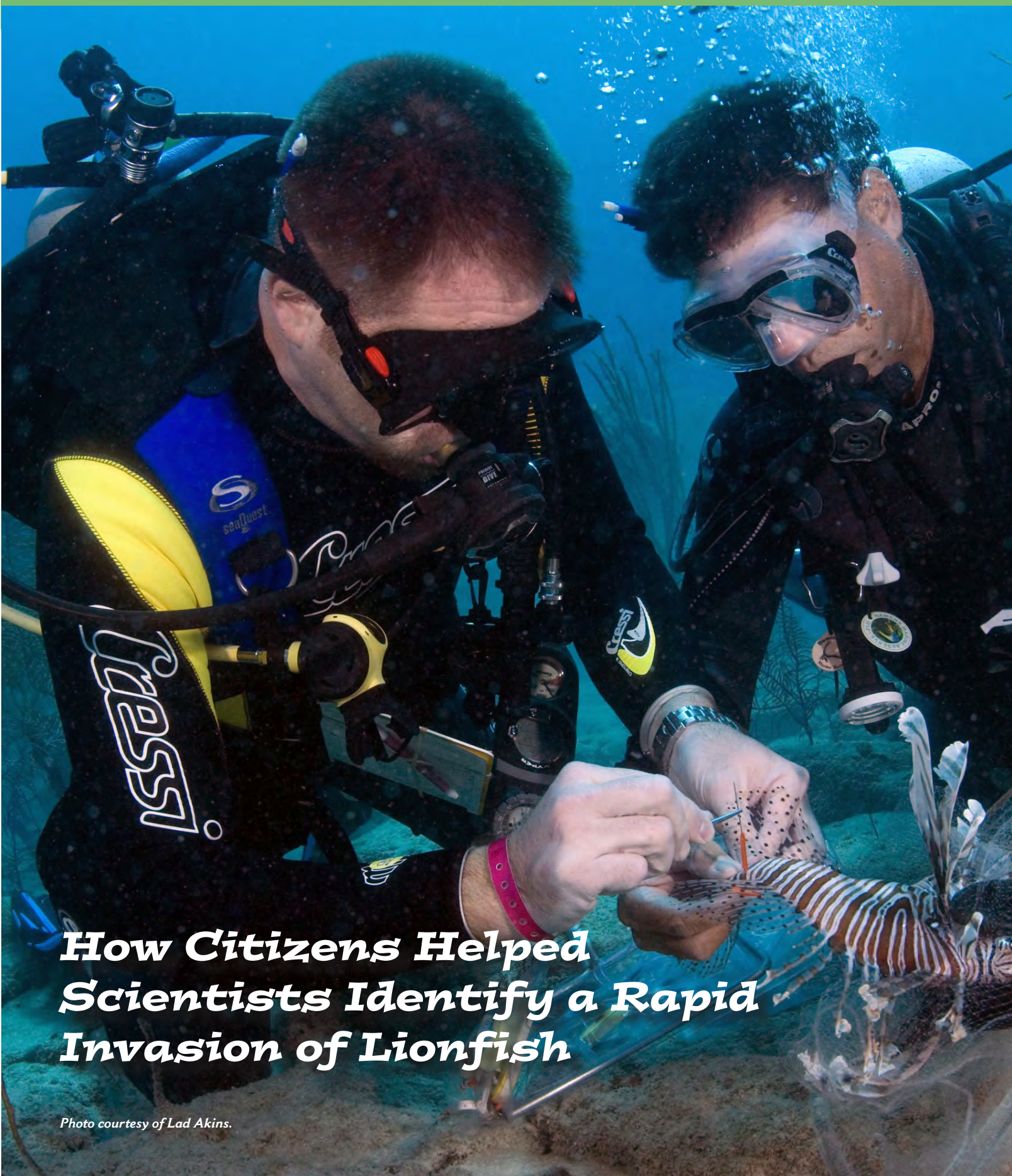
Lion in Wait



How Citizens Helped Scientists Identify a Rapid Invasion of Lionfish

Photo courtesy of Lad Akins.

