

Invasion Ecology



Week 4

Invasive species in aquatic
ecosystems

Week 4: Learning Outcomes

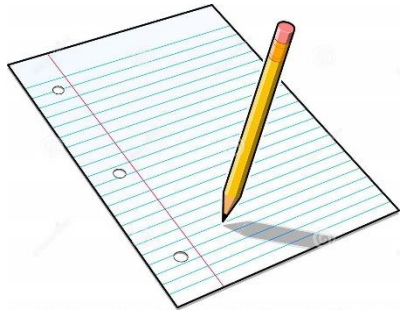
By the end of this week you will know:

- what aquatic invasive species are
- how aquatic invasive species impact native communities

By the end of this week you will be able to:

- describe various modes of aquatic species introduction
- differentiate between control methods
- name at least five aquatic invasive species

Class Activities



Worksheet



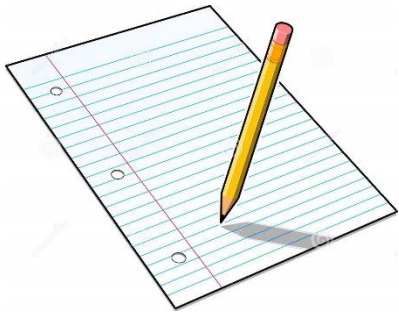
Small group discussion



All-class-discussion



In-class ungraded quizzes



Aquatic Invasive Species?

Worksheet Part 1.



Please modify the formal definition of invasive species we discussed previously so that it would be applicable to aquatic invasive species (5 min):

“Invasive species is a non-native species whose introduction does or is likely to cause economic or environmental harm or harm to human, animal, or plant health” (National Invasive Species Management Plan, 2006)



Aquatic Invasive Species?



Please compare your definitions in pairs and create a 'combined' definition (2-3 min)



Aquatic Invasive Species

“**non-native plants and animals** that have been **introduced** (accidentally or intentionally) into **lakes and rivers**, and whose introduction **threatens** the diversity or abundance of native species, the stability of the ecosystem and/or the use of the infested water body.

[They] are **a major threat to freshwater ecosystems** and a significant management concern because of their ecological and socio-economic costs.”



Please compare your version with formal definition of invasive species (2-3 min) (use 'Yes/No cards')

Freshwater Invasive Species



Curly-leaf pondweed



Purple loosestrife



Asian carp



Asian Swamp Eel



Eurasian watermilfoil



Earthworms



Ruffe



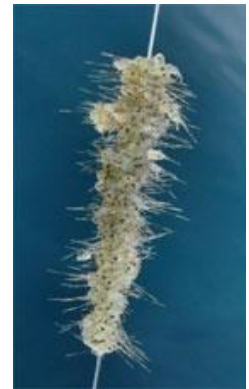
Channeled Apple Snail



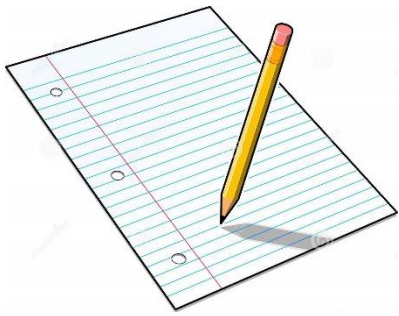
Zebra mussel



Asian Clam



Spiny waterflea



Freshwater Invasive Species

Worksheet Part 2.



Zebra mussel

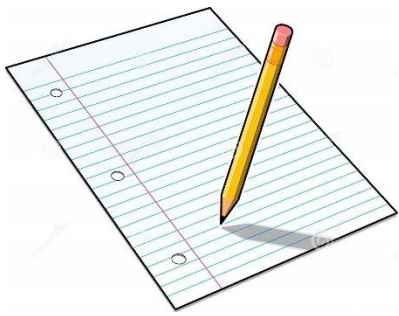
“Brought here from Europe in ships’ ballast water; zebra mussels were first discovered in the Great Lakes region in 1988. Zebra mussels have inflicted tremendous damage to native ecosystems and to facilities using water, like power plants and municipal water suppliers.

Millions of dollars have been spent by water users, to control and eradicate zebra mussels. And, as zebra mussel populations in an area increase, native mussels decrease; a strong indication that zebra mussels are the cause.” *U.S. Fish & Wildlife Service, 2017*



Why is it an invasive species? Please check ALL that applies (30 sec):

- Introduced to the US from other countries
- Causes damage to freshwater ecosystem
- Has economic impact



Aquatic Invasive Species in the US


Worksheet Part 3.

Every state in the United States has been affected by aquatic nuisance species: nutria, mosquito fish, purple loosestrife, Eurasian watermilfoil, etc.

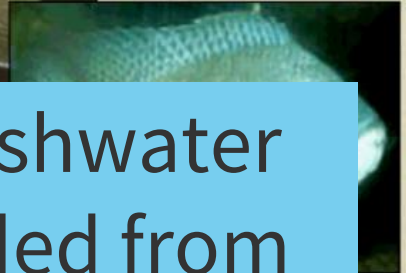
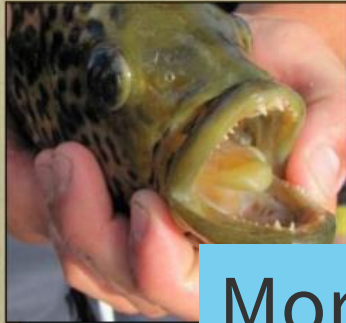
National Environmental Education Foundation:

<https://www.neefusa.org/nature/water/invasive-aquatic-species-united-states>

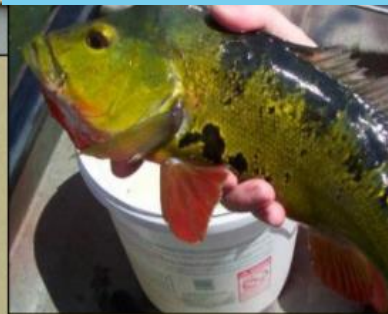
Please check the link above, choose your home state, read about a representative invasive species, and answer the following questions:

- 
- Why is this species invasive?
 - Have you heard about this species before? If yes, did you know that this species is invasive?

Exotic Fishes



More than 145 non-native freshwater fish species have been recorded from Florida since the 1880s.





