



aquatic INVASIONS!

A Menace to the West

A Toolkit Linking
Science, Community, and
Action through Education



aquatic INVASIONS!



About This Report

This toolkit is for use in non-formal science centers in the Western region of the United States. It is one component of the **Aquatic Invasions! A Menace to the West** package of curricula and outreach materials put together by the West Coast Sea Grant Programs.

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Overview

Introduction

The **Aquatic Invasions! A Menace to the West Science Center Toolkit** focuses on the global issue of aquatic invasive species (AIS). These species and evidence of their impact are in your visitors' backyards, communities and coastlines. The topic of AIS offers a hands-on opportunity to explore a local issue with global implications. The dynamics of invasion and mechanisms of impact are also the basis for effective strategies for engaging the public in citizen science.

The goal of **Aquatic Invasions! A Menace to the West Science Center Toolkit** is to provide interpreters and naturalists with relevant and engaging resources on the topic of aquatic invasive species that convey your conservation messages. The resources of this toolkit are suitable for both classroom and discovery cart engagement.

The Issue

Today, an estimated 50,000 species have been introduced into the United States. Most of these species are not considered invasive, but by one calculation, those that are invasive may cause \$138 billion each year in economic and ecological damages. Purely aquatic species make up a few billion of this, but impacts in uplands often directly or indirectly affect aquatic environments.

Aquatic invasive species are organisms that:

- live in direct association with fresh, estuarine or marine waters
- have been transported by people outside their native range
- impact economic, ecological or human health

Aquatic invasive species represent the most insidious form of water pollution. Once a "spill" has taken place, be it ballast water discharge or a well-intentioned student releasing a classroom aquarium pet, there is usually no going back. The initial event may appear innocuous, but unlike chemical pollution, AIS begin to multiply, move and directly consume or displace native organisms and damage water resources.

An example of this phenomenon is the introduction of the European Green Crab, first introduced to the United States with sailing ships in the mid 1800's and later introduced to the West Coast in 1989 with seaweed packaging of lobsters or baitworms. Once introduced, they rapidly spread

along the coast moving with the currents during their larval stage. Green crabs out compete native crabs for food and significantly impact clams, smaller crabs and young oysters that they voraciously consume.

Once established, an aquatic invader population is usually permanent. Either the astronomical price tag or difficult logistics make “clean up” or eradication of AIS impossible; at best managing established species is the only option. For this reason, the most effective and cost-efficient way to deal with an invasive species is to prevent its introduction, while supporting and maintaining healthy ecosystems that are more likely to resist new introductions.

Prevention includes:

- never releasing organisms into the wild (find a new home for an unwanted pet and the associated algae or plants; return them to a pet store or rescue center; freeze any plants or algae for 24 hours before disposing in a sealed plastic trash bag; select species that are not invasive when picking a pet, plants or seaweed)
- cleaning all gear after hiking, fishing or boating especially when going between different water bodies or shorelines
- planting native vegetation in your garden and ponds

Not all non-native species are harmful; only a small percentage of them become invasive and costly to the environment and economy. They tend to share characteristics that make them very effective invaders. They:

- tolerate and are adaptable to a wide range of environmental conditions
- grow quickly and reproduce quickly producing lots of offspring
- live in large groups
- are associated with human activities that spread them further or enhance their population

Aquatic invasive species are a global problem. When our native species are transported elsewhere, some become invasive and can cause a great deal of damage.

Aquatic Invasive Species Impacts

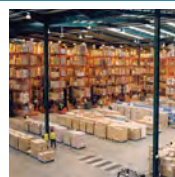
Environmental Impacts	Economic Impacts	Wildlife and Public Health
ecosystem disruption	municipal & industrial water supply	disease epidemics
predation	power plant cooling	viruses
parasitism	commercial fisheries	parasites
competition	recreational activities	bacteria
introduced pathogens	tourism	
hybridization	aquaculture & agriculture	

Pathways: the road to invasion

Species have always moved from place to place through natural pathways such as migration and dispersal mechanisms including wings, wind and water. In today's interconnected world, species can move from place to place including great distances through human created pathways, and identifying those pathways is a crucial element in preventing the introduction of potentially harmful organisms. Human created pathways can include large and global means like cargo ships and agriculture, but also individual actions such as aquarium maintenance, gardening and fishing practices. Here is a list of some common human created pathways. Can you identify actions that you can take in an effort to reduce the spread of invasive species?



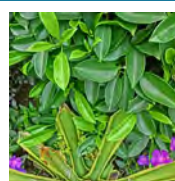
AQUARIA: Species from around the globe are sold for use in aquaria and can become problematic when contents are dumped into a waterbody.



SUPPLY HOUSES: Supply houses provide classrooms with specimens for science education. This practice can introduce a variety of species including crayfish & Brazilian Elodea.



BOATS: Aquatic plants, seaweeds and animals can attach to the undersides of boats, motors and propellers, or in the sea chests and ballast water.



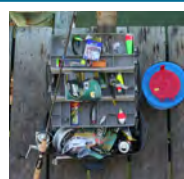
GARDENS & PONDS: Many species prized for gardens may also be successful invaders, such as English Ivy, and yellowflag iris and water hyacinth.



TRAVEL: Travelers may unintentionally carry invasive species, whether they are traveling by air, water or land.



TRAIL USE: Those who explore nature by foot – on or off trail – may unintentionally transport invasive species in clothing, shoes and boot treads.