Meet the Scientists

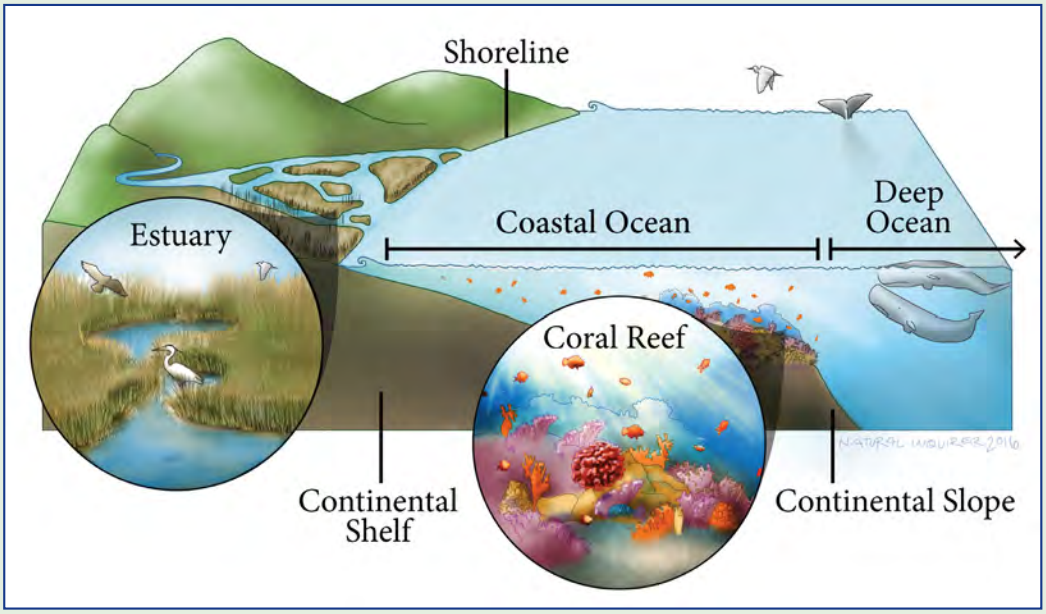
Photo courtesy of Steven Scyphers.

◄ **Dr. Steven Scyphers,** Sustainability Scientist: My favorite science experience is meeting and hearing stories directly from commercial fishers and other residents of coastal communities. Commercial fishers are people who fish as a part of their job.

As scientists, we spend quite a bit of our time designing surveys and experiments to better understand our coasts. However, the amount of time that we are able to spend on the water is often far less than folks who work or live near the coast. For example, a waterfront homeowner showed us his homemade boat powered by a bicycle. He peddles his boat around the bay to visit neighbors by water.

Scientists increasingly recognize the value of local citizens' knowledge and experiences for our efforts to understand coastal oceans. For example, we were able to obtain photographs taken by the coastal resident who peddles his bicycle-powered boat. From his photographs, we were able to scientifically document how recent hurricanes had affected coastal marshes and fishing vessels. Experiences like these continually remind us why talking with people in coastal communities is important for our science. It is also a lot of fun!

What Is a Coastal Ocean?



A coastal ocean is the strip of ocean from the outer continental shelf to the **estuaries** (**es** chə **wer** ēs) close to the shore. Although coastal oceans represent only 7 percent of the ocean's surface worldwide, they are the richest in marine life of all ocean areas. With an estuary's mix of fresh and salt water, estuaries are some of the most productive ecosystems on Earth. Illustration by Stephanie Pfeiffer.

Meet the Scientists

►**Lad Akins,** Director of Special Projects: My favorite science experience is working with nonscientists to answer scientific questions. Many students, SCUBA divers, and interested members of the general public are helping to address issues like the lionfish invasion.

Some of these people have first-hand knowledge to share, such as the underwater observations from SCUBA divers. Others have time, money, or energy to donate to research projects. One thing all of these people have in common is passion for helping to keep our environment healthy.

Photo courtesy of Lad Akins.