Some of the 180 181 183 184 Non-Native Species Established in the Great Lakes

<p>Sea lamprey <i>Petromyzon marinus</i> USA</p>	<p>Hudt lamprey <i>Salvelinus nigricornis</i> R. Barkley - USGS</p>	<p>Shortnose gar <i>Lepisosteus platostomus</i> USGS</p>	<p>Rainbow smelt <i>Osmerus mordax</i> W. Hensley/USGS</p>	<p>Alewife <i>Alosa pseudoharengus</i> Murray/DNR</p>	<p>Kokanee <i>Cynoscion nebulosus</i> NOAA-GLERL</p>	<p>Coho salmon <i>Oncorhynchus kisutch</i> USPS</p>	<p>White perch <i>Morone americana</i> D. Peary</p>	<p>Hound goby <i>Neogobius melanostomus</i> D. Jule</p>	<p>Orange-spotted sunfish <i>Lepomis humilis</i> D. Swales, USGS</p>	<p>Oriental weatherfish <i>Aplocheilichthys argenteostriata</i> R. Barkley - USGS</p>	<p>Hecker sunfish <i>Lepomis heckeri</i> P. Hensley</p>	<p>Sturgeon minnow <i>Pimephales notatus</i> USGS</p>	<p>Nembo/waterhead trout <i>Oncorhynchus mykiss</i> M. O'Rourke</p>	<p>Common carp <i>Cyprinus carpio</i> NOAA-GLERL</p>	<p>Ghost shrimp <i>Stygopoda auctorum</i> Texas State Univ.</p>	<p>Bluntnose sunfish <i>Lepomis macrochirus</i> R. Barkley - USGS</p>	
<p>Western mosquitofish <i>Gambusia affinis holbrooki</i> Wikipedia</p>	<p>Goldfish <i>Carassius auratus</i> Wikipedia</p>	<p>Tubenose goby <i>Pneumatophorus tuberosus</i> D. Jule</p>	<p>Chinook salmon <i>Oncorhynchus tshawytscha</i> NOAA-GLERL</p>	<p>Ruffe <i>Gymnogenys curcus</i> USGS</p>	<p>Margined madmin <i>White sucker</i> R. Barkley - USGS</p>	<p>Pink salmon <i>Oncorhynchus gorbuscha</i> NOAA-GLERL</p>	<p>Fourspine saddleback <i>Ambloplites rupestris</i> M. Galvan, New Brunswick</p>	<p>Brown trout <i>Salmo trutta</i> NOAA</p>	<p>Blueback herring <i>Alosa aestivalis</i> Wikipedia</p>	<p>Chain pickerel <i>Esox niger</i> R. Barkley</p>	<p>Calewaft coopepd <i>Silurus glanis</i> USGS</p>	<p>Cyrtopid coopepd <i>Cyrtopoma senhousii</i> USGS</p>	<p>Cyrtopid coopepd <i>Macropodus chinensis</i> USGS</p>	<p>Calewaft coopepd <i>Procambarus dehaeni</i> J. Chavel</p>	<p>Harpacticoid coopepd <i>Diacyclops thomasi</i> USGS</p>	<p>Harpacticoid coopepd <i>Diacyclops thomasi</i> USGS</p>	
<p>Harpacticoid coopepd <i>Diacyclops thomasi</i> USGS</p>		<p>Parasitic coopepd <i>Schistocephalus solidus</i> USGS</p>	<p>Japanese fish house <i>Aquas apiculatus</i> USGS</p>	<p>Parasitic coopepd <i>Ichthyophonus hoferi</i> H. Fahren - USGS</p>	<p>Amphipod <i>Echinogammarus lacustris</i> C. von Oreski</p>	<p>Amphipod <i>Echinogammarus lacustris</i> K. Hultine</p>	<p>Bluntnose shrimpr <i>Paratropis ansonae</i> NOAA-GLERL</p>	<p>Fishhook waterbug <i>Chironomus tentans</i> C. von Oreski</p>	<p>Waterflea <i>Daphnia roseae</i> K. Herens</p>	<p>Waterflea <i>Sabotia mediana</i> USGS</p>	<p>Waterflea <i>Diacyclops thomasi</i> EPA/AG</p>	<p>Waterflea <i>Daphnia mendotae</i> T. Fero</p>	<p>Spiry waterflea <i>Eubosmina longirostris</i> NOAA-GLERL</p>	<p>Red swamp crayfish <i>Procambarus clarkii</i> Dovnar - Wikipedia</p>			
<p>Water chestnut <i>Trapa natans</i> L. Melnikoff - Univ. of Conn.</p>	<p>European hogbit <i>Hydrocotyle sphenoloba</i> SOHB</p>	<p>Curlyleaf pondweed <i>Potamogeton zosterifolius</i> M. T. - TNC</p>	<p>European water clover <i>Hydrocotyle sphenoloba</i> R. Molnar/USGS</p>	<p>Moneywort <i>Hydrocotyle sphenoloba</i> R. Molnar/USGS</p>	<p>Sweetflag <i>Potamogeton amplifolius</i> M. Pappas - Wikipedia</p>	<p>Marsh thistle <i>Chrysopsis alpestris</i> K. Peters - Wikipedia</p>	<p>Marsh fescue, sweetflag <i>Poa annua</i> USDA</p>	<p>Eurasian watermilfoil <i>Myricophyllum spicatum</i> MCHNR</p>	<p>Carolina seawort <i>Cladophora caroliniana</i> L. Melnikoff - Univ. of Conn.</p>	<p>European brooklime <i>Juncus bulbosus</i> Wikipedia</p>	<p>Yellow iris <i>Iris pseudacorus</i> K. Peters - OR Dept. of Ag.</p>	<p>Water cross <i>Hydrilla verticillata</i> R. Molnar/USGS</p>	<p>Flattened rush <i>Juncus flaccidus</i> K. Peters - Wikipedia</p>	<p>P. Hudson <i>P. Hudson</i> K. Peters - Wikipedia</p>	<p>Black-grass rush <i>Juncus flaccidus</i> USDA</p>		
<p>Flowering rush <i>Sparganium angustifolium</i> Wikipedia</p>	<p>Crossing yellow cress <i>Scilla maritima</i> Wikipedia</p>	<p>Western water horsetail <i>Equisetum arvense</i> K. Peters - Wikipedia</p>	<p>European water horsetail <i>Equisetum arvense</i> K. Peters - Wikipedia</p>	<p>Lady's thumb <i>Thymophylla americana</i> S. Dewey - Utah State Univ.</p>	<p>Tun. flag-rod-ool <i>Myrica sparganii</i> Wikipedia</p>	<p>Water foxtail <i>Alopecurus pratensis</i> Wikipedia</p>	<p>Scirpus <i>Scirpus olivaceus</i> K. Peters - Wikipedia</p>	<p>Swamp scirpus <i>Scirpus americanus</i> Wikipedia</p>	<p>Bullethead reed <i>Phragmites australis</i> Wikipedia</p>	<p>Spiry reed <i>Phragmites australis</i> K. Peters - Wikipedia</p>	<p>Poison hemlock <i>Conium maculatum</i> W. S. W. Fulford</p>	<p>Great hairy willow herb <i>Epilobium montanum</i> P. Unruh - Wikipedia</p>	<p>Water mint <i>Mentha aquatica</i> Wikipedia</p>	<p>Lupine <i>Lupinus polybotrys</i> Wikipedia</p>	<p>Purple loosestrife <i>Lythrum salicaria</i> MCHNR</p>	<p>Yellow loosestrife <i>Lythrum scariosa</i> Wikipedia</p>	
