PURE GENIUS

GLOBE-TROTTING HITCHHIKERS: INVASIVE SPECIES ASSAULT U.S. WATERS

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POSTING IN **DESIGN**

NON-NATIVE ORGANISMS CREATE ECONOMIC, ECOLOGICAL AND SOCIAL PROBLEMS IN THE UNITED STATES. WILL NEW REGULATIONS,

SCIENTIFIC FINDINGS AND INNOVATIVE SOLUTIONS WIN THE ALL-OUT WAR AGAINST THESE BORDER-CROSSERS?

Special Feature: The **Borders** Issue

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(http://i.bnet.com/blogs/3842473545_ce8e78d4aa_z11.jpg)

A container ship from China pulls into the port of San Francisco. Attached to its hull, or living in the ship's nooks and crannies below the water line, are tens of thousands of organisms, many of which are native to Chinese waters. The ship begins to unload its containers. It's only in port for about 24 hours. But during this time, a game of probability begins, and it has nothing to do with the products that will

soon be trucked or sent by rail to Wal-Marts and Home Depots across the country.

“If you think about this tiny microscopic thing in a new water system, the chance of it finding a mate and finding a food source is pretty small,” said Chris Brown, who manages the Marine Invasions Lab at the Smithsonian’s West Coast environmental research center. "Most things that come in probably don’t even survive. But it does happen.”

All it takes is one or two organisms from a particular species to cause trouble. And keep in mind that there are about 10,000 vessels arriving in California’s ports alone every year. In this age of globalization, as ships cruise around the world with our microprocessors and minivans, petroleum and prosecco, invasive species have become a serious problem--economically, ecologically and socially.

“There is an economic impact of an enormous magnitude,” said Tuck Hines, director of the Smithsonian Environmental Research Center (SERC) on the Chesapeake Bay. “It’s everything from what’s growing on the bottom of your sailboat, to what’s fouling your power plant cooling intake systems, to the diseases that are preventing fisheries from being maintained, to red tides, to fish gobbling up other fish. It’s almost an endless array of ecological and economic impacts at almost every level.”

A species is considered invasive if it has reproduced and is spreading and causing harm. Aquatic invasive species can out-compete native species, damage biodiversity, threaten endangered species, damage

habitat, change food webs, and alter the chemical and physical marine environment. Some of the individual invaders don't cause problems, but others become major nuisances. Collectively, the damage to the environment is often irreversible.

Freeloading on ships--bobbing around in ballast water or fouling on ships' hulls--these invaders have been determined to be the cause of a range of calamities, from the strains of cholera that caused an epidemic in Peru in 1991, killing more than 10,000 people by 1994; to toxic algae that causes red tide, which can lead to massive kills of marine life. But thanks to some soon-to-be-adopted regulations, new scientific findings and innovative solutions, an all-out war against these border-crossers is about to begin.

Girding for battle

The poster child for invasive species is the zebra mussel, which is native to Eastern Europe but was introduced to the U.S. through the Great Lakes in the late 1980s. These filter feeders attach to just about any hard surface in large numbers, from water intake pipes to irrigation ditches, displacing native aquatic life and causing massive infrastructure damage. The water pipes in Michigan were so clogged with zebra mussels that they completely blocked the flow of water. According to the International Maritime Organization (IMO), the resulting cost to the United States between 1989 and 2000 exceeded $750 million.

It's often possible to pinpoint the region of the world where a species originated through DNA sequencing and understanding its native

habitat. But it's much more difficult to track these species back to a particular ship, or determine whether they came from a ship at all. So there's some detective work involved, but the consensus among experts is that many of these species are coming in at ports. They also come across our borders through the aquarium trade, scientific introduction, aquaculture, the live food industry and fishing bait releases.

"The more things get moved around, the more homogenized everything gets," Brown said. At the end of the day, invasive species affect diversity, aesthetics and the delicate balance of the ecosystem. And not too far in the future, they will affect the cost of many of the goods on our shelves.

Cleaner water, fewer problems?

Ballast water, used to stabilize vessels at sea, can carry bacteria, microbes, small invertebrates, eggs and larvae of countless species. Currently, ships are required to exchange ballast water at sea, which creates a habitat mismatch -- it's unlikely that any coastal organisms will be able to survive in the ocean, and vice-versa. So a ship coming from overseas to pick up goods in Baltimore would have to discharge all its water a couple hundred miles off the coast and take in new ocean water, before it empties its ballast in the port. The exchange can take as long as two days, and it occurs when the ship is moving.

