# Introduced marine species and marine pests

Environmental indicators reported in this section:

| Environmental Indicator | |
|---|---|
| **CO 3.11** | Pest numbers |
| **CO 3.15** | Species outbreaks |

[CO Indicator 3.11]

Because Australia is an island continent, we depend on maritime transport; over 95% of our imports and exports are transported by ship. While Australia has taken steps to reduce pest introductions, for example through border controls, incursions continue to occur. Pest species are a threat to marine biodiversity as well as marine industries such as fishing and aquaculture.

Introduced marine pest species include large seaweeds, such as *Undaria pinnatifida* (Japanese Kelp) in Tasmania and *Caulerpa taxifolia* in New South Wales, and minute planktonic dinoflagellates, and animals such as crabs and starfish. Those of greatest threat have been listed as target species by the Australian Introduced Marine Pests Advisory Council.

There is, however, no continental-scale trend information available on the number of introduced species that are classified as marine pests. Partly this is because the definition of 'pest species' has changed and partly because this information has not been systematically collected in the past. However, it is known that about 200 marine species have been intentionally or accidentally introduced into Australian waters since the start of trade and shipping.

Some existing native species may multiply to the point of being a pest, either through apparently natural cycles or possibly by some human trigger. The best-known example is the Crown of Thorns Starfish on the Great Barrier Reef. The Ningaloo Reef in Western Australia has been affected by outbreaks of *Drupella*, a coral-eating snail. There are other marine pests that have been introduced to Australian waters in some way and which displace native species from their habitat.

One of the most important ways in which marine pests can be introduced is through the discharge of ballast water in our coastal waters. Ballast water is used in ships for stability while travelling to and from Australia. Around 150 million tonnes of ballast water are released in Australian coastal waters annually from international vessels, and a further 34 million tonnes from coastal vessels.

Other ways in which marine pests can be introduced into Australian waters include: as fouling organisms on vessels' hulls and anchor chains, and in internal water systems; attachment to drilling platforms; deliberately and accidentally through the aquarium trade, movement of fish products, mariculture and aquaculture; and in imported seafood.

The relative importance of these different means has changed over recent years, with hull-fouling, recreational vessels and translocation of species between Australian ports becoming recognised as more important means of pest introductions. Information on foreign ship visits to Australian ports is on page 80.

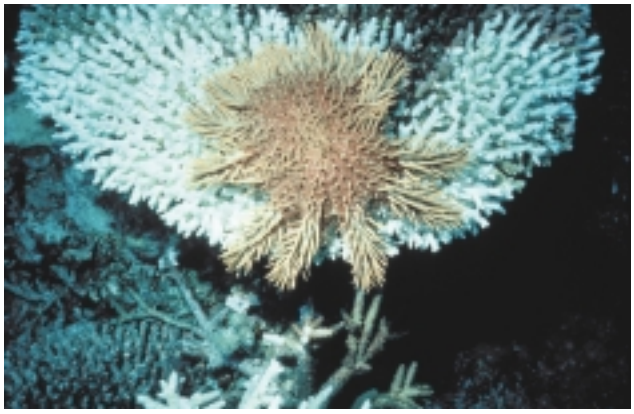
The threat of incursions of new introduced marine pests, or of existing pests to new locations within Australia, is real and immediate (Commonwealth of Australia 2000) and can have significant economic consequences. The outbreak of the Black Striped Mussel in Darwin, for example, had the potential to severely damage the pearling industry ($225 million value of production in 1998).

Introductions of pest species have been detected in all States of Australia. The most intensively studied port region in Australia is Port Phillip Bay in Victoria. This is one of the few areas where it possible to evaluate the historical patterns of invasion by exotic marine species **(**Hewitt et al. 1999). The study identified between 99 and 178 introduced species in the Bay, and estimated that the actual number of exotic marine species is between 300 and 400. The study further estimated that two to three new exotic species are establishing in Port Phillip Bay each year.

A series of baseline surveys of ports and harbours to assess how many marine pests have been introduced into Australian waters was initiated in 1995 by the Australian Association of Ports and Marine Authorities, CSIRO Marine Research, and CSIRO Centre for Research on Introduced Marine Pests. As of 2001, 22 out of 65 ports of first call for international vessels

have been surveyed. When all these port baseline surveys have been completed, a better assessment of the risks posed by introduced species will be possible.