LIVE BAIT: The release of bait into water is a practice that can have significant consequences.



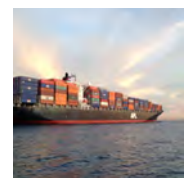
FIREWOOD: Many different invasive pests and diseases can be harbored in firewood, inflicting significant damage to native trees and forests.



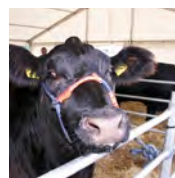
FOOD & AQUACULTURE: A number of invasive species may be grown and sold, or hitch a ride on food products introducing exotic pests, parasites in shellfish and diseases.



VEHICLES: Invasive species may be transported on tires, wheel wells, undercarriage, or otherwise on vehicles, farm equipment and mobile machinery.



SHIPPING & INTERNATIONAL TRADE: Vessels can be a significant pathway for the introduction or spread of invasive species on the hull and through the discharge of ballast water.



LIVESTOCK: Invasive species can be transported on livestock, in their hooves and in fodder or seed.

Adapted from AIS Pathways pptx from WA Invasive Species Council

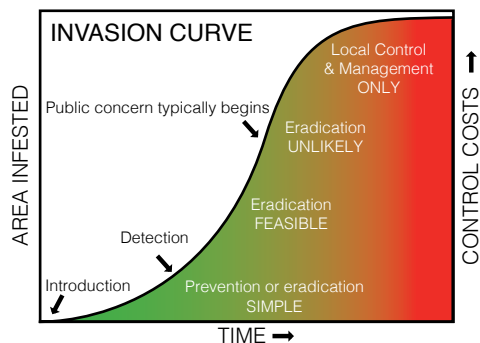
Common myths about AIS

Myth 1: Invasive species are a natural phenomenon.

Humans move far more species, faster and over natural barriers, significantly more quickly than would ever occur with natural colonization or range expansion. Before humans began to disperse across the planet, natural processes would periodically bring new species into an ecosystem, but that rare occurrence would give the ecosystem a chance to adapt to that species. The slow natural movement of species and sometimes surprising level of isolation of water bodies is evident from the diverse and dramatically different collections of species found in watersheds or bays that are separated by only short distances. The constant bombardment of natural ecosystems with new and potentially aggressive species is only possible because of human activity.

Myth 2: By the time you find an aquatic exotic species, it's too late to control it.

True, in some cases. Some organisms, particularly those living in water, often are not detectable until their populations are quite large. That's why early detection monitoring efforts and an informed public are so important. It is still possible to control the spread of an invading species if correctly done.



Myth 3: One person can't stop a new invader.

Did you ever wonder if one person's actions really make a difference? With AIS, one action by one person can make ALL the difference! Individuals have unknowingly and knowingly (though likely not maliciously) introduced scores of species into our waters. With almost 45,000,000 people living in California, Oregon and Washington, and throngs of national and international tourists visiting every year, the possibilities for species introduction seem almost limitless. Still, personal and collective actions can stop the spread and introduction of aquatic invasive species.

It truly only takes one person to introduce a new invader, but often species are introduced a number of times before they become established. Of those that become established, only a few become invasive. That's why any reduction in the number of introductions greatly reduces the overall likelihood of a new aquatic invasive species successfully establishing in Western waters. Eventually, we can eliminate introductions from some pathways all together if we all understand our roles in eliminating these biological pollutants.

Solutions

Invasive species spread and impact may seem complex, but there are some very simple steps you can take to help prevent their spread.

- Always cleaning your boots, boat, gear and vehicle before or after hiking or fishing can have an enormous impact.
- Individuals and groups can be a huge help by doing stewardship projects that help raise awareness about invasive species in your community, reduce invasive species impacts and help to keep ecosystems healthy. Overall, increased awareness, education, and cooperation are fundamental to stopping new invasions and slowing their spread.
- Be on the lookout for invasive or unfamiliar species. If you see a plant that looks out of place, report it!
 - In California Report to: 1-916-651-8797
 - In Oregon and Washington report to 1-866-INVADER
 - In other states, report aquatic species to: 1-877-STOP-ANS. To report online, go to: nas.er.usgs.gov/SightingReport.aspx
- Educate yourself before you travel to avoid mistakenly introducing an invasive species.
- Don't purchase or move plants or animals that are known to be invasive.
- Replace invasive plants in your garden with non-invasive alternatives.
- Help remove invasives on your personal or school's property.
- Volunteer at your local park, refuge or wildlife area to remove invasive species and restore with native species of vegetation.
- Use only local firewood.

Boaters and Anglers:

- Inspect - For motorized boats, look closely at the hitch, rollers, motor, propeller, axle, tires and bilge. For non-motorized boats, look along the paddles and the hull. Remove and properly discard any plants and animals that you find before entering the water.
- Drain & Empty - Your motor, wet well and bilge should be entirely drained on land after leaving the water. Empty your bait bucket on land after leaving the water and never release live bait into the water or release aquatic animals from one water body into another.
- Rinse & Dry - High-pressure, hot water is ideal for rinsing your boat. A garden hose is an option if there is nothing else available. Then let the boat air dry if possible.
- Never move live fish from one body of water to another. With the exception of floods, it is often human pathways that help invasive species move to aquatic ecosystems – like your favorite fishing hole.

Consumers or Travelers:

- Know the origin of what you're buying. Imported goods are a pathway for invasive species, so buy local when you have the option.