Every year, millions of tons of ballast sourced in foreign waters are released into U.S. waters. The Coast Guard, which has a presence at most U.S. ports, examines ships, sometimes randomly. Those that are

in violation can be fined anywhere from $500 to $33,000 a day. While ballast exchange removes the majority of organisms, a small amount of water may still include countless microscopic critters. So this method is not an ideal solution and has mostly been viewed as a stop-gap measure until stricter standards are enforced.

The other type of free ride organisms can take is on the hull of a ship, or in crevices, notches and areas around the intake systems or propellers of the ship. These species can be anywhere from microscopic to one- to two-inch mussels and barnacles. Shipping companies have some financial incentive to keep their hulls barnacle-free, because fouling creates drag, burning more fuel and slowing it down. But there are plenty of other places for critters to hide, which more or less protect them during the voyage across the ocean. Researchers say biofouling is responsible for about 60 percent of California's invasive marine life.

"Treating the side of your ship to prevent things from fouling has probably been around from millennia," said Chris Scianna with California's Marine Invasive Species Program, who has been working on some of the country's strictest hull fouling standards. "Today, the paint usually has a biocide in it that prevents the organisms from attaching." The proposed regulations would require each vessel to have a biofouling management plan, under which they would have to detail the coatings and technologies used to prevent fouling.

Catching critters before they destroy

Since invasive species don't go through customs, there's a complicated

web of regulations that govern shipping activity. The good news is that the three major governing bodies involved -- the IMO, the Coast Guard and the U.S. Environmental Protection Agency (EPA) -- are close to releasing similar standards (although California and New York laws are stricter than any of the proposed federal or international standards). The IMO's Ballast Water Management Convention and the Coast Guard regulations are both close to adoption, and the EPA's new standards will be finalized in November, taking effect in December 2013.

Since 1990, the Coast Guard has had regulatory authority over ballast water discharges, but it's taken more than two decades for stricter standards to be implemented. Initially, ballast water exchange was a voluntary program, but it's been mandatory since 2004. The Coast Guard is continually reviewing data, funding research and trying to determine the next step. And now, it's clear that the next step is treatment of ballast water. Today "we have the technology," said the Coast Guard's Ryan Allain, chief of the Environmental Standards Division.

According to Allain, these treatment systems range from about $300,000 to more than $1 million, and roughly 60,000 vessels will be affected by the regulations.

The shipping industry has been expecting to install ballast water treatment systems for nearly a decade. But because all the standards are not yet set, companies have been standing by to learn exactly when—and to what extent--they will have to comply. Some new ships have

been built with the systems, in anticipation of the new rules, but according to experts, the industry at large is not thrilled about the beefed up regulations and new expenses, especially in an economy that has many ships sitting in port and waiting to be hired. The cost, inevitably, will be passed along to the consumer.

In the meantime, the pending regulations have sparked innovation and development from start-up companies and the drinking and waste-water treatment field.

“We know how to clean water,” SERC’s Hines said. “But when you’re talking about tens of thousand of metric tons, and you have a turnaround time of 24 hours when ship’s in port, it’s a challenge to do it efficiently.”

What's really harmful?

As the industry waits for rules to go into effect, a handful of independent organizations around the world are testing ballast water treatment systems and providing data on performance.

“The idea is to be prepared for Coast Guard and EPA rules,” said Mario Tamburri of the University of Maryland’s Maritime Environmental Resource Center (MERC). “Monitoring compliance for ships will be really hard. So you test ahead and then just make sure that the systems are one the ships and are being used.”

Many of the new systems use filtration, while others use technologies ranging from biocides to ultraviolet light. Today, there are about 20 systems recognized by the IMO. Most treatment systems work as the

ballast water is being taken up and are activated when a crew member pushes a button to ballast the system. So if a ship is coming from a freshwater port in China, any ballast water will be treated on uptake in China. When it's discharged in San Francisco, the water will have already been treated to reduce the number of invasive species. This will make ballast exchange unnecessary.

MERC works off a barge in the Chesapeake that allows testing in different temperatures and with different levels of salinity. The organization is also developing a searchable database of ship discharge regulations for ports around the world so ship operators and crews understand the rules they are facing in various ports.