However, this baseline information will not be used to maximum effect unless ports and harbours at greatest risk are re-surveyed on a regular basis. At the same time, measures such as ballast water treatment to reduce the risk of introductions should be developed as a matter of urgency.



**Crown of Thorns Starfish feeding on plate coral.**

**Source:** B Legg, Great Barrier Reef Marine Park Authority.

## Examples of pest species [CO Indicator 3.15]

### Crown of Thorns Starfish

At low densities, this starfish (*Acanthaster planci*) is considered a natural component of the Great Barrier Reef. However, when its density reaches about 30 mature starfish per hectare, the level at which it eats coral faster than coral can grow, a major reduction in living coral occurs. It has been extensively studied (e.g. Wachenfeld et al. 1998), but the cause of outbreaks is still not fully understood, although freshwater runoff has been implicated.

The intensity and frequency of outbreaks have not abated since they were first noticed in 1962. The first outbreak occurred off Cairns, with a slow southwards spread over the next 14 years. A second outbreak followed between 1979 and 1991, affecting about 17% of the World Heritage Area reefs, with 5% severely affected. In 1993 a third outbreak commenced, and has continued. By 2000 the percentage of reefs on the Great Barrier Reef with outbreaks of the starfish was the highest since surveys began (Sweatman et al. 2000).

Tourism operators receive permits to clear Starfish from small areas at selected tourist sites in order to maintain live coral cover, and so consider the Crown of Thorns Starfish to be a pest species in these areas.

The causes of the outbreaks are not fully known, so that it is not possible to assess whether the outbreaks are natural or not. Some factors that could influence Starfish populations include increased nutrients in runoff from the land, freshwater runoff and the effects of the removal of predators from the ecosystems by fishing.

### Urchin barrens

An example of a native species becoming a pest in the south of Australia is that of the Purple Sea-urchin (*Centrostephanus rodgersii*), which can cause denuded environments called urchin barrens. It is thought that over-harvesting of competing Blacklip Abalone (*Haliotis rubra*) contributed to the expansion of barrens habitat. Once established, barrens are unsuitable as abalone habitat and populations decline as the biomass of food algae decreases.

The White Urchin (*Heliocidaris erythrogramma*) has also been responsible for the creation of barrens by denuding forests of the Giant String Kelp (*Macrocystis pyrifera*) along the East Coast of Tasmania. In this instance it is believed that over-harvesting of the Southern Rock-lobster (*Jasus edwardsii*), an important predator of urchins, promoted substantial increases in urchin abundance.

### Caulerpa

The macroalga *Caulerpa taxifolia* was found on the New South Wales South Coast for the first time in 2001 and is now known at a number of sites along the coast. It can smother seagrass beds that are important nursery habitats for fish. The identity of the *C. taxifolia* strains found in New South Wales is still uncertain, although it appears to be related to native *C. taxifolia* strains found in Queensland. It appears to have been translocated from Queensland on a vessel.

### Mussels

The Asian Mussel (*Musculista senhousia*) can dramatically alter habitat by forming major outbreaks that out-compete other shellfish and native species. This mussel was first recorded in the Swan River in Western Australia, arrived in Victoria in 1987, and is now abundant in Port Phillip Bay. An infestation of New Zealand Green-lipped Mussel (*Perna canaliculus*) was found and removed from Port Adelaide River in 1996.

## The Black Striped Mussel

The Black Striped Mussel (*Mytlopsis sallei*) can tolerate a wide salinity and temperature range, putting at risk of invasion an area encompassing much of the coast of Australia, from Fremantle in the west to Sydney in the east, and even the warmer regions of the Great Australian Bight.

In early 1999, this exotic marine bivalve was discovered in Darwin Harbour during a resurvey of the Port of Darwin. Its presence in Cullen Bay Marina, and subsequently two other marinas, were the first recorded sighting of the species in Australia. It was not present two years earlier when a baseline survey of the Harbour had been carried out.

Having witnessed the ecological and financial disaster caused in the Great Lakes region of North America by its near-relative the Zebra Mussel, the Northern Territory and Commonwealth governments mounted a major effort to eradicate this pest. This is one of the first instances in the world of a successful eradication of an established marine pest population.

