes to light.

(6) Only Parties may participate in decisions taken by the Committee described in paragraphs (3) and (5).

ARTICLE 7
Technical Groups

(1) The Committee shall establish a technical group pursuant to article 6 when a comprehensive proposal is received. In circumstances where several proposals are received concurrently or sequentially, the Committee may establish one or more technical groups as needed.

(2) Any Party may participate in the deliberations of a technical group, and should draw on the relevant expertise available to that Party.

(3) The Committee shall decide on the terms of reference, organization and operation of the technical groups. Such terms shall provide for protection of any confidential information that may be submitted. Technical groups may hold such meetings as required, but shall endeavour to conduct their work through written or electronic correspondence or other media as appropriate.

(4) Only the representatives of Parties may participate in formulating any recommendation to the Committee pursuant to article 6. A technical group shall endeavour to achieve unanimity among the representatives of the Parties. If unanimity is not possible, the technical group shall communicate any minority views of such representatives.

ARTICLE 8
Scientific and Technical Research and Monitoring

(1) The Parties shall take appropriate measures to promote and facilitate scientific and technical research on the effects of anti-fouling systems as well as monitoring of such effects. In particular, such research should include observation, measurement, sampling, evaluation and analysis of the effects of anti-fouling systems.

(2) Each Party shall, to further the objectives of this Convention, promote the availability of relevant information to other Parties who request it on:

(a) scientific and technical activities undertaken in accordance with this Convention;

(b) marine scientific and technological programmes and their objectives; and

(c) the effects observed from any monitoring and assessment programmes relating to anti-fouling systems.

ARTICLE 9
Communication and Exchange of Information

(1) Each Party undertakes to communicate to the Organization:

(a) a list of the nominated surveyors or recognized organizations which are authorized to act on behalf of that Party in the administration of matters relating to the control of anti-fouling systems in accordance with this Convention for circulation to the Parties for the information of their officers. The Administration shall therefore notify the Organization of the specific responsibilities and conditions of the authority delegated to nominated surveyors or recognized organizations; and

(b) on an annual basis, information regarding any anti-fouling systems approved, restricted, or prohibited under its domestic law.

(2) The Organization shall make available, through any appropriate means, information communicated to it under paragraph (1).

(3) For those anti-fouling systems approved, registered or licensed by a Party, such Party shall either provide, or require the manufacturers of such anti-fouling systems to provide, to those Parties which request it, relevant information on which its decision was based, including information provided for in Annex 3, or other information suitable for making an appropriate evaluation of the anti-fouling system. No information shall be provided that is protected by law.

ARTICLE 10
Survey and Certification

A Party shall ensure that ships entitled to fly its flag or operating under its authority are surveyed and certified in accordance with the regulations in Annex 4.

ARTICLE 11
Inspections of Ships and Detection of Violations

(1) A ship to which this Convention applies may, in any port, shipyard, or offshore terminal of a Party, be inspected by officers authorized by that Party for the purpose of determining whether the ship is in compliance with this Convention. Unless there are clear grounds for believing that a ship is in violation of this Convention, any such inspection shall be limited to:

(a) verifying that, where required, there is onboard a valid International Anti-fouling System Certificate or a Declaration on Anti-fouling System; and/or

(b) a brief sampling of the ship's anti-fouling system that does not affect the integrity, structure, or operation of the anti-fouling system taking into account guidelines developed by the Organization.* However, the time required to process the results of such sampling shall not be used as a basis for preventing the movement and departure of the ship.

(2) If there are clear grounds to believe that the ship is in violation of this Convention, a thorough inspection may be carried out taking into account guidelines developed by the Organization.*

(3) If the ship is detected to be in violation of this Convention, the Party carrying out the inspection may take steps to warn, detain, dismiss, or exclude the ship from its ports. A Party taking such action against a ship for the reason that the ship does not comply with this Convention shall immediately inform the Administration of the ship concerned.

(4) Parties shall co-operate in the detection of violations and the enforcement of this Convention. A Party may also inspect a ship when it enters the ports, shipyards, or offshore terminals under its jurisdiction, if a request for an investigation is received from any Party, together with sufficient evidence that a ship is operating or has operated in violation of this Convention. The report of such investigation shall be sent to the Party requesting it and to the competent authority of the Administration of the ship concerned so that the appropriate action may be taken under this Convention.

ARTICLE 12
Violations

(1) Any violation of this Convention shall be prohibited and sanctions shall be established therefor under the law of the Administration of the ship concerned wherever the violation occurs. If the Administration is informed of such a violation, it shall investigate the matter and may request the reporting Party to furnish additional evidence of the alleged violation. If the Administration is satisfied that sufficient evidence is available to enable proceedings to be brought in respect of the alleged violation, it shall cause such proceedings to be taken as soon as possible, in accordance with its laws. The Administration shall promptly inform the Party that reported the alleged violation, as well as the Organization, of any action taken. If the Administration has not taken any action within one year after receiving the information, it shall so inform the Party which reported the alleged violation.

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* Guidelines to be developed.

(2) Any violation of this Convention within the jurisdiction of any Party shall be prohibited and sanctions shall be established therefor under the law of that Party. Whenever such a violation occurs, that Party shall either:

(a) cause proceedings to be taken in accordance with its law; or

(b) furnish to the Administration of the ship concerned such information and evidence as may be in its possession that a violation has occurred.

(3) The sanctions established under the laws of a Party pursuant to this article shall be adequate in severity to discourage violations of this Convention wherever they occur.

ARTICLE 13
Undue Delay or Detention of Ships

(1) All possible efforts shall be made to avoid a ship being unduly detained or delayed under article 11 or 12.

(2) When a ship is unduly detained or delayed under article 11 or 12, it shall be entitled to compensation for any loss or damage suffered.

ARTICLE 14
Dispute Settlement

Parties shall settle any dispute between them concerning the interpretation or application of this Convention by negotiation, enquiry, mediation, conciliation, arbitration, judicial settlement, resort to regional agencies or arrangements, or other peaceful means of their own choice.

ARTICLE 15
Relationship to International Law of the Sea

Nothing in this Convention shall prejudice the rights and obligations of any State under customary international law as reflected in the United Nations Convention on the Law of the Sea.

ARTICLE 16
Amendments

(1) This Convention may be amended by either of the procedures specified in the following paragraphs.

(2) Amendments after consideration within the Organization:

(a) Any Party may propose an amendment to this Convention. A proposed amendment shall be submitted to the Secretary-General, who shall then circulate it to the Parties and Members of the Organization at least six months prior to its consideration. In the case of a proposal to amend Annex 1, it shall be processed in accordance with article 6, prior to its consideration under this article.

(b) An amendment proposed and circulated as above shall be referred to the Committee for consideration. Parties, whether or not Members of the Organization, shall be entitled to participate in the proceedings of the Committee for consideration and adoption of the amendment.

(c) Amendments shall be adopted by a two-thirds majority of the Parties present and voting in the Committee, on condition that at least one-third of the Parties shall be present at the time of voting.

(d) Amendments adopted in accordance with subparagraph (c) shall be communicated by the Secretary-General to the Parties for acceptance.

(e) An amendment shall be deemed to have been accepted in the following circumstances:

(i) An amendment to an article of this Convention shall be deemed to have been accepted on the date on which two-thirds of the Parties have notified the Secretary-General of their acceptance of it.

(ii) An amendment to an Annex shall be deemed to have been accepted at the end of twelve months after the date of adoption or such other date as determined by the Committee. However, if by that date more than one-third of the Parties notify the Secretary-General that they object to the amendment, it shall be deemed not to have been accepted.

(f) An amendment shall enter into force under the following conditions:

(i) An amendment to an article of this Convention shall enter into force for those Parties that have declared that they have accepted it six months after the date on which it is deemed to have been accepted in accordance with subparagraph (e)(i).

(ii) An amendment to Annex 1 shall enter into force with respect to all Parties six months after the date on which it is deemed to have been accepted, except for any Party that has:

(1) notified its objection to the amendment in accordance with subparagraph (e)(ii) and that has not withdrawn such objection;

(2) notified the Secretary-General, prior to the entry into force of such amendment, that the amendment shall enter into force for it only after a subsequent notification of its acceptance; or

(3) made a declaration at the time it deposits its instrument of ratification, acceptance or approval of, or accession to, this Convention that amendments to Annex 1 shall enter into force for it only after the notification to the Secretary-General of its acceptance with respect to such amendments.

(iii) An amendment to an Annex other than Annex 1 shall enter into force with respect to all Parties six months after the date on which it is deemed to have been accepted, except for those Parties that have notified their objection to the amendment in accordance with subparagraph (e)(ii) and that have not withdrawn such objection.

(g) (i) A Party that has notified an objection under subparagraph (f)(ii)(1) or (iii) may subsequently notify the Secretary-General that it accepts the amendment. Such amendment shall enter into force for such Party six months after the date of its notification of acceptance, or the date on which the amendment enters into force, whichever is the later date.

(ii) If a Party that has made a notification or declaration referred to in subparagraph (f)(ii)(2) or (3), respectively, notifies the Secretary-General of its acceptance with respect to an amendment, such amendment shall enter into force for such Party six months after the date of its notification of acceptance, or the date on which the amendment enters into force, whichever is the later date.

(3) Amendment by a Conference:

(a) Upon the request of a Party concurred in by at least one-third of the Parties, the Organization shall convene a Conference of Parties to consider amendments to this Convention.

(b) An amendment adopted by such a Conference by a two-thirds majority of the Parties present and voting shall be communicated by the Secretary-General to all Parties for acceptance.

(c) Unless the Conference decides otherwise, the amendment shall be deemed to have been accepted and shall enter into force in accordance with the procedures specified in paragraphs (2)(e) and (f) respectively of this article.

(4) Any Party that has declined to accept an amendment to an Annex shall be treated as a non-Party only for the purpose of application of that amendment.

(5) An addition of a new Annex shall be proposed and adopted and shall enter into force in accordance with the procedure applicable to an amendment to an article of this Convention.

(6) Any notification or declaration under this article shall be made in writing to the Secretary-General.

(7) The Secretary-General shall inform the Parties and Members of the Organization of:

(a) any amendment that enters into force and the date of its entry into force generally and for each Party; and

(b) any notification or declaration made under this article.

ARTICLE 17
Signature, Ratification, Acceptance, Approval and Accession

(1) This Convention shall be open for signature by any State at the Headquarters of the Organization from 1 February 2002 to 31 December 2002 and shall thereafter remain open for accession by any State.

(2) States may become Parties to this Convention by:

(a) signature not subject to ratification, acceptance, or approval; or

(b) signature subject to ratification, acceptance, or approval, followed by ratification, acceptance, or approval; or

(c) accession.

(3) Ratification, acceptance, approval, or accession shall be effected by the deposit of an instrument to that effect with the Secretary-General.

(4) If a State comprises two or more territorial units in which different systems of law are applicable in relation to matters dealt with in this Convention, it may at the time of signature, ratification, acceptance, approval, or accession declare that this Convention shall extend to all its territorial units or only to one or more of them and may modify this declaration by submitting another declaration at any time.

(5) Any such declaration shall be notified to the Secretary-General and shall state expressly the territorial units to which this Convention applies.

ARTICLE 18
Entry into force

(1) This Convention shall enter into force twelve months after the date on which not less than twenty-five States, the combined merchant fleets of which constitute not less than twenty-five percent of the gross tonnage of the world's merchant shipping, have either signed it without reservation as to ratification, acceptance or approval, or have deposited the requisite instrument of ratification, acceptance, approval or accession in accordance with article 17.

(2) For States which have deposited an instrument of ratification, acceptance, approval or accession in respect of this Convention after the requirements for entry into force thereof have been met, but prior to the date of entry in force, the ratification, acceptance, approval or accession shall take effect on the date of entry into force of this Convention or three months after the date of deposit of instrument, whichever is the later date.

(3) Any instrument of ratification, acceptance, approval or accession deposited after the date on which this Convention enters into force shall take effect three months after the date of deposit.

(4) After the date on which an amendment to this Convention is deemed to have been accepted under article 16, any instrument of ratification, acceptance, approval or accession deposited shall apply to the Convention as amended.

ARTICLE 19
Denunciation

(1) This Convention may be denounced by any Party at any time after the expiry of two years from the date on which this Convention enters into force for that Party.

(2) Denunciation shall be effected by the deposit of written notification with the Secretary-General, to take effect one year after receipt or such longer period as may be specified in that notification.

ARTICLE 20
Depositary

(1) This Convention shall be deposited with the Secretary-General, who shall transmit certified copies of this Convention to all States which have signed this Convention or acceded thereto.

(2) In addition to the functions specified elsewhere in this Convention, the Secretary-General shall:

(a) inform all States which have signed this Convention or acceded thereto of:

(i) each new signature or deposit of an instrument of ratification, acceptance, approval, or accession, together with the date thereof;

(ii) the date of entry into force of this Convention; and

(iii) the deposit of any instrument of denunciation of this Convention, together with the date on which it was received and the date on which the denunciation takes effect; and

(b) as soon as this Convention enters into force, transmit the text thereof to the Secretariat of the United Nations for registration and publication in accordance with Article 102 of the Charter of the United Nations.

ARTICLE 21
Languages

This Convention is established in a single original in the Arabic, Chinese, English, French, Russian and Spanish languages, each text being equally authentic.

IN WITNESS WHEREOF the undersigned being duly authorized by their respective Governments for that purpose have signed this Convention.

DONE AT LONDON, this fifth day of October, two thousand and one.

* * *

ANNEX 1

CONTROLS ON ANTI-FOULING SYSTEMS

Anti-fouling system	Control measures	Application	Effective date
Organotin compounds which act as biocides in anti-fouling systems	Ships shall not apply or re-apply such compounds	All ships	1 January 2003
Organotin compounds which act as biocides in anti-fouling systems	Ships either: (1) shall not bear such compounds on their hulls or external parts or surfaces; or (2) shall bear a coating that forms a barrier to such compounds leaching from the underlying non-compliant anti-fouling systems	All ships (except fixed and floating platforms, FSUs, and FPSOs that have been constructed prior to 1 January 2003 and that have not been in dry-dock on or after 1 January 2003)	1 January 2008

* * *

ANNEX 2

REQUIRED ELEMENTS FOR AN INITIAL PROPOSAL

(1) An initial proposal shall include adequate documentation containing at least the following:

(a) identification of the anti-fouling system addressed in the proposal: name of the anti-fouling system; name of active ingredients and Chemical Abstract Services Registry Number (CAS number), as applicable; or components of the system which are suspected of causing the adverse effects of concern;

(b) characterization of the information which suggests that the anti-fouling system or its transformation products may pose a risk to human health or may cause adverse effects in non-target organisms at concentrations likely to be found in the environment (e.g., the results of toxicity studies on representative species or bioaccumulation data);

(c) material supporting the potential of the toxic components in the anti-fouling system, or its transformation products, to occur in the environment at concentrations which could result in adverse effects to non-target organisms, human health, or water quality (e.g., data on persistence in the water column, sediments and biota; the release rate of toxic components from treated surfaces in studies or under actual use conditions; or monitoring data, if available);

(d) an analysis of the association between the anti-fouling system, the related adverse effects and the environmental concentrations observed or anticipated; and

(e) a preliminary recommendation on the type of restrictions that could be effective in reducing the risks associated with the anti-fouling system.

(2) An initial proposal shall be submitted in accordance with rules and procedures of the Organization.

* * *

ANNEX 3

REQUIRED ELEMENTS OF A COMPREHENSIVE PROPOSAL

(1) A comprehensive proposal shall include adequate documentation containing the following:

(a) developments in the data cited in the initial proposal;

(b) findings from the categories of data set out in paragraphs (3)(a), (b) and (c), as applicable, depending on the subject of the proposal and the identification or description of the methodologies under which the data were developed;

(c) a summary of the results of studies conducted on the adverse effects of the anti-fouling system;

(d) if any monitoring has been conducted, a summary of the results of that monitoring, including information on ship traffic and a general description of the area monitored;

(e) a summary of the available data on environmental or ecological exposure and any estimates of environmental concentrations developed through the application of mathematical models, using all available environmental fate parameters, preferably those which were determined experimentally, along with an identification or description of the modelling methodology;

(f) an evaluation of the association between the anti-fouling system in question, the related adverse effects and the environmental concentrations, either observed or expected;

(g) a qualitative statement of the level of uncertainty in the evaluation referred to in subparagraph (f);

(h) a recommendation of specific control measures to reduce the risks associated with the anti-fouling system; and

(i) a summary of the results of any available studies on the potential effects of the recommended control measures relating to air quality, shipyard conditions, international shipping and other relevant sectors, as well as the availability of suitable alternatives.

(2) A comprehensive proposal shall also include information on each of the following physical and chemical properties of the component(s) of concern, if applicable:

- melting point;
- boiling point;
- density (relative density);
- vapour pressure;

- water solubility / pH / dissociation constant (pKa);
- oxidation/reduction potential;
- molecular mass;
- molecular structure; and
- other physical and chemical properties identified in the initial proposal.

(3) For the purposes of paragraph (1)(b) above, the categories of data are:

(a) Data on environmental fate and effect:

- modes of degradation/dissipation (e.g., hydrolysis/photodegradation/ biodegradation);
- persistence in the relevant media (e.g., water column/sediments/biota);
- sediments/water partitioning;
- leaching rates of biocides or active ingredients;
- mass balance;
- bioaccumulation, partition coefficient, octanol/water coefficient; and
- any novel reactions on release or known interactive effects.

(b) Data on any unintended effects in aquatic plants, invertebrates, fish, seabirds, marine mammals, endangered species, other biota, water quality, the seabed, or habitat of non-target organisms, including sensitive and representative organisms:

- acute toxicity;
- chronic toxicity;
- developmental and reproductive toxicity;
- endocrine disruption;
- sediment toxicity;
- bioavailability/biomagnification/bioconcentration;
- food web/population effects;
- observations of adverse effects in the field/fish kills/ strandings/ tissue analysis; and
- residues in seafood.

These data shall relate to one or more types of non-target organisms such as aquatic plants, invertebrates, fish, birds, mammals and endangered species.

(c) Data on the potential for human health effects (including, but not limited to, consumption of affected seafood).