- Declare all food and plant materials at the airport. Many of these items are safe and legal, but let professionals make the decision instead of putting your resources at risk.
- Don't pack a pest and don't be a human pathway for invasives. Don't bring produce from one area into another area. When buying goods packed in crates or wood packaging, take a look. Report any holes or evidence of insects in the wood.

Pet owners:

- Don't release pets, aquarium fish, algae and plants, live bait or other exotic animals into the wild. If you plan to own an exotic pet, do your research and plan ahead to make sure you can commit to looking after it for its lifetime. If you have a pet that you can no longer care for, contact your local pet store, humane society, veterinarian, rescue organization or other expert for guidance on appropriate and humane options.
- Don't dump your aquarium water into natural habitats. Many aquarium plants are invasive so if you're going to throw them out, seal them in plastic bags, and freeze them before you put them in the trash.
- Make responsible pet purchases. Many pets may live longer, grow bigger and take more care than you realize. Before you choose a pet do your research and be sure you're ready to care for it long term.

Remember, everyone can make a difference in reducing and preventing the spread of invasive species.

Key Aquatic Invasive Species Messages

An aquatic invasive species is an introduced organism that causes harm and has a direct relationship with freshwater or marine habitats.

- If it is not native to the specific area or ecosystem the species can be called an exotic, alien, nonindigenous or non-native species. If the organism has been moved to a new area by human activity, it may be called an "introduced species".
- There are many species that we don't know if they're native or not and are called "cryptogenic".
- Most introduced species are not invasive.
- A small fraction of introduced species become invasive and cause harm.
- It is difficult to predict if a non-native species will be invasive, but characteristics that many invasive species share include: producing lots of offspring; eating a wide range of food; living in large numbers; tolerating a broad range of environments and disturbances; growing and maturing quickly; and living in association with humans.
- Organisms can become invasive when they are no longer kept in balance by predators, diseases, and other constraints found in their native range.
- Biological invasions in the water have a lot in common with more familiar invasions on land (e.g., weeds in your garden), but can be even more difficult to eliminate once introduced.

AIS have harmful effects on their new environment, local economies and/or human health.

- AIS have major impacts on biodiversity, the environment, the economy and our quality of life.
- AIS can cause major ecological damage, including extinction of native species.
- Aquatic invasions are almost always permanent.
- Impacts can be very expensive to all of us – both in terms of damage caused and control costs.
- Biological invasion is a form of pollution that moves and multiplies, making it very difficult to “clean up”.
- Invasive species change our quality of life (loss of fishing, beaches covered with mussel shells, etc.).
- Many AIS are already established and impacting the West Coast, but many ecosystems in the west are still intact and worth protecting from new invasions.

A wide range of pathways lead to both accidental and intentional AIS introductions.

- Aquatic invasions are a global issue, with impacts felt worldwide.
- AIS are introduced intentionally or accidentally.
- Recent increases in global trade, modern transportation systems and increased engagement with nature have accelerated the rate of aquatic invasions over the last century.
- Habitat disturbance and climate change can facilitate invasions.
- There are many nonnative species – particularly at the microscopic level – for which the impacts are not well studied or understood.
- Species can spread on their own, but human-led introductions often bypass natural barriers and take place much more quickly (garden plant selection, not washing boots and gear, etc.).

Everyone can make a difference.

- Preventing the spread of AIS is the most effective method for invasive species management.
- Early detection and response is critical to successful AIS control and eradication. If you suspect a new invader, report it!
- Improve understanding about the distinctions between native and non-native and nuisance and invasive aquatic species.
- Raise awareness about AIS that already occur on the West Coast and keep on the lookout for potential invaders.
- Continue to support AIS research.
- Increase knowledge about the negative ecological, economic, health, and social (recreational) impacts of AIS.
- Influence behavior to promote prevention of AIS introductions and to slow their spread.
- Enhance regional capacity for early detection and response to new AIS introductions.
- Engage teachers and educators to help youth and adult audiences learn about AIS.
- Improve West Coast coordination of AIS education efforts.
- Stimulate science and social science learning with an issue that is broadly relevant, geographically close, increasing and pervasive.

Links for further AIS Information

Aquatic Nuisance Species (ANS) (joint NOAA and US Fish & Wildlife project)

<http://www.westernais.org/>

ANS Task Force

<http://www.anstaskforce.gov/default.php>

Western Regional Panel of Aquatic Invasive Species

<http://www.fws.gov/answest/>

California Department of Fish and Wildlife

<https://www.wildlife.ca.gov/Conservation/Invasives>

National Oceanic and Atmospheric Administration (NOAA)

<http://oceanservice.noaa.gov/facts/invasive.html> (includes links to podcasts)

<http://coastalscience.noaa.gov/research/pollution/invasive/> (NOAA research)

California Sea Grant

<https://caseagrants.ucsd.edu/project/aquatic-invasive-species-eradication-control>

Oregon Sea Grant

<http://seagrants.oregonstate.edu/invasive-species>

USC Sea Grant

<http://dornsife.usc.edu/uscseagrants/ais/>

Washington Sea Grant

<http://wsg.washington.edu/students-teachers/k-12-activities/ais-toolkit/>

NOAA Fisheries Invasive Species Threats

http://www.westcoast.fisheries.noaa.gov/habitat/habitat_types/habitat_threat_pages/habitat_threats_invasive_species.html

NEMESIS Project

<http://invasions.si.edu/nemesis/databases.html>

University of California Riverside Center for Invasive Species Research

http://civr.ucr.edu/aquatic_invasive_species.html

United States Department of Agriculture (USDA)

