Pest control in the deep

Could a barnacle rescue us from the clutches of the European green crab? Chris Viney investigates the underwater potential of biological control.

Scientists at CSIRO's Division of Fisheries in Hobart are working towards a world 'first': the use of biological control measures to combat introduced marine pests. The work is one of a number of projects initiated by the Centre for Research on Introduced Marine Pests (CRIMP), a program established by the division in 1994 to help protect Australia's waters from 'foreign invasion'.

Although biological control has become commonplace on land, it has never been attempted in the marine environment. A better long-term option would be to prevent exotic species from coming here in the first place, but that's no easy task. According to CRIMP leader Dr Ron Thresher, there are no cost-effective, technically feasible, safe and environmentally-sound barriers that can be used against marine pests. Biological controls must therefore be developed as a second line of defence.

While the centre's research is focused on biocontrol, its scientists are also working with other authorities on a range of different approaches. To identify marine pests already in the port environments, a program of port surveys is being conducted. This program is supported by the Australian Association of Port and Marine Authorities and the Australian Ballast Water Management Advisory Council.

A number of barrier control measures are also being studied. These include better control of water discharge, treatment of ballast tanks, and ocean exchange procedures, in which port ballast water is discharged and replaced at sea. But all these have their drawbacks.

'Ocean exchange can pose a stability risk to vessels, and in any case, a single litre of ballast water can contain viable numbers of invaders such as toxic dinoflagellates, so no water exchange could be certain of success,' Thresher says.

Attempts have been made to sterilise ballast water, but this is considered neither a practical, nor long-lasting remedy. Heat treatment en route is being tested, using heat from the ship's boilers to raise ballast water temperature to about 40°C, killing many organisms in the water.

'A recent study estimated that at any given moment, up to 2000 organisms are being transported across the oceans in ballast tanks,' Thresher says.

'While most die in the dark and often dirty conditions, or fail to survive the new environment at their port of discharge, those that do make the journey and establish themselves tend to be tough species with wide tolerances, well adapted to disturbed environments common in busy ports. When unleashed on ecosystems that have no ecological resistance, they can quickly reach plague numbers.'

In Australia, several introduced marine pests have the potential to damage the environment and the economy. Thresher believes that biological control in the affected environment offers the most likely

method of combating two introduced species in particular: the Northern Pacific sea star *Asterias amurensis* and the European green crab *Carcinus maenas*.

Other introduced species of concern in Australian waters are the Japanese kelp *Undaria pinnatifida*, the fan worm *Sabella spallanzanii*, and the toxic dinoflagellate *Gymnodinium catenatum*. All could create environmental damage and serious economic impact. In some cases, the effects have already been felt. *Sabella*, which carpets some areas of Port Phillip Bay, has affected for the bay's scallop fishery, while the presence of toxic dinoflagellates have on occasions forced the closure of oyster farms in Tasmania and Victoria.

Thresher says it is vital to take action before problems escalate as they have in the Great Lakes of North America. There, an alien invader called the zebra mussel has infested Midwest waterways and is spreading fast, offering proof of how badly things can go wrong when an introduced species gets away.

Zebra mussels, a European freshwater mollusc that reached the United States in Black Sea ballast water, is today the single most common species in the Great Lakes, encrusting and killing native species and clogging water pipelines and plumbing of cities, industries and services. The cost? Up to $5 billion a year!

'The environmental and economic impact of a "bad" alien species is greater and longer-lasting than even a serious oil spill,' Thresher says. 'While a spill may have severe and highly-visible immediate effects, the damage is likely to be localised and within a narrow depth band. Fifty years after a serious spill, the biological damage will have long since healed.'

But the impact of an invader may have far-reaching and often unpredictable effects. Habitat changes, and the extinctions that are associated with loss of biodiversity, alter the way an ecosystem works, causing damage to the marine environment that will not heal in 50 or 500 years.

Biodiversity may be a key factor in the introduced species equation. Pristine Australian marine environments exhibit high levels of endemic biodiversity, even though during the two centuries since European settlement that richness has been reduced.

In the logs of James Cook's voyages of discovery, there are repeated references to 'untold numbers' of fish, and anecdotal evidence of fishermen indicates that even in the relatively recent past, biodiversity in populated areas has reduced noticeably. In the context of introduced species, loss of biodiversity is dangerous.

'One of the possible reasons that introduced pests do so well in disturbed environments such as busy port areas is that biodiversity has already been reduced by human interaction and pollution,' Thresher says. 'As a result, some of the checks and balances, which in a healthy and diverse environment could reduce the impact of an invading species, may no longer operate.'

Furthermore, introduced species may lead to greater loss of biodiversity in an already disturbed environment, making later introductions of other exotic species more likely.

Top: The fan worm, a native of the Mediterranean, is now present in Victorian, Tasmanian, South Australian and West Australian waters.

Above: The Northern Pacific seastar: identified by scientists as a primary target for biological control.

Barnacles to the rescue?

In Australian waters, one of the oldest residents among the invaders is the European green crab, which probably arrived during the 1890s, perhaps in rock ballast, loaded in home ports and dumped here at voyage end. The crab, which is widely accepted as a ubiquitous local from the rocky shores of Bass Strait to South Australia, has so integrated into the local fauna that assessing its impact presents major problems.

In its native habitat, the green crab is parasitised by a curious barnacle, *Sacculina carcini*, which infiltrates the body of the crab, replacing the host animal's sex organs with its own body. The crab survives, but is unable to reproduce. As host numbers decline, so does the parasite population; a favourable biological control situation.

The interaction between crab and barnacle has been studied in Europe for many years. Research in California, where green crabs have also been introduced, complements the Australian research.

CRIMP's other key target species for biocontrol measures is the Northern Pacific sea star *Asterias amurensis*, which is believed to have arrived in Tasmanian waters in the ballast water of Japanese ships, and was first observed in the Derwent estuary near Hobart in 1986.

The sea star is a prolific breeder and a voracious feeder, preying on oysters, mussels and scallops, and its continued but slow spread represents a serious threat to marine life, aquaculture farms and some fisheries. Biological control measures for the sea star also focus on a parasite, a ciliate protozoan that enters the gonads, sterilising the male sea stars.

Thresher believes that the marine biocontrol studies in progress at the centre point the way to a new approach to tackling the problems of introduced pest species. He says it is important, however, to distinguish between the control organisms under consideration at the centre, and bacterial or viral biocontrol programs.

'For example, in the case of green crab and its parasite *Sacculina*, we're not dealing with a microscopic airborne virus, but a relatively large metazoan parasite,' he says. 'Rather than 'germ warfare', our work more closely resembles an entomological model, using marine creatures instead of insects.'

Recognising the links between marine and terrestrial biological control issues, the centre will be working with the CSIRO divisions of Entomology, Forestry and Tropical Agriculture, all of which have experience in biocontrol.

High on Thresher's agenda is the need for a national aquarium facility for the secure holding of introduced species for the next stage of study. He says that in view of the importance of the mariculture industry to this country, such infrastructure could serve a vital quarantine role, apart from its value as a biocontrol study centre.

The work under way at CRIMP is heightening our understanding of population dynamics in the marine environment, and has the potential to prove the concept of biological control in the sea. By taking the lead in this important new field, an international model can be formed of how the health and biodiversity of the marine ecosystems can be stabilised, restored and safeguarded for the future.