<p>Bar root <i>Sagittaria arifolia</i> USGS</p>	<p>Narrow leaved cattail <i>Typha angustifolia</i> M. T. - TNC</p>	<p>Bitterroot nightshade <i>Solanum elaeagnifolium</i> Wikipedia</p>	<p>Sparganium <i>Sparganium angustifolium</i> Wikipedia</p>	<p>Creeping whorled mint <i>Marjolin spicata</i> Wikipedia</p>	<p>Suaide godronod <i>Sagittaria arifolia</i> USGS</p>	<p>Oak leaved grasshopper <i>Chrysopa sordida</i> Wikipedia</p>	<p>Ragwort reedgrass <i>Phragmites australis</i> Wikipedia</p>	<p>Indian balsam <i>Aquilaria glandulifera</i> Wikipedia</p>	<p>Giant chickweed <i>Myricophyllum spicatum</i> K. Peters - Wikipedia</p>	<p>Weeping alkali grass <i>Phragmites australis</i> Wikipedia</p>	<p>Reed marmia grass <i>Phragmites australis</i> Wikipedia</p>	<p>Barnyard grass <i>Echinochloa crusgalli</i> R. Molnar/USGS</p>	<p>Yard dock <i>Rumex crispus</i> Wikipedia</p>	<p>Bitter dock <i>Rumex obtusifolius</i> Wikipedia</p>	<p>Crack willow <i>Salix fragilis</i> Z. Szewczuk - Univ. of Zurich</p>		
<p>Purple willow <i>Salix purpurea</i> Wikipedia</p>	<p>White willow <i>Salix alba</i> Wikipedia</p>	<p>Black alder <i>Alnus incana</i> Wikipedia</p>	<p>Glossy buckhorn <i>Fraxinus excelsior</i> USGS</p>	<p>Common reed <i>Phragmites australis</i> E. Stoermer - NPS</p>	<p>Red alga <i>Gracilaria tikvahiae</i> R. Love</p>	<p>Red alga <i>Gracilaria tikvahiae</i> R. Love</p>	<p>Alga <i>Fragilaria virescens</i> E. Stoermer</p>	<p>Brown alga <i>Sargassum muticum</i> Wikipedia</p>	<p>Brown alga <i>Sargassum muticum</i> Wikipedia</p>	<p>Grass kelp <i>Ulva lactuca</i> Wikipedia</p>	<p>Grass kelp <i>Ulva lactuca</i> Wikipedia</p>	<p>Slurry stonewort <i>Hydrocolea setacea</i> USGS</p>	<p>Green alga <i>Ulva lactuca</i> E. Stoermer</p>	<p>Blue-green alga <i>Cylindrocapsa raciborskii</i> R. Love</p>	<p>Diatom <i>Cyclotella choctawhatcheeana</i> R. Love</p>	<p>Diatom <i>Cyclotella choctawhatcheeana</i> R. Love</p>	
<p>Diatom <i>Cyclotella choctawhatcheeana</i> E. Stoermer</p>	<p>Diatom <i>Sphaerococcyx birsteinensis</i> R. Love</p>	<p>Diatom <i>Cyclotella choctawhatcheeana</i> E. Stoermer</p>	<p>Diatom <i>Sphaerococcyx birsteinensis</i> R. Love</p>	<p>Diatom <i>Sphaerococcyx birsteinensis</i> R. Love</p>	<p>Diatom <i>Discosira rotunda</i> E. Stoermer</p>	<p>Diatom <i>Discosira rotunda</i> E. Stoermer</p>	<p>Diatom <i>Discosira rotunda</i> E. Stoermer</p>	<p>Diatom <i>Thalassiosira weissflogii</i> M. Kuyumkian & R. Kerkhof</p>	<p>Diatom <i>Thalassiosira weissflogii</i> E. Stoermer</p>	<p>Diatom <i>Thalassiosira weissflogii</i> R. Love</p>	<p>Diatom <i>Thalassiosira weissflogii</i> R. Love</p>	<p>Diatom <i>Thalassiosira weissflogii</i> R. Love</p>	<p>Diatom <i>Thalassiosira weissflogii</i> R. Love</p>	<p>Diatom <i>Thalassiosira weissflogii</i> R. Love</p>	<p>Diatom <i>Thalassiosira weissflogii</i> R. Love</p>	<p>Diatom <i>Thalassiosira weissflogii</i> R. Love</p>	
<p>Freshwater hydroid <i>Craspedocheilus sapidus</i> M. Faase</p>	<p>Freshwater jellyfish <i>Craspedocheilus sapidus</i> USGS</p>	<p>Erycinid damselfly nymph <i>Erycinid damselfly nymph</i> L. Storaasli</p>	<p>Aquatic weevil <i>Procladius tenax</i> Wikipedia</p>	<p>European water moth <i>Acanthodes caryocera</i> R. Johnson - Cornell Univ.</p>	<p>Oligochaete <i>Limnodrilus hoffmeieri</i> H.S. Naissonet</p>	<p>Oligochaete <i>Rubia pressa</i></p>	<p>Oligochaete <i>Gammarus subtypicus</i></p>	<p>Oligochaete <i>Paratropis ansonae</i></p>	<p>Oligochaete <i>Paratropis ansonae</i></p>	<p>Oligochaete <i>Paratropis ansonae</i></p>	<p>Oligochaete <i>Paratropis ansonae</i></p>	<p>Flatworm <i>Paratropis ansonae</i></p>	<p>Digenea fluke <i>Microphallium fortis</i></p>	<p>Asian tapeworm <i>Platyhelminthes</i> www.sciencedirect.com</p>	<p>Digenea fluke <i>Microphallium fortis</i></p>	<p>Digenea fluke <i>Microphallium fortis</i></p>	<p>Monogeneic fluke <i>Microphallium fortis</i> M. S. Niggler and G. Kraus</p>
<p>Monogeneic fluke <i>Microphallium fortis</i></p>	<p>Ciliate <i>Paratropis ansonae</i></p>	<p>Microsporidian parasite <i>Microsporidium</i> More DNR/USGS</p>	<p>Microsporidian parasite <i>Microsporidium</i> More DNR/USGS</p>	<p>Microsporidian parasite <i>Microsporidium</i> More DNR/USGS</p>	<p>Salmonid whirling disease <i>Myxobolus cerebralis</i></p>	<p>Tetrahelminth <i>Pleistomonas communis</i></p>	<p>Tetrahelminth <i>Pleistomonas communis</i></p>	<p>Tetrahelminth <i>Pleistomonas communis</i></p>	<p>Suctorian <i>Acinetus retusus</i> L. Dudgeon</p>	<p>Flagellate <i>Paratropis ansonae</i></p>	<p>Nematode kidney disease <i>Paratropis ansonae</i> USGS</p>	<p>Funaria <i>Acinetus retusus</i> NOAA</p>	<p>Mastixia <i>Paratropis ansonae</i> M. O'Rourke</p>	<p>Spring virenia of carp <i>Rhabdovirus carp</i></p>	<p>Largemouth bass virus <i>Morone virus</i></p>	<p>VHSV virus <i>Herpesvirus</i> M. Faase</p>	
<p>European ear snail <i>Radix auricularia</i> USGS</p>	<p>New Zealand mudsnail <i>Potamopyrgus antipodum</i> M. Sargent</p>	<p>Japanese mystery snail <i>Campelomabdomus japonica</i> USGS</p>	<p>Banded mystery snail <i>Physa gyrans</i> A. Jagger</p>	<p>Green foater mussel <i>Lemnaea gibbosa</i> A. Jagger</p>	<p>Asian clam <i>Corbicula fluminea</i> R. Barkley - USGS</p>	<p>Quagga mussel <i>Dreissena polymorpha galeata mendotae</i></p>	<p>Zebra mussel <i>Dreissena polymorpha galeata mendotae</i></p>	<p>Faucet snail <i>Bithynia tentaculata</i> USGS</p>	<p>Piedmont elima <i>Ceriodaphnia dubia</i></p>	<p>Chinese mystery snail <i>Physa integra</i> USGS</p>	<p>European valve snail <i>Valva sinuata</i></p>	<p>Buffed pebbleshell <i>Glycymeris glycymeris</i></p>	<p>Grewer European pea clam <i>Platystrophia auricularia</i></p>	<p>Humpback pea clam <i>Platystrophia auricularia</i> R. Barkley - USGS</p>	<p>Henslow pea clam <i>Platystrophia auricularia</i> R. Barkley - USGS</p>	<p>European figgenail clam <i>Saxidomus nutalli</i></p>	<p>Pygmy pea clam <i>Platystrophia auricularia</i> R. Barkley - USGS</p>

