invasive alien species

– a growing threat in Regional Seas

GISP
The Global Invasive Species Programme

UNEP Regional Seas


Marine and Coastal Management

Invasive alien species

are introduced species that become established in a new environment, then proliferate and spread in ways that are destructive to human interests and natural systems.

Invasive species have been identified as one of the four greatest threats to marine and coastal ecosystems, together with land-based sources of marine pollution, overexploitation of living marine resources, and habitat degradation.

Marine and coastal invasive species are introduced to new regions through a variety of pathways. Many introductions are **intentional** – for example, species of plants and animals have been deliberately introduced to support new fisheries or mariculture ventures, to display in aquaria, and to use in coastal management practices, such as erosion control and dune stabilisation. Although the original aim may have been to confine them to a particular site, they frequently spread unaided, escape from captivity or are subsequently released, after which they have the potential to invade new areas.

Other introductions have been **unintentional**, when species have been transported to new areas as biofouling hitchhikers or as stowaways in ships' ballast water. The opening of new canals and seaways between previously unconnected waterbodies has further facilitated unintentional introductions, not only as a result of shorter transit times for those introduced via biofouling and ballast water, but also due to natural dispersal by currents and self-mediated migration.

Biofouling algae and invertebrates may attach themselves to any boat surfaces that remain submerged, such as hulls and propellers, as well as those in intermittent or continuous contact with water, such as anchors and water pipes. Once the vessel has arrived at its destination, the biofoulers and their offspring may quickly 'jump ship' to colonise new areas, with nearby wharf pilings and breakwaters offering convenient settlement sites. Slow-moving barges and oil rigs are especially implicated in the transfer of invasive species, as they often spend lengthy periods in one location – increasing the risk of colonisation by biofoulers – and are cleaned infrequently, since the increased drag and fuel consumption associated with biofouling is not critical to their operational profit margins.


US Fish and Wildlife Society

Management action against invasive species aims to:

- Prevent or minimise new introductions
- Prevent or minimise their establishment and spread
- Eradicate or control established populations of invasives.

Since eradication is extremely difficult once a species has become established – and control very expensive – prevention is considered the best defence against invasion. Prevention can be achieved through intervention at a number of different stages.

Pre-border interventions to prevent the introduction of invasive species include Environmental Impact Assessments (EIAs) prior to importation of alien species, permit systems for trade or movement of listed species, and appropriate ballast water management.

Border controls are designed to stop potentially invasive species at the point of entry, with officials responsible for inspecting cargo, checking compliance with permit systems, and imposing quarantine periods or treatment regimes.

Post-border interventions occur once the potentially invasive species is present in the area, and include early detection and rapid response, eradication, and control and mitigation.

Apart from their ecological impacts, marine and coastal invasive species also have a range of economic and human health consequences.

Ecological impacts: They reduce biodiversity by displacing indigenous species through predation, competition, habitat modification and food-web disturbance. They also disrupt ecological processes and compromise ecosystem services such as flood attenuation and shore protection.

Economic impacts: They cause losses due to reduced productivity and efficiency, and also incur costs associated with their prevention and management. Biofouling poses a particular problem for shipping, mariculture infrastructure and industrial installations, while fisheries production may be hampered by operational impacts, such as gear damage, as well as a decline in target populations.

Health impacts: Ballast water is capable of transferring bacteria and viruses that may cause diseases, and toxic phytoplankton that form harmful algal blooms, often resulting in shellfish poisoning or allergic reactions in people. In addition, introduced animals may harbour diseases that could potentially spread to humans, while invasive populations of coastal plants may cause health problems such as hayfever and skin irritations.

Biofouling organisms are also introduced on fishing gear, mariculture equipment and even on drifting marine debris. For example, barnacles and mussels may colonise fish cages and floating litter, while fishing nets may contain eggs and larvae that remain viable during transit, or fragments of algae, starfish and sea squirts that can regenerate from small pieces.

Ballast water is used to provide stability to ships during transit. The ballast tanks are filled with water when the cargo holds are emptied before a journey, and flushed out at the next port of call, when new cargo is loaded. Suspended sediment is taken up with the water, and later settles out onto the floor of the ballast tank.

It is estimated that up to 14 billion tonnes of ballast water are transferred globally each year, and that as many as 10 000 species of marine organisms may be present in ballast water at any given time. Most marine plants and animals have a planktonic stage in their lifecycle, and can easily be taken up with ballast water. The sediments commonly contain dinoflagellate cysts that can remain in a state of dormancy until they are deposited in a suitable environment, where they divide and multiply to form harmful algal blooms.