Initial research revealed the Black Striped Mussel is able to grow inside pipes and on any solid surface in contact with seawater. Its establishment in Territory waters had the potential to seriously affect marine biodiversity and threaten the social and economic benefits derived from aquaculture, recreational and commercial fishing, domestic and international tourism, and the shipping industry.

A Special Meeting of the Territory Cabinet enacted regulatory amendments and approved the appointment of a task force and expenditure of funds, within four days of the initial discovery.

Amendments to the Fisheries Regulations empowered the Director of Fisheries to authorise the closure and inspection of potentially infested areas. The Commonwealth *Quarantine Act* and the Northern Territory Fisheries Regulations were subsequently used in tandem to control vessel movements and order the inspection and cleaning of vessels. All vessels known to have been in any of Darwin's three marinas between 1 October 1998 and 31 March 1999 were tracked down by the coordinated efforts of AFMA and the Australian Quarantine and Inspection Service (AQIS) and checked.

The task force was responsible for coordinating research, surveys, vessel movements, inspection and cleaning of vessels, the eradication of the bivalve, and keeping the community informed.

Over 300 people participated in the response. The Northern Territory Department of Primary Industry acted as the lead agency. Further assistance was provided by CSIRO's Centre for Research on Introduced Marine Pests, the Museum and Art Gallery of the Northern Territory, the Northern Territory University (NTU) and the Australian Defence Force. Private business operators supplied supplementary divers, equipment and chemicals.

Research was undertaken at NTU into the efficacy and field logistics of eradication and treatment options such as temperature, salinity, chlorination and copper sulfate. Cullen Bay Marina, which was the worst affected, was dosed with a total of 163 tonnes of hypochlorite and 4.3 tonnes of copper sulfate over a three-week period, resulting in a complete kill of the Black Striped Mussel. Frances Bay Marina was dosed with 51 tonnes of hypochlorite and 1 tonne of copper sulfate, with the smallest private marina, Tipperary Waters, receiving 1.1 tonnes of copper sulfate. The chemical treatments killed all the marine life within the marinas.

**The fouling caused by Black Striped Mussels.**

**Source:** Centre for Introduced Marine Pests, CSIRO Marine Research.

Throughout the operation, the public and media were kept well informed via the newspaper, radio, Internet, and fact sheets distributed by volunteers to businesses and households surrounding the marinas.

Following the eradication, an ongoing biological monitoring program for the Black Striped Mussel and other exotic marine species was implemented in Darwin Harbour. In July 1999 the first samples in the greater Darwin Harbour were collected. No Black Striped Mussels were found. In November 1999, the Northern Territory Government established a fully funded Aquatic Pest Management Program to develop and implement protocols to protect Territory waters from the threat of aquatic pest species.

Long-term monitoring of the three Darwin marinas has shown that the 100% kill of all biological material has had no lasting effects, with marine life returning to marina waters within weeks of the lock gates being opened. The annual influx of freshwater during the tropical monsoon season between November and March results in the death of all marine life in the top two metres of marina waters—an effect similar to that of the chemical treatment.

In this incident, eradication of the Black Striped Mussel was successful. There were several reasons for this:

- the initial discovery was made in a small marina,
- the mussel was detected quickly, and
- dosing with chlorine was feasible in the marinas.

There is no guarantee that such a fortuitous set of circumstances would occur again in the future. The successful response to this incident may not be repeatable.

### Northern Pacific Seastar — a national pest

The Northern Pacific Seastar (*Asterias amurensis*) is one of the most nationally threatening of the introduced marine pests to invade Australia. It grows rapidly, is highly fecund, forms dense populations, and appears to have few native enemies. It is a major predator of a wide range of marine species, including commercial shellfish.

It was introduced from Japan into the Derwent Estuary in Tasmania in the 1980s, either as larvae in ballast water or as adults on the hulls of international vessels. It was already well established by the time it was correctly identified in 1992. By 1999, the Seastar had become the largest component of the estuary's biomass.

A second population became established in Port Phillip Bay between 1995 and 1997, probably transported from Hobart by shipping. The population in Port Phillip Bay had grown to possibly 90 million by 2001 (Parry and Cohen 2001).

There is now a high risk of the Seastar appearing in other temperate ports in the future, from Western Australia to central New South Wales, and may eventually spread to the mid and outer continental shelf due to its depth tolerance (to 100 metres).