(4) A comprehensive proposal shall include a description of the methodologies used, as well as any relevant measures taken for quality assurance and any peer review conducted of the studies.

* * *

ANNEX 4

SURVEYS AND CERTIFICATION REQUIREMENTS FOR ANTI-FOULING SYSTEMS

REGULATION 1
Surveys

(1) Ships of 400 gross tonnage and above referred to in article 3(1)(a) engaged in international voyages, excluding fixed or floating platforms, FSUs, and FPSOs, shall be subject to surveys specified below:

(a) an initial survey before the ship is put into service or before the International Anti-fouling System Certificate (Certificate) required under regulation 2 or 3 is issued for the first time; and

(b) a survey when the anti-fouling systems are changed or replaced. Such surveys shall be endorsed on the Certificate issued under regulation 2 or 3.

(2) The survey shall be such as to ensure that the ship's anti-fouling system fully complies with this Convention.

(3) The Administration shall establish appropriate measures for ships that are not subject to the provisions of paragraph (1) of this regulation in order to ensure that this Convention is complied with.

(4) (a) As regards the enforcement of this Convention, surveys of ships shall be carried out by officers duly authorized by the Administration or as provided in regulation 3(1), taking into account guidelines for surveys developed by the Organization*. Alternatively, the Administration may entrust surveys required by this Convention either to surveyors nominated for that purpose or to organizations recognized by it.

(b) An Administration nominating surveyors or recognizing organizations** to conduct surveys shall, as a minimum, empower any nominated surveyor or recognized organization to:

(i) require a ship that it surveys to comply with the provisions of Annex 1; and

(ii) carry out surveys if requested by the appropriate authorities of a port State that is a Party to this Convention.

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* Guidelines to be developed.

** Refer to the guidelines adopted by the Organization by resolution A.739(18), as may be amended by the Organization, and the specifications adopted by the Organization by resolution A.789(19), as may be amended by the Organization.

(c) When the Administration, a nominated surveyor, or a recognized organization determines that the ship's anti-fouling system does not conform either to the particulars of a Certificate required under regulation 2 or 3, or to the requirements of this Convention, such Administration, surveyor or organization shall immediately ensure that corrective action is taken to bring the ship into compliance. A surveyor or organization shall also in due course notify the Administration of any such determination. If the required corrective action is not taken, the Administration shall be notified forthwith and it shall ensure that the Certificate is not issued or is withdrawn as appropriate.

(d) In the situation described in subparagraph (c), if the ship is in the port of another Party, the appropriate authorities of the port State shall be notified forthwith. When the Administration, a nominated surveyor, or a recognized organization has notified the appropriate authorities of the port State, the Government of the port State concerned shall give such Administration, surveyor, or organization any necessary assistance to carry out their obligations under this regulation, including any action described in article 11 or 12.

REGULATION 2

Issue or Endorsement of an International Anti-fouling System Certificate

(1) The Administration shall require that a ship to which regulation 1 applies is issued with a Certificate after successful completion of a survey in accordance with regulation 1. A Certificate issued under the authority of a Party shall be accepted by the other Parties and regarded for all purposes covered by this Convention as having the same validity as a Certificate issued by them.

(2) Certificates shall be issued or endorsed either by the Administration or by any person or organization duly authorized by it. In every case, the Administration assumes full responsibility for the Certificate.

(3) For ships bearing an anti-fouling system controlled under Annex 1 that was applied before the date of entry into force of a control for such a system, the Administration shall issue a Certificate in accordance with paragraphs (2) and (3) of this regulation not later than two years after entry into force of that control. This paragraph shall not affect any requirement for ships to comply with Annex 1.

(4) The Certificate shall be drawn up in the form corresponding to the model given in Appendix 1 to this Annex and shall be written at least in English, French, or Spanish. If an official language of the issuing State is also used this shall prevail in the case of the dispute or discrepancy.

REGULATION 3

Issue or Endorsement of an International Anti-fouling System Certificate by Another Party

(1) At the request of the Administration, another Party may cause a ship to be surveyed and, if satisfied that this Convention has been complied with, it shall issue or authorize the issue of a Certificate to the ship and, where appropriate, endorse or authorize the endorsement of that Certificate for the ship, in accordance with this Convention.

(2) A copy of the Certificate and a copy of the survey report shall be transmitted as soon as possible to the requesting Administration.

(3) A Certificate so issued shall contain a statement that it has been issued at the request of the Administration referred to in paragraph (1) and it shall have the same force and receive the same recognition as a Certificate issued by the Administration.

(4) No Certificate shall be issued to a ship which is entitled to fly the flag of a State which is not a Party.

REGULATION 4
Validity of an International Anti-fouling System Certificate

(1) A Certificate issued under regulation 2 or 3 shall cease to be valid in either of the following cases:

(a) if the anti-fouling system is changed or replaced and the Certificate is not endorsed in accordance with this Convention; and

(b) upon transfer of the ship to the flag of another State. A new Certificate shall only be issued when the Party issuing the new Certificate is fully satisfied that the ship is in compliance with this Convention. In the case of a transfer between Parties, if requested within three months after the transfer has taken place, the Party whose flag the ship was formerly entitled to fly shall, as soon as possible, transmit to the Administration a copy of the Certificates carried by the ship before the transfer and, if available, a copy of the relevant survey reports.

(2) The issue by a Party of a new Certificate to a ship transferred from another Party may be based on a new survey or on a valid Certificate issued by the previous Party whose flag the ship was entitled to fly.

REGULATION 5
Declaration on Anti-fouling System

(1) The Administration shall require a ship of 24 meters or more in length, but less than 400 gross tonnage engaged in international voyages and to which article 3(1)(a) applies (excluding fixed or floating platforms, FSUs, and FPSOs) to carry a Declaration signed by the owner or owner's authorized agent. Such Declaration shall be accompanied by appropriate documentation (such as a paint receipt or a contractor invoice) or contain appropriate endorsement.

(2) The Declaration shall be drawn up in the form corresponding to the model given in Appendix 2 to this Annex and shall be written at least in English, French, or Spanish. If an official language of the State whose flag the ship is entitled to fly is also used, this shall prevail in the case of a dispute or discrepancy.

APPENDIX 1 TO ANNEX 4

MODEL FORM OF INTERNATIONAL ANTI-FOULING SYSTEM CERTIFICATE

INTERNATIONAL ANTI-FOULING SYSTEM CERTIFICATE
(This certificate shall be supplemented by a Record of Anti-fouling Systems)

(Official seal) *(State)*

Issued under the
International Convention on the Control of Harmful Anti-Fouling Systems on Ships

under the authority of the Government of

....
(name of the State)

by
....
(person or organization authorized)

When a Certificate has been previously issued, this Certificate replaces the certificate dated ....

Particulars of ship[1]

Name of ship ....

Distinctive number or letters ....

Port of registry ....

Gross tonnage ....

IMO number[2] ....

An anti-fouling system controlled under Annex 1 has not been applied during or after construction of this ship ....□
An anti-fouling system controlled under Annex 1 has been applied on this ship previously, but has been removed by .... *(insert name of the facility)* on .... *(date)* ....□
An anti-fouling system controlled under Annex 1 has been applied on this ship previously, but has been covered with a sealer coat applied by .... *(insert name of the facility)* ....on...................*(date)*.........................□
An anti-fouling system controlled under Annex 1 was applied on this ship prior to.... *(date)*[3], but must be removed or covered with a sealer coat prior to ....*(date)*[4]..........................□

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1 Alternatively, the particulars of the ship may be placed horizontally in boxes.
2 In accordance with the IMO Ship Identification Number Scheme adopted by the Organization with Assembly resolution A.600(15).
3 Date of entry into force of the control measure.
4 Date of expiration of any implementation period specified in article 4(2) or Annex 1.

THIS IS TO CERTIFY THAT:

1 the ship has been surveyed in accordance with regulation 1 of Annex 4 to the Convention; and

2 the survey shows that the anti-fouling system on the ship complies with the applicable requirements of Annex 1 to the Convention.

Issued at...
(Place of issue of Certificate)

....
(Date of issue) *(Signature of authorized official issuing the Certificate)*

Date of completion of the survey
on which this certificate is issued: ....

MODEL FORM OF RECORD OF ANTI-FOULING SYSTEMS

RECORD OF ANTI-FOULING SYSTEMS

This Record shall be permanently attached to the International Anti-Fouling System Certificate.

Particulars of ship

Name of ship : ....
Distinctive number or letters : ....
IMO number : ....

Details of anti-fouling system(s) applied

Type(s) of anti-fouling system(s) used ....
....

Date(s) of application of anti-fouling system(s)..

Name(s) of company(ies) and facility(ies)/location(s) where applied ....
....

Name(s) of anti-fouling system manufacturer(s) ....
....

Name(s) and colour(s) of anti-fouling system(s)...
....

Active ingredient(s) and their Chemical Abstract Services Registry Number(s) (CAS number(s))
....

Type(s) of sealer coat, if applicable ....
....

Name(s) and colour(s) of sealer coat applied, if applicable
....

Date of application of sealer coat...

THIS IS TO CERTIFY that this Record is correct in all respects.

Issued at..
(Place of issue of Record)

....
(Date of issue) *(Signature of authorized official issuing the record)*

Endorsement of the Records[5]

THIS IS TO CERTIFY that a survey required in accordance with regulation 1(1)(b) of Annex 4 to the Convention found that the ship was in compliance with the Convention

Details of anti-fouling system(s) applied

Type(s) of anti-fouling system(s) used...
....

Date(s) of application of anti-fouling system(s)...

Name(s) of company(ies) and facility(ies) location(s) where applied...
....

Name(s) of anti-fouling system(s) manufacturer(s)..
....

Name(s) and colour(s) of anti-fouling system(s)...
....

Active ingredient(s) and their Chemical Abstract Services Registry Number(s) (CAS number(s)) ...
....

Type(s) of sealer coat, if applicable ....

Name(s) and colour(s) of sealer coat applied, if applicable
....

Date of application of sealer coat ....

Signed:...
(Signature of authorized official issuing the Record)
Place: ....
Date[6]: ....

(Seal or stamp of the authority)

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[5] This page of the Record shall be reproduced and added to the Record as considered necessary by the Administration.
[6] Date of completion of the survey on which this endorsement is made.

APPENDIX 2 TO ANNEX 4

MODEL FORM OF DECLARATION ON ANTI-FOULING SYSTEM

DECLARATION ON ANTI-FOULING SYSTEM

Drawn up under the
International Convention on the Control of Harmful Anti-Fouling Systems on Ships

Name of ship ....

Distinctive number or letters ....

Port of registry ....

Length ....

Gross tonnage ....

IMO number (if applicable) ....

I declare that the anti-fouling system used on this ship complies with Annex 1 of the Convention.

....
(Date) *(Signature of owner or owner's authorized agent)*

Endorsement of anti-fouling system(s) applied

Type(s) of anti-fouling system(s) used and date(s) of application ....
....

....
(Date) *(Signature of owner or owner's authorized agent)*

Type(s) of anti-fouling system(s) used and date(s) of application ....
....

....
(Date) *(Signature of owner or owner's authorized agent)*

Type(s) of anti-fouling system(s) used and date(s) of application ....
....

....
(Date) *(Signature of owner or owner's authorized agent)*

___

11

Making innovation a way of life – A speech by Senator the Hon Kim Carr – 2008

MAKING INNOVATION A WAY OF LIFE

A SPEECH DELIVERED BY SENATOR THE HON KIM CARR

TO THE NATIONAL INNOVATION FORUM 2008

MINISTER FOR INNOVATION, INDUSTRY, SCIENCE AND RESEARCH

Note: On line at http://minister.innovation.gov.au

Australian Government

Innovation, Industry, Science and Research: Ministers and Parliamentary Secretary

IISR Minister > Senator the Hon Kim Carr

Speech

Senator the Hon Kim Carr

01 Apr 2008

MAKING INNOVATION A WAY OF LIFE

National Innovation Forum
Committee for Economic Development of Australia
Sydney

[Check Against Delivery]

The human faculty for solving problems and finding order in a chaotic universe is the basis of creativity, and creativity is the basis of innovation.

I believe our capacity for creativity is infinite.

But to release that capacity we must give people the freedom to explore and the confidence to speak.

We can't afford to be complacent, or inward-looking, or authoritarian.

We must be aware that every day brings new challenges, and that new challenges require new solutions.

The Australian settlement

Think back to the dispensation that prevailed in Australia from the early 1900s to the 1980s.

Some historians call it the Australian settlement, but those who created it called it protection all round.

That meant protection for manufacturers through tariffs and quotas, protection for workers through centralised wage fixing, and protection for farmers through marketing monopolies, stabilisation schemes, input subsidies and more.

The only ones not in the fold were the sheep.

It was export earnings chiefly from wool – and in later years from minerals – that bankrolled the whole arrangement.

As the value of these exports declined through the sixties and seventies, the settlement became untenable. Radical reform was required, and the Labor governments of Hawke and Keating delivered it.

It's easy these days to disparage the Australian settlement.

But for three or four generations it delivered standards of living that were the envy of the world, a balanced economy, jobs for a growing population, a relatively equitable distribution of wealth, and a high degree of social cohesion, certainty and security.

Of course this situation was completely unsustainable, and the reforms of the eighties and early nineties were absolutely essential.

I'm not defending the settlement, but I am defending the majority of Australians who identified with it through much of the last century.

The faith they placed in protection all round – even as recently as thirty years ago – was not irrational. It's just that the world had changed. Although few knew it, the foundations on which the settlement was built had crumbled into dust.

If Hawke and Keating failed in one thing, it was in explaining why reform was necessary, why the old Australia was dying, and why a new one had to be born.

That failure left people feeing confused, vulnerable and angry – sentiments exploited crudely by Pauline Hanson, and more subtly by John Howard, who promised to make us relaxed and comfortable, but whose political weapon of choice was fear.

After seventeen years of continuous growth, people are more comfortable with the new Australia.

A decade of conservative spin may have obscured the fact that we owe our present prosperity to the courage and vision of Hawke and Keating, but their contribution has gradually gained the recognition it deserves.

I'm raising all this for two reasons.

The first is that the great reform project that began in 1983 remains unfinished. When the pause button was pressed in 1996, there was still a long way to go.

But before we press play again, we need to be make sure everyone is ready.

That's the second moral of my tale – people will embrace reform if they are clear about why it's needed and certain it will produce better outcomes for themselves and their children.

It's our job as a government to include everyone in the process, and to give everyone a stake in its success.

The government has taken some stick for being too consultative – for establishing reviews, for organising community cabinets, for convening the 2020 Summit.

Our style is to get out and listen to what Australians have to say. We don't just want people's votes – we want their opinions.

Those who knock that style need to explain just what it is they've got against evidence-based policy. While they're at it, they can explain what they've got against democracy.

NIS review

One of my first actions as minister was to establish a review of the national innovation system, which is being conducted by a panel of experts from business and the academy chaired by Dr Terry Cutler.

The review reflects our commitment to consultation, our belief in basing policy on firm facts, and our determination to tackle the unfinished business of reform.

The Hawke-Keating years saw some important innovation initiatives, including the R&D tax concession introduced in 1985 and the Cooperative Research Centres program established in 1991.

But despite these achievements, today's Australian innovation system is still recognisably the same system that evolved in response to protection all round.

The institutions and practices we rely on to discover, disseminate and adopt new knowledge are still tethered to the past.

It hasn't helped that much of the good work done in the eighties and early nineties has been undone in the last decade.

Support for business R&D was reduced when most other OECD countries were maintaining or increasing theirs.

An analysis by my department shows that business R&D spending as a share of GDP grew 9 per cent a year in the decade before 1995-96, but less than 3 per cent a year in the decade after. By 2005-06 we had tumbled from eighth to fifteenth in the OECD rankings for this measure.

At the same time, the CRC program was stripped of its capacity-building and public benefit rationale.

The upshot is that we still have an innovation system bedevilled by legacies of the Australian settlement.

Legacies such as:

- uneven R&D performance and capabilities in the private sector
- financial institutions and markets with no experience of supporting innovation
- universities and public research organisations with only patchy links to industry
- an inadequate focus on workforce skills
- and fragmentation across the board.

Australian business had little incentive to innovate while it was cocooned by protection. Many firms and industries are doing outstanding work these days, but in the aggregate we are still well below the world's best.

Our business expenditure on R&D is just 68 per cent of the OECD average, and less than half of what pacesetters like Japan, South Korea, Sweden and Finland are achieving.

Gulfs and barriers between regions, technologies, disciplines, sectors and organisations make it hard to achieve economies of scale, attain critical mass, or even get everyone reading from the same page.

This is the landscape we have to change. Dr Cutler and his colleagues are already making the earth move.

NIS consultations

They have just completed a series of consultations, with sessions in every state and territory. They attracted over a 1,000 people from the private, government and research sectors.

Dr Cutler tells me that the sessions with business and industry were the best attended, but that all sessions were lively and the whole exercise was extremely productive.

The anecdotal evidence filtering back to me is that people came away feeling they were being listened to – and in some cases feeling sufficiently inspired to go home and start writing a formal submission.

The more systematic evidence collated by the review panel's secretariat gives us a valuable insight into where we are at.

One key message is that innovation policy must go beyond support for science and technology.

We should also recognise the value of operational and organisational innovations – new ideas in management and service delivery.

And while we're all susceptible to the gee-whiz appeal of big breakthroughs, we should also consider the transformational power of modest, incremental improvements over time.

Many stakeholders feel that the government should walk the walk by embracing new technologies and developing innovative policy and service responses to Australia's needs.

I agree.

A second strong message was that we need to boost skills.

Everyone in the country knows we are facing a skills crisis – well, everyone except Malcolm Turnbull – and this has serious implications for our innovation effort, just as it does for every other area of activity.

Science, technology, engineering and mathematics skills are critical, but they are not the whole story.

An innovation system also needs people who can think creatively, people who can solve problems, people who can imagine a different and better world.

An innovation system with a global outlook – which is what I'm determined to create – needs people who can communicate in languages other than English.

Much has been said about the government's education revolution, but even now I'm not sure the scale of what we are doing is fully understood.