GLANSIS

A one-stop source for information about non-indigenous species in the Great Lakes region!

GLANSIS ENHANCEMENTS 2010-2011

The GLANSIS project has received funding under the Great Lakes Restoration Initiative (GLRI) for several improvements in support of early detection and rapid response.

- Addition of 'range expansion' species — those native to one portion of the Great Lakes but are considered invasive to other portions of the basin.
- Addition of high priority 'watchlist' species — those that have been identified in the literature as high risk for invading and becoming established in the Great Lakes.
- Updated and consistent 'impact' information allowing cross-taxa comparisons that are better able to support risk assessment and management.
- Addition of management information — regulations, best management practices, and control methodologies—for all the species in the database.
- Enhanced bibliographic information. (IL-IN Sea Grant)
- Addition of non-technical fact sheets for priority species of public interest. (IL-IN Sea Grant)

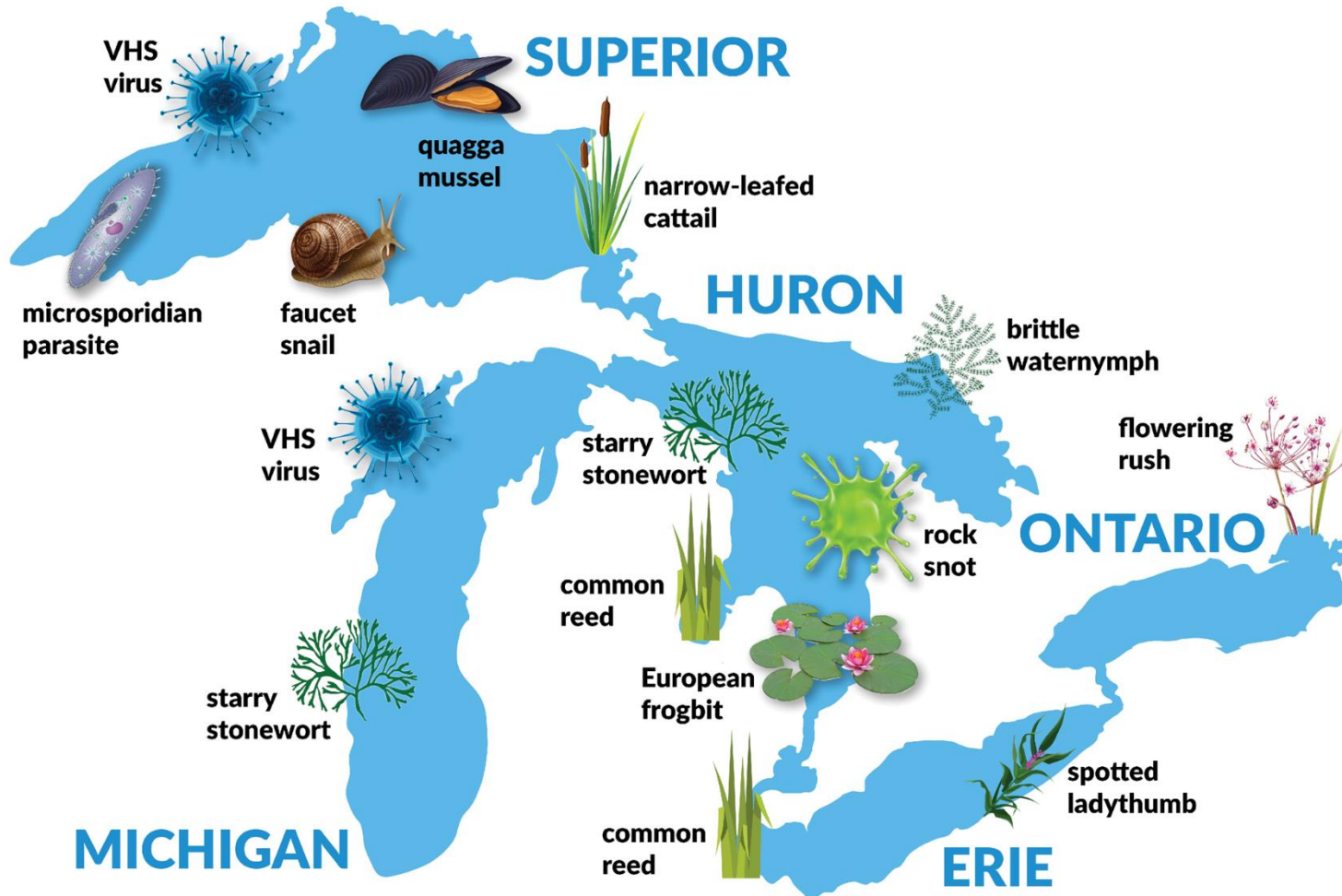


GLANSIS NEEDS Your Verified Reports

Send reports to:
Dr. Rochelle Sturtevant
rochelle.sturtevant@noaa.gov
NOAA Great Lakes Environmental Research Laboratory
4840 South State Road
Ann Arbor, MI 48108
734-741-2235
www.glerl.noaa.gov

Invaders keep spreading

Just three new nonnative species have been detected in the Great Lakes in recent years. Their introduction has been slowed by ballast water regulations for ocean-faring ships. But scientists and regulators struggle to keep unwanted creatures from traveling between lakes. Here's a look at species that have spread to each lake over the past decade.





Quick Review and Discussion

Is it true that.. :

- aquatic invasive species have only ecological impact on native communities? (Yes/No) Examples?
- Florida is one of the states with the large number of introduced species? (Yes/No) Why?
- Invasive species in The Great Lakes are under control right now? (Yes/No) Example?

Modes of Introduction

Intentional Introduction

- Aquaculture (transferring contents of home aquarium into a lake)
- Water gardening (planting exotic plants)

Unintentional Introduction

- ships, boats, barges
- aquatic recreation (fishing, hunting, boating, diving, etc.)
- seaplanes, connected waterways

Native Community



Modes of Introduction

Intentional Introduction

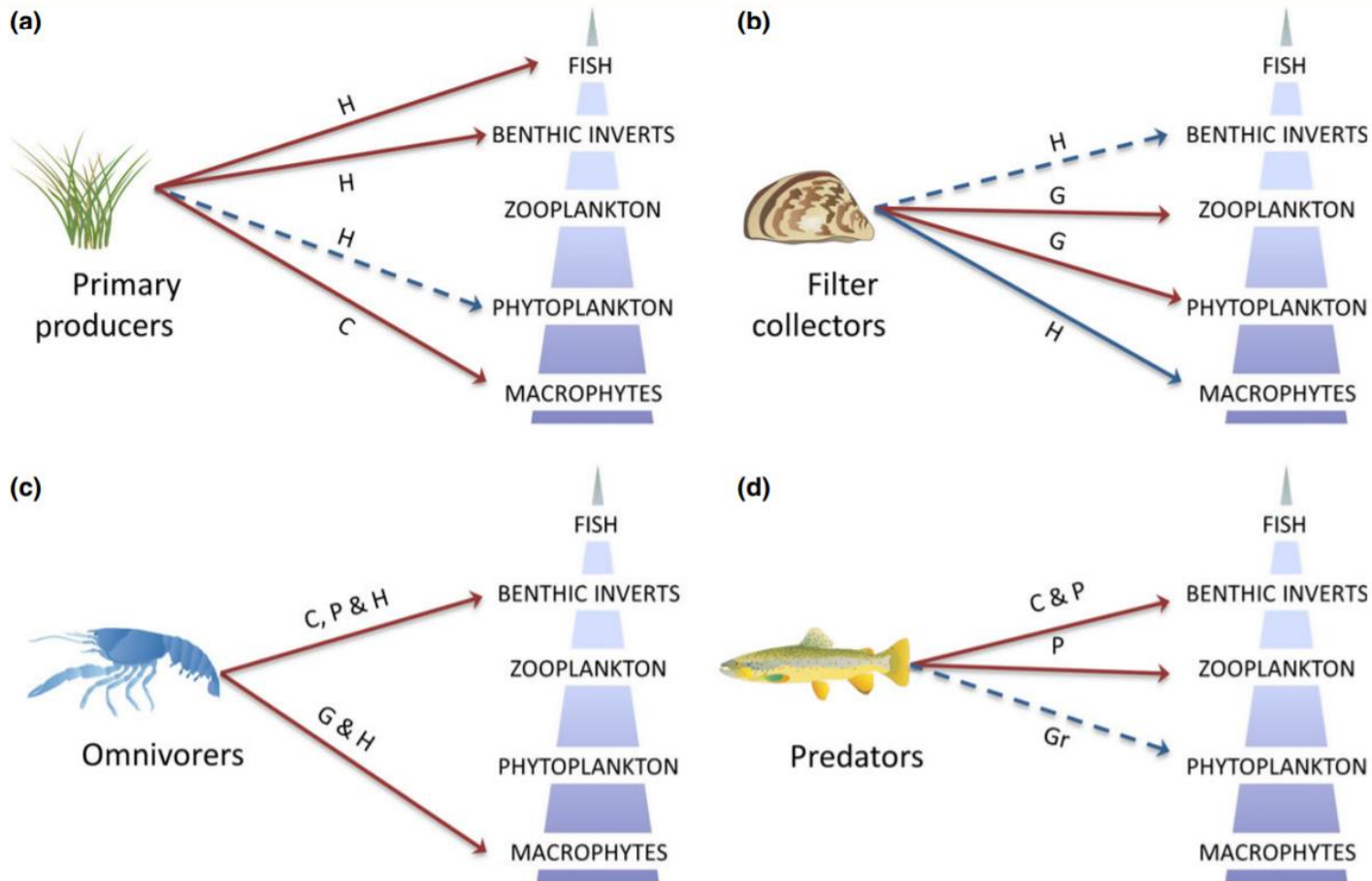
- Aquaculture (transferring contents of home aquarium into a lake)
- Water gardening (planting exotic plants)

