What is invading Maine's coastal waters?

The Asian shore crab.[1] Dead man's fingers.[2] Bonamia oyster disease.[3] These are just a few of the 33 non-native species that have been documented in marine waters and shorelines along the Maine coast in a preliminary count.[4] While many non-native species are unable to survive, reproduce, and overtake native plants and animals in Maine's coastal waters, those that are successful become known as "invasive species."

The white crust covering on this kelp is a colony of small animals known as "lacy crust bryozoans" (Membranipora membranacea)*. In late summer and fall, these animals grow in dense mats, covering kelp and decreasing its growth. These animals have become the most abundant species living on kelps in Maine.*

*Known by names such as "oyster thief," "green fleece" and "dead man's fingers," this alga (*Codium fragile *ssp.* tomentosoides*) is believed to have been introduced to Boothbay Harbor in the 1960s through oyster aquaculture. In the Gulf of Maine, this species displaces kelp beds and has had impacts on shellfish and other marine life, aquaculture, and recreation.*

Invasive species are plants, animals, and other organisms that have been introduced by human activities and develop abundant, widespread populations where they did not occur historically. In marine environments, invasive species have the potential to cause harm by displacing or preying on native organisms, impacting habitat, or introducing new parasites and diseases. With more potential invaders making their way up the East Coast and entering the U.S. from other countries, marine invasive species present a growing challenge to the state of Maine.

What are the costs?

According to Pimentel and others in the January 2000 issue of *Bioscience*, the U.S. spends $137 billion per year to deal with invasive species in all environments. Less information exists on the economic damage caused by marine invasions, but examples suggest that the costs are significant. For example, on the Pacific Coast, monitoring and control of the Mediterranean green seaweed (*Caulerpa taxifolia*) and Chinese mitten crab (*Eriocher sinensis*) cost the state and federal governments $2.3 and $1 million, respectively, between 2000 and 2001.[5]

Marine invasive species can negatively impact marine industries by fouling boat hulls, docks, fishing nets, and aquaculture pens; outcompeting commercially harvested species; and damaging wooden structures (such as piers and boats). Diseases that can be associated with certain non-native species pose human health risks. Other costs include expenses related to the research, prevention, and control of marine invasions. There are also undocumented costs of invasions to marine ecosystems.

Photos by Marney Pratt, Bowdoin College.

How do marine invasive species get into Maine waters?

New species can arrive in Maine via several vectors, or pathways. Historically, shipping has accounted for most introductions into U.S. waters. Species can "hitchhike" from one region to the next when they attach to ship hulls or are transported in ballast water, which is pumped into empty or unfilled ship hulls to provide stability at sea. Ships may pump millions of gallons of ballast water into their hulls at foreign ports. This seawater, along with potentially more than one billion foreign organisms it carries,[6] can be discharged into Maine harbors to make room for new cargo.[7]

Pathways unrelated to shipping have also been responsible for marine introductions. A wide variety of non-native marine species are sold at pet and aquarium stores and over the Internet. In some cases, these species have escaped or have been released into marine waters by pet owners or the aquarium industry. Marine introductions also have occurred through the mishandling of non-native marine species by research and educational facilities, such as universities and public aquariums, which buy or collect non-native marine species.[8]

The aquaculture and seafood industries play substantial roles in marine invasions.[9] The U.S. imports 2 billion metric tons of seafood each year,[10] and both the types and origins of food species are becoming more diverse, opening new avenues for introduction. Boats, fishing gear, and any marine material that is relocated, such as barges, dry docks, and transport trailers, can transport organisms to new areas. Finally, some non-native species are introduced intentionally to control another pest species or as a food source.[11] Currently, non-native species are introduced intentionally in the U.S. only after studies have determined that they are unlikely to become invasive and likely to serve a beneficial purpose.

In Maine, it has been estimated that nearly 400 businesses import live or frozen non-native marine species.[12] One study conducted in Massachusetts found that most importers of non-native marine organisms engage in potentially risky behaviors that could increase the likelihood of non-native species introductions into the Gulf of Maine.[13] Many importers reported discharging tank water used to hold non-native species directly into local bodies of water, although some treat or filter the water before disposal. The study also found that some seafood businesses in New England sell non-native species to local fishermen for bait, and others wash down trucks that carry imported species in close proximity to water.

Maine seaweed, used for packing live bait, seafood, and aquaculture products, carries hitchhikers from this state to other locations and is implicated in several marine invasions on the West Coast.[14] There are many existing pathways by which marine invasions may occur, and additional mechanisms for introduction could become a threat as population, trade, boating, sales of species over the Internet, and shipping traffic increase in Maine.