We are bringing fresh ideas to every stage of the learning journey, from pre-school to post-doc.

We are increasing technological literacy – and educational equity – by supplying computers and broadband to Australian schools.

We are massively expanding vocational education by establishing trade training centres in high schools and creating 450,000 new training places.

We are doubling the number of Commonwealth scholarships for undergraduates and halving HECS fees for students who do maths and science.

In my own portfolio we are doubling the number of PhD scholarships and offering 1,000 Future Fellowships to attract and retain the best mid-career researchers in the world.

And Julia Gillard is taking steps to boost the number of students studying languages other than English – not least by encouraging the states and territories to match our $68 million commitment to Asian languages.

I'm not going to pretend we have all the answers, but we are certainly heading in the right direction.

Of the many other messages to come out of the consultations, one struck a special chord with me.

If we want innovation to flourish, we must become more tolerant of risk and better at managing it.

I've always defended people's right to be wrong. Trial and error are part of the learning process. Every experiment teaches us something, and the ones that fail often teach us more than the ones that succeed.

Our innovation system needs to enshrine these values.

The final message I want to respond to is actually a group of messages.

Some people said the local and regional dimension was critical, especially if we want to do justice to our innovative SMEs.

I don't disagree. It's worth remembering that a third or more of the R&D in some service industries is done by firms with fewer than twenty employees. (ABS 2005-06)

Others said the national dimension was what mattered – that a high-level commitment from the federal government would open doors and mobilise change. I don't disagree with them either.

A third group emphasised the international dimension, and how we must look beyond our shores for opportunities, partnerships, facilities, investment and benchmarks. You guessed it – I don't disagree with them either.

My aim is to create a system that has room for every innovator – from the bright kid with a great idea and one clean pair of sneakers, to the multinational with so many resources they need a thousand bright kids just to keep track of them.

A system that can improve neighbourhood services in Bermagui one day, and negotiate a scientific alliance in Brussels the next.

A system that can meet the local needs of Australian families and communities precisely because it is part of an international knowledge network.

Internationalising the NIS review

To demonstrate just what being part of such a network means, I'd like to take this opportunity to announce the appointment of four expert advisers to the NIS review. They are:

- Professor Alan Hughes from the University of Cambridge
- Professor Richard K. Lester from the Massachusetts Institute of Technology
- Professor Stan Metcalfe from the University of Manchester
- and Professor Keith Smith, now at the Australian Innovation Research Centre.

Professor Smith has returned to Australia after a decade as Director of the Group for Studies in Technology, Innovation and Economic Policy in Norway, and stints with the Institute for New Technologies in the Netherlands and the European Commission's Joint Research Centre in Spain.

He is a reminder of just how international Australians can be. As the author of Innovation and Growth in Resource-based Economies – an important CEDA paper released last year – he will be no stranger to this group.

Together, the four advisers have expertise in just about every aspect of innovation systems, processes, measurement and policy.

They will provide strategic advice to the NIS review panel and its working groups. They will share the fruits of their own research through presentations, workshops, visits and input to papers.

And they will bring a rigorous global perspective to the review process.

In appointing these advisers I am extending and formalising an international dialogue that began the day the review was announced.

One very important participant in that dialogue is Nick Donofrio, IBM's Global Vice-President and Head of Innovation and Technology.

Another is Professor Mark Dodgson, Director of the University of Queensland's Technology and Innovation Management Centre. He is an authority on international collaboration and a consultant to governments in Asia, the US, Europe and Africa.

Dr Cutler and his colleagues have made no secret of how much they owe these two thinkers.

In fact, every member of the review panel has been using their international connections to gather information and sound out ideas.

Terry Cutler himself is drawing on his work with countries such as Finland, Ireland and Chile, which have many small-economy characteristics in common with Australia.

The new international advisers will extend the web further by tapping into their own global networks, including Professor Smith's extensive links into the EU and the OECD.

The future

The review panel reports on the 31st of July and few people can be looking forward to its findings with more anticipation than I am.

Submissions close on the 30th of April, which gives you exactly a month to get your thoughts down on paper if you haven't done so already.

The review panel is especially keen to receive contributions from people with an independent viewpoint and fresh ideas, and I know CEDA, its members and its friends fall into that category.

It's not my job to second guess-what the review will come up with, but some of its parameters are already clear.

The review will give us an understanding of where we are. It will recommend policies to guide us where we want to go. And it will propose realistic interventions to help us get there.

All innovation requires three things.

The first and most important is human capital – smart people who can think creatively and see the big picture.

How do we create the kind of richly networked, multidisciplinary environment that produces such people?

How do we mine the creativity of smart people outside Australia – including our own diaspora – remembering that it's people's knowledge we're after, not their bodies and souls?

Knowledge, like capital, now flows in global currents which increasingly transcend national and institutional boundaries.

Radical financial and monetary reform in the 1980s revolutionised Australia's relationship with the global market for capital.

What reforms do we need to secure a place in the global market for ideas?

The second thing innovation depends on is access to finance – credit, venture capital, private equity or internal reserves.

How can we generate or unlock funds for innovation?

The review panel has a specific reference to consider how well the R&D tax concession is working and how it might be made to work better. One option under consideration is a premium concession for public-private research collaboration.

The third thing we need is infrastructure.

The government is already taking huge steps to improve both the hard infrastructure required for innovation – such as broadband; and the soft infrastructure – such as educational services.

How can we build on this foundation? What other kinds of infrastructure should we be thinking about?

My goal is to foster a pervasive culture of innovation. Nothing less will do if we are to close the gap between ourselves and our competitors.

That's why we need to increase our investment in science, research and innovation capacity more generally.

That's why Kevin Rudd has identified innovation as one of our three main instruments for boosting productivity – the others being education and infrastructure.

This is vitally important given our sorry performance on productivity over the last decade. Productivity growth was zero in 2007.

I don't want an innovation system that serves industry and government.

I want a system that includes industry and government, both as co-authors of new ideas with the research establishment and as originators and adapters of new ideas in their own right.

I want a system that can harness creativity wherever we find it and bring it to bear wherever it is needed to meet human needs and fulfil human aspirations.

That's what I mean by making innovation a way of life.

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Marine Environmental Management Profile

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MARINE ENVIRONMENTAL MANAGEMENT PROFILE

A GUIDE TO THE BUREAUCRATIC HIERARCHY

MARINE ENVIRONMENTAL MANAGEMENT PROFILE

Around 97% of Australia's marine area, is under Commonwealth government jurisdiction. However, coastal areas where most introduced species occur are covered in State and the Northern Territory jurisdiction.

Within the three nautical mile zone the Commonwealth has handed the title to an area called 'Coastal Waters' and partial management responsibility to the states and Northern Territory under a series of arrangements reached with the states known as the **Offshore Constitutional Settlement** (OCS). The Commonwealth still retains concurrent Legislative powers in this area.

Australia has rights and responsibilities for 16 million square kilometres of ocean. This includes an EEZ of over 11 million square kilometres.

The following bureaucratic hierarchy has various responsibilities:

Federal Authorities

Department of the Environment and Heritage

- Coasts and Oceans; Introduced Marine Pests Program. Support actions that will lead to the control and local eradication of IMP'S.

Australian Quarantine and Inspection Service (AQIS)

- Administrative and enforcement of quarantine regulations in the case of intentional and unintentional introduction of organisms.

Department of Transport and Regional Services (DOTRS)

- Administering of Marine Safety and Environment issues related to shipping.
- Australian Maritime Safety Authority (AMSA) administers and enforces maritime safety and environment protection related regulations.

Department of Industry Tourism and Resources

- Commonwealth Scientific and Industrial Research Organisation (CSIRO). Controlling the introduction and spread of exotic species in the marine environment and assessing the impacts of known marine pests that require a multi-disciplinary approach.

State Authorities

Department of Primary Industries, Water and Environment, Tasmania.

Queensland Environmental Protection Agency

Primary Industry and Resources, South Australia.

Natural Resources and Environment, Victoria.

Fisheries Western Australia

Department of Primary Industry and Fisheries, Northern Territory.

New South Wales Department of Transport

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13

Protection of the sea (Harmful anti-fouling systems) Act 2006

PROTECTION OF THE SEA (HARMFUL ANTI-FOULING SYSTEMS) ACT 2006

An Act relating to the protection of the sea from the effects of harmful anti-fouling systems

Note: An electronic version of this Act is available in ComLaw (http://www.comlaw.gov.au/)

AUSTRALIA

Protection of the Sea (Harmful Anti-fouling Systems) Act 2006

No. 107, 2006

An Act relating to the protection of the sea from the effects of harmful anti-fouling systems

Note: An electronic version of this Act is available in ComLaw (http://www.comlaw.gov.au/)

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Protection of the Sea (Harmful Anti-fouling Systems) Act 2006

No. 107, 2006

An Act relating to the protection of the sea from the effects of harmful anti-fouling systems

[*Assented to 27 September 2006*]

The Parliament of Australia enacts:

Part 1—Preliminary

1 Short title

This Act may be cited as the *Protection of the Sea (Harmful Anti-fouling Systems) Act 2006*.

2 Commencement

(1) Each provision of this Act specified in column 1 of the table commences, or is taken to have commenced, in accordance with column 2 of the table. Any other statement in column 2 has effect according to its terms.

Commencement information		
Column 1	**Column 2**	**Column 3**
Provision(s)	**Commencement**	**Date/Details**
1. Sections 1 and 2 and anything in this Act not elsewhere covered by this table	The day on which this Act receives the Royal Assent.	27 September 2006
2. Sections 3 to 25	A single day to be fixed by Proclamation. A Proclamation must not specify a day that occurs before the day on which the Convention enters into force for Australia. However, if the provision(s) do not commence within the period of 6 months beginning on the day on which the Convention enters into force for Australia, they commence on the first day after the end of that period. If the provision(s) commence in this way, the Minister must announce by notice in the *Gazette* the day on which the provision(s) commenced. The notice is not a legislative instrument.	17 September 2008 (*see* F2008L00369)

Note: This table relates only to the provisions of this Act as originally passed by the Parliament and assented to. It will not be expanded to deal with provisions inserted in this Act after assent.

(2) Column 3 of the table contains additional information that is not part of this Act. Information in this column may be added to or edited in any published version of this Act.

3 Definitions

In this Act:

anti-fouling certificate means a certificate issued under section 10.

Australia includes the external Territories.

Australian law means a law of the Commonwealth or of a State or Territory.

Australian ship means:

(a) a ship registered, or required to be registered, under the *Shipping Registration Act 1981*; or

(b) an unregistered ship that has Australian nationality under the *Shipping Registration Act 1981*.

Australian shipping facility means a shipping facility in Australia or in Australia's exclusive economic zone (within the meaning of the *Seas and Submerged Lands Act 1973*).

Authority means the Australian Maritime Safety Authority established by the *Australian Maritime Safety Authority Act 1990*.

complies with the anti-fouling requirements has the meaning given by section 4.

conduct, in relation to an offence, has the same meaning as in the *Criminal Code*.

Convention means the International Convention on the Control of Harmful Anti-fouling Systems on Ships, done at London on 5 October 2001.

Note: In 2006, the text of the Convention was accessible through the Australian Treaties Library on the AustLII Internet site (www.austlii.edu.au).

designated external surface means any part of the hull or external parts or surfaces. For this purpose, ***hull or external parts or surfaces*** has the same meaning as in the Convention.

engage in conduct has the same meaning as in the *Criminal Code*.

exempt platform means any of the following (within the meaning of the Convention):

(a) a fixed or floating platform;

(b) a floating storage unit;

(c) a floating production, storage and off-loading unit.

foreign Convention law means a law of a foreign country that gives effect (wholly or partly) to the Convention.

foreign ship means a ship that is not an Australian ship.

gross tonnage has the same meaning as in the Convention.

HAFC (short for harmful anti-fouling compound) means an organotin compound that acts as a biocide in an anti-fouling system. For this purpose, ***organotin compound***, ***biocide*** and ***anti-fouling system*** have the same meaning as in the Convention.

inspector has the meaning given by section 16.

international voyage has the same meaning as in the Convention.

length has the same meaning as in the Convention.

master, in relation to a ship, means the person having command or charge of the ship, but does not include a person exercising powers under an Australian law.

offence against this Act includes:

(a) an offence against the regulations; and

(b) an offence against Chapter 7 of the *Criminal Code* that relates to this Act or the regulations.

orders means orders under section 24.

owner, in relation to a ship that is operated by a person other than the owner, includes the operator.

pre-2003 exempt platform means an exempt platform that was constructed before 1 January 2003 and has not been in dry dock on or after that date.

prescribed means prescribed by the regulations.

regulations includes orders.

ship has the same meaning as in Article 2 of the Convention, but does not include a ship that is being used for non-commercial purposes by:

(a) the Commonwealth, a State or a Territory; or
(b) the government of a foreign country.

shipping facility means:

(a) a port; or
(b) a shipyard; or
(c) an offshore terminal;

within the meaning of the Convention.

survey authority means:

(a) the Authority; or
(b) a body corporate approved by the Authority under section 5.

4 Definition: compliance with anti-fouling requirements

A ship ***complies with the anti-fouling requirements*** if, and only if:

(a) it has no HAFC applied on any designated external surface; or
(b) each HAFC that is applied on any designated external surface has a coating that forms a barrier to the HAFC leaching into the water.

5 Approving a body corporate approved as a survey authority

(1) The Authority may, in writing, approve a body corporate as a survey authority.

(2) An approval made under subsection (1) is not a legislative instrument.

6 Scope of Act

(1) This Act applies to every external Territory.

(2) This Act extends to acts, omissions, matters and things outside Australia (unless the contrary intention appears).

7 Act to bind Crown

(1) This Act binds the Crown in each of its capacities.

(2) This Act does not make the Crown liable to be prosecuted for an offence.

(3) Subsection (2) does not affect any liability of any employee or agent of the Commonwealth or of a State or Territory to be prosecuted for an offence.

Part 2—Application or use of harmful anti-fouling systems

8 HAFC not to be applied to a ship

Ordinary offence: applying an HAFC

(1) A person commits an offence if:

(a) the person engages in conduct; and

(b) the conduct results in an HAFC being applied or re-applied on a designated external surface of a ship; and

(c) the person is negligent as to causing that result; and

(d) either:

(i) the ship is an Australian ship; or

(ii) the ship is a foreign ship and the conduct occurred in an Australian shipping facility.

Penalty: 2,000 penalty units.

Strict liability offence: applying an HAFC

(2) A person commits an offence if:

(a) an HAFC is:

(i) applied or re-applied on a designated external surface of an Australian ship; or

(ii) applied or re-applied on a designated external surface of a foreign ship in an Australian shipping facility; and

(b) the person is the owner or master of the ship.

Penalty: 500 penalty units.

(3) An offence against subsection (2) is an offence of strict liability.

Note: For strict liability, see section 6.1 of the *Criminal Code*.

No offence if State or Territory law applies

(4) If:

(a) apart from this subsection, particular conduct would constitute an offence against this section; and

(b) the conduct constitutes an offence against a law of a State or Territory;

then the conduct does not constitute an offence against this section.

Note: A defendant bears an evidential burden in relation to the matter in subsection (4): see subsection 13.3(3) of the *Criminal Code*.

9 Non-complying ships not to enter or remain in shipping facilities

Ordinary offence: non-complying Australian ship entering shipping facility

(1) A person commits an offence if:

(a) on or after 1 January 2008, the person:

(i) takes an Australian ship to a shipping facility; or

(ii) permits an Australian ship to be taken to a shipping facility; and

(b) the person is the master or owner of the ship; and

(c) the ship does not comply with the anti-fouling requirements; and

(d) the ship is not a pre-2003 exempt platform.

Penalty: 2,000 penalty units.

Ordinary offence: non-complying Australian ship remaining in shipping facility

(2) If:

(a) on or after 1 January 2008, a person allows an Australian ship to remain in a shipping facility (whether or not it entered before that date); and

(b) the person is the master or owner of the ship; and

(c) the ship does not comply with the anti-fouling requirements; and

(d) the ship is not a pre-2003 exempt platform;

then the person commits an offence for each day on which the ship so remains.

Penalty: 1,000 penalty units.

Ordinary offence: non-complying foreign ship entering Australian shipping facility

(3) A person commits an offence if:

(a) on or after 1 January 2008, the person:

(i) takes a foreign ship to an Australian shipping facility; or

(ii) permits a foreign ship to be taken to an Australian shipping facility; and

(b) the person is the master or owner of the ship; and

(c) the ship does not comply with the anti-fouling requirements; and

(d) the ship is not a pre-2003 exempt platform.

Penalty: 2,000 penalty units.

Ordinary offence: non-complying foreign ship remaining in Australian shipping facility

(4) If:

(a) on or after 1 January 2008, a person allows a foreign ship to remain in an Australian shipping facility (whether or not it entered before that date); and

(b) the person is the master or owner of the ship; and

(c) the ship does not comply with the anti-fouling requirements; and

(d) the ship is not a pre-2003 exempt platform;

then the person commits an offence for each day on which the ship so remains.

Penalty: 1,000 penalty units.

Strict liability offence: non-complying Australian ship entering shipping facility

(5) A person commits an offence if:

(a) on or after 1 January 2008, an Australian ship enters a shipping facility; and

(b) the person is the master or owner of the ship; and

(c) the ship does not comply with the anti-fouling requirements; and

(d) the ship is not a pre-2003 exempt platform.

Penalty: 500 penalty units.

Strict liability offence: non-complying Australian ship remaining in shipping facility

(6) If:

(a) on or after 1 January 2008, an Australian ship remains in a shipping facility (whether or not it entered before that date); and

(b) the ship does not comply with the anti-fouling requirements; and

(c) the ship is not a pre-2003 exempt platform;

then the master and owner each commit an offence for each day on which the ship so remains.

Penalty: 400 penalty units.

Strict liability offence: non-complying foreign ship entering Australian shipping facility

(7) A person commits an offence if:

(a) on or after 1 January 2008, a foreign ship enters an Australian shipping facility; and

(b) the person is the master or owner of the ship; and

(c) the ship does not comply with the anti-fouling requirements; and

(d) the ship is not a pre-2003 exempt platform.