In an effort to limit the transfer of marine species via ballast water and sediment, the International Maritime Organisation (IMO) developed a set of guidelines for ballast management during the 1990s. The guidelines recommended the exchange of ballast water at sea, regular removal of sediment from ballast tanks, and treatment of ballast water and sediment before discharge.

The IMO subsequently developed a legal framework – the International Convention for the Control and Management of Ships' Ballast Water and Sediments – that was adopted in February 2004 but has yet to come into force.

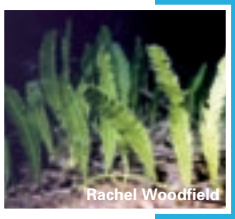
Early detection and rapid response aims to prevent invasive species from establishing and spreading. Monitoring methods, field surveys, and public awareness-raising campaigns can all be useful in detecting the presence of invasive species in a timely manner. The next step is to conduct a rapid assessment to gauge the probability and consequences of the species establishing and spreading, as well as the feasibility of various response actions and their costs and benefits.

If eradication is found to be impractical, a control programme to reduce the population and contain its spread should be initiated. Control techniques include:

- Physical control, such as removal by hand, mechanical harvesting, or the creation of physical barriers
- Chemical control, including chemical dosing, use of toxic baits, and application of herbicides and pesticides
- Biological control, which involves the introduction of natural enemies, such as pests and pathogens, from the invader's country of origin.

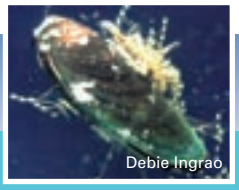
The Nature Conservancy

Bruce Caster


Rachel Woodfield

The green seaweed *Caulerpa taxifolia* is widespread in the world's tropical seas, but a robust, cold-tolerant strain has become an aggressive invader outside the species' natural range. In 1984, the seaweed was discovered growing in a small patch outside the Monaco Aquarium, from where it probably escaped. It has since spread throughout the northern Mediterranean, forming dense monocultures that carpet the seafloor. Apart from their devastating impact on local biodiversity, the caulerpa beds impede commercial fishing and spoil recreational diving sites.

Genetic studies have confirmed that the Mediterranean populations and collections in several European aquaria represent a single strain. Introductions to the United States and Australia can probably be attributed to releases from home aquaria, as the Mediterranean strain has been widely traded.


Debie Ingrao

The green mussel *Perna viridis* is indigenous to the tropical Indo-Pacific, but has been introduced to the Gulf of Mexico, probably either as adults attached to ships' hulls or as larvae in ballast water. First discovered in Trinidad in 1990, the mussel was later reported from Venezuela, Jamaica and Tampa Bay, Florida. Currents subsequently dispersed the larvae along Florida's Gulf coast, while boat movements allowed it to spread to the neighbouring state of Georgia.

The species has a broad salinity and temperature tolerance, and quickly forms dense fouling populations on bridge pilings, jetties and buoys. Apart from concerns about its ecological impacts, due to its potential to outcompete native filter-feeders for food and space, the species has a range of economic impacts. Its fouling clogs the cooling water intakes of industrial plants, reduces the fuel efficiency of boats, and interferes with shellfisheries and mariculture operations, all of which necessitate increased maintenance costs.

Plos Medicine

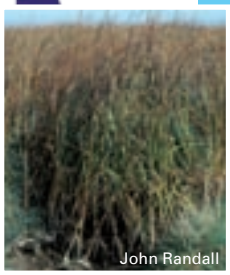
The cholera bacteria *Vibrio cholerae* that caused an outbreak of the disease in South America in 1991 may have been brought to the region by a ship from Asia. The bacterial strain was isolated from ballast water samples, and shown to be genetically similar to strains that are common in Asia. The disease was first reported in coastal towns in Peru, but within a few weeks had spread throughout the country. It subsequently became an epidemic that was able to spread throughout much of Central and South America due to overcrowded living conditions and poor sanitation systems in the region's shanty towns. By the end of 1994, over a million cases of cholera and more than 10 000 deaths had been reported.

West to East: North-East Pacific South-East Pacific Wider Caribbean West & Central Africa Mediterranean Black Sea Eastern Africa Red Sea & Gulf of Aden ROPME Sea Area South Asian Seas East Asian Seas North-West Pacific Pacific **Partner Programmes:** Arctic North-East Atlantic Baltic Sea Caspian Sea Antarctic


Richard Harbison

The North American comb jelly *Mnemiopsis leidyi* was introduced to the Black Sea via ballast water in the early 1980s. In 1988 the population began expanding rapidly, and by the following year its total biomass had reached a billion tons for the entire Black Sea. By competing with pelagic fish for zooplankton food, and preying on their eggs and larvae, the comb jelly caused the collapse of commercial fisheries, resulting in severe socio-economic hardship in the region.