Unintentional Introduction

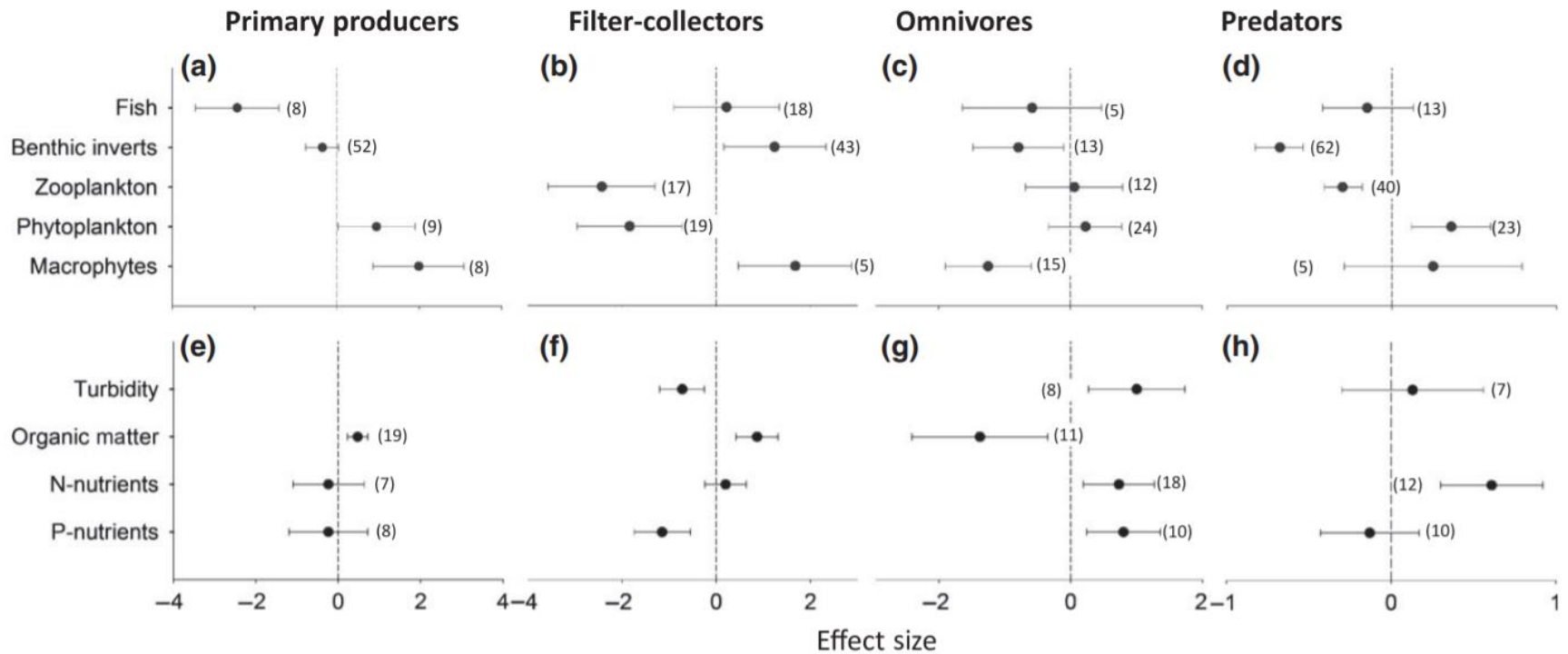
- ships, boats, barges
- aquatic recreation (fishing, hunting, boating, diving, etc.)
- seaplanes, connected waterways

Native Community

Impacts of invasive species on native aquatic communities



Impacts of invasive species on native aquatic communities



Invasive Species Dispersal

Ecological Applications, 11(6), 2001, pp. 1789–1799
© 2001 by the Ecological Society of America

OVERLAND DISPERSAL OF AQUATIC INVASIVE SPECIES: A RISK ASSESSMENT OF TRANSIENT RECREATIONAL BOATING

LADD E. JOHNSON,^{1,3} ANTHONY RICCIARDI,² AND JAMES T. CARLTON¹

¹*Maritime Studies Program, Williams College, Mystic Seaport, Mystic, Connecticut 06255, USA*

²*D*

TABLE 1. Survey questions asked of boaters departing public boat launches on Lake St. Clair (Michigan, USA).

- 1) How long were you out on the lake today? (number of hours, days or weeks)
- 2) Were you fishing today? (yes/no)
- 3) Were you equipped with a live well or similar device? (yes/no)
If “yes,” then
 - a) Did you use this device today? (yes/no)
 - b) What was the fate of any water in it?
(dumped in lake/dumped at ramp/taken from ramp/unknown)
- 4) What kind of bait did you use today? (minnows, worms, artificial, other)
If minnows,
 - a) Did you use a bait bucket today? (yes/no)
 - b) What was the fate of any water it contained?
(dumped in lake/dumped at ramp/taken from ramp/unknown)
- 5) Did you use your anchor today? (yes/no)
- 6) Where is your next planned use of this boat? (return here/other Great Lake launch/inland lake/unknown)
- 7) When do you plan to use this boat next? (Number of days or weeks/unknown)

Notes: For arriving boats, Questions 1–5 were framed in the present or future tense. Type of data or possible responses recorded are in parentheses.