Penalty: 500 penalty units.

Strict liability offence: non-complying foreign ship remaining in Australian shipping facility

(8) If:

(a) on or after 1 January 2008, a foreign ship remains in an Australian shipping facility (whether or not it entered before that date); and

(b) the ship does not comply with the anti-fouling requirements; and

(c) the ship is not a pre-2003 exempt platform;

then the master and owner each commit an offence for each day on which the ship so remains.

Penalty: 400 penalty units.

(9) An offence against subsection (5), (6), (7) or (8) is an offence of strict liability.

Note: For strict liability, see section 6.1 of the *Criminal Code*.

Exception for emergencies etc.

(10) Subsections (1) to (8) do not apply if:

(a) the ship enters or remains (as the case may be) for the purpose of securing the safety of the ship or seeking urgent medical attention for a person on board the ship; or

(b) the ship is under the control of a person exercising powers under an Australian law.

Note: A defendant bears an evidential burden in relation to the matter in subsection (10): see subsection 13.3(3) of the *Criminal Code*.

No offence if State or Territory law applies

(11) If:

(a) apart from this subsection, particular conduct would constitute an offence against this section; and

(b) the conduct constitutes an offence against a law of a State or Territory;

then the conduct does not constitute an offence against this section.

Note: A defendant bears an evidential burden in relation to the matter in subsection (11): see subsection 13.3(3) of the *Criminal Code*.

Part 3—Anti-fouling certificates and anti-fouling declarations

10 Issue and endorsement of anti-fouling certificates

Initial certificate

(1) If:

(a) a survey authority surveys an Australian ship with a gross tonnage of 400 or more, for the purpose of determining whether the ship complies with the anti-fouling requirements; and

(b) the ship does not have a current anti-fouling certificate; and

(c) on the basis of the survey, the survey authority is satisfied that the ship complies with the anti-fouling requirements;

then the survey authority must issue an anti-fouling certificate in respect of the ship, in the prescribed form.

Endorsement of existing certificate

(2) If:

(a) a survey authority surveys an Australian ship with a gross tonnage of 400 or more, for the purpose of determining whether the ship complies with the anti-fouling requirements; and

(b) the ship has a current anti-fouling certificate, but needs an endorsement in order for the certificate to continue in effect; and

(c) on the basis of the survey, the survey authority is satisfied that the ship complies with the anti-fouling requirements;

then the survey authority must endorse the anti-fouling certificate in accordance with the regulations.

Status of certificate and endorsement

(3) An anti-fouling certificate issued under subsection (1), or the endorsement of an anti-fouling certificate under subsection (2), is not a legislative instrument.

11 Lapsing of anti-fouling certificates

(1) An anti-fouling certificate ceases to be in force if the ship ceases to be an Australian ship.

(2) An anti-fouling certificate ceases to be in force if:

(a) since the certificate was issued or last endorsed, any coating or treatment is applied to any designated external surface of the ship; and

(b) after the coating or treatment is applied, the ship is taken to sea without the certificate having been endorsed in respect of the coating or treatment.

12 Cancellation of anti-fouling certificates

(1) The Authority may cancel an anti-fouling certificate that is in force in respect of an Australian ship if the Authority has reason to believe that:

(a) the ship does not comply with the anti-fouling requirements; or

(b) the anti-fouling certificate was issued or endorsed upon false or erroneous information.

(2) The Authority may cancel an anti-fouling certificate under subsection (1) whether or not the certificate was issued by the Authority.

Note: Under section 10, an anti-fouling certificate can be issued by the Authority or by another survey authority.

(3) The cancellation takes effect when the Authority gives notice in writing of the cancellation:

(a) addressed to the master, owner or agent of the ship; and

(b) served in accordance with the regulations.

(4) If an anti-fouling certificate in respect of an Australian ship is cancelled under this section, the Authority may:
  (a) require the certificate to be given to a specified person; and
  (b) detain the ship until the requirement is complied with.

(5) The requirement under paragraph (4)(a) must be:
  (a) made by notice in writing; and
  (b) addressed to the owner, agent or master of the ship; and
  (c) served in accordance with the regulations.

(6) A requirement made by notice under paragraph (5)(a) is not a legislative instrument.

13 Obligation to carry anti-fouling certificate

Ordinary offence: failing to carry anti-fouling certificate

(1) A person commits an offence if:
  (a) on or after 1 January 2008, the person:
    (i) takes an Australian ship to or from a shipping facility on an international voyage; or
    (ii) permits an Australian ship to be taken to or from a shipping facility on an international voyage; and
  (b) the ship has a gross tonnage of 400 or more; and
  (c) the person is the master or owner of the ship; and
  (d) the ship does not have on board a current anti-fouling certificate for the ship; and
  (e) the ship is not an exempt platform.

Penalty: 1,000 penalty units.

Strict liability offence: failing to carry anti-fouling certificate

(2) A person commits an offence if:
  (a) on or after 1 January 2008, an Australian ship with a gross tonnage of 400 or more enters or leaves a shipping facility on an international voyage; and
  (b) the person is the master or owner of the ship; and

(c) the ship does not have on board a current anti-fouling certificate for the ship; and

(d) the ship is not an exempt platform.

Penalty: 400 penalty units.

(3) An offence against subsection (2) is an offence of strict liability.

Note: For strict liability, see section 6.1 of the *Criminal Code*.

No offence if State or Territory law applies

(4) If:

(a) apart from this subsection, particular conduct would constitute an offence against this section; and

(b) the conduct constitutes an offence against a law of a State or Territory;

then the conduct does not constitute an offence against this section.

Note: A defendant bears an evidential burden in relation to the matter in subsection (4): see subsection 13.3(3) of the *Criminal Code*.

14 Obligation to report damage etc. to ship

(1) If:

(a) an Australian ship has a current anti-fouling certificate; and

(b) something happens to the ship that affects, or might affect, its compliance with the anti-fouling requirements; and

(c) notice of the happening is not given in accordance with the regulations within 7 days after the happening;

then the master and owner each commit an offence for each subsequent day that passes without the notice having been given.

Penalty: 100 penalty units.

(2) An offence against subsection (1) is an offence of strict liability.

Note: For strict liability, see section 6.1 of the *Criminal Code*.

No offence if State or Territory law applies

(3) If:

(a) apart from this subsection, particular conduct would constitute an offence against this section; and

(b) the conduct constitutes an offence against a law of a State or Territory;

then the conduct does not constitute an offence against this section.

Note: A defendant bears an evidential burden in relation to the matter in subsection (3): see subsection 13.3(3) of the *Criminal Code*.

15 Obligation to carry anti-fouling declaration

Ordinary offence: failing to carry anti-fouling declaration

(1) A person commits an offence if:

(a) on or after 1 January 2008, the person:

(i) takes an Australian ship to or from a shipping facility on an international voyage; or

(ii) permits an Australian ship to be taken to or from a shipping facility on an international voyage; and

(b) the person is the master or owner of the ship; and

(c) the ship is at least 24 metres in length and has a gross tonnage of less than 400; and

(d) the ship does not have on board an anti-fouling declaration for the ship; and

(e) the ship is not an exempt platform.

Penalty: 1,000 penalty units.

Strict liability offence: failing to carry anti-fouling declaration

(2) A person commits an offence if:

(a) on or after 1 January 2008 an Australian ship enters or leaves a shipping facility on an international voyage; and

(b) the person is the master or owner of the ship; and

(c) the ship is at least 24 metres in length and has a gross tonnage of less than 400; and

(d) the ship does not have on board an anti-fouling declaration for the ship; and

(e) the ship is not an exempt platform.

Penalty: 400 penalty units.

(3) An offence against subsection (2) is an offence of strict liability.

Note: For strict liability, see section 6.1 of the *Criminal Code*.

No offence if State or Territory law applies

(4) If:

(a) apart from this subsection, particular conduct would constitute an offence against this section; and

(b) the conduct constitutes an offence against a law of a State or Territory;

then the conduct does not constitute an offence against this section.

Note: A defendant bears an evidential burden in relation to the matter in subsection (4): see subsection 13.3(3) of the *Criminal Code*.

Definition

(5) In this section:

anti-fouling declaration means a declaration relating to compliance with the anti-fouling requirements, being a declaration in a form prescribed for the purposes of this definition.

Part 4—Inspection and enforcement powers

16 Inspectors and identity cards

(1) Each of the following persons is an ***inspector*** for the purposes of this Act:

(a) a person appointed by the Authority under subsection (2);

(b) a surveyor for the purposes of the *Navigation Act 1912*;

(c) a member, or special member, of the Australian Federal Police.

(2) The Authority may, in writing, appoint appropriately qualified persons as inspectors.

(3) The Authority must issue an identity card to each inspector appointed under subsection (2). The card must incorporate a photograph of the inspector.

(4) A person commits an offence if:

(a) the person has been issued with an identity card; and

(b) the person ceases to be an inspector; and

(c) the person does not immediately return the identity card to the Authority.

Penalty: 1 penalty unit.

(5) Subsection (4) does not apply if the identity card was lost or destroyed.

Note: The defendant bears an evidential burden in relation to the matter in subsection (5): see subsection 13.3(3) of the *Criminal Code*.

(6) A person to whom an identity card has been issued under subsection (3) must carry the card at all times when exercising powers or performing functions as an inspector under this Act.

(7) In this section:

appropriately qualified means having such training or experience as may be prescribed for the purposes of this definition.

17 Inspection of ships

(1) An inspector may exercise the powers under this section in relation to a ship in an Australian shipping facility for the purpose of ascertaining:

(a) whether this Act and the regulations are being complied with in respect of the ship; or

(b) whether the Convention is being complied with in respect of the ship; or

(c) whether a foreign Convention law is being complied with in respect of the ship.

(2) The inspector may do any of the following:

(a) go on board the ship with such assistants and equipment as the inspector considers necessary;

(b) require the master of the ship to take such steps as the inspector directs to facilitate the boarding;

(c) examine, and take samples of, any substances on board the ship or on any designated external surface of the ship;

(d) inspect any part of the ship or its machinery or equipment;

(e) require the master of the ship to take such steps as the inspector directs to facilitate the inspection of any part of the ship or its machinery or equipment;

(f) open, or require the master of the ship to cause to be opened, any hold, compartment or receptacle in or on board the ship and inspect the contents of any hold, compartment or receptacle in or on board the ship;

(g) require the master of the ship to produce:

(i) any certificate, declaration, endorsement or record that is required by this Act or the regulations to be carried on the ship; or

(ii) any other documents, records or books relating to the ship or its cargo that are carried on the ship;

(h) make copies of, or take extracts from, any such documents, records or books;

(i) require the master of the ship to certify that a true copy or extract made by the inspector under paragraph (h) is a true copy of the original;

(j) take photographs (including video recordings) of the ship or of equipment, or anything else, in or on board the ship;

(k) require a person to answer questions.

(3) This section does not authorise an inspector to exercise powers in a manner inconsistent with the Convention.

(4) A person must not fail to comply with a requirement made of the person by an inspector under this section.

Penalty: 80 penalty units.

(5) An offence against subsection (4) is an offence of strict liability.

Note: For strict liability, see section 6.1 of the *Criminal Code*.

18 Detention of ships

(1) The Authority may detain a ship in an Australian shipping facility if the Authority has reasonable grounds for believing that an offence against this Act has been committed in respect of the ship.

(2) The ship must be released immediately if:

(a) security is provided in accordance with subsection (3); or

(b) all proceedings that have been instituted in respect of the offence have been discontinued; or

(c) all such proceedings have been concluded (whether or not any appeal is pending) without any person being convicted of an offence or being found liable to pay an amount of money; or

(d) all such proceedings have been concluded, and all penalties and other amounts of money, and all costs and expenses ordered to be paid, in respect of the offence have been paid; or

(e) the Authority forms the belief that the offence did not occur, or did not occur as a result of actions in relation to the ship; or

(f) the Authority determines for any other reason that the ship should be released.

(3) Security referred to in subsection (2) must:

(a) be provided in a form acceptable to the Authority; and

(b) be an amount that, in the Authority's opinion, is equivalent to the maximum amount of all penalties, other amounts of money, costs and expenses that could be payable by the master and owner of the ship in respect of the offence.

(4) If the ship leaves the shipping facility while it is under detention, then the master and owner each commit an offence.

Penalty: 1,000 penalty units.

(5) An offence against subsection (4) is an offence of strict liability.

Note: For strict liability, see section 6.1 of the *Criminal Code*.

19 Compensation for undue detention or delay

(1) If a ship is unduly detained or delayed under this Act, then the Authority is liable to pay the owner reasonable compensation for any loss or damage suffered by the owner as a result of the undue detention or delay.

(2) If the Authority and the owner are unable to agree on the amount of the compensation, then the owner may institute proceedings in the Federal Court of Australia for such reasonable compensation as the Court determines.

(3) In this section:

unduly detained or delayed has the same meaning as in Article 13 of the Convention.

Part 5—Miscellaneous

20 Service of documents on master or owner of ship

(1) A document to be served on the master or owner of a ship under this Act, or in respect of an offence against this Act, may be served on the agent of the ship instead.

(2) A document served on the agent of a ship under subsection (1) is taken to have been served on the master and owner of the ship.

21 Time limit for prosecution of offences

(1) Subject to subsection (2), a prosecution for an offence against this Act may be brought at any time.

(2) If the prosecution relates to an offence involving a foreign ship:

(a) the prosecution must not be brought more than 3 years after the commission of the offence; and

(b) the prosecution must be suspended if, under paragraph 1 of article 228 of the Law of the Sea Convention, it is required to be suspended; and

(c) the prosecution must be terminated if, under paragraph 1 of article 228 of the Law of the Sea Convention, it is required to be terminated.

(3) In this section:

Law of the Sea Convention means the United Nations Convention on the Law of the Sea, done at Montego Bay on 10 December 1982.

Note: The text of the Convention is set out in Australian Treaty Series 1994 No. 31. In 2006, the text of a Convention in the Australian Treaty Series was accessible through the Australian Treaties Library on the AustLII Internet site (www.austlii.edu.au).

22 Evidence of terms of the Convention

(1) The Minister may issue a certificate stating that a document set out in, or annexed to, the certificate sets out the terms of the Convention.

(2) Such a certificate is prima facie evidence of the matters so certified.

23 Evidence of analyst

Authority may appoint analysts

(1) The Authority may, in writing, appoint appropriately qualified persons to be analysts for the purposes of this Act.

Analyst may issue certificate

(2) An analyst appointed under subsection (1) may issue a certificate setting out, in relation to a substance, one or more of the following:
- (a) when and from whom the substance was received by the analyst;
- (b) what labels or other means of identifying the substance accompanied it when it was received by the analyst;
- (c) what container the substance was in when it was received by the analyst;
- (d) a description of the substance received by the analyst;
- (e) that he or she has analysed or examined the substance;
- (f) the date on which the analysis or examination was carried out;
- (g) the method used in conducting the analysis or examination;
- (h) the results of the analysis or examination.

Certificate admissible in proceedings for offence

(3) The certificate is admissible in any proceeding for an offence against this Act as prima facie evidence of:
- (a) the matters in the certificate; and
- (b) the correctness of the results of the analysis or examination.

Restriction on admissibility of certificate

(4) A certificate must not be admitted in evidence under subsection (3) in proceedings for an offence unless:

(a) the person charged with the offence; or

(b) a barrister or solicitor who has appeared for the person in those proceedings;

has, at least 14 days before the certificate is sought to be so admitted, been given a copy of the certificate together with reasonable notice of the intention to produce the certificate as evidence in the proceedings.

Document taken to be a certificate unless contrary established

(5) A document purporting to be a certificate referred to in subsection (2) is taken to be such a certificate and to have been duly given unless the contrary is established.

Analyst may be called to give evidence

(6) If the certificate is admitted in evidence, the person charged may require the analyst to be called as a witness for the prosecution and the analyst may be cross-examined as if he or she had given evidence of the matters stated in the certificate.

(7) Subsection (6) does not entitle a person to require an analyst to be called as a witness for the prosecution unless:

(a) the prosecutor has been given at least 5 days notice of the person's intention to require the analyst to be so called; or

(b) the court, by order, allows the person to require the analyst to be so called.

Evidence in support, or rebuttal, of matter in certificate to be considered on its merits

(8) Any evidence given in support, or in rebuttal, of a matter stated in a certificate issued under subsection (2) must be considered on its merits. The credibility and probative value of the evidence is neither increased nor diminished because of this section.

24 Orders

The Authority may, by legislative instrument, make orders on any matter on which regulations may be made. However, orders cannot impose penalties for contraventions of the orders.

25 Regulations

The Governor-General may make regulations prescribing matters:

(a) required or permitted by this Act to be prescribed; or

(b) necessary or convenient to be prescribed for carrying out or giving effect to this Act;

and, in particular:

(c) for and in relation to giving effect to the Convention, other than provisions of the Convention to which effect is given by a provision of this Act; and

(d) prescribing penalties not exceeding 30 penalty units for a contravention of the regulations.

Note: The regulations can prescribe penalties for contraventions of the orders: see the definition of ***regulations*** in section 3.