However, in 1997 another comb jelly invaded the Black Sea. *Beroe ovata* feeds primarily on other comb jellies, showing a marked preference for *M. leidyi*. Within a few years it had brought the *M. leidyi* population under control, leading to a recovery of the zooplankton community and the region's pelagic fish stocks.


John Randall

The cordgrass *Spartina alterniflora*, which is indigenous to the Atlantic coast of the United States, is advancing across south-eastern China, after being introduced in 1979 for erosion control.

It rapidly invades intertidal mudflats and channels, seriously impacting birds, fish and invertebrates that depend on this vital habitat, and inhibiting boat traffic. By increasing sedimentation rates and reducing seawater exchange it causes further ecosystem degradation, threatening the region's important mangroves.


Charles Griffiths

The European green crab *Carcinus maenas*, also called the shore crab, is indigenous to the Atlantic coast of Europe and North Africa, but has invaded the coastal waters of South Africa's Cape Peninsula, as well as Australia, Japan, Sri Lanka, Hawaii, and both the Atlantic and Pacific coasts of North America.

The crab is a voracious predator, and has the potential to alter the structure of marine communities by feeding heavily on a variety of invertebrates. It is also considered a threat to shellfish industries, as the adults are capable of eating 30 to 40 clams or mussels per day, and may outcompete commercially important crabs for food and habitat.


Jan Haaga

The North Pacific seastar *Asterias amurensis* is thought to have been introduced to Tasmania, Australia, in the early 1980s, probably through the discharge of larvae in ballast water. By the mid-1990s it had become well established in Tasmania's Derwent River estuary, and soon afterwards it reached Port Phillip Bay on the mainland, where its population quickly grew to approximately 30 million. There are now concerns that the invader will spread to other areas, particularly on fishing gear and mariculture equipment, which have been identified as major vectors of dispersal.

The starfish is an adaptable predator, preferring mussels, scallops and clams but feeding opportunistically on a wide range of food, including other starfish. It therefore poses a severe threat to shellfisheries and mariculture operations, as well as native biodiversity.

The Regional Seas Programmes: Platforms for

A decision by the 22nd UNEP Governing Council in February 2003 set out the elements of a new global strategy for the Regional Seas Programmes. The strategy is based on the principle that the Regional Seas Conventions and Action Plans should be used as regional instruments, contributing to sustainable development.

The Strategic Directions for 2004-2007 aim to enhance the Regional Seas Programmes at the global level, while continuing the implementation of the programmes of work agreed upon by their respective governing bodies. They provide an opportunity to improve efficiency, increase cooperation, and incorporate new elements in future programmes of work.

Once an introduced species has become established in a new area, it is relatively easy for it to spread and invade adjacent areas. Invasive alien species are therefore best addressed as a cross-boundary issue managed at regional level.

The Regional Seas Programme, launched by the United Nations Environment Programme (UNEP) in 1974, has emerged as one of the most globally comprehensive initiatives for the protection of marine and coastal environments. Today, more than 140 countries participate in 13 Regional Seas Programmes established under the auspices of UNEP: the Black Sea, Wider Caribbean, East Africa, south East Asia, ROPME Sea Area, Mediterranean, North-East Pacific, North-West Pacific, Red Sea and Gulf of Aden, South Asia, South-East Pacific, South Pacific, and West and Central Africa. Programmes in the Antarctic, Arctic, Baltic Sea, Caspian Sea and North-East Atlantic also have links to the Regional Seas family.

The Regional Seas Programmes function through Action Plans, in most cases underpinned by strong legal frameworks in the form of Regional Conventions – with fairly general and wide-ranging provisions – and associated technical Protocols on more specific problems. These expressions of political commitment of governments to tackle their common problems collectively make the Regional Seas Programmes ideal platforms to implement international conventions such as the Convention on Biological Diversity (CBD), the IMO Ballast Water Convention, and the FAO Framework for the Responsible Management of Fisheries, all of which have provisions relating to invasive species.

A number of the Regional Seas Programmes have already made progress in taking action against marine and coastal invasives.

- The **Mediterranean** region became the first Regional Seas Programme to develop a dedicated strategy on marine and coastal invasive species when it adopted its "Action Plan concerning species introductions and invasive species in the Mediterranean Sea" in November 2003. The opening of the Suez Canal in 1869 provided a new pathway for the introduction of invasive species into the Mediterranean. The "Lessepsian migrations" – named after the French engineer who designed the canal and supervised its construction – have resulted in some 300 tropical Indo-Pacific species establishing in the oligotrophic waters of the eastern Mediterranean. The main objective of the Action Plan is to promote the development of coordinated measures and efforts throughout the Mediterranean region in order to prevent, control and monitor the effects of species introductions.