<http://www.invasivespeciesinfo.gov/aquatics/main.shtml>

United States Fish and Wildlife

<http://www.fws.gov/fisheries/ANS/index.html>

Protect Your Waters National Task Force “Stop the Aquatic Hitchhikers”

<http://www.protectyourwaters.net/>

United States Geological Service (USGS)

<http://nas.er.usgs.gov/>

Smithsonian Environmental Research Center Museum

<http://smithsonianscience.org/2012/03/serc-database/>

Department of the Interior National Invasive Species Council

<http://www.invasivespecies.gov/>



Glossary of Terms

aquatic nuisance species (ANS) – a nonindigenous species living in or adjacent to water that has a negative economic, human health or ecological impact

competition – an interaction between organisms or species, in which the survival of one is lowered by the presence of another. Limited supply of at least one resource (such as food, water, and territory) used by both is required.

cosmopolitan – occurring over several areas or regions extending up to most of the world. For example, *Sargassum* are considered cosmopolitan.

cryptogenic species – those organisms for which the origin is questionable or unclear

early detection and rapid response (EDRR) – the process by which invasive species are detected and controlled early, while populations are very small and invasion is limited

ecosystem – a community of organisms, interacting with one another and the environment in which they live

endangered – in immediate danger of extinction

endemic – a species that is only native to a limited area

environment – one's surroundings

exotic – species introduced accidentally or intentionally beyond their normal geographic range

food web – the feeding relationships by which energy and nutrients are transferred from one species to another

habitat – the place or environment where a plant or animal naturally occurs

indigenous species – naturally or historically found within that range without human intervention

introduced species – organisms that have been moved to a non-native ecosystem or geographic area through human activity

invasive species – an alien or introduced species whose introduction does or is likely to cause economic or environmental harm or harm to human health

native species – those organisms that occur naturally in an area

native range – the area or region where a species evolved to its present form

niche – a unique ecological role or function of an organism in an ecosystem or community

nonindigenous species - organisms living beyond its native range, not occurring naturally in a particular area, exotic, introduced, invasive

nuisance species – a native or non-native species that threatens the diversity or abundance of native species, the ecological stability of specific waters or commercial agriculture, aquaculture or recreational activities dependent upon those waters

pathway – the means by which species move from one location to another often overcoming natural barriers

population (ecology) – all the organisms of a single species that occur in a specified area or habitat

predation –the act or practice of capturing another organism (prey) as a means for securing food

prevention – stopping or restricting the movement and growth of potentially harmful species; the single best way to limit the impacts of nonnative species

producers (autotroph) - organisms that make their own food from the sun's energy

resources – the materials, objects or substances needed by an organism to ensure survival for normal maintenance, growth and reproduction

Species of Special Concern – may become threatened due to restriction to specific habitats that are undergoing development or because threatened in nearby areas

succession – the gradual process of ecosystem development brought about by changes in community composition

threatened species – very likely to become endangered in the near future due to severe population decline

watershed – the area of land where all of the water drains to a common outlet, into a river, reservoir, mouth of a bay or other body of water

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Activity Materials

MATERIAL	USE	IMPACT	PREVENTION
Red Swamp Crayfish stored in plastic container	Interpretive specimen	Pathway: unused fishing bait or from classroom projects Impacts: decreased fish, amphibian and native crayfish populations	don't release anything into the wild; use native bait and classroom specimens
Purple loosestrife replica and info card	Interpretive specimen	Pathway: planted in gardens but produces so many seeds, rapidly goes beyond boundaries Impacts: causes sediments to fill in wetland areas	plant native and noninvasive plants in gardens and ponds
Red Eared Slider turtle replica	Interpretive specimen	Pathway: purchased as pets but released when get too large Impacts: outcompete native turtles for habitat and food	recognize life spans and adult size of pets; pledge to be a responsible pet owner; find a new owner or return to pet store
Pacific Oyster Shell	Interpretive specimen	Pathway: ballast water, bred in aquaculture and sold fresh in open circulation seawater systems Impacts: outcompete native oysters, changing ecosystem communities	develop fish market and aquaculture practices that are sustainable and don't have a negative impact
Lionfish replica 3-D puzzle	Interpretive specimen	Pathway: aquarium fish released into nature Impacts: voracious predator that consumes anything that fits in its mouth; tremendous disruption to reef ecology along Atlantic, Gulf and Caribbean coasts	NEVER release aquarium fish into the environment; find a new home instead

MATERIAL	USE	IMPACT	PREVENTION
Quagga mussel shell	Interpretive specimen	Pathway: ballast water first into the Great Lakes and has since spread with recreational fishing boats Impacts: outcompetes native species in settling; tremendous filtering ability that decreases diversity and abundance of life in freshwater lakes	clean, drain, dry your boat and follow guidelines before entering another water body
New Zealand Mudsail Shell	Interpretive specimen	Pathway: ballast water or by recreational fishing; spread through recreational fishing and hiking Impacts: rapidly replaces life in streams outcompeting native animals	clean all gear; freeze boots after entering streams before using in another stream
American Bull Frog	Interpretive specimen	Pathway: raised for food (frog legs) Impacts: outcompetes native species	never release organisms into the environment
Peruvian Peppertree pressing	Interpretive specimen	Pathway: grown as an ornamental plant Impact: an aggressive invader; same family as poison ivy and poison oak, so can cause dermatitis	select native or noninvasive plants; remove entire plant, seeds and roots when removing invasives
<i>Sargassum honeri</i> pressing	Interpretive specimen	Pathway: commercial ship Impacts: forms dense beds outcompeting native algae and is able to live in a broader temperature span than native kelp; provides less beneficial habitat	make sure boat and gear are cleaned when moving from one region to another; dispose of invasives in trash
Lotteria Game Boards, cards, game pieces	game	understand the pathways and impacts of invasive species introductions	
Where in the World species cards, inflatable globe and map	game	understand origin of different invasive species, natural barriers and how humans have increased the spread of invasive species	