*Orange or red sheath tunicates (*Botrylloides violaceus*).*

These colonies of non-native "sea squirts" were photographed during a scientific survey of floating docks in northeastern U.S. ports in 2003. Ports and harbors are potential hotspots for marine invasive species because activities that can transport and potentially introduce new species can be concentrated in these areas, including ballast water exchange, hull cleaning, bait and seafood transport, and boat travel.

*The colonial tunicate (*Didemnum *sp.) to the right is native to the North Sea and is spreading rapidly in George's Bank and some waters in Maine.*
Photos by Gretchen Lambert, courtesy of MIT Sea Grant College Program.

How is Maine addressing the threat of marine invasive species?

Maine is addressing marine invasions on several fronts, including agency actions, regulations, and participation in local and regional efforts.

Maine Plan for Managing Invasive Aquatic Species

Maine's Action Plan for Managing Invasive Aquatic Species, adopted in 2002, calls for understanding the ecology and impacts of species that have the greatest potential to disrupt Maine's commercial fisheries and marine infrastructure. Some of the tasks identified for managing the threat of marine invasive species include working with the U.S. Coast Guard and other entities to make sure that ballast water is controlled; identifying alternative seaweed packing materials; developing a database of companies and organizations involved in the transport and trade of non-native organisms; and establishing suspicious species reporting procedures.

Maine Department of Environmental Protection

The Maine Department of Environmental Protection (DEP)'s Marine Program is defining which marine species will be considered Aquatic Nuisance Species by this agency. To make this determination, DEP is examining species historical collection records for Maine, and examining the roles of species in question within marine and estuarine communities.[15] DEP will not consider species to be Aquatic Nuisance Species if they were introduced to Maine many years ago, have become integrated into the marine community (such as the green crab, *Carcinus maenas,* and common periwinkle, *Littorina littorea*) or if they are hard to identify.

Maine Marine Invasive Species Working Group

The Maine Marine Invasive Species Working Group has formed to collaborate on marine invasive species issues and identify priorities for education, research, monitoring, and management. The working group is comprised of representatives from: Casco Bay Estuary Project, Census of Marine Life, Cornell University, U.S. Environmental Protection Agency, Friends of Casco Bay, Gulf of Maine Research Institute, Maine Coastal Program/Maine State Planning Office, Maine Department of Marine Resources, Maine Sea Grant College Program, MIT Sea Grant College Program, The Ocean Conservancy, University of Maine, and Wells National Estuarine Research Reserve.

Maine Department of Marine Resources

The Maine Department of Marine Resources (DMR) conducts surveys for green crabs (*Carcinus maenas*) and collects reports of exotic organisms. DMR is also working with the U.S. Coast Guard and regional groups in managing ballast water discharges; compiling a list of Maine facilities that hold live marine organisms and have the potential for accidental introductions; examining ways to prevent the spread of species from Maine to other regions; and proposing changes to regulations regarding the transport of aquaculture species within state waters. DMR also regulates the importation of live marine organisms to minimize the entry of diseases, parasites or any organisms that may be dangerous to native marine life.[16]

Northeast Aquatic Nuisance Species Panel

Through several representatives on the federal Northeast Aquatic Nuisance Species (NEANS) Panel, Maine works with other states to address the spread of marine invasive species within the region. NEANS was established in 2001 as a regional, coordinated effort to address the spread and threat of Aquatic Nuisance Species in the Gulf of Maine and in freshwater systems of the northeastern U.S. and Atlantic Canada.

*Rocks and dense mats of seaweed serve as ideal hiding places for species introduced to Maine such as the Asian shore crab (*Hemigrapsus sanguineus*), above, found on the shores of Lowell Cove, Harpswell, Maine.*

Photo by Tracy Hart; screened photo by Cheryl Daigle.

Top: *Scientists and volunteers survey native and non-native species attached to the bottom of floating docks during the 2003 Rapid Assessment Survey. The survey included three marinas in southern Maine. For more information about species found during the survey, visit http://massbay.mit.edu/exoticspecies.* Photo by Paul Dyrynda, University of Wales, Swansea. Courtesy of MIT Sea Grant.

Middle: *A graduate student investigates under rocks for Asian shore crabs* (Hemigrapsus sanguineus) *during a survey conducted in Harpswell, Maine.* Photo by Tracy Hart.

Bottom: *Transects are one method used to track marine invasive species in intertidal areas. Divers can also conduct transects underwater.* Photo by Natalie Springuel.

How can Maine citizens help stem the invasion?