A National Control Plan (National Task Force on the Prevention and Management of Marine Pest Incursions 2000) has been put forward for the next five years to minimise the rate of spread and reduce its impacts. Although eradication of the Seastar is not possible, the Plan aims to reduce the risks of it spreading to new areas.

The Strategic Ballast Water Research Program of AQIS also addresses limiting the translocation of introduced species such as Seastars around the coast.

### Dinoflagellates

Toxic dinoflagellates can become part of the shellfish feeding cycle. These protozoa produce toxins which can cause paralysis and sometimes death in humans who eat affected shellfish (see the 'Seafood quality' box on page 72).

In Tasmania, authorities have been forced to close down shellfish harvesting in the Huon River several times in recent years due to the presence of dinoflagellates in south-east Tasmanian waters. Scientists have linked the introduction of toxic dinoflagellates to ballast water and sediment discharged from overseas vessels.

### Lyngbya

*Lyngbya* is a toxic marine cyanobacterium (blue-green alga) that appears to tolerate a wide range of salinity. It has a very rapid expansion rate and can smother seagrass. *Lyngbya* is a contact irritant that can produce skin and eye irritation following direct contact.

Blooms of *Lyngbya* were recorded in Moreton Bay in Queensland in the 1990s. In March 2000, a large bloom of approximately 30 $km^2$ was reported in Moreton Bay and persisted until about June 2000. This is in excess of previous blooms recorded within Moreton Bay.

Over the 2000–2001 summer, the blooms returned. In January 2001 the bloom at Deception Bay covered about eight to ten square kilometres. The bloom was still affecting Deception Bay in mid-February 2001.

A taskforce has been assembled by the relevant authorities in Queensland to investigate the causes of the bloom formation and to develop a management strategy.

### Disease organisms

Ships' ballast water may have the potential to transport cholera organisms (Desmarchelier and Wong 1998), although an outbreak of cholera would depend on the breakdown of effective public health measures. A major outbreak in South America was circumstantially attributed to a ship's discharge.

Disease organisms can affect marine life. There is now some evidence that two mass mortalities of pilchards around southern Australia were caused by an introduced virus, although there are still uncertainties about how it could have been transported to Australia and around the coastline over such distances.

## Minimising the risk of introducing pest species

The issue of introduced marine species transported by shipping is complex and involves stakeholders as diverse as the International Maritime Organisation (IMO), Commonwealth and State Governments, the shipping industry, mariculture, environmental organisations, and

## The biggest fish kill in Australia

The largest recorded fish kill in Australian history occurred in southern Australia between late 1998 and early 1999. Huge numbers of dead Australian Pilchards (*Sardinops sagax*) were found on the sea surface, on the sea floor, and along beaches in southern Western Australia.

Australian Pilchards are commonly found in bays and coastal waters across southern Australia. Pilchards support purse-seine fisheries in southern Western Australia, South Australia and Victoria. Ten years ago the pilchard population was high and they were fished as an 'on-demand' fishery, relatively independently of the population.

There have been two major pilchard kills in the last five years. The first kill in 1995 originated near the Eyre Peninsula in South Australia then progressed west and east around southern Australia (Gaughan et al. 2000).

The origin of the episode, its fast rate of spread, apparently high mortality rate and the lack of previous comparable kills led Fletcher et al. (1997) to conclude that the disease agent was probably an exotic pathogen to which Australian Pilchards had not previously been exposed.

The second mass kill originated in South Australia in early October 1998 and also spread across southern Australia over a period of seven months. The kill of pilchards on the south coast of Western Australia during early 1999 is estimated to have been at least 28 000 tonnes of mature fish. This equates to three to five years of catch at current purse-seine fishing rates, in a period of only two months (Gaughan et al. 2000).

It is estimated that this mass mortality in both South Australia and Western Australia caused the loss of about 60% of the pilchard stock in both States.

The origin of the infectious agent in Australia is still unknown. Scientists (Whittington et al. 1997) have hypothesised that a herpes virus may have been introduced via ballast water, seabirds or imported baitfish. They noted at that time that more than 10 000 tonnes of pilchards were being imported annually from California, Peru, Chile and Japan without quarantine inspection. They were fed to sea-caged Southern Bluefin Tuna near the southern extremity of the Eyre Peninsula in South Australia.