I feel satisfied when I am able to help coordinate citizen scientists' energies and expertise to address a problem. We can't always rely on others to fix problems for us. Therefore, it is important to pick a cause, take a stand, and help address issues by being active. The Reef Environmental Education Foundation's motto captures that idea. Our motto is: Explore. Discover. Make a Difference. In this photo, I am close to an Indo-Pacific lionfish. You will soon learn why I am wearing a glove!

What is SCUBA?

SCUBA's name came from its purpose. SCUBA is a self-contained underwater breathing apparatus. Its purpose is to give divers the ability to breathe underwater. Lad Akins is using SCUBA gear to swim close to the lionfish in the photo.

Glossary words are **bold** and are defined on page 53.

Meet the Scientists

Photo courtesy of David Hay Jones.

◄ **Dr. Marcus Drymon,** Marine Fisheries Ecologist: My favorite science experience has been the opportunity to use data from our shark population monitoring program. This program keeps track of shark populations and applies the information to management plans. These plans promote the conservation and management of sharks in the Gulf of Mexico. In this photo, our team is sampling an adult tiger shark. I am on the left, closest to the camera.

►**Dr. Pam Schofield,** Fishery Biologist: So far, my favorite science experience has been living and working in Uganda, East Africa, where I studied the effects of nonnative fishes on the Lake Victoria ecosystem. Uganda is a beautiful country full of amazing wildlife.

I lived very simply in Uganda–with no running water or electricity. Living simply taught me that much of what we think we need in life we really don't need. The people I met in Uganda were incredibly kind and friendly, and I never would have completed my research without their generosity and guidance.

Photo courtesy of Pam Schofield.

Photo courtesy of Charles Martin.

◄ **Dr. Charles Martin,** Senior Field Ecologist: My favorite science experience is answering questions about nature. My curiosity about how the natural world works, and how humans have changed the world, drives my scientific research program. I love the creativity involved in asking new questions and figuring out new and unique ways of finding the answers. I feel satisfied with knowing that the science I participate in contributes to a greater understanding of our natural ecosystems. This science also affects the decisions we make to conserve our planet.

What Kinds of Scientists Did This Research?

director of special projects: This scientist works in a variety of areas and directs unusual projects. At the Reef Environmental Education Foundation, this scientist also conducts scientific research, trains others, and works with citizen scientists.

fishery biologist: This scientist studies fish and how the environment and other outside forces affect fish throughout their life cycle.

marine fisheries ecologist: This scientist studies ocean and coastal marine environments to understand the relationship of fish and other living organisms with each other and the nonliving environment.

senior field ecologist: This experienced scientist conducts field studies to understand the relationship of living things with each other and the nonliving environment.

sustainability scientist: This scientist studies the relationships between human, environmental, and engineered systems. This scientist works to understand and develop solutions to problems that threaten the long-term health of life on Earth.

Thinking About Science

The Gulf of Mexico is a large body of salt water along the Southeastern United States (**figures 1 and 2**). Take a moment to look at how much area is covered by the Gulf of Mexico. The Gulf of Mexico is larger than the combined States of Texas, New Mexico, Arkansas, and Louisiana.

Figure 1. The Gulf of Mexico is a body of salt water along Mexico's east coast, around the east and north coasts of parts of Central America, along the U.S. Gulf Coast, along the west coast of Florida, and in western Cuba. The Gulf of Mexico covers a surface area of 579,153 square miles (1.5 million square kilometers). Maps by Carey Burda and Stephanie Pfeiffer.

Number Crunch

Write out 1.5 million in numeric form.

Figure 2. The Gulf of Mexico near Pensacola, Florida. Photo courtesy of Babs McDonald.

Think about trying to figure out whether a particular species of marine fish is swimming in the Gulf of Mexico. Now think about trying to figure out how many of these fish are swimming in the Gulf of Mexico, and where they are swimming. This identification and counting is a challenge for marine scientists. The Gulf of Mexico covers a large area, and fish and other marine animals are constantly moving. In addition, seeing large areas under the water's surface can be difficult.

Citizens, and in particular people engaged in outdoor recreation, may be visiting areas far away from other people. Often, these people have opportunities to observe, count, and report what they have observed. By doing this, they can help scientists because scientists cannot be everywhere. SCUBA divers, for example, may dive in areas where scientists might not be.