Eradicating marine invaders once they are established has proven to be extremely costly and usually impossible, making prevention the best tool. The key to preventing new marine introductions is identifying and minimizing the pathways by which marine invasive species arrive and spread in Maine. Through actions such as proper disposal of food, trash, and waste water and proper handling of non-native species, Maine citizens and businesses can minimize the risks of introducing new marine species:

- Discard bait and seafood products and containers in the trash or compost only. Dispose of shellfish and shellfish waste (e.g. lobster and clam shells) in trash receptacles or composting facilities.
- Clean boat hulls thoroughly before launching in a new area (even within the state) and do so away from shore to prevent runoff into the water.
- Avoid buying organisms that are potential invaders through pet or aquarium shops or the Internet.
- Never release a non-native aquatic pet, or the water in which it is held, into a waterway, storm drain, sewer system, or near the shore. The release of some species is illegal.
- Support efforts to strengthen state and federal laws on the import and export of marine organisms.
- Support legislation to provide funding for invasive species research, monitoring, management, education and prevention.
- Learn more about marine invasive species and participate in public education programs on the topic.
- Join a citizen monitoring group, such as the Maine Shore Stewards Program.

**If you find any unusual organisms,
check the MIT Sea Grant Web site
http://massbay.mit.edu/exoticspecies/exoticmaps/index.html
and Hitchhiker's Guide to Exotic Species
http://massbay.mit.edu/images/HHall.pdf
to identify the organism.**

**If your suspect matches one of the species listed, please call
Pete Thayer, Maine Department of Marine Resources,
(207) 633-9539,
so that state officials may better track the appearance
and spread of invasive species in Maine.**

What actions are still needed in Maine?

Addressing marine invasive species issues is difficult due to the large number of pathways by which species can be introduced into marine waters and the presence of environmental factors, such as water currents, that make it difficult to halt the spread of introduced species. Yet, more actions are needed in Maine to minimize the impacts of established invasions and prevent new ones. These actions include developing a rapid detection and response system for new invasions, funding marine invasive species research, monitoring and management, inventorying activities that can lead to new species introductions, and educating citizens and business owners about the risks of various behaviors.

*Green crabs (*Carcinus maenus*) have been touted as an example of the need for prevention when dealing with marine invasive species. Despite ongoing eradication attempts, the green crab has become a dominant species in Maine's intertidal zones and has had significant effects on Maine's soft-shell clam industry.*

Photo by Cheryl Daigle. Screened green crab illustration by Kathy Villarreal.

Glossary of Terms

Introduced species are those 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.[17] Introduced species are also known as non-native, exotic, or alien species.

An **invasive species** is an organism that is introduced to an area where it is not native, and where it successfully invades and disturbs natural ecosystems, displacing indigenous and endemic (native) species.[18] An invasive species can also be defined as an introduced species that outcompetes native species for space and resources.[19] According to some definitions, these organisms also must have the potential to cause harm. U.S. Executive Order 13112 (1999), for example, defines an invasive species as an alien species whose introduction does, or is likely to, cause economic or environmental harm or harm to human health.

Aquatic nuisance species are non-native aquatic plants or animals that threaten the diversity or abundance of native species, the ecological stability of infested waters, or the commercial, agricultural or recreational activities that depend on such waters.[20]

For more information on marine invasive species, check out the following Web sites:

Smithsonian Institution Marine Invasions Research Lab
www.serc.si.edu/labs/marine_invasions

National Ballast Information Clearinghouse
http://invasions.si.edu/nbic

Sea Grant Nonindigenous Species
www.sgnis.org

Massachusetts Bays Program
www.massbays.org

The Global Invasive Species Database
www.issg.org/database/welcome

Sea Grant National Aquatic Nuisance Species Clearinghouse
www.aquaticinvaders.org

MIT Sea Grant Center for Coastal Resources
http://massbay.mit.edu/exoticspecies

Northeast Aquatic Nuisance Species Panel
www.northeastans.org

Maine's Marine Invasion Forum
www.cascobay.usm.maine.edu/invasives.html
www.seagrant.umaine.edu/extension/coastcom/invasive.htm

Maine Department of Marine Resources Asian Shore Crab Site:
www.state.me.us/dmr/rm/asian_shore_crab.htm

Endnotes

1. Asian shore crab (*Hemigrapsus sanguineus*).

2. Dead man's fingers (*Codium fragile* ssp. *tomentosoides*), also known as green fleece. An alga.

3. Bonamia oyster disease (*Bonamia ostrea*), a pathogen.

4. Carlton, J. T. 2004. A checklist of the introduced marine and estuarine organisms on the coast of Maine, U.S.A.: A preliminary checklist. Unpublished. Williams College, Mystic, CT. www.seagrant.umaine.edu/documents/pdf/invchk.pdf