MATERIAL	USE	PURPOSE	
Musical Chairs species cards and Billy B Biodiversity CD	game	simulates invasion of species with limited habitat space by playing musical chairs; each participant represents a native or non-native species	
Script for mock interview	interactive interpretation	introduces the problem of the European Green Crab	
DVD player, case and DVDs	portable DVD player - AV resources	allows you to bring DVD, music and other resources to share with audience	
Invaders from Around the World- DVD	DVD	animation explaining biodiversity and impacts of invasive species; builds basic understanding of how invasives are spread and their impacts	
A New Home for an Old Friend	children's book; pre k - 2nd	story about what to do when you can't keep a pet and impacts if you release it; responsible pet ownership	
Fish Invaders at Gypsy Point	children's book; 3rd - 6th	children serve as stewardship heros, identifying and notifying about invasive species and observing its impacts on the environment	
Invasive Plants of Western North America	pocket guide	identification fieldguide for common introduced plants in Western region	
On the Lookout for Aquatic Invaders	field guide	In-depth information of select aquatic invasive species of the West Coast region, including those in the specimens kit	
Aquatic Invasive Species of California Poster	poster (CA kits only)	identification guide of common aquatic invasive species for CA and information for what to do if you spot an invasive species	
Don't Let it Loose	poster	guidelines for teachers and others responsible for selecting and caring for classroom pets and live specimens in schools	

MATERIAL	USE	PURPOSE	
Stop Ballast Water Invasions	poster	Poster shows historical impacts from discarded ballast water; allows for discussion of how ballast water regulations help to protect our ports, wetlands and estuaries and how early detection can help stop the spread	
Spread of Quagga and Zebra Mussels map	map	visual way to see how just one boat can impact a whole region	
magnifying lens	tool	use to examine shells and specimens more closely	
Don't let it Loose stamp and washable ink stamp pad	stamp and pad	used to reinforce concept and take message home with them	
Cleaning brush	tool	used as reminder to clean boots and other gear before going into a natural area and before leaving an area, especially one known to have invasive species	

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Activities

- American Bullfrog Sample Script
- Mock Interview with European Green Crab
- Where in the World?
- Invasive Species Loteria Instructions
- Musical Chairs Ecological Disruption





American Bullfrog Puppet Sample Script

MATERIALS

- American Bullfrog hand puppet
- Script

Rib-bit, Rib-bit! Who are you?

Please don't eat me!!

People brought American Bullfrogs west to grow for food. I have very fine strong legs, but that doesn't mean I should be on someone's dinner plate, does it?

What do you know about frogs? Can you do a frog jump? We can jump up to 6 feet! Can you do that?

And that is just what we've done - jumped away, out into nature!

I love to be in a pond or stream, listening to crickets (they're delicious by the way) and relaxing. It does take a lot of food to keep me full. And my mouth is so big I can eat anything that fits. There seem to be a lot fewer of the native frogs around since I've arrived.

That seems to be what all this invasive species talk is about. We are aquatic invaders because people have brought us into areas where we aren't normally found and we are very good at expanding our range, outcompeting and overtaking an area so that the area changes.



Mock Interview Sample Script: European Green Crab

MATERIALS

- 2 copies of the script (one for interviewer and one for Green Crab)
- Image of European Green Crab
- Costume and microphone (optional)

Welcome everyone. Today's guest is the European green crab (*Carcinus maenas*):

Reporter: You guys came over from Europe a long time ago. It's almost like you've been here forever.

Green Crab: [Laughs] I wish you'd tell that to all the people who still treat us like we don't belong here. I mean, it's been almost 200 years since our ancestors jumped ship in the Long Island Sound, and this generation is still taking the heat. Give me a break. We've made our way all over the East Coast and even out to the West Coast. This country is as much our home as anywhere else. And by "anywhere else" I mean practically everywhere.

R: That's right. You guys sure have made the rounds — South Africa, Japan, Argentina and Canada, just to name a few. Where does this love of travel come from?

GC: We're just a very low-maintenance species, very adaptable. Some call us eurythermal.
(yuri-ther-mal)

R: Eurythermal?

GC: It sounds pretentious, I know. It just means we thrive in a wide range of water temperatures. For most of us, that means anywhere between 32 and 95 degrees F. So we could be in Iceland, or we could be in Africa — either way, we're happy as clams!

R: Don't you eat clams?

GC: So do you!

R: Yeah, but we don't eat 40 in one day like you guys. You can totally wreck local clam populations going on benders like that.

GC: Hey — you snooze you lose. Fortunately for us, we love all bivalves, so if we make our way through the clams, we'll just move on to scallops, mussels, oysters ... I'll take one of everything, please! [Laughs]

R: We have to change the subject. You're starting to make me hungry. Let's go back to this eurythermal thing. Is that unusual among crustaceans?

GC: It is, and that's really too bad. Most crabs and lobsters just can't survive in that kind of heat. Their hearts can't take it.

