



MIT Sea Grant
College Program

COASTAL RESOURCES FACT SHEET

Exotic Species

an ecological roulette with nature

What are exotic species?

Exotic species, also called non-indigenous, or invasive species, are organisms that have moved beyond their natural geographical range of habitat. They represent all phyla, from microorganisms to various plants and animals, both terrestrial and aquatic. Sea Grant is concerned with the increasing number of aquatic exotic species which are entering bodies of water outside of their normal range. Invasions are both intentional and accidental, but the risk is the same. Invasion of non-indigenous aquatic species, according to the 1995 National Research Council's study "Understanding Marine Biodiversity: A Research Agenda for the Nation", is "one of the five most critical environmental issues facing the ocean's marine life".

What are the impacts of foreign introduction?

The impacts of introducing non-indigenous species can be divided into two areas: ecological, and economic. These categories, however, are inter-dependent; an exotic species which has an ecological impact also has an economic one, and vice versa. It is important to note that there are many species introduced each day which do not survive in their new environment and cause no damage whatsoever. But exotic species have the potential to cause far reaching economic and ecological impacts.

•ECOLOGICAL

Every introduction of exotic species that become established results in changes to the receiving ecosystem. Unfortunately, most of the observed effects have been detrimental and irreparable by displacing native species, and altering trophic level structure. Introduced species often prey on many parts of an already established food web or compete with indigenous species for resources such as food or space. Without any natural predators, invaders can threaten or even eliminate indigenous species. They also carry with them the threat of new diseases which can destroy vulnerable native inhabitants. In some areas, native species are on the brink of extinction due to the introduction of an exotic species.

Occasionally, exotic species reproduce with natives and produce hybrids. Hybrids not only change the gene pool of an area, they also simplify an ecosystem. By simplifying an ecosystem, as well as causing population declines and species extinctions, exotic species can reduce biodiversity. Biodiversity is the variation and variety of genes, organisms and species found in an ecosystem. As biodiversity decreases, the vulnerability of an ecosystem to pests and diseases increases. Because the makeup of communities is not always

studied, when biodiversity decreases, it is not noticed. It is important to have naturalist biologists who can identify which species are indigenous and which are not, as well as which have disappeared.

Introductions do not always have a negative impact, however. Exotic species can help an ecosystem by providing a missing link in a failing food chain. Some scientists believe that introductions can also be beneficial by preserving species in cases where they are endangered or threatened in their natural habitats. Sometimes introducing them into a different habitat enables them to survive, and thus preserve biodiversity.

•ECONOMIC

Introduced non-native species may cause widespread destruction by rapidly taking over an area and eliminating economically profitable native species. This can result in enormous spending by state and federal agencies as they attempt to eradicate pests and restore natural species. A study published by the US Congress, Office of Technology Assessment, Harmful Non-Indigenous Species in the United States, finds that the US alone spends hundreds of millions to perhaps billions of dollars trying to repair the damage of harmful exotic species. Numerous other economic sectors may be negatively affected, including agriculture, forestry, fisheries and water use, utilities, and natural areas. Exotic species may cause economic damage by (1) hybridizing with valuable species and producing worthless crossbreeds, (2) carrying or supporting harmful pests, and (3) possibly reducing recreational prospects in an area. Another part of economic impact is one which has social and health consequences as well.

Not only may exotic species import diseases that affect related species, but humans as well. Often cures are costly. The threat of non-indigenous species is their unpredictability. They may be poisonous, serve as vectors for human disease, or create conditions for disease to spread. Invading species may also breed with native species, resulting in dangerous or poisonous hybrids, which humans may unknowingly consume. Again, any cures and preventions may be expensive, and many people might suffer in the meantime.

Some argue that the benefits of introducing exotics are worth the risk. Cultivation of non-indigenous crops and livestock is the foundation of US agriculture. Introduction and cultivation of aquatic species is now believed to be economically profitable, also.

How are they introduced to a new habitat?

There are numerous ways in which exotic marine and freshwater species are introduced, generally associated with human activity. In the past, the aquarium fish culture industry and hobby was the primary source of exotic fishes; releases were both accidental and in some cases intentional. Intentional introductions were also made for sport or food, as well. The two more recent sources of introductions are for the purposes of aquaculture, and via ballast water.