[*Minister's second reading speech made in—*
House of Representatives on 22 June 2006
Senate on 7 September 2006]

(97/06)

14

The effects of Dry-dock Treatment and coating selection on hull efficiency

THE EFFECTS OF DRYDOCK TREATMENT AND COATING SELECTION ON HULL EFFICIENCY

A PRESENTATION DELIVERED BY PROPULSION DYNAMICS INC.
AT
THE SHIPBUILDING MACHINERY AND MARINE TECHNOLOGY CONFERENCE

Hamburg September 28th, 2006

The Effect of Drydock Treatment and Coating Selection on Hull Efficiency

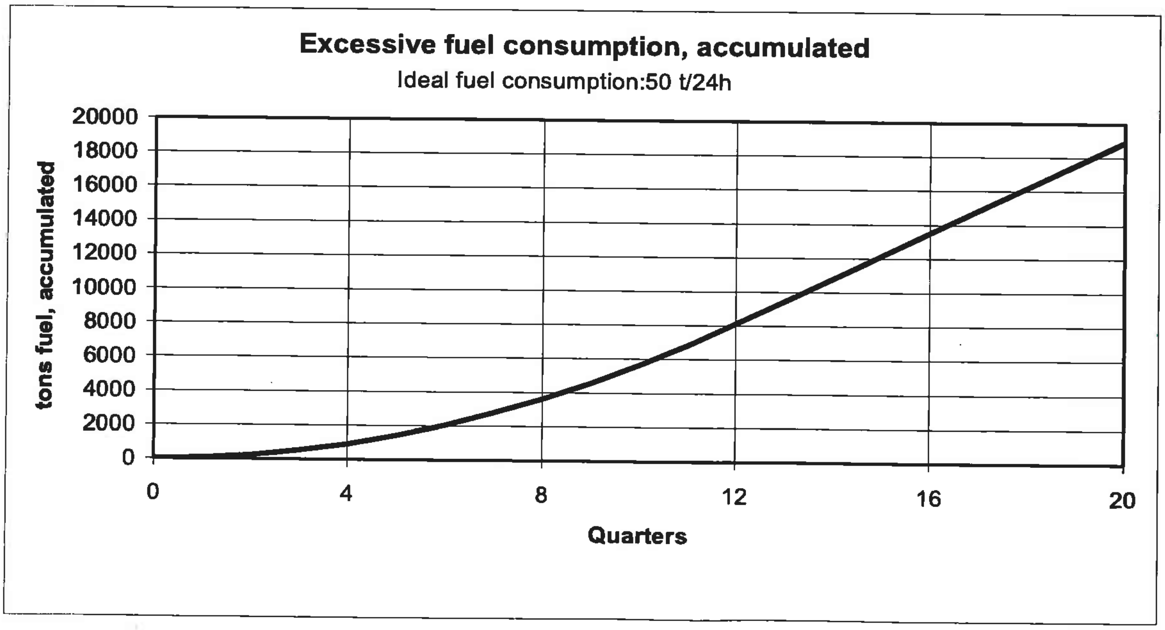
Shipbuilding Machinery and Marine Technology, Hamburg September 28th, 2006

By:Torben Munk, M.Sc., Propulsion Dynamics Inc. (PDI)

Abstract
In this presentation, we will show the results of CASPER® (Computerized Analysis of Ship PERformance) analyses over a 3-year period, for quantifying the added resistance (of the hull and propeller due to fouling) for ships in operation. Reliable before-and-after results of drydock treatment and comparing the development of fouling for different ships will be illustrated.
In addition, cost-benefit of maintenance intervals will be mentioned.

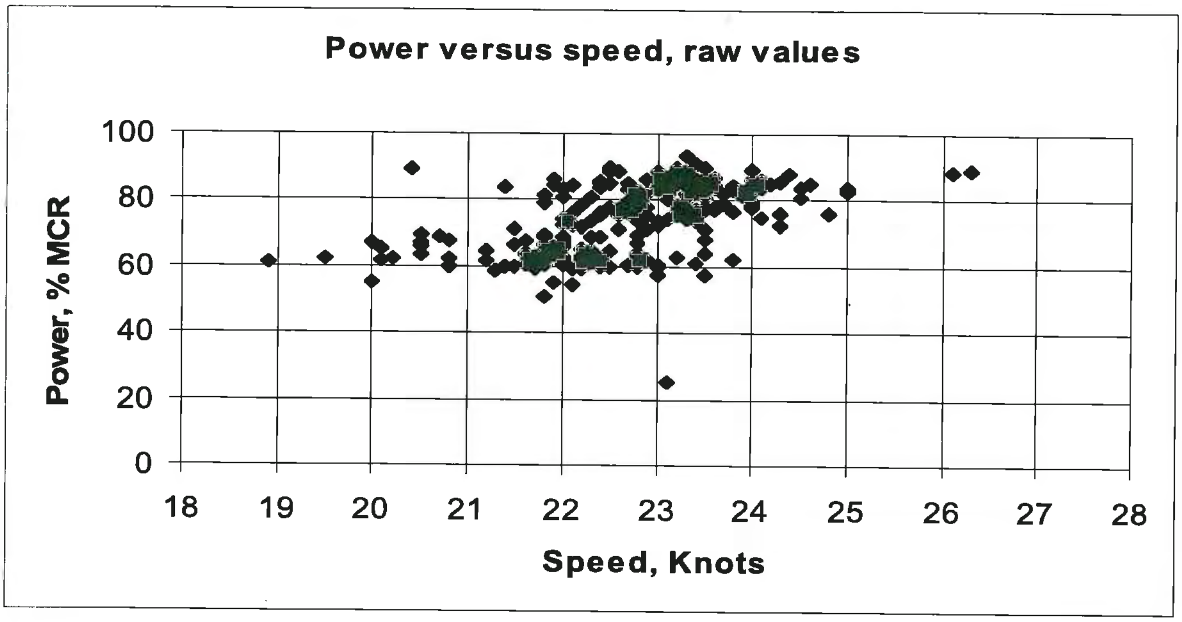
Degradation of ship performance
The main reason for performance degradation is marine growth on the ship's hull. This subject is treated thoroughly in the technical literature, for instance in an excellent way in Ref. 1. Here it shall only be mentioned that ship owners are allocating a lot of time and money to mitigate the degradation. The main remedies are various types of coatings applied to the underwater part of the hull at regular intervals, and in some cases, in-water brushing of the hull and polishing of the propeller. Altogether, the total costs of all ship owners' anti-fouling precautions are of the order of 1.5 billion USD per year or approximately 5% of the total marine fuel oil costs. Unfortunately, it is difficult to determine if this money is invested in the optimum way. There are many different types of hull treatments, and the price for the coatings varies greatly. In addition, each shipowner has his own way of handling coating selection and maintenance. Furthermore, it is difficult to evaluate and compare the effect of the different hull treatments, unless more precise methods of analysis are available.

Figure 1 (below) shows an example of the effect that the development of hull and propeller resistance has on fuel consumption for a typical ten year old Aframax tanker. This curve assumes a maintained service speed with no hull or propeller cleanings during the five-year period. In reality, most ship operators will not see see an increase in fuel consumption of this magnitude, but will see a speed loss that corresponds to this increase in fuel consumption as time goes on. See Figure 8 and Figure 13 for speed losses that correspond to increases in fuel consumption due to different stages of fouling.



Background on performance monitoring

Figure 2. Most ship operators have established a procedure for speed/power monitoring, for instance by measuring the daily fuel consumption and the daily distance covered. In this way, the daily mean power and mean speed may be calculated, and the result may be plotted in the speed/power diagram for comparison with the trial trip results. Unfortunately, results achieved in this way usually scatter so much that it is impossible to conclude anything directly from such a diagram, as it may be seen from the following plot for a well-maintained container ship. It will be shown that correction of performance variables will result in a practical tool for Conditon-Based Drydocking and quantifying long term development of hull and propeller resistance.



Underwater inspections of the hull as a supplement to speed and power measurements are of course useful; however, they do not provide a meaningful metric between surface roughness and impact on vessel performance. For more information on the biological aspects of hull coatings, see Ref. 2.

Factors influencing the speed/power monitoring

There are many reasons why the directly obtained speed/power values are scattered as in the above illustration. The main factors, which need to be taken into account, are:

1. Drafts. Mean draft and trim has a great influence on the ship resistance. It is reasonably easy to adjust the results for differences in mean draft, but differences in trim are more difficult to deal with, especially when most ships today are equipped with a bulbous bow.
2. Weather. Wind and waves can seldom be totally ignored; therefore, the results will need to be corrected accordingly. It is not that difficult to measure and make corrections for the wind, but waves can neither be measured nor be easily corrected for.
3. Sea current. Today the speed over ground may be measured with great accuracy by means of the DGPS; however, this speed will not be the true speed due to the presence of sea current. The true speed, the speed through the water, is more difficult to deal with. The problem is that most speed logging devices are measuring the speed through water too close to the ship, so that the ship's boundary layer influences the result. Normally, it will not be possible to correct the speed for sea current, unless a reciprocal run is performed, and this is usually regarded as too time consuming to be done during commercial operation.
4. Temperature and salinity. These two factors do have some influence on the result, but they are seldom taken into account.
5. Frictional resistance and wave-making resistance. Even if reliable speed/ power values, corrected for all the above-mentioned factors are obtained and plotted in the speed trial speed/power diagram it may be difficult to accurately describe the degradation of the performance. The reason is that the ship's resistance may be roughly divided into frictional resistance and wave-making resistance. The fouling only influences the frictional resistance, and as the frictional resistance fraction of the total resistance depends on the speed and the draft, the additional power

demand, expressed as percentage of the total power requirement, will not be the same for different loading conditions and different speeds.

6. Degradation due to wear and tear of engine, bearings and propeller shaft.
The specific fuel consumption of a well-maintained 2-stroke main engine will normally not change much during the lifetime. A possible engine degradation will not show itself in the same way as a hull degradation, but in a number of other ways; for example as a high residual resistance and a high exhaust temperature.

7. Potential damage of the hull and / propeller. In the unlikely event that there is damage to the hull or propeller, these can usually be identified since the wake fraction coefficients are not influenced by damage to the hull or propeller, whereas, the wake fraction coefficient is directly influenced by hull and propeller resistance.

Proposed measure for performance degradation

The effect of hull resistance on propulsion performance is complicated and difficult to describe in an unambiguous way. The primary effect is that more water is dragged forward along with the ship, and this will of course increase the ship resistance. The increased forward velocity of the water in the ship's boundary layer will also cause the inflow velocity to the propeller to be reduced. This has several effects. On one hand the efficiency of the propeller will decrease, on the other hand some of the power lost in the boundary layer will be re-gained. Altogether, the required power will increase, however, not quite as much as the resistance. Since it is not possible to state a fixed relation between added resistance and added power, for simplicity it is proposed to use the added resistance as a measure for degradation and not the added power.

Even a description of the hull degradation in the form of the added resistance as a percentage of the total resistance is ambiguous, unless it is specifically designated, for which speed and which loading condition this percentage is valid. It is therefore further proposed to refer the added resistance to "the design speed and the design draft." This is not a precise reference, but it works in practice and is quite useful, not only for evaluation of the condition of a single ship, but also for comparison of several ships, which not need to be of the same shape and size. The implication here is that different drydock treatments and fouling factors may be compared, even if they are applied to ships of different size or hull form.

It should be kept in mind that the added resistance as defined here is *not* equal to the actual increase of power. Even at "design speed and draft" the increase of power will normally be a few per cent lower than the "added resistance". At deep draft and low speed the power increase will be more than the "added resistance", and in ballast condition at full speed it may be less than half of the "added resistance". It is however always possible to calculate the actual power increase for any draft/speed from the found "added resistance".

Analysis of performance data

One way of processing the performance data is to compare the observed power and RPM values to those, which are found for similar weather and loading conditions from a mathematical model of the ship's propulsion performance. It can then be determined, at which speed through the water and with which added resistance the calculated values matches the measured values, and both speed through water and added resistance are then determined.

This method requires that such a mathematical model is available or can be established, however, this is not as easy as it sounds. There are complicated, theoretical methods for the calculation of resistance, propulsion system performance, weather resistance, and influence of hull roughness for a specific ship, but in practice a simple and robust general mathematical model, which can easily be adapted to any ship, is needed. Such a model may be established by means of a combination of theoretical considerations and approximation formulas with empirical constants. For more information on analysis of performance data, see Ref. 3.

CASPER®, a Hull Efficiency Analysis

CASPER® Computer Analysis of Ship PERformance is based on a general mathematic model; build up by well-known, state-of the art elements for the calculation of ship resistance, propeller performance, weather resistance, etc. The general model, based on the type and main dimensions of ship and propeller, may stand alone and may be used directly for comparison to actual performance data, but a more reliable model can easily be established by an adjustment of the general model, considering tank test/trial data. Even this model will not normally reflect all changes in the operational conditions, and the model is therefore not used for performance evaluation until it has been adjusted further by means of a statistical analysis of a number of performance observations.

Based on the speed trials at the delivery of the ship, CASPER establishes a mathematical performance model, covering all speeds and drafts. The mathematical model contains modules for calculation of ship resistance as a function of ship type, main dimensions, draft, trim, and speed. It also contains modules for calculation of propeller power and thrust as a function of diameter, number of blades, area ratio, and pitch ratio. Further, it contains modules for calculation of wind and wave resistance as a function of wind speed and direction and wave height and direction. Finally and most importantly are modules for calculation of the effects of marine growth and roughness (resistance) caused by corrosion and coating defects. The investigation for a certain ship should generally show that the mean value of the residual resistance and the sea current is close to 0, and that the found added resistance is independent of draft, speed and weather conditions.

Whatever the actual speed, draft and weather is, CASPER compares the actual performance to the performance under "new-building sea trial" conditions as found from sea trial data and ship particulars inputted into the mathematical model. From this comparison, the added resistance caused by hull and propeller resistance (marine fouling) are found. *This added resistance (in percent of the total resistance, design draft, and speed) describes the condition of hull and propeller and may be used to predict the speed/fuel consumption for any draft, speed, and weather condition.*

Added Resistance

In the following, a number of diagrams are shown in order to illustrate the described method and utilization of the analysis in ship operations. The individual analysis results are shown, and a 1st order curve (a straight line) is faired through the points in order to show the general development for most ships. It is not possible at this point to mathematically distinguish propeller friction from hull resistance, however, once a hull is cleaned or a propeller is polished, the changes in added resistance can be clearly seen. Later, it will be shown how the added resistance (hull+propeller) translate into precise figures for vessel performance.

Figure 3. This tanker (below) sailed on its maiden voyage after sitting in port for 4 weeks. Note the added resistance as calculated from initial performance observations indicate that only a few weeks in port increased the resistance up to approximately 9%. The self-polishing effects for this SPC coating are seen as the vessel sailed over the first 200 days, (by applying a 2nd degree curve) then the added resistance began to increase as shown in Figure 4.

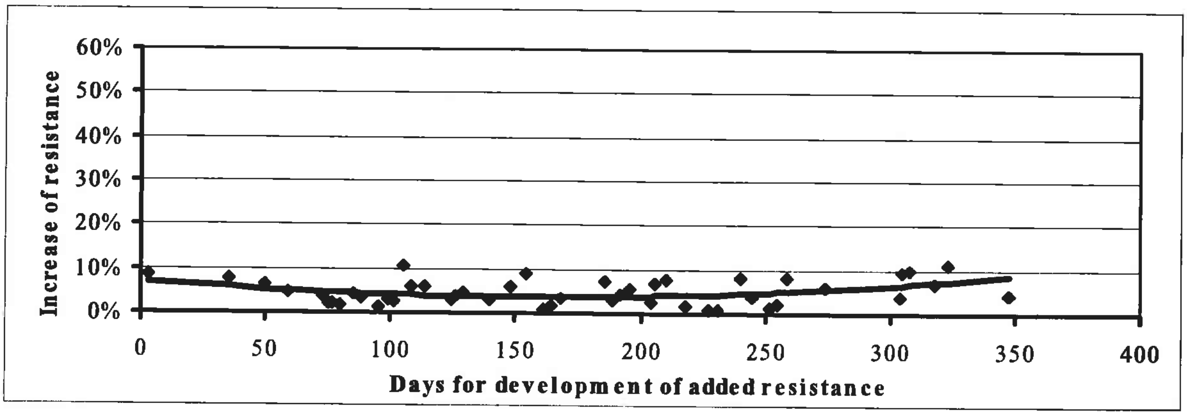


Figure 4. Same tanker from Figure 2, (below) now after two years in service. Performance data has been linearized to reflect the gradual development of resistance, in comparison to maiden voyage.

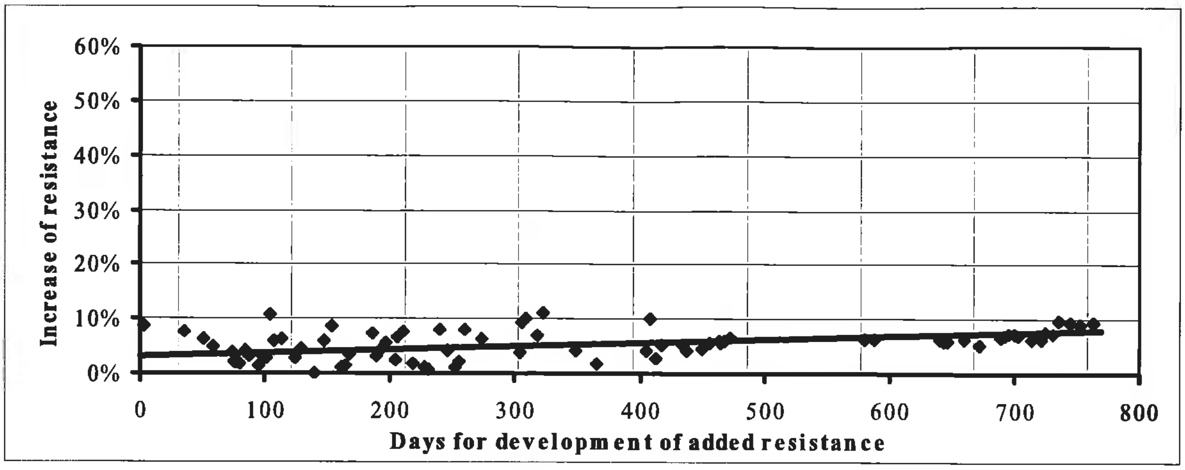


Figure 5. For this cement bulker (below), the shipmanager decided to proceed with a full sandblast of the hull in drydock, due to heavy attachment of raw cement to the hull during loading/unloading. The results for this 20 year old bulker were remarkable. Note that the added resistance at out-docking was zero and that the development of resistance is very low, less than 0.5% per month.