R: That is too bad, but let's be honest, it's also kind of good for you, right? I mean, with climate change warming things up, you guys will have a clear advantage in some places.

GC: You know, I really don't enjoy benefiting from the misfortune of others, but it's true. A lot of species are really worried about climate change, and they should be. It's going to really mess things up for a lot of them. But for us? Bring it on, baby. We can handle it. Just look at how much our population expanded off the coast of California traveling from San Francisco Bay estuaries to Bodega harbor riding the El Nino currents of 1993. In 1997 we even rode to Oregon and Washington with the next set of El Nino's. Coastal waters have been warming up unusually fast compared to other parts of the ocean, and trust me, fisherman were getting so sick of seeing our ugly faces in their nets. It is hilarious!

R: Right ... a net full of crabs. Sounds hysterical.

GC: Seriously, though, if this year's conditions are any indication of what's to come, it looks like we'll be doing just fine for a while. And if other animals die, no worries, we'll eat 'em!

R: If this year's conditions are any indicator of what's to come, perhaps we should empty those nets into a pot for a crab boil.

Thanks to Suzanne Jacobs who allowed us to adapt script from her Grist article "Meet the invasives: We've got crabs, but maybe they're not so bad" February 25, 2014



European Green Crab



Luis Miguel Bugallo Sánchez

aquatic INVASIONS!



Where In The World?

AUDIENCE

small to large group of visitors;
all ages

LENGTH

5 minutes - 1 hour

SUBJECTS

ecology, environmental
science, geography

OBJECTIVES

- Participants will gain an increased understanding of the distribution of various aquatic exotic species and will use critical thinking skills to analyze common traits of locations vulnerable to invasive species.

MATERIALS

- Inflatable globe
- Species cards
- Map showing native range/origin of select species

VOCABULARY

- cosmopolitan
- indigenous
- ecosystem
- exotic
- native range
- nonindigenous species
- habitat

Introduction

This activity uses geographical skills to understand the nature and extent of the problem of invasive species. Using a world globe, students map the routes of invasive species from their native habitat to some of the regions to which the exotics have spread. Note cards on different species give the students some basic information about the species and how they spread.

Background

Biological invasions are a global problem. Human activities, especially through the movement of ocean-going ships, have distributed marine organisms to new regions all over the world. One such species, the European green crab, has spread from its origin in Northern Europe to both coasts of North America, Africa and Australia. Species that have had multiple introductions around the

world are considered “cosmopolitan.” Exotic species, or invasives, become established in different regions and affect native organisms and ecosystems, often outcompeting native species. They can alter nutrient regimes, develop into monocultures, or drive native species to extinction. Reducing the risk of species introduction is a difficult task, and although the risk has been recognized in many countries, measures to reduce introductions have been difficult to implement.

Preparation

- inflate globe
- familiarize yourself with species cards and map

Procedures

Key Idea or Message: The ocean once served as a barrier to prevent species from reaching other parts of the world. With increased human transportation efforts, new species are now introduced daily.

1. Engage participants' interest by placing the globe in view of participants and asking them what they notice about the globe.
2. Distribute or allow participants to select species cards. Ask them what do they already know about that species and encourage them to look at the back to find out more.
3. Ask what they discovered by reading the back. If it is a large group, have them share with a neighbor what they discovered. Mention that all species have a native range or a place where they have been found in nature before human influence.
4. Ask if the participants want to work together to find out where the organism started and discuss how it might have reached the West Coast. Use the map, if needed, to find the native range of the species and then find the range on the globe.
5. Ask participants how does the invasive species move from its native range to California, Oregon or Washington.
6. Make sure to share that all of the ocean basins connect to form one ocean, and so once something is in the ocean, it can travel on its own or with help from human transportation to anywhere along the coast.

Conclusion & Evaluation

Discuss with the participants:

- Do the impacted regions have similar characteristics to one another or to the native habitat of the introduced species?
- Are there longitude or latitude similarities in the distribution pattern? Does that mean anything?
- How do you think these species are likely to have traveled these distances?
- What characteristics, if any, do the species that have been successful invaders share?
- What can you do to reduce the invasion of species to our coastline?

Allow participants to stamp their hand with Don't Let it Loose stamp and encourage them to share what they have learned with others.

Adapted from original lesson by Paul Heimowitz and Nancy Lerner





Invasive Species Loteria Instructions

AUDIENCE

2nd grade to adult

LENGTH

15 minutes - 1 hour

SUBJECTS

invasive species, biology,
ecology

OBJECTIVES

- Participants apply their current knowledge and interest of invasive species and water quality to match the descriptions in the clues to the pictures in their game boards.
- Participants increase knowledge of invasive species found in the Western Region and gain understanding of how to prevent invasive species in their everyday actions.

MATERIALS

- Game boards
- Deck of clue cards
- Game markers

VOCABULARY

- competition
- ecosystem
- invasive species
- native species
- resources
- pathways

Introduction

The game boards provide a conversation starting point to build on the participants' understanding of regional invasive species. The clues provide the descriptive characteristics, impacts and pathways for introduction, methods of control and prevention for aquatic invasive species.

Background

- Aquatic invasive species are organisms introduced from somewhere else that take over the environment and impact the value of that aquatic environment.
- They cause problems for native seaweeds, plants, animals, ecosystems and people.
- Aquatic invasive species often have physical traits that enable them to reproduce, spread rapidly and outcompete native species for resources making them difficult to control.