**Dead pilchards on the coast.**

**Source:** South Australian Research and Development Institute (Aquatic Systems).

The imported pilchard hypothesis suggests that importation of untreated frozen pilchards carries a very high risk for Australian stocks of *S. sagax*.

Research aimed at answering some of the questions surrounding the 1995 and 1998–99 mass mortalities is under way. The mass kills have serious implications for our trade, quarantine and for the species dependent on pilchards as a source of food.

recreational interests. Within the shipping sector, no single solution could be applied to recreational, fishing, container and other commercial vessels.

The 1999 Black Striped Mussel incursion prompted the establishment of the National Task Force on the Prevention and Management of Marine Pest Incursions. This task force recommended reforms to current arrangements in December 1999, the major one being the establishment of a single national management regime for vessels. Its recommendations are being implemented through the work of the National Introduced Marine Pests Co-ordination Group to reform border prevention and management of existing pests.

A national coordination mechanism for emergency responses to introduced marine pests was established in 2000 as part of the reforms (the Consultative Committee on Introduced Marine Pest Emergencies). It has available an interim $5 million emergency response fund, pending longer-term arrangements that will be in place after 2002.

### Ballast water

Internationally, implementation of improved ballast water management has been slow. The Marine Environment Protection Committee of the IMO has been drafting binding ballast

water management arrangements for international shipping since 1997, but is not expected to have a treaty document available for the signature of member nations until 2001 or 2002.

The Australian Quarantine and Inspection Service (AQIS) is the lead agency for the management of ballast water in international vessels. Voluntary measures and guidelines to manage ballast waters have been in place in Australia since 1990. Australia introduced mandatory ballast water management arrangements in July 2001 for international shipping entering Australian waters. The new arrangements incorporate a risk assessment management tool that provides vessels with an assessment of the likelihood of their introducing exotic species into Australian ports or waters via ballast water. A revised ballast water reporting system and verification inspections is also an integral part of the new arrangements. Vessels are assessed by the Australian Quarantine and Inspection Service (AQIS) as either high risk (in which case full exchange of ballast water at sea is required) or low risk (in which case exchange of ballast waters within coastal waters is allowable).

Another technology, apart from exchanging water at sea, that is showing potential is to heat the ballast water using waste heat from a ship's engine. Development of other technical solutions such as filtration, ozonation and ultraviolet treatment is under way.

### Translocation

The Victorian Department of Natural Resources and Environment is managing two projects that are relevant to translocation issues nationally. The projects target two major pests: the Northern Pacific Seastar and *Undaria* seaweed. One project will develop sterilisation techniques and a mandatory code of practice for sterilising mariculture equipment that farmers move from one coastal site to another. The second project will develop voluntary operating practices that encourage small vessel operators and port managers to help prevent marine pests spreading to and between local ports.

### Hull fouling

The control and management of hull fouling presents particular challenges that have not yet been analysed on a national basis. Anecdotal information suggests that hull fouling is more likely to be a problem for smaller vessels than for large international vessels. Improved ways of dealing with pest introductions via hull fouling are being sought through the work of the National Introduced Marine Pests Co-ordination Group.

## Summary

The susceptibility of Australian waters to the introduction of exotic marine species is significantly higher than previously thought. Our isolation through geological time has allowed a unique and highly endemic fauna and flora to develop and flourish in our waters. This uniqueness means that species introduced from other regions can be particularly damaging to our ecological systems.

Scientists have estimated that there is at least one new introduction per year, but there are large gaps in the data on which to base a national assessment. Both tropical and temperate waters are susceptible to the threat of introduced species.

The surveys of ports and harbours being undertaken by CSIRO's Centre for Research on Introduced Marine Pests are providing a necessary baseline of information on introduced species. However, unless the ports and harbours at greatest risk are resurveyed regularly, we will not become aware of any new introductions either from overseas or from ports around Australia. Currently Darwin is the only port that undertakes an annual survey and monitors for pest species. This lack of survey and monitoring could pose an unacceptable risk to Australia. The use of a standard protocol could enable the issue to be addressed on a consistent national basis.

There are still a number of issues to be addressed by the various stakeholders, mainly those of integrating responses across jurisdictions and across marine industries.