In testing the systems, Tamburri's team of engineers, chemists, toxicologists and biologists are often asking questions that he said have never been asked before. "If a regulation says you have to have less than 10 live organisms per mil of water, how do you measure it? And for algae, how do you know if it's alive or not? For bigger things, you can tell if they're moving, or if their heart is pumping. But for microscopic ones, how do you know if it's really alive?"

The Venturi Oxygen Stripping System is a treatment system that Peter McNulty designed and patented in California. The system essentially removes the oxygen that most marine organisms need to live. An ancillary benefit is that the low-oxygen environment also protects the ship's ballast tank coatings against corrosion, which shipping companies like because it slows down rusting.

"The objective isn't to completely sterilize the water," McNulty said.

“We’re just trying to stop the spread of invasive species.” He said the systems cost $300,000 to $1.5 million depending on the size, and while they are designed to last five years, he admitted he wasn’t sure how long they will hold up. So far, a few major shipping companies -- Germany’s Hartmann and Russia’s Sovcomflot -- have become customers.

McNulty said it’s been nearly a decade since he designed this system, in anticipation of new regulations, and he said he couldn't have guessed it would have taken so long. “The Invasive Species Act was passed 22 years ago,” he said. “Part of the problem was that there had never been a water-treatment challenge where you are sterilizing natural water in the confines of the engine room of the ship, with very few people to operate it, and a prohibition on any toxicity.” The scale of these systems is staggering: Imagine, he said, a sewage treatment plant or a drinking water plant for 200,000 people and you’ve got an idea of the size.

Beyond filtration systems, it seems there is still room for innovation. “From what I know, there are all kinds of devices out there that can analyze water,” Allain said. “We have things that can tell us the oil content of water, that tell us if a ship is discharging oil. But it’s been hard to get a device developed that can tell us the presence of some type of invasive species in the ballast of a ship.”

Increasing accountability

The attack on invasives also involves reporting and analytics. SERC has been monitoring marine invasions in California waters for more

than a decade, which enables researchers to look at patterns of invasions along the entire West Coast, from San Diego into Alaska. Results show that many of the invasive species in western North America are coming from California ports and spreading to other states. Of 257 non-native marine species established in California, 59 percent of them had first been recorded in San Francisco Bay and then spread up and down the coast by other vessels, often recreational boats.

While it's evident that California is a major entry point, it's not clear if that's because there is more shipping activity and recreational boating along the coast (spreading species to non-native habitats) or because the ecosystem is more susceptible. It's also hard to know if the numbers of invasive species are climbing today because there are more species infiltrating our waters, or simply because they are now being studied and documented more. What is clear is that there are steps that can be taken by the shipping industry to reduce the likelihood of critters hijacking their way to the United States.

This spring, SERC will launch a national database of about 500 marine invasions. Called the National Exotic Marine and Estuarine Species Information System (NEMESIS), the database identifies which species have been reported, their current population status, and when, where and how (if it's known) they invaded. It also summarizes information on the known impact of each invader.

Another resource is the National Ballast Information Clearinghouse (NBIC), a joint program of SERC and the Coast Guard. This database

includes information from ballast water reporting forms from more than 100,000 ships that have come to the United States from overseas. Collecting and analyzing this ballast water data also helps reveal patterns, which lead to best practices for commercial vessels. “Every two years we report this through the Coast Guard to Congress,” Hines said. “When ballast exchange was voluntary, our data showed it was only about 50 percent compliance. So it was made mandatory. Now, compliance is about 90 percent.”

When a species does take hold, there are a variety of ways to eradicate it, such as using heat and freshwater treatments. But other approaches are surprisingly low-tech.

Wakame, or Asian kelp (the kind that’s in miso soup), is one of the species targeted in an ongoing eradication effort. “It’s on the top-10 invader list,” Brown said. “It’s super fast growing, it can get really big, it takes up space and it will outcompete all the native algae.”

The kelp had invaded Southern California and Monterey Bay, but it didn’t show up in San Francisco Bay until two years ago when it was discovered on a dock. Since then, more than 150 volunteers have worked to eliminate it from marinas in the bay.

“The volunteers manually pull it out,” Brown said. “It’s labor intensive, but it works.”

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- The dirty side of economic booms: smog knows no borders (http://www.smartplanet.com/blog/pure-genius/the-dirty-side-of-economic-booms-smog-knows-no-borders/)

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