- The best solution for aquatic invasive species is to be proactive and to prevent introduction in the first place.
- Pathways of introduction can be identified and strategies developed to reduce the risk of introducing harmful species. This can include cleaning gear, checking for pests, legislating best practices and more.

Preparation

Prior knowledge of aquatic invasive species is helpful but not required (see the Introduction). Also review the Introduction Pathways page.

Procedures

1. Engage participants in playing Loteria. Ask if they have ever heard of introduction pathways. Explain how pathways are the methods where an invasive species may be introduced to an area.
2. Work individually or in teams of 2 or 3. Have each individual or team select a game board and game markers.
3. Inform students they will need to listen to the clues and mark their square with a game piece if the clues match one of their photos.
4. Read clues aloud to the students, then show the photo as well. Students use their knowledge to find the answer to the clue on their game board.
5. Once students find the correct match to the clue, they mark off that square with a game piece. Once students fill the defined area of the board (like a row or the whole board, depending on how much time you have), they call out “Loteria” and win the game.
6. Keep playing until you have announced all the clues in the whole deck, or you feel it is a good time to stop. Each clue covers different concepts. While playing the game students will need to consider:
 - What are the characteristics of these species?
 - What are the possible pathways to spread invasive species?
 - What impacts do invasive species have on other plants and animals?
 - What impacts do invasive species have on the economy?
 - What impacts do invasive species have on natural resources (e.g. water) and communities?
 - What are some things we can do to stop the spread of invasive species?

Conclusion & Evaluation

Discuss with participants whether they know that invasive species are a problem in our area (as well as worldwide), and if they have ideas of what can be done to prevent the spread of invasive species.

Some simple actions include:


- Check and clean all of your gear including fishing gear, boats and the bottoms of boots or shoes before going into natural areas.
- Never release a pet, plant or algae into a park or natural environment.
- Select native or non-invasive plants for your garden and pets you can care for their entire lifespan.
- Report invasive species if you find them.

Assess participants' knowledge of aquatic invasive species concepts through a general discussion. Sample questions are listed below.

- What is an invasive species?
- What happens when invasive species are introduced to a new area?
- What are some of the characteristics that allow species to be invasive?
- What role do biological controls play in controlling invasive species?
- What were the consequences of introducing a species adjacent to natural habitat?
- Why is it important to detect small populations of invasive species early?
- What role do humans play in the introduction of invasive species worldwide?
- What can individual people do to help prevent the spread of invasive species?

Extensions

- Select one species to research how it has impacted this region.
- Have students research and create their own Loteria card.



Adapted from original lesson by Lupe Diaz, 2008



Musical Chairs Ecology Disruption

AUDIENCE

small to large group of visitors;
all ages

LENGTH

10 – 20 minutes

SUBJECTS

invasive species, ecology,
biodiversity

OBJECTIVES

- Participants gain a better understanding of the impact of invasive species on native species through role-playing.
- Participants are able to explain how to prevent invasive species from being released into nature and alternatives for unwanted pets, plants and seaweeds.

MATERIALS

- Species cards with images of native and non-native species and neck strings
- Chairs or carpet squares to represent chairs
- CD player with Billy B Biodiversity cued up

VOCABULARY

- competition
- environment
- invasive species
- non-indigenous
- Species of Special Concern
- ecosystem
- food web
- native species
- predation
- endangered
- habitat
- niche
- producers (autotroph)
- threatened species

Introduction

Natural habitats or ecosystems exist in a delicate balance. When new organisms are introduced or loss of habitat occurs, the balance is eliminated. Aquarium release is one pathway aquatic invasive species are introduced. Sometimes people try to give their pets a “better” place to live by letting them go, but this can be hard on the pet (many don’t survive) and on the ecosystem (some introduced species do so well they outcompete the native species). Pet or plant release disturbs the balance in the local ecosystem. This game helps show the speed at which native species can be overcome by invasive species and teaches alternatives to releasing aquarium pets, water plants and algae into the wild.

Background

All species have a native ecosystem and natural range where they are historically found. Ranges may change gradually, when the environment changes, and there is a chance to adapt to those changes. When changes occur rapidly through human intervention, whether accidentally or intentionally, both the native and introduced species may have trouble surviving. Some species are keenly able to adapt to a wide range of conditions and are able to outcompete the native species, especially if the native species have limited diets and/or restricted habitat needs. Those that outcompete and have an environmental, economic or human health impact are referred to as invasive species.

Introduced species often don't have predators or competitors in their new environment. This allows them to flourish so well they can become over populated, taxing the resources in that environment. In addition to displacement of native species by sheer numbers, they use the resources (prey) that native species are dependent upon causing an interruption of the food web.

The over population of one species can cause native species to decline in number, become endangered and possibly go extinct.

Many native species with limited ranges or prey are unable to adapt and do not have defenses against these new organisms. The invasive *Sargassum sp.* found worldwide, Nutria in Oregon, *Caulerpa* in the Mediterranean and the Lionfish off of the Florida Coast are all examples that have a predator in their natural environment to keep the population in check. Once introduced into a new region the predator is not in that new environment, allowing the invader to thrive.

Non-indigenous plants and seaweeds can cause different problems such as overgrowth of native plants, which reduces the ability of sunlight to reach them. Brazilian Pepper, Japanese Knotweed, *Undaria sp.* and *Sargassum sp.* are all very effective in overgrowing and shadowing habitat. Some invasive species even release chemicals into the ground, which can prevent other plants from growing there.