5. Carlton, J.T. 2003. Introduced Species in U.S. Coastal Waters: Environmental Impacts and Management Priorities. Arlington, VA: Pew Oceans Commission. www.pewoceans.org/reports/introduced_species.pdf

6. A single large cargo carrier can release over one billion organisms into a harbor when it dumps its ballast water. Smith, L.D. 2002. Written testimony to U.S. House of Representatives Subcommittee on Environment. www.house.gov/science/hearings/ets02/jun20/smith.htm

7. Smith, L.D., M.J. Wonham, L.D. McCann, G.M. Ruiz, A.H. Hines, and J.T. Carlton. 1999. Invasion pressure to a ballast-flooded estuary and an assessment of inoculant survival. Biological Invasions 1: 67-87.

8. It is believed that the successful invasion of the lionfish (*Pterois volitans*) from the Indian and West Pacific Oceans into coastal waters from Florida to North Carolina occurred as the result of aquarium release. Hare, J.A., and P.E. Whitfield. 2003. An integrated assessment of the introduction of lionfish (*Pterois volitans*/miles complex) to the western Atlantic Ocean. NOAA Technical Memorandum NOS NCCOS 2. http://shrimp.ccfhrb.noaa.gov/research/reprint1541.pdf

9. Weigle, S.M., L.D. Smith, J. Pederson, and J.T. Carlton. 2005. Assessing the risk of exotic species introductions via the live marine species trade. Conservation Biology, in press.

10. Smith, D. 2004. Pathways for marine invaders to New England. Presented at Maine's Marine Invasion forum, May 5, 2004, University of Southern Maine, Portland, ME. www.cascobay.usm.maine.edu/invasforum.html

11. U.S. Environmental Protection Agency. Introduced Species. Mid-Atlantic Integrated Assessment. www.epa.gov/maia/html/intro-species.html

12. Weigle, S.M., L.D. Smith, J. Pederson, and J.T. Carlton. 2005. Assessing the risk of exotic species introductions via the live marine species trade. Conservation Biology, in press.

13. Weigle, S.M., L.D. Smith, J. Pederson, and J.T. Carlton. 2005. Assessing the risk of exotic species introductions via the live marine species trade. Conservation Biology, in press.

14. Carlton, J.T., and A.N. Cohen 1998. Periwinkle's progress: the Atlantic snail *Littorina saxatilis* (Mollusca: Gastropoda) establishes a colony on a Pacific shore. Veliger 41: 333-338.
Cohen, A.N., J.T. Carlton, and M.C. Fountain. 1995. Introduction, dispersal and potential impacts of the green crab *Carcinus maenas* in San Francisco Bay. Marine Biology 122: 225-237.
Lau, W. 1995. Importation of baitworms and shipping seaweed: vectors for introduced species? Pages 21-38 in Environmental issues: from a local to a global perspective, Environmental Sciences Senior Seminar (D. Sloan and D. Kelso, eds.) University of California, Berkeley.

15. In the context of standards for classifying estuarine and marine waters under MSRA Title 38 Article 4-A.

16. Maine Department of Marine Resources Chapter 24 - Importation of Live Marine Organisms. www.state.me.us/dmr/aquaculture/aqtaskforce/briefing/Chapter24.pdf

17. Carlton, J.T. 2003. Introduced Species in U.S. Coastal Waters: Environmental Impacts and Management Priorities. Arlington, VA: Pew Oceans Commission. www.pewoceans.org/reports/introduced_species.pdf

18. Websters Online Dictionary: www.websters-online-dictionary.org/definition/english/In/Invasive+species.html

19. A Glossary of Relevant Terms for Teachers and Students: http://oceanlink.island.net/biodiv-web/glossary.htm

20. Aquatic Nuisance Species Program: www.psat.wa.gov/Publications/manplan00/06_ans.pdf

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This fact sheet was produced by the Maine Sea Grant College Program in coordination with the Maine Marine Invasive Species Working Group. Maine Sea Grant supports marine science research and outreach activities to promote the understanding, sustainable use, and conservation of ocean and coastal resources. To obtain additional copies of this publication, please call 207-581-1435, or visit our Web site at www.seagrant.umaine.edu.

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Edited by Catherine Schmitt
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Printed with support from the Casco Bay Estuary Project and Maine Sea Grant.

Sea Grant Maine

Casco Bay Estuary Project

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