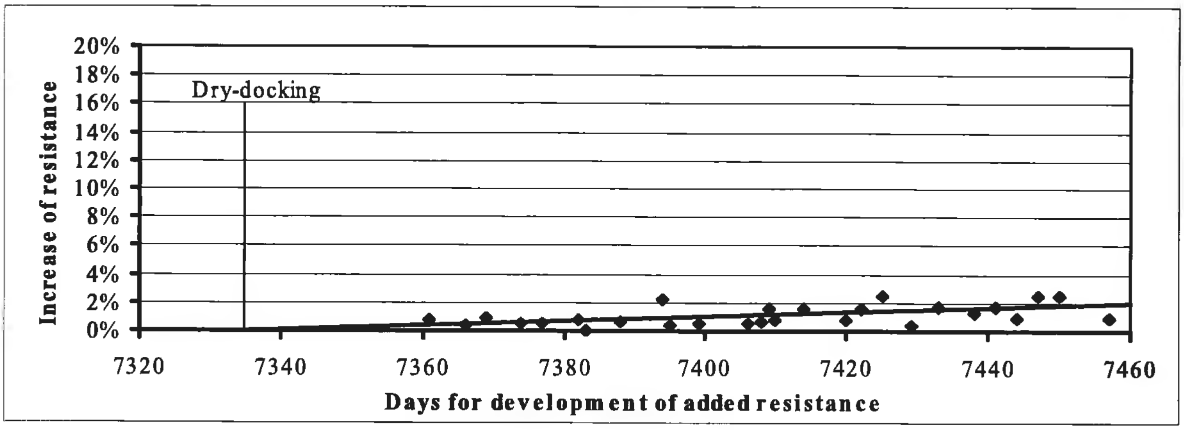


Figure 6. Typical example (below) of development of added resistance for a tanker, before and after drydock. It is seen that at indocking (day 2080) the added resistance was 37% and at outdocking the added resistance was reduced to 12%. The added resistance in this case, develops very slowly, less than 0.5% per month. This tanker received only partial spot blasting in drydock.

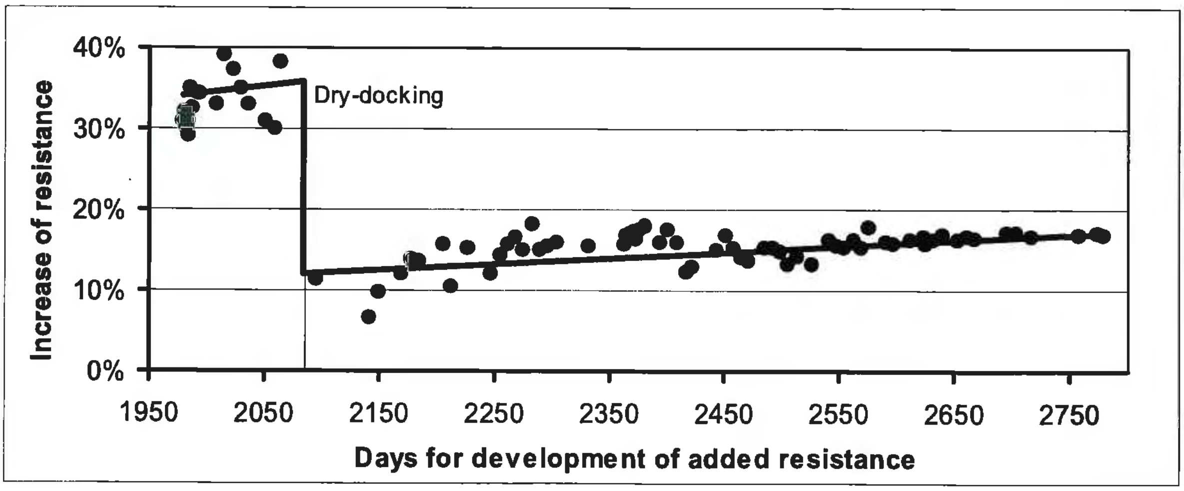
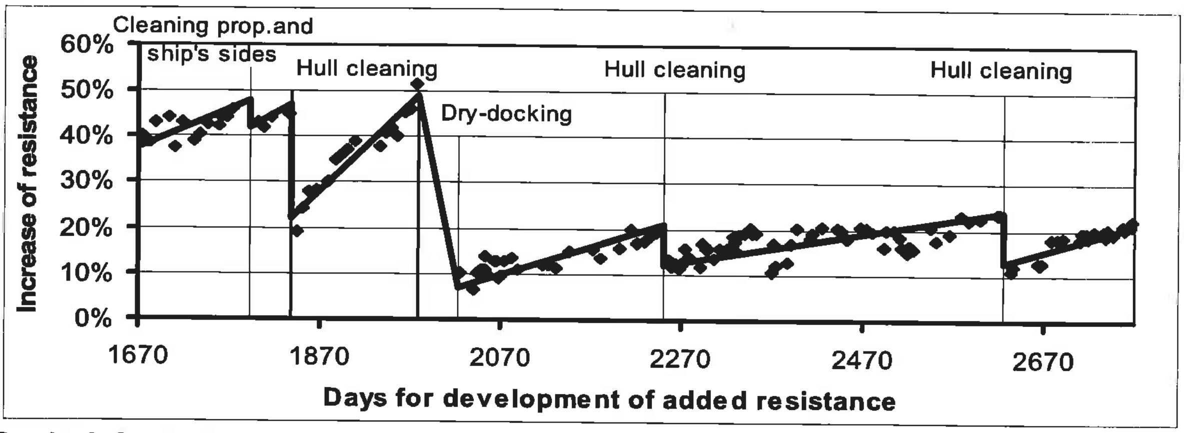


Figure 7. This tanker (below) had initially a high added resistance (day 1670), approximately 39% after four years in service. When this was discovered, the propeller was polished and the ship's sides were brushed. It is seen that the effect of this was marginal.

The Operator was advised to have the ship dry-docked, but as this was inconvenient at that time he decided to conduct a full cleaning the sides *and bottom* of the hull thoroughly a few weeks late when the resistance reached 48%. The result of this brushing was significant, however, as the anti-fouling was apparently depleted, the result did not last long, (the development of resistance was over 5% per month after the full cleaning of sides and bottom) and the ship was dry-docked on schedule (added resistance was 50% at indocking). Subsequent to the dry-docking, the hull was cleaned, as soon as the added resistance exceeded 20% and the slope of the line after hull cleanings has not changed substantially. From this example, it is also seen that the quality of the hull cleaning on day 1820 was inadequate.



Drydock Analysis

Figure 8. In the below graph, there are 3 curves drawn for the same tanker (design draft with a 5% weather margin for each curve) as shown in Figure 7. The green line represents sea trial performance. The red line represents performance near her first drydock, where the added resistance of the hull and propeller was nearly 50%. The blue line represents the improved performance (compared to before drydock) immediately after drydock (day 2050). The added resistance after drydock was 9%.

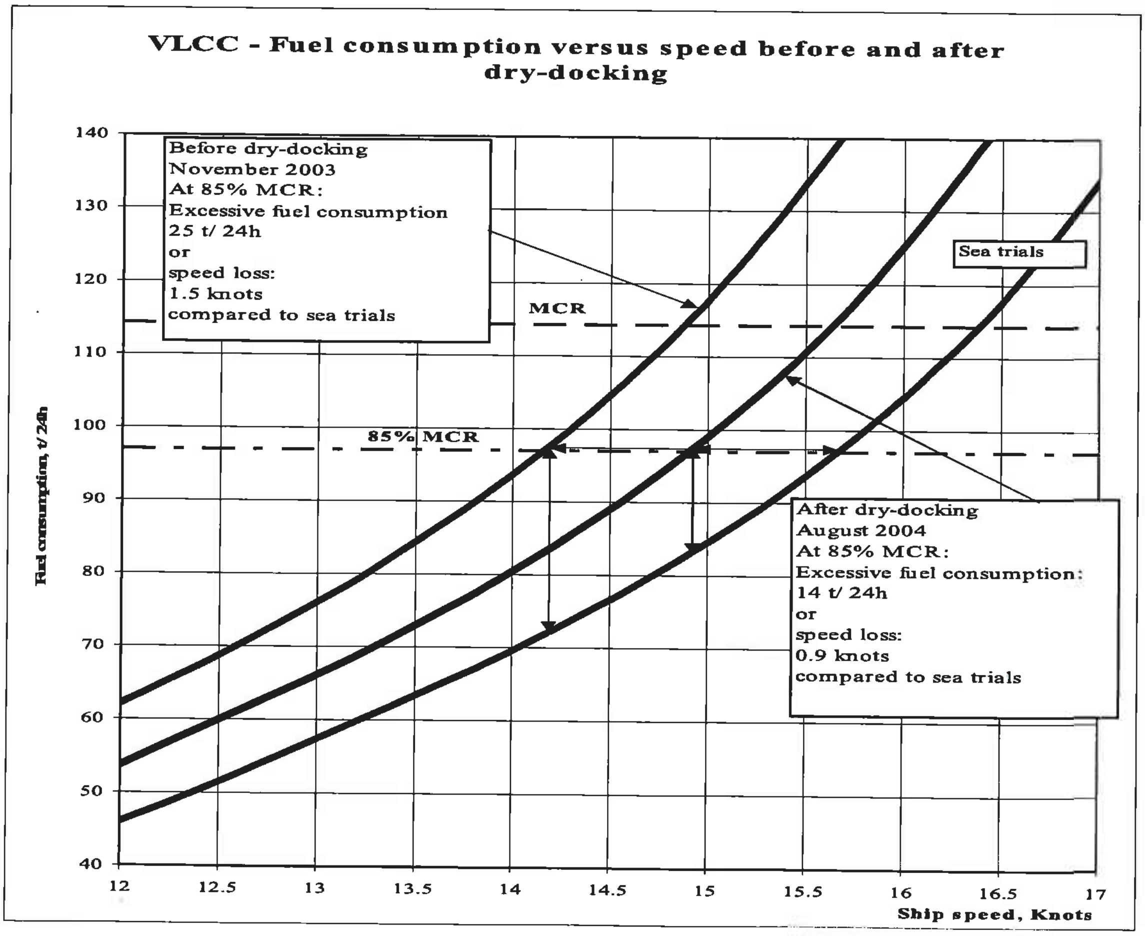
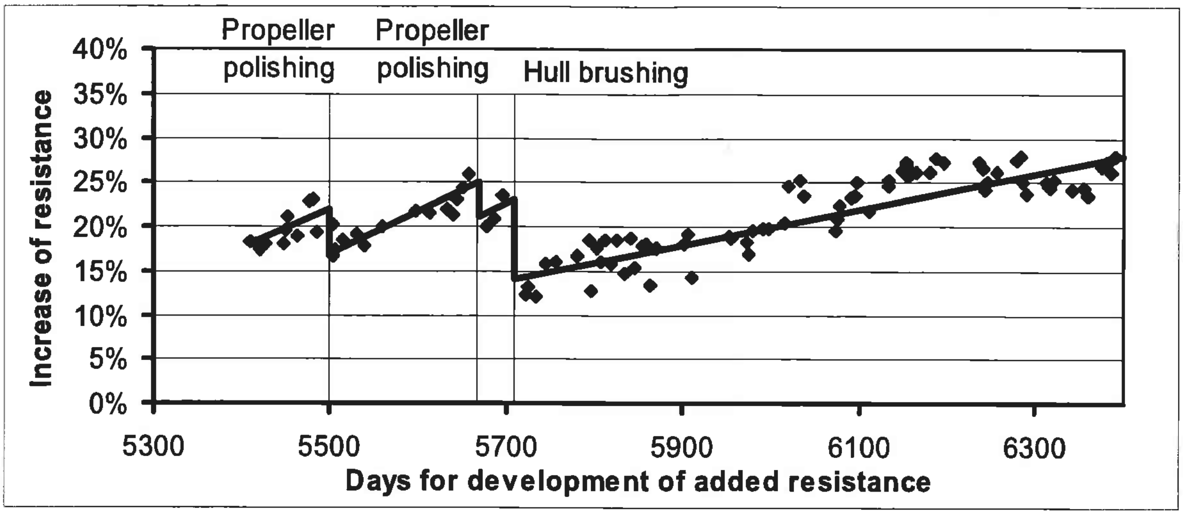


Figure 9. The added resistance for this containership (below) upon initial analysis of performance data was 18% (less than one year out of dock). The development of resistance of the hull+propeller was slightly over 1% per month. Note that the slope of the line remained nearly the same after the hull cleaning, indicating that the cleaning did not damage the integrity of the hull coating.



The practicality of utilizing the added resistance as a metric for establishing the propulsion condition is that it can always be translated into a speed and consumption curve as in the proceeding two diagrams (Figures 10 and 11).

Figure 10. Before-and-after effect of the first propeller polishing as shown at Day 5500 for the containership in Figure 8. At 24 knots, the propeller polishing saved approximately 8 tons of bunker fuel per 24 hours per day. Conversely at a maintained consumption of 180 tons per day, the speed gain resulting from the propeller polish was approximately 0.3 knots.

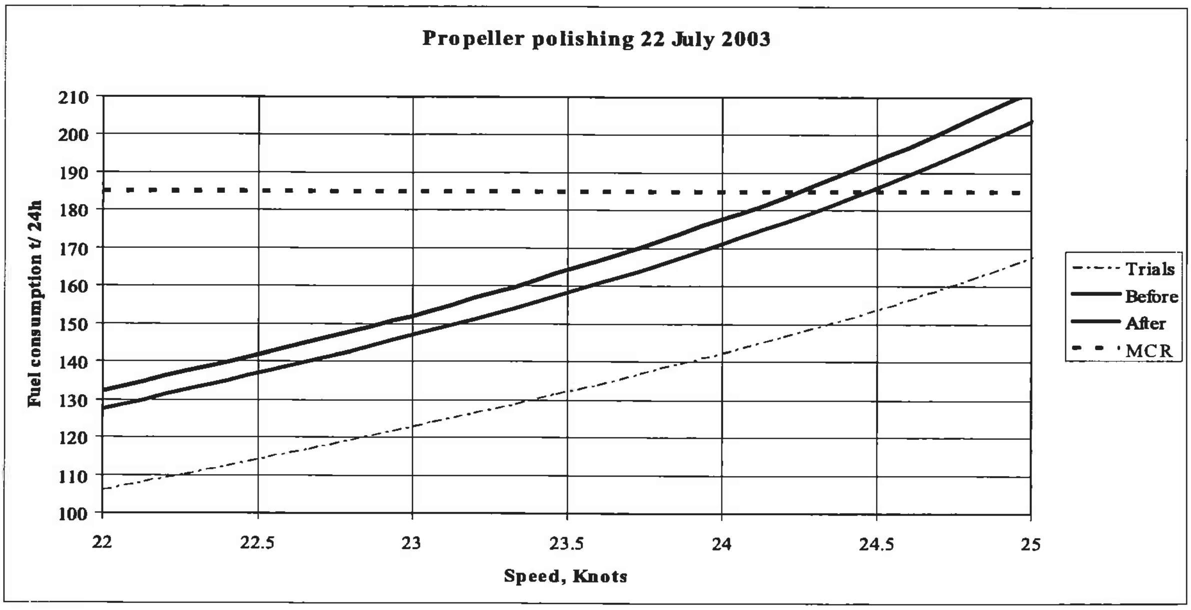


Figure 11. Before-and-after effect of the hull cleaning as shown at Day 5710 for the same containership in Figure 8. At 24 knots, the vessel saved 11 tons of bunker fuel per 24 hours. Conversely, the speed gain resulting from the hull cleaning at a maintained fuel consumption of 180 tons per day consumption is 0.45 knots.

Figure 11.