Ballast Water

All cargo ships contain huge ballast tanks. These tanks are filled at ports to help steady cargo-less ships as they travel and emptied once cargo is loaded. Each tank can hold millions of gallons of water containing any and all of the aquatic life found at a port; everything from bacteria and algae to worms and fish have been found in ballast water. As ships travel faster and world trade grows, species are better able to survive the journey, and the threat of invasive species from ballast water increases. The US alone receives at least 21 billion gallons of ballast water each year from around the world, leading to problems like that of the well-known **zebra mussels**.

• Eurasian **zebra mussels**, *Dreissena polymorpha*, (Pallas), were introduced via ballast to the Great Lakes in the mid 80s. Able to thrive, the mussels spread throughout the Lakes, as well as the Mississippi and Hudson River. The mussels have had a number of negative effects: because they rapidly reproduce, they have clogged up water and drain pipes at municipal water supplies and at industries. They are expected to cost the US \$5 billion in control efforts and reparation. They have displaced native freshwater mussels of the area, and drastically altered the food web. The zebra mussel population continues to grow and no immediate end is foreseen.

Another example of an exotic species which has invaded an area after introduction via ballast-water is the American comb jelly, *Mnemiopsis leidyi*. A comb-jelly is a small, marine invertebrate superficially resembling a jellyfish. It is carnivorous, and preys on tiny aquatic animals, such as plankton. Transported in ballast possibly from New England, the American comb jelly invaded the Black and Azov Seas in Europe. The rapidly expanding population preyed so heavily on plankton that its biomass declined by as much as 90 percent. Anchovies, which feed on plankton, sharply declined as well, causing local fisheries to suffer.

Ballast tanks are filled and emptied off the coastline, in estuaries and bays where freshwater and salt water meet. Thus species picked up during a filling are able to survive when emptied back into conditions similar to their native community. If, instead, ballast was emptied in the ocean and filled with marine water, species would be much less likely to survive in the foreign location.

Aquaculture

Aquaculture, as defined in the USDA National Aquaculture Development Plan, is the "manipulation of marine or freshwater organisms and/or their environment before eventual release, harvest, or capture; the controlled cultivation and harvest of aquatic animals and plants". In order to control the cultivation of fish or other aquatic species, one of two different methods are generally used. The species are either released freely into regional water, or else they are contained in a closed or open circulation pen. In the latter case, reproduction, food, growth, and spread can be

controlled, but any resulting changes in the conditions of the environment cannot. If released freely, a species can affect the ecosystem in the ways already mentioned, such as competing or breeding with the indigenous species. Proponents of aquaculture, however, cite many reasons why it is the next market that should be expanded and explored. Throughout the world, the demand for fish and all seafood is increasing as consumption increases. However, the supply of fish from the wild has declined as they are over-exploited, and their habitats polluted and destroyed. Thus, supporters maintain that now is the time to encourage aquaculture.

Because "fish [and other aquatic species] have certain advantages over land animals in their suitability for farming", aquaculture is more efficient and profitable than agriculture. They are more efficient at converting food to flesh because they do not have to maintain their body temperature (they are cold-blooded), nor do they have to support their weight. Because the farms where these species are raised have the added dimension of depth, there are greater yields per acre when raising a species in water as opposed to on land.. If regulated strictly, it is believed that aquaculture could provide food and profit without negative effects. While the support for aquaculture is growing, some, like Jim Carlton, professor of marine science at Williams College, feel that introducing exotic species for any purpose is too great a risk. "Whenever we introduce a new species, it's an ecological roulette with nature...We'd rather not play that game."

Conclusion

The role and impacts of exotic species introductions, both deliberate and accidental, are not well-documented in the marine environment. In order to begin to predict the behavior of an ecosystem when an exotic species is introduced, basic information about indigenous species and their natural history, community structure, and biodiversity of regional systems is essential. An often neglected aspect in the consideration of exotic species introductions is the integration of economic and ecological impacts of introduced species that may occur under scenarios where species "escape" or behave unexpectedly in ways that may disrupt normal ecosystem functions. For example, the introduction of diseases along with oysters has closed some areas permanently, whereas it may be possible to release sterile, genetically engineered species. Adoption of a precautionary approach by regulators that has realistic goals, incorporates scientific information, and provides opportunities for those developing aquaculture enterprises, will be beneficial to all.

Further Readings

Massachusetts Institute of Technology Sea Grant College Program 1996. *Abstracts from the Exotic Species Workshop: Issues Relating to Aquaculture and Biodiversity*, MITSG, Cambridge, MA 57 pp.

National Research Council 1995. *Understanding Marine Biodiversity*, National Academy Press, Washington, D.C. 114 pp.

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