The one method that works consistently in combating invasive species is preventing invasive species in the first place.

For this activity wetlands serve as our representative habitat. Wetlands are critical in slowing the movement of freshwater as it enters the ocean, removing excess nutrients and in some cases toxins from the water. They serve as nurseries for many animals, resting and foraging locations for migratory birds, and are biologically highly productive coastal habitats. They are also one of the most impacted habitats by aquatic invasive species along the West Coast.

Preparation

- Select native and invasive species cards
- Place chairs, carpet squares or marks on the ground representing the individual niche for the game

Procedures

Key idea or message: Invasive species can cause harm to the natural environment by replacing native species and by reducing the value of the ecosystem.

Engage your audience with some of the following questions:

- Who likes to visit the shoreline to see the organisms living there?
- Can you identify a native organism to our coastal wetland area. (*Show images of native organisms or specimens as needed*)
- Does anyone know what an introduced or invasive species is? (*Share local example – crayfish, Sargassum, mitten crab, etc.*)
- Does anyone know how invasive species become a problem?

Sample Script

We are going to play a game and tell a story to find out more about the impact of invasive species on our area. I'll need the help of some volunteers to show how our outdoor places are changing and what that means to us.

We need six volunteers from the audience. (Give each of the volunteers a species card to put around her/his neck as you identify the native species to the whole group.)

(Point out the chairs, spots on the ground or carpet squares.) Each empty chair represents a niche, a unique role and home for our native species. Notice there are six homes and six species.

Ask everyone if they are familiar with musical chairs. When I begin the music, our volunteers will begin the game. There is no need to rush, since we know there is a home for everyone. (Make sure to emphasize NO RUNNING or PUSHING.)

(Start track two on Biodiversity & Billy B., the Biodiversity song. Stop the music when you are ready for the volunteers to pick a niche.)

Explain that each of our native species have their own niche. Let me tell you about the habitat where they live. It is near here, just along the shore. It's a beautiful place where I love to walk and see what I can find. How many of you like to visit the wetlands? (Show a photo of the wetlands.)

In fact, I like the ocean and fish so much that I have a home aquarium. How many of you have a home aquarium?

An aquarium is a ton of work to keep it clean and to keep the fish fed. I've decided that last time I went on vacation it was too much trouble to ask someone to take care of my fish so I am thinking the wetland will be a perfect place to let my fish go. There are lots of other fish there and seaweed to hide among right along that spot on the shoreline. It is also a marine protected area so no one will catch it. Besides there is lots of food so my fish will do great and I can still visit it there just like when I visit now.

We need two more volunteers. (One to be the fish and the other to be the *Caulerpa sp.* Place the invasive species cards around their necks.)

We are going to continue our game again following the rules for musical chairs.

(Start the music. When you stop, have any native species that didn't get a spot come stand by the leader. Have any invasive species who didn't get a spot go up to a native species and ask for the spot.)

Many introduced species reproduce more quickly, can tolerate environmental extremes like changes in temperature or salinity, and eat many different things so they have an advantage over native species. That is why we give them an advantage in this game. The native species can't compete. In this game, like in nature, the native species lose their niche, so please give up a spot for an invasive species and come stand beside me.

(Show a photo of the wetlands with invasive species) What do you notice happening to the habitat?

Once I let my fish go, I realized how nice it is to have extra time on my hands so I went to the aquarium store and I saw a really cool crab I've never seen along the shore. I bought it and will put it with the other animals. I also stopped at the garden supply store and asked what would grow well and brighten the wetland. They recommended Purple Loosestrife since it fills in quickly and can just take off once established. So I need two more volunteers to join us. (Put the introduced species cards around the new volunteers' necks.)

And earlier today my friends went fishing up stream but had some extra bait. They didn't want the crayfish to die so they released all the leftover fishing bait along the shore too, so I'll need another volunteer to join us. (Put the introduced species card around the new volunteers' neck.)

Let's play one more time:

- What do you notice about life along this bit of shore?
- Why did the habitat change so much?
- Who would miss the native species?

- What could we have done instead of releasing the pets into the pond?

Conclusion & Evaluation

Can you help me think of some guidelines or rules we should all follow to protect our environment?
(record ideas and share)

Be part of the solution: (Share on cards or a board)

- NEVER release animals, plants or seaweed into nature!
- If you no longer can keep your pet, check with a friend or neighbor that may want a pet.
- Check with local pet shops and rescue organizations that take unwanted pets.
- Put water plants in a plastic bag and freeze, then discard them.
- Dispose of unused bait into the garbage.
- Use non-invasive and native plants in your garden and pond, local bait and firewood.
- Clean your boat and drain your bilge before moving your boat to a different body of water.

Now that you all have seen or participated in this activity, you know that you should never release a non-native pet or non-native plant into the wild. Let's thank our volunteers.

These invasive species not only change the way your backyard and our wild areas look and function, but they can also impact your local economy and change your way of life. Please spread the word and prevent them from becoming a menace to the west.

Extension

If working with an individual class, before passing out native species tags:

- Have students list native species and write them on the board. Make sure to get aquatic ones that could live in the habitat on which you are focusing.
- Have students list some invasive species we have here and write them on the board too. Bring out some other animals that could either represent a native or invasive.



Adapted from AQUATIC INVADERS A Sea Grant/AZA Partnership Northwest Program Text

aquatic INVASIONS!



Be Part of The Solution!

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