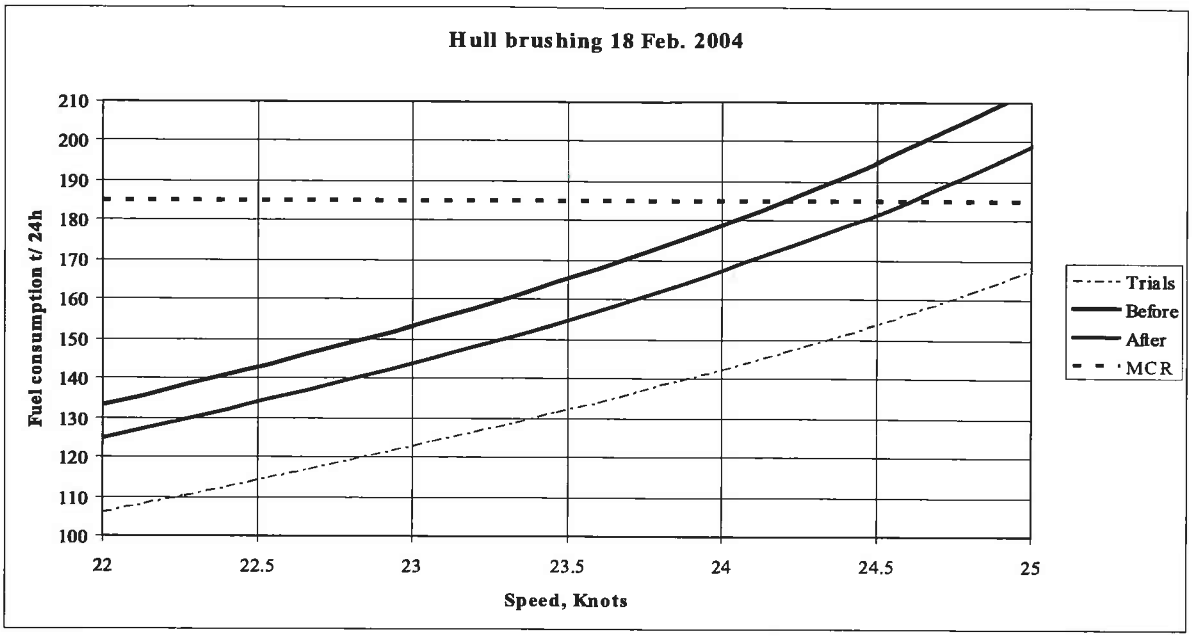
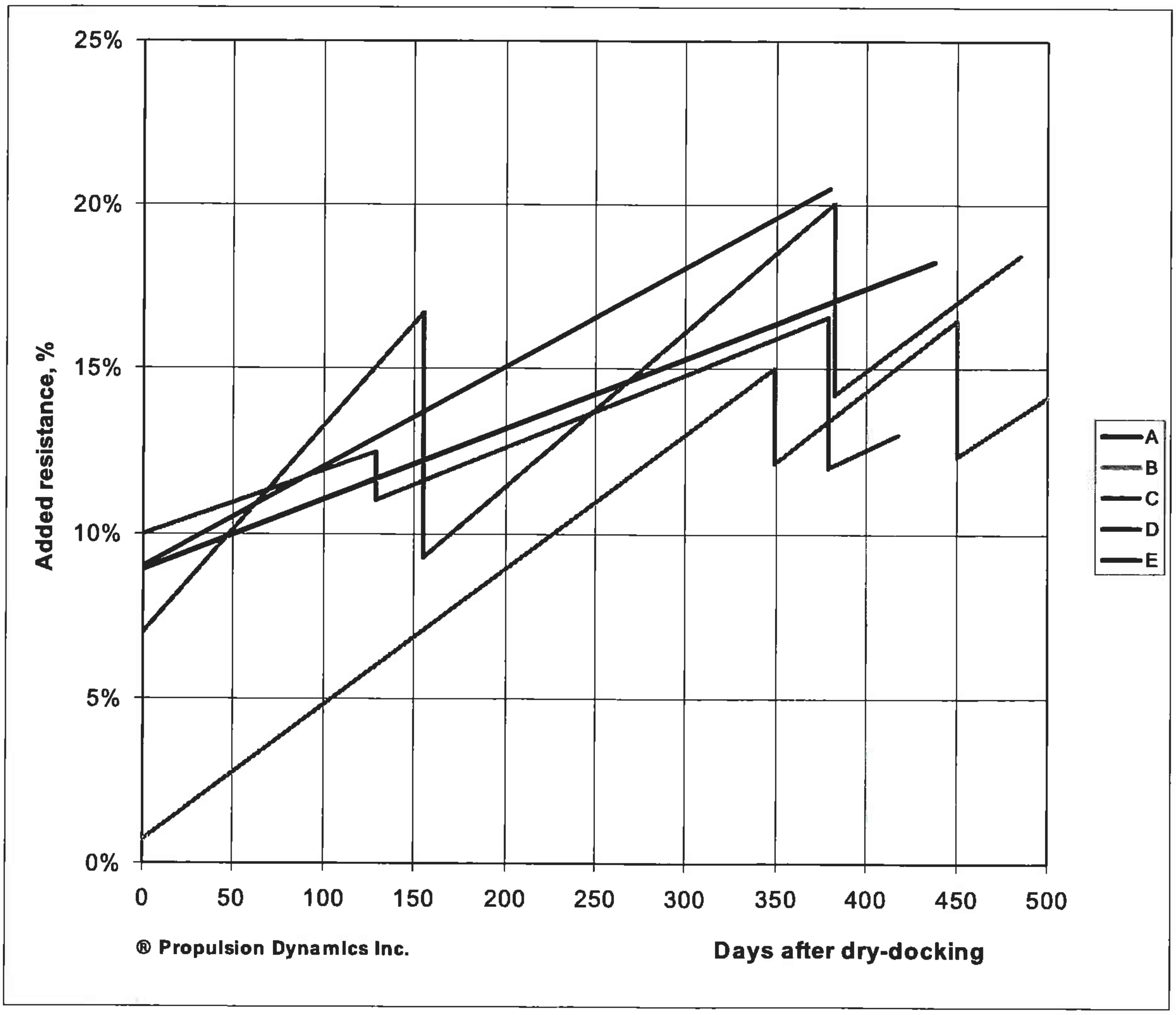


Figure 12. This fleet (below) of five sister containerships were drydocked within the last two years with various hull treatments and coatings applied. The baseline 'added resistance' for each has been calculated and plotted as shown, along with the development of resistance and changes in resistance for three of the ships due to propeller polishing are shown .



In the above graph, Ships B, C, D exhibit decreases in the added resistance, resulting from propeller polishing. All five ships were originally built in a one year time frame and operate in similar service patterns and were drydocked in the same shipyard, thus extraneous variables in the above benchmarking were minimal.

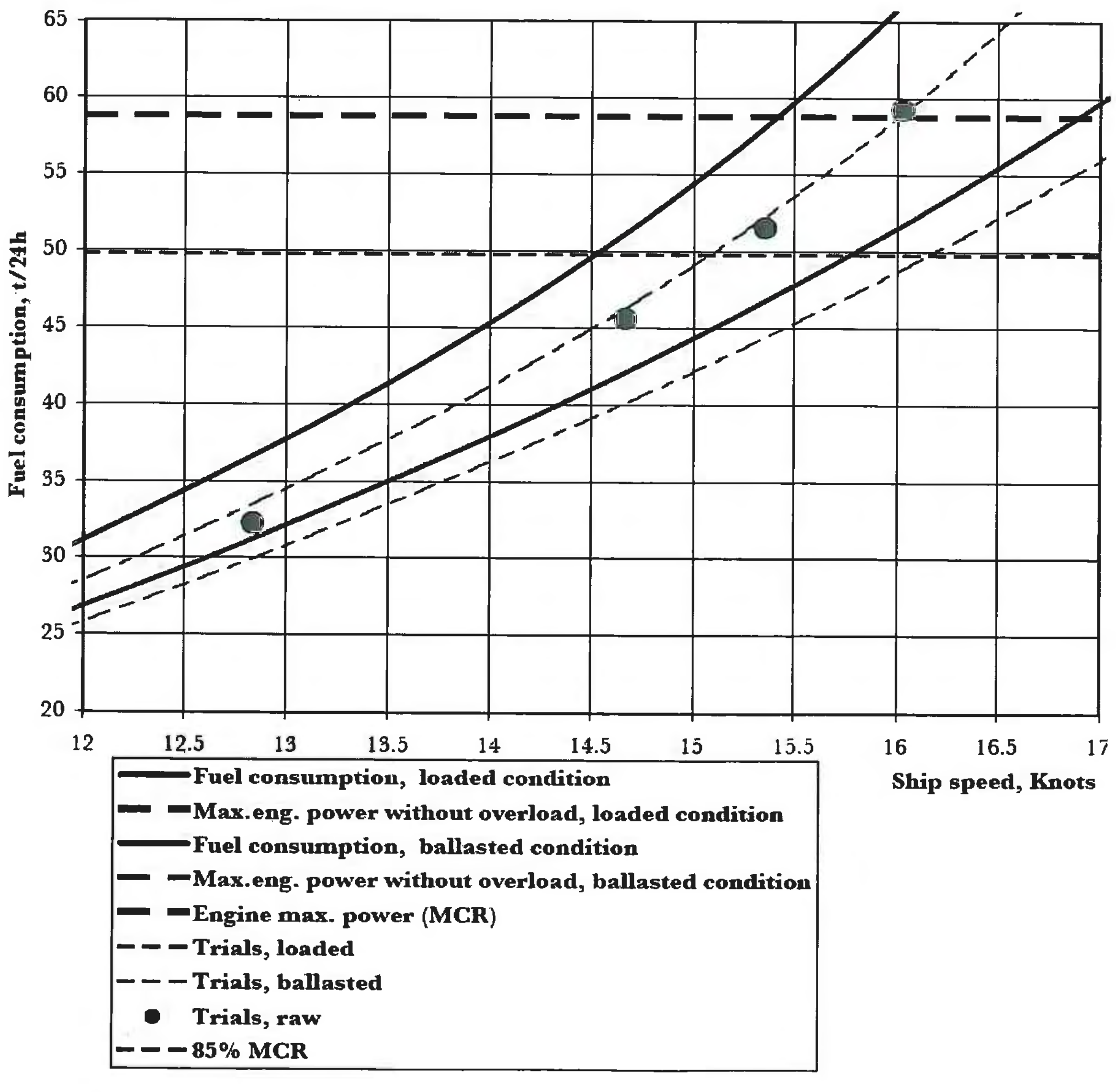
The added resistance equates the following performance losses, for full draft at design speed, in comparison to sea trials:

10% added resistance = 8% increase in fuel consumption at a maintained speed
= 3% decrease in speed at same fuel consumption

15% added resistance = 11% increase in fuel consumption at a maintained speed
= 4% decrease in speed at same fuel consumption

20% added resistance = 15.5% increase in fuel consumption at a maintained speed
= 4.5% decrease in speed at same fuel consumption

Validation of Sea Trials and plotting the 'Actual Obtainable Speed / Consumption Curve'.
Figure 13. Again, the practicality of utilizing the added resistance is that it can always be translated into a speed and consumption curve as in the below figure. The bold curves represent the actual obtainable speed / consumption given the present state of fouling. The red dots represent raw sea trial data and the dashed curves represent adjusted sea trial curves. For this ship, the added resistance was 9% at the time the curve was calculated.



Lessons learned

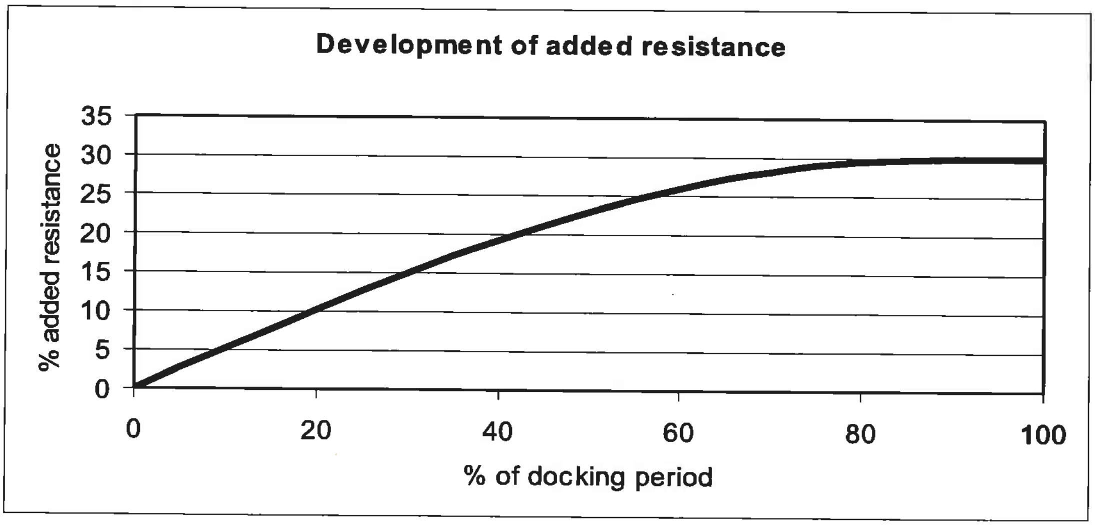
Since this technology has been utilized for more than 10 years, and on more than 100 ships (prior to commercialization as CASPER® in 2002) it is possible to draw some general conclusions from the results.

1) Many factors contribute to variations in added resistance (of the hull and propeller), even if identical hull forms in similar service patterns.

a. Efficiency of treatment in drydock.
b. Contaminated ports and rivers may add to the resistance.
c. Water temperature, fouling increases in warmer waters and decreases in colder water.
d. Change of loading condition and duration. A period of navigation in ballast condition will decrease the added resistance due to "wave washing" of the upper part of the hull.
e. Speed. A period with low speed will increase the resistance, and vice versa.
f. Navigational pattern. Going from one geographical area to another may influence the marine
growth and thus the resistance.
g. Frequency and intensity of hull cleanings and propeller polishing.
h. Type of hull treatment. Some types of coating are more prone to dependence on the above mentioned conditions than others.

2. The added resistance (due to fouling of the hull and propeller) varies from around 6% and up to 80% in the worst cases. *In average, the added resistance for a ship is approximately 30%, if no special attention has been paid to the ship.*
a.) Roughly, one third of all ships are in a good condition with added resistance less than 20%;
b.) Half of the rest of the ships are in a reasonable condition, but in a condition, which easily could be improved, with an added resistance between 20% and 40%, but exhibit no unusual fouling pattern. For these ships, improvement in performance can be achieved by some standard maintenance procedures without interfering with the normal course of operations;
c.) The remainder of the world fleet (over 10,000 dwt) is in poor condition, where the added resistance is over 40%.

3. Figure 14. The development of the added resistance (hull+propeller) normally follows a curve as shown below and corresponds to the increase in fuel consumption as shown in Figure 1 (assuming no hull or propeller cleanings).



The increase will normally be between 0.5% and 2% per month in the beginning of a dry-docking period. For some cases, 5% - 6% per month for a limited duration have been seen as in Figure 6 Day 1850 to Day 2050. Later in the period, when the added resistance has reached a certain level, the development may be more restricted. *The overall value for the added resistance and slope of the lines for development of resistance are a good business tool for predicting condition-based cleanings and drydocking as well.*

4. The basic hull treatment in the drydock has a pronounced influence on the added resistance after the dry-docking. In the best cases, the base-line added resistance will only be 0 % to 4 %, as in Figures 2, 3 and 4. A partial treatment in drydock has been seen to result in an added resistance of 5% - 20%, as was the case for most ships in which only minimal treatment in drydock was prescribed as in Figures 5, 6 and the most recent drydock in Figure 7. In the worst cases there may be no effect at all from the dry-docking.

5. The type of coating has a pronounced influence on the development of the added resistance. It is not only a question of type of coating, it is also important that the coating is applied in correct thickness, and that the dissolution speed or, for self-polishing paint the polishing speed, is carefully adjusted to the service speed and operational patterns of the ship. See Figure 7 where the development of hull resistance after Day 1670 is very rapid, indicative of an inadequate amount of paint (or incorrect polishing speed) applied in the newbuild phase.

6. Hull brushing between dry-dockings may have a remarkable effect, especially if one of the less active types of antifoulants has been used as shown in Figure 6 and 8. Hull brushing may to a certain degree compensate for low efficiency of the antifoulant. It is advisable to clean the hull *before* the slimy layer of bacteria and algae has turned into a layer of seaweed. In that case, very soft brushes (for example - softer than the bristles of a toothbrush) can be used, and the anti fouling paint will not be damaged. This stage corresponds to approximately 12% of resistance added to the resistance after dry-docking as in Figure 11 in which only one ship exhibits visible fouling that divers would recommend cleaning. At a later stage, harder brushes are required, and though they easily can remove the growth they will most probably remove some of the anti fouling paint, and this may result in an increased development of the added resistance after the brushing.

Conclusions

A ships' added resistance in the design condition is a sound metric for quantifying the condition of the hull and propeller as well as a cost-benefit tool for drydock treatment, coating selection and maintenance activities.

Although the benefits of using the added resistance and corresponding performance curves are readily seen, there are several opportunities for continued study:

- Benchmark the efficiency and true life cycle cost (Total Cost of Ownership) of various coating systems by comparing ships with different coating systems applied to the hull and/or propeller;

- Validate the effectiveness of cleaning methods developed for silicon coatings;

- Validate the effectiveness of hull treatement processes in drydock;

- Correlate Average Hull Roughness measurements to added resistance measurements.

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The world's merchant fleet

THE WORLDS MERCHANT FLEET

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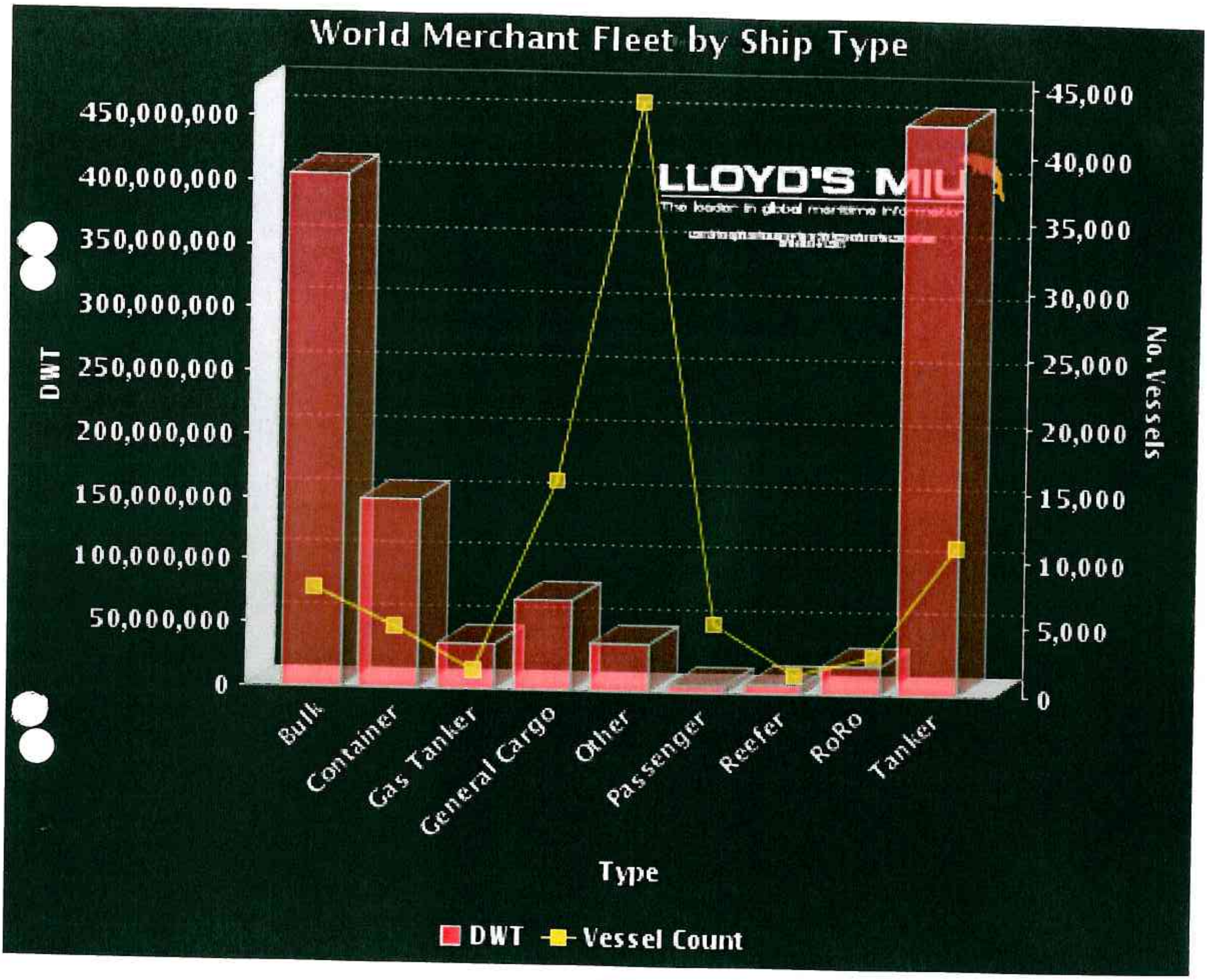