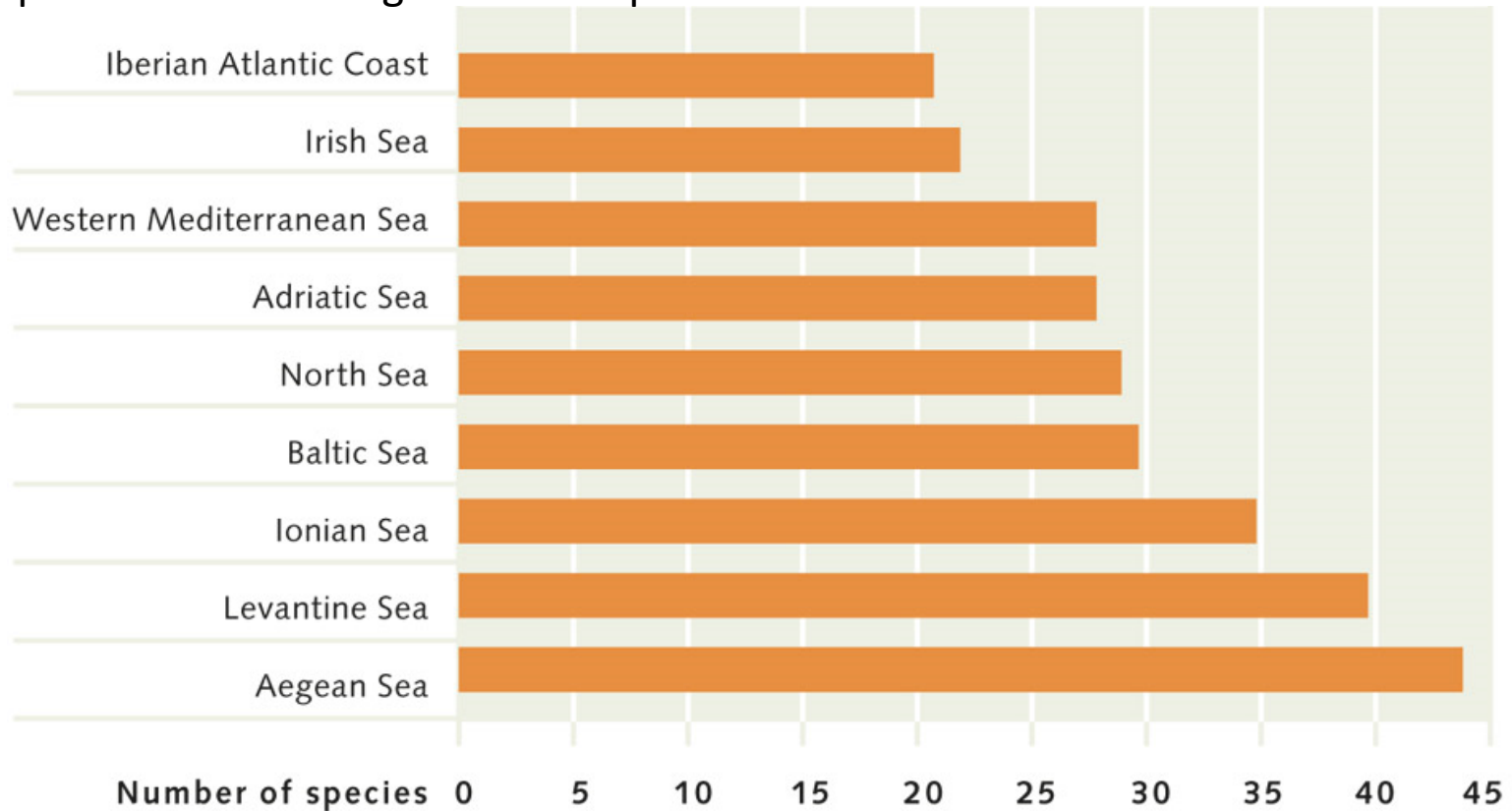


Quick Review

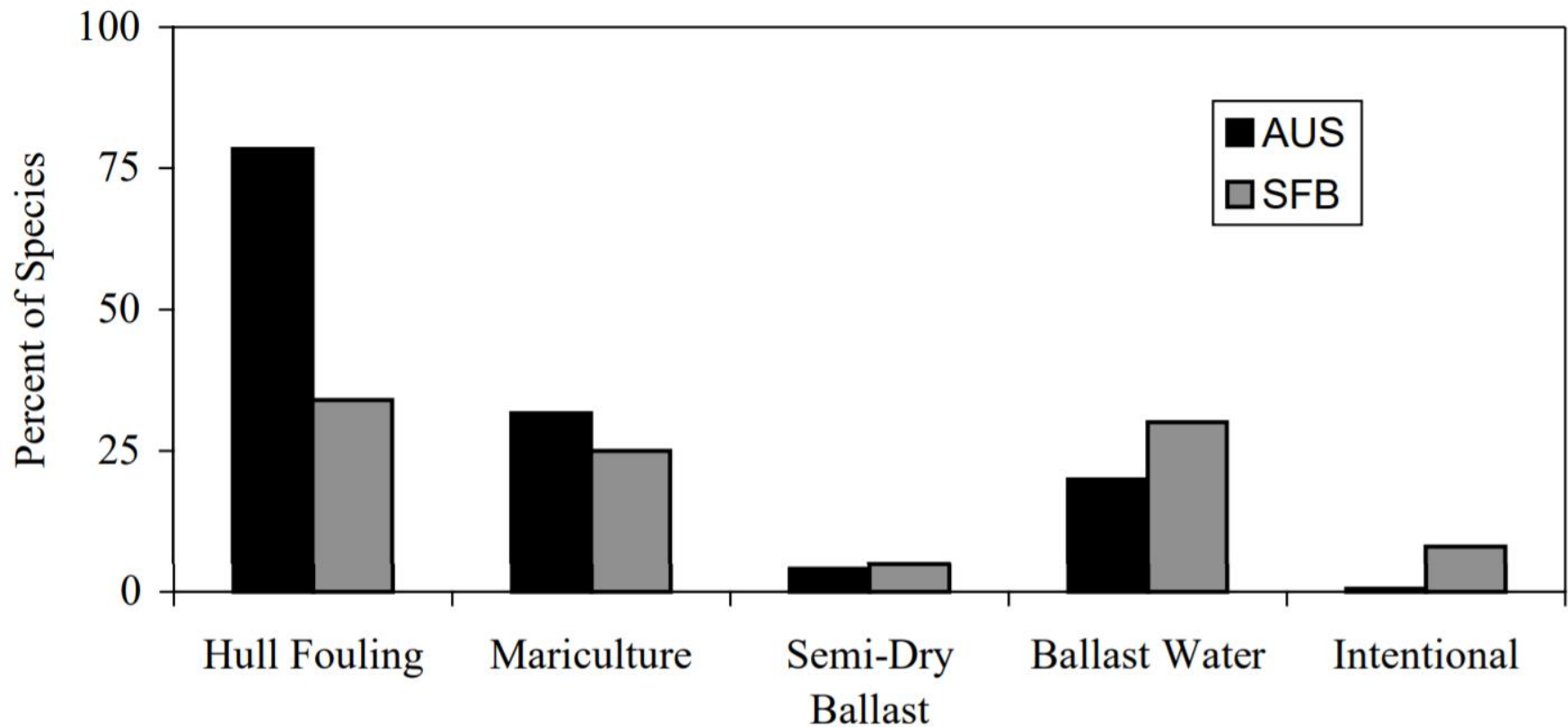
- Is transferring species by ships, boats, barges an unintentional introduction? (Yes/No)
- Is transferring species through aquaculture an unintentional introduction? (Yes/No)
- Do filter collectors have the most impact on trophic levels in native aquatic communities? (Yes/No)

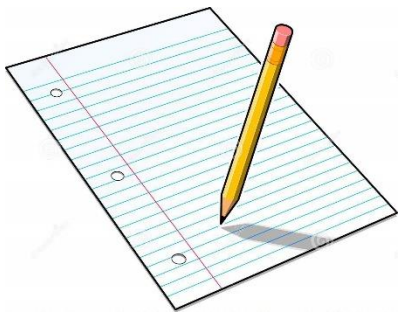
Marine Invasive Species

Invasive species in marine regions in Europe:



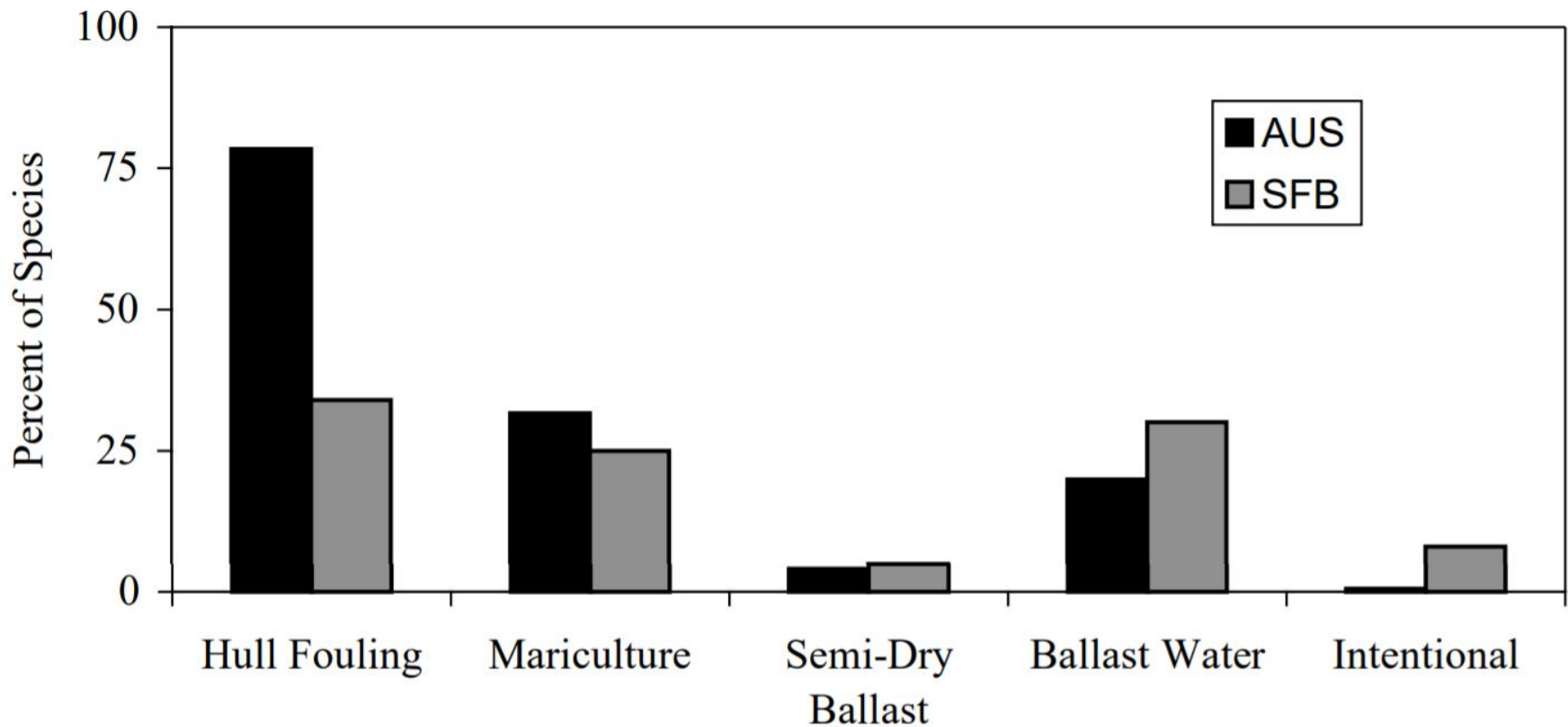
Anthropogenic vectors for marine introductions





Anthropogenic vectors for marine introductions

Worksheet Part 4.

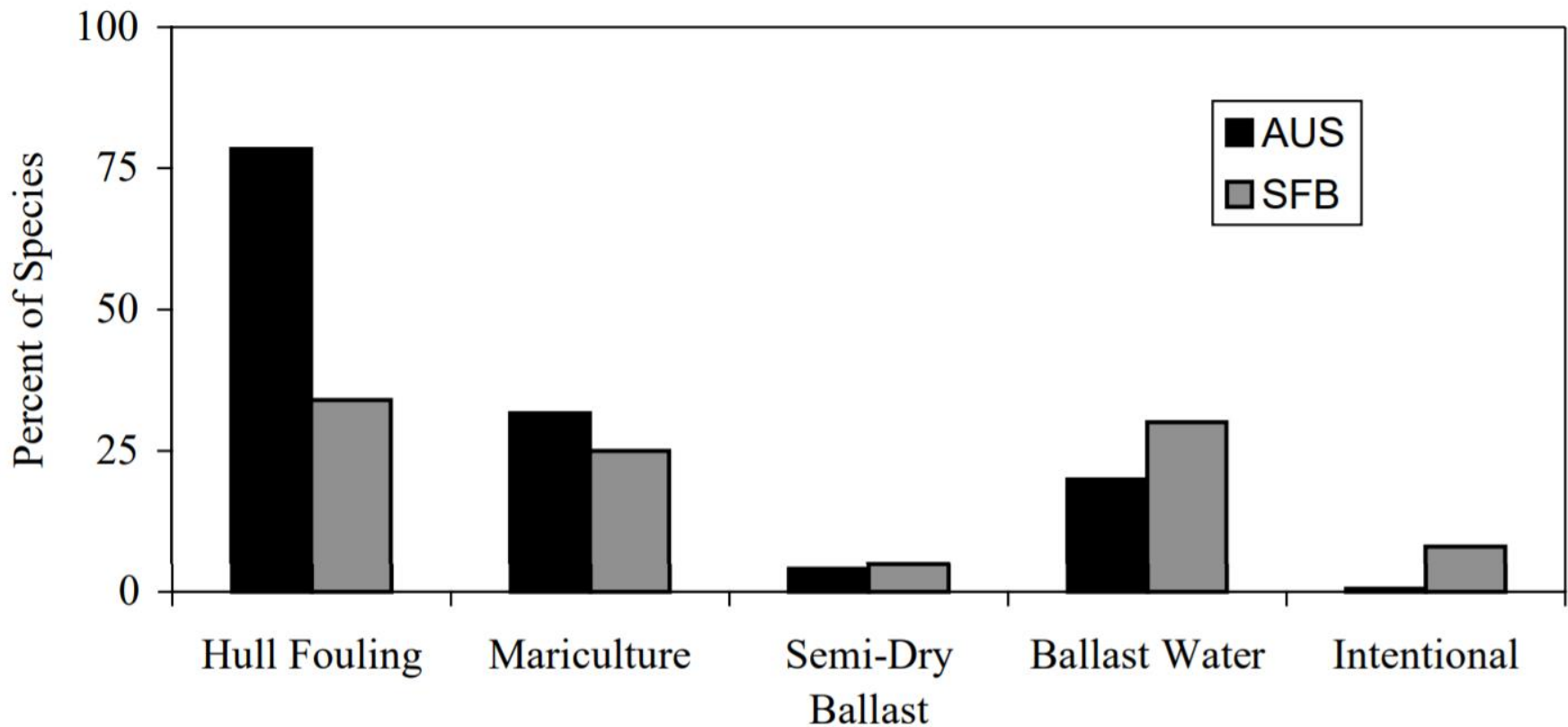


Anthropogenic vectors for marine introductions

Source	Vector	Target taxa
Commercial shipping	Ballast water	Plankton, nekton, benthos in sediment
	Hull fouling	Encrusting, nestling, and some mobile species
	Solid ballast (rocks, sand, etc.)	Encrusting, benthos, meiofauna and flora
Aquaculture and fisheries	Intentional release for stock enhancement	Single species
	Gear, stock or food movement	Various
	Discarded nets, floats, traps, trawls, etc.	Various
	Discarded live packing materials	Various
	Release of transgenic species	Single species
Drilling platforms	Ballast water	Plankton, nekton, benthos in sediment
	Hull fouling	Encrusting, nestling, and some mobile species
Canals	Movement of species through locks due to water motion or active swimming	Various
Aquarium	Accidental or intentional release	Aquarium fauna and flora
Industry	Hull fouling	Encrusting, nestling, and some mobile species
Recreational boating	Snorkeling and scuba gear	Algal spores, bacteria, some small mobile species
Dive practices		
Floating debris	Discarded plastic debris	Encrusting and some mobile species



Anthropogenic vectors for marine introductions



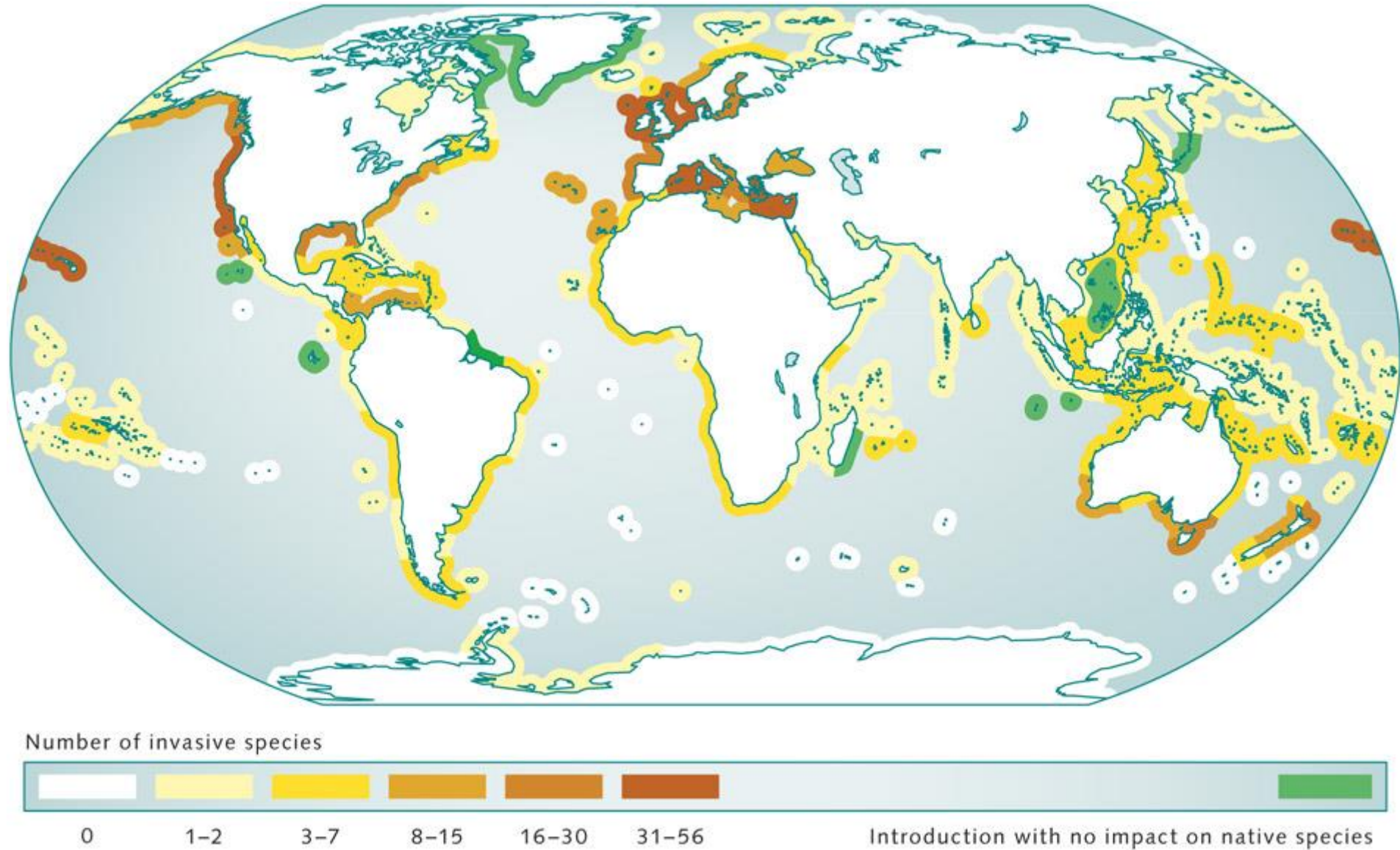


Quick Review

Which taxa can be affected by anthropogenic vectors:

- Plankton (Yes/No)
- Nekton (Yes/No)
- Meiofauna (Yes/No)
- Benthos (Yes/No)

Invasive species in coastal ecoregions



Invasive Species Are Still Hitching Rides on Tsunami Debris

RESEARCH

BIOGEOGRAPHY

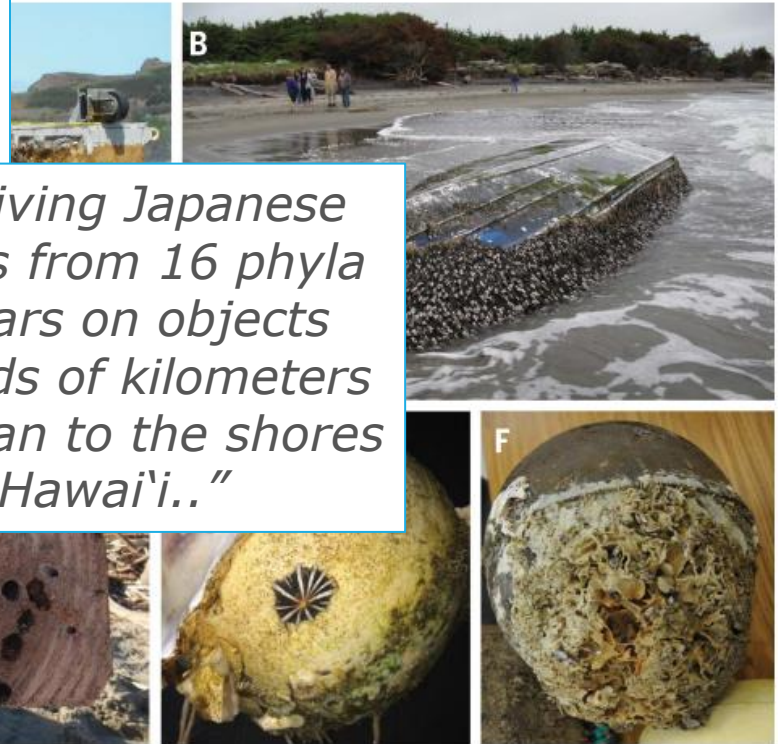
Tsunami-driven rafting: Transoceanic species dispersal and implications for marine biogeography

James T. Carlton,^{1,2*} John W. Chapman,³ Jonathan B. Geller,⁴ Jessica A. Miller,³ Deborah A. Carlton,¹ Megan I. McCuller,^{1,†} Nancy C. Treneman,⁵ Brian P. Steves,⁶ Gregory M. Ruiz^{6,7}

The 2011 East Japan earthquake generated a massive transoceanic biological rafting event with We document 289 living Japanese coastal marine species over 6 years on objects that traveled thousands of kilometers to the shores of North America and Hawai'i. Most of the

ent across all object types (figs. S7 and S8). We documented peak richness in 2012 to 2014 for each object type and region (fig. S7 and fig. S4), 2 to 3 years after debris entry into the Western Pacific Ocean. Strong spring pulses were evident for both landings and species accumulation for each year between 2012 and 2016 (Fig. 2 and fig. S2). These pulses were most pronounced in the Pacific Northwest (5) and were associated with springtime southwesterly or downwelling-favorable winds.

Temporal analyses of a subset of 110 JTMD objects that were most thoroughly sampled for macrobiota [higher-resolution objects (JTMD-



"..We document 289 living Japanese coastal marine species from 16 phyla transported over 6 years on objects that traveled thousands of kilometers across the Pacific Ocean to the shores of North America and Hawai'i.."

Fig. 1. Japanese tsunami marine debris rafts and associated biota.
(A) Fisheries dock (JTMD-BF-1) (4) from the Port of Misawa, Aomori Prefecture,

Peninsula, Pacific County, Washington (photograph by A. Pleus). (D) Post-and-beam wood (JTMD-BF-297) from Tōhoku coast, Honshu, washed ashore 1 April

Control Methods

- Physical removal*
- Ecological control*
- Chemical control*
- Biological control*



Almost done...

Learning Outcomes Review

1. Aquatic invasive species:

- are introduced species unintentionally introduced in native communities (yes/no)
- impact all trophic levels in aquatic native communities (yes/no)



2. Introducing a native enemy to control an aquatic invasive species is an example of:

- physical control (yes/no)
- biological control (yes/no)
- ecological control (yes/no)



3. Please name at least two aquatic invasive species

4. One thing which you didn't know about...

Thank you!



Image credits and resources

USDA

Maryland Cooperative Extension

<https://www.nhbs.com/the-ecology-of-invasions-by-animals-and-plants-book>

<http://www.socialstudiesforkids.com>

<https://oceanservice.noaa.gov>

<https://www.ecori.org/natural-resources/2015/6/23/gypsy-moth-caterpillars-take-ri-by-storm>

Louis-Michel Nageleisen, Département de la Santé des Forêts, Bugwood.org

<http://bugoftheweek.com/blog/2017/4/29/good-bye-ash-trees-of-the-potomac-emerald-ash-borer-eab-iagrilus-planipennisi>