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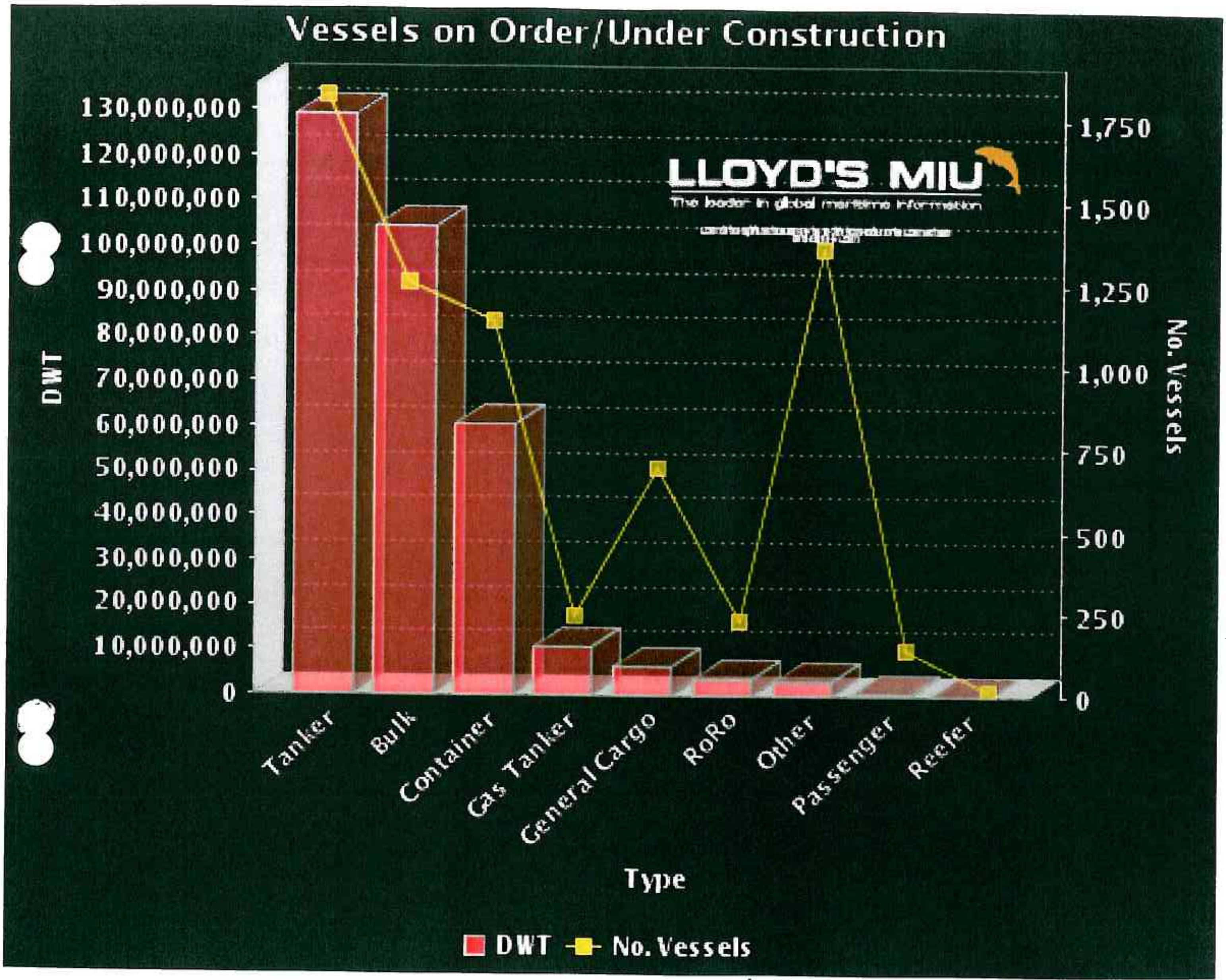

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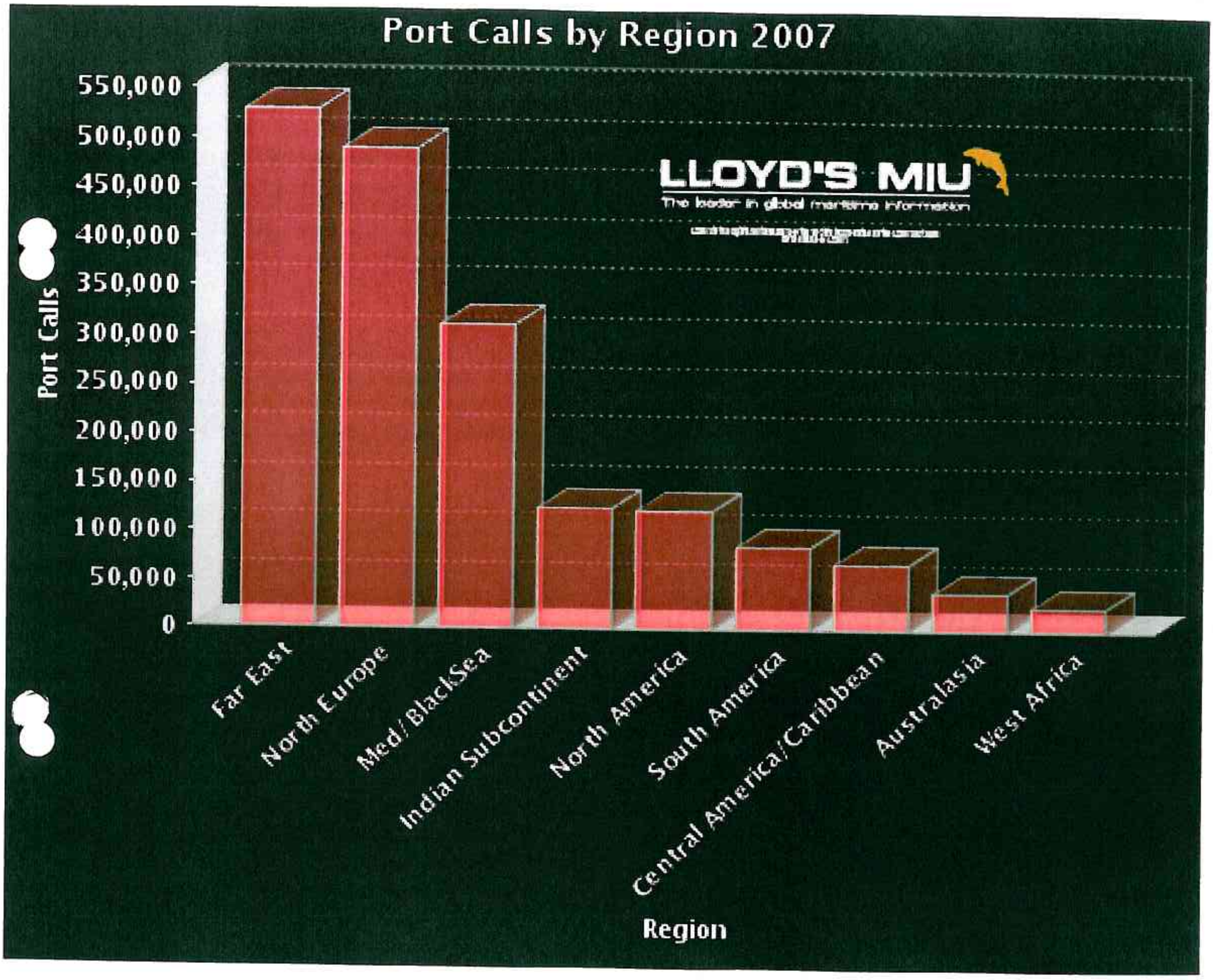
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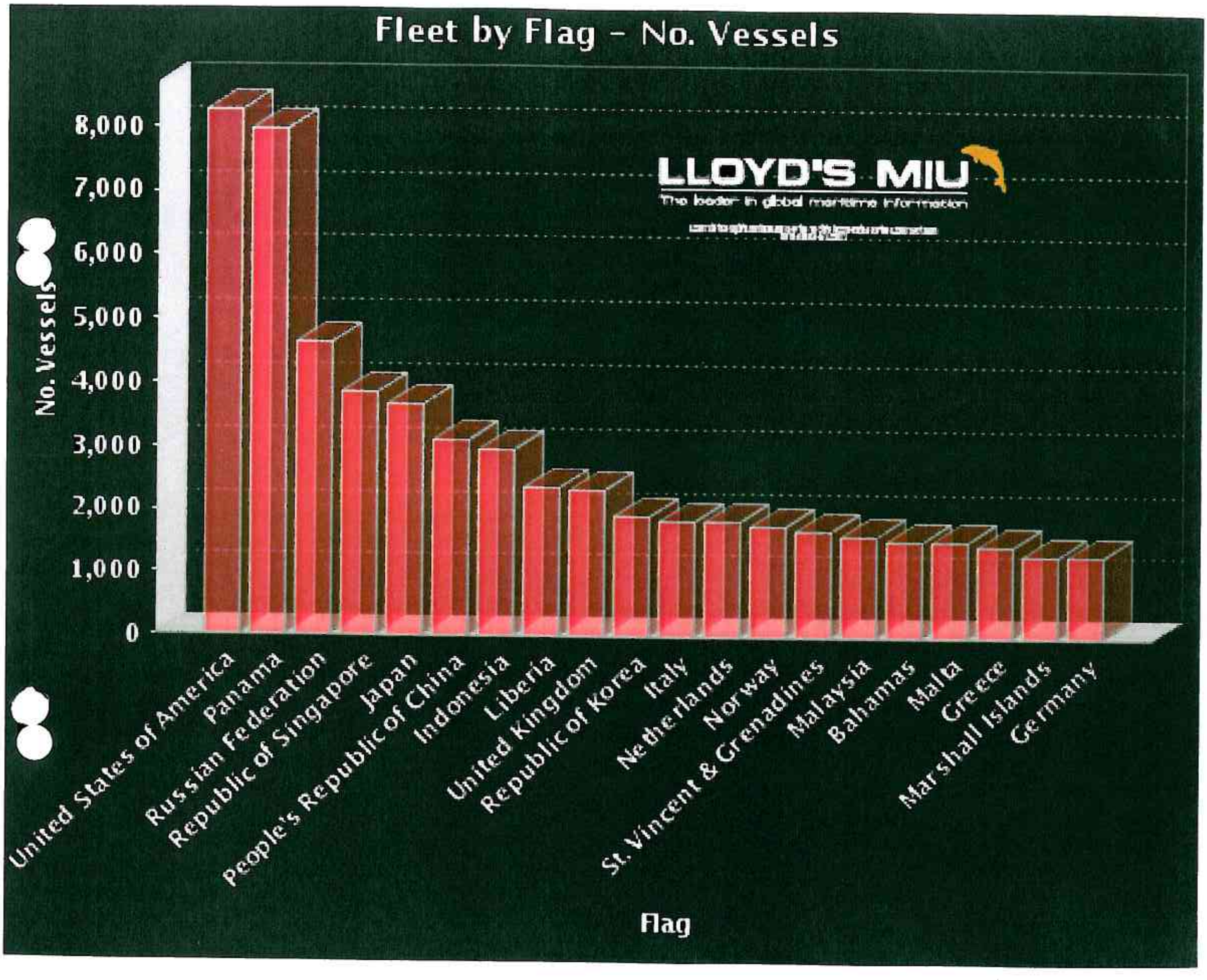
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Malta
Greece
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Germany
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16

The ‘Clean-ship’ concept for anti-fouling

THE 'CLEANSHIP' CONCEPT FOR ANTI-FOULING

NOTE: Available on line at http://www.cleanship.info/present/anti-fouling.htm

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Anti-Fouling

Ships travel trough water and an unwanted growth of biological material such as algae and molluscs called fouling attach themselves to the hull. These organisms will slow down the ship and fuel consumption will increase. A clean ship can sail faster and with less energy. Chemicals industry developed effective anti-fouling paints. One of the most effective anti-fouling-paints contains the organ tin compound tributyltin (TBT). Environmental studies prove that organ tin compounds remain in the water, killing sea life, harming the environment. . On 5 October 2001 The International Maritime Organisation (IMO) adopted a convention which will lead to a world-wide ban on the use of anti-fouling coatings containing the biocide tributyltin (TBT) effective from 1 January 2003. The generalised ban of TBT-paint has forced paint producers to look into alternatives to organ tin compounds. Since organ tin based antifouling paints are prohibited, increased research efforts are concentrated on new non-toxic alternatives such as natural products, non-stick coatings based on silicones or hydro gels, application of electric currents and mechanical cleaning. Natural products which prevent fouling based on capacity of marine organisms such as corals and sponges to remain free of fouling Non-stick coatings are mainly based upon silicones. They have an extremely slippery surface, preventing fouling to occur and making it easier to clean. Electrical currents create a difference in electrical charge between the hull and seawater starting a chemical process which prevents fouling. Underwater cleaning is carried out on moored ships or in harbours during loading and unloading by divers using of an impeller system with rotating brushes. Some cleaning companies developed a non-toxic hull concept. The idea was to coat the hull with a hard anti-corrosive system and to maintain it in this condition by regular underwater cleaning every several years. More sophisticated systems as robots are needed. A network of hull cleaning stations at all the important trade routes would be necessary. The cleaning should be entirely automatic, either by means of a remotely controlled

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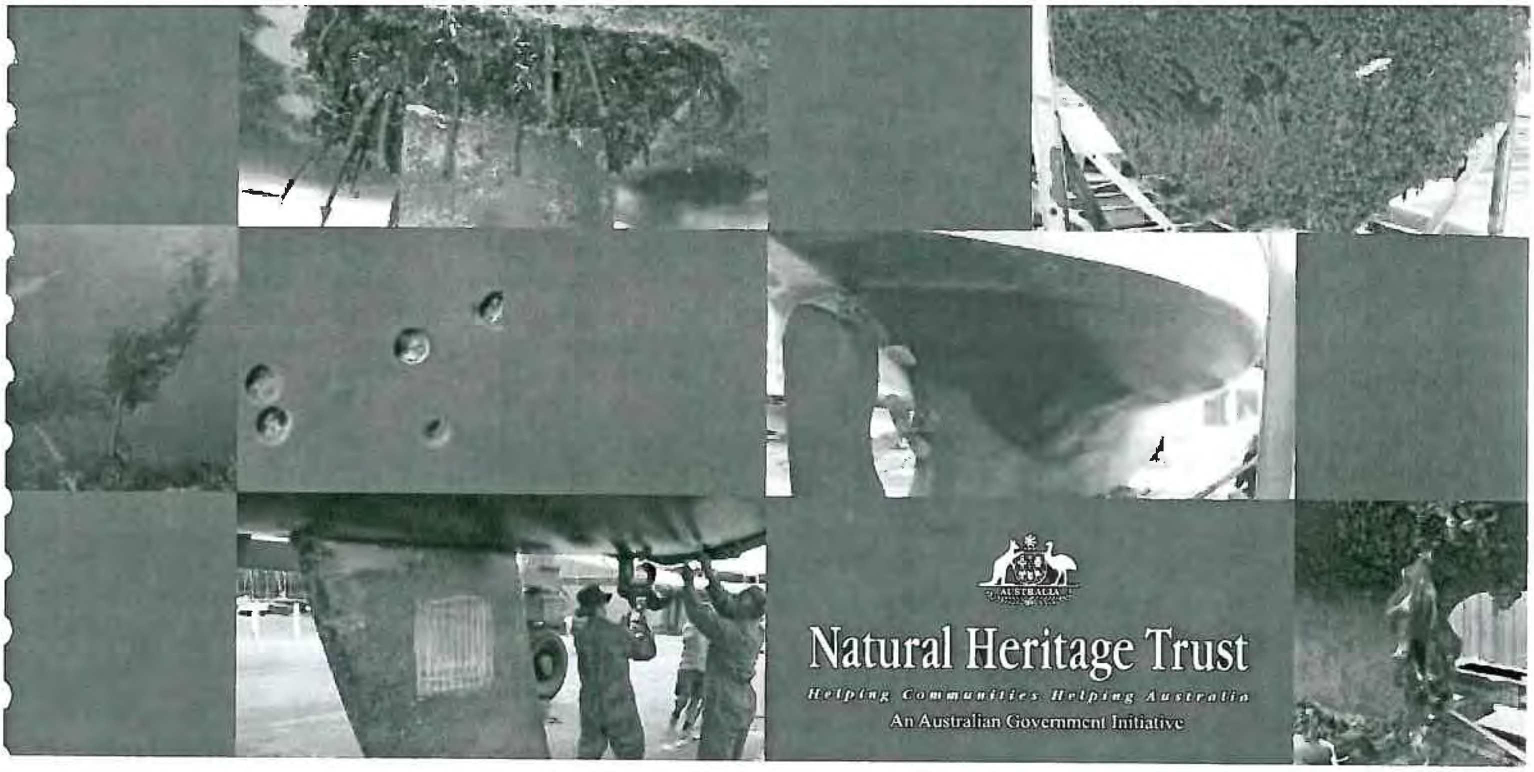
vehicle or along the lines of a car wash system.

Previous

Empirical Validation – Small vessel translocation of key threatening species



March 2007

Empirical validation: Small vessel translocation of key threatening species

Stage II – Undaria pinnatifida

Prepared by:
Keith R. Hayes, Rasanthi Gunasekera, Jawahar Patil, Cath Sliwa, Sasha Migus, Felicity McEnnulty, Piers Dunstan, Mark Green, and Caroline Sutton

Final Report for the Australian Government Natural Heritage Trust (Project No. 46630) by CSIRO Marine and Atmospheric Research

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Empirical validation: Small vessel translocation of key threatening species

Natural Heritage Trust

Helping Communities Helping Australia

An Australian Government Initiative

Stage II – Undaria pinnatifida

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Australian Government Natural Heritage Trust Project 46630

Final Report, revised February 2007

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