The scientists in this study were interested in identifying how many of a particular fish species were swimming in an area of the Gulf of Mexico. The scientists wanted to compare the numbers reported by recreational SCUBA divers with the numbers reported by other methods for identifying and counting marine fish. Recreational SCUBA divers are people who use SCUBA gear to dive and swim under water for pleasure.

Thinking About the Environment

You may have heard the phrase, "The only constant is change." This phrase means that most things on Earth change over time. Think about the world around you. Does this statement seem true to you?

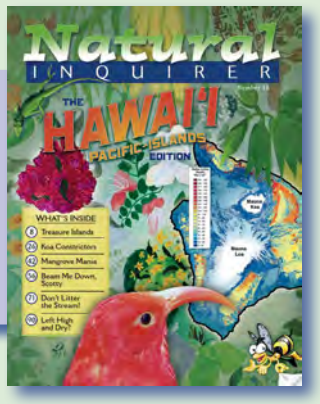
Some scientists are changing their understanding of invasive species. Invasive species are species that are not **native** to the place they live and are likely to cause harm to the environment, the economy, or human health. Humans have moved many plant and animal species to new areas. In some cases, the movement of species has been accidental, and in other cases, it has been on purpose. In many instances, invasive species have caused ecosystems to change so much that native species are unable to thrive in the ecosystem.

Invasive plant and animal species rapidly reproduce in new habitats. Some scientists have noticed situations, however, in which invasive species do not cause the harm to these new habitats that might be expected. These invasive species seem to fill an ecological role in an ecosystem. For example, in the Western United States, an invasive tree provides habitat for an **endangered** bird species. In another situation, native Hawaiian flowers are pollinated by an invasive bird species where native pollinators no longer live. Invasive species might especially fill ecological roles where humans have destroyed native habitat.

Some scientists are expanding their view of invasive species. In some instances, for example, everything possible should be done to reduce the harm caused by an invasive species. Native ecosystems should be preserved if possible. In other instances, we should realize that invasive species are creating new ecosystems.

As you can see, scientific thinking can change as scientists observe the world around them. Think of another example of when scientific thinking changed as a result of new observations. Think of an example of when your own thinking changed as a result of new observations. Do you think your thinking will continue to change? Why?

Read the *Natural Inquirer* Hawai'i-Pacific Islands edition to learn more about plants and animals in Hawai'i.



Introduction

Over the past decade, humans have introduced two species of Indo-Pacific lionfish (*Pterois volitans* and *Pterois miles*) into the Atlantic Ocean (**figures 3a and 3b**). These species have spread into the northwestern Atlantic Ocean, the Caribbean Sea, and the Gulf of Mexico (**figure 4**). These fishes' native ecosystem is the Indo-Pacific region **(figure 5**). These fishes have been seen in a wide range of Atlantic marine habitats, including coral reefs, hard bottoms, seagrass meadows, mangroves, and oyster reefs (**figure 6**). Sightings in different habitats mean that Indo-Pacific lionfish are found across a wide area, making it difficult to track their expanding numbers.

Marine scientists use established methods to monitor the presence of different fish species in marine ecosystems. These methods include the use of underwater cameras and underwater remotely operated vehicles (ROVs) **(figure 7**). In recent years, scientists have also provided online opportunities for citizens to report fish and other marine sightings. Lad Akins has also developed a method to tag lionfish (**figure 8**). When a lionfish is tagged, its movements can be tracked.

In this research, the scientists wanted to compare the different ways that information is

collected about Indo-Pacific lionfish in an area of the Gulf of Mexico. In particular, the scientists wanted to compare observations and sightings of Indo-Pacific lionfish by recreational SCUBA divers with scientifically taken photographs and ROV videos.

Figures 3a & 3b. Indo-Pacific lionfish are colorful fish with **venomous** spines that protect them from **predators**. This fish eats smaller fish and **invertebrate** marine animals such as shrimp. Lionfish can live for decades. Photos courtesy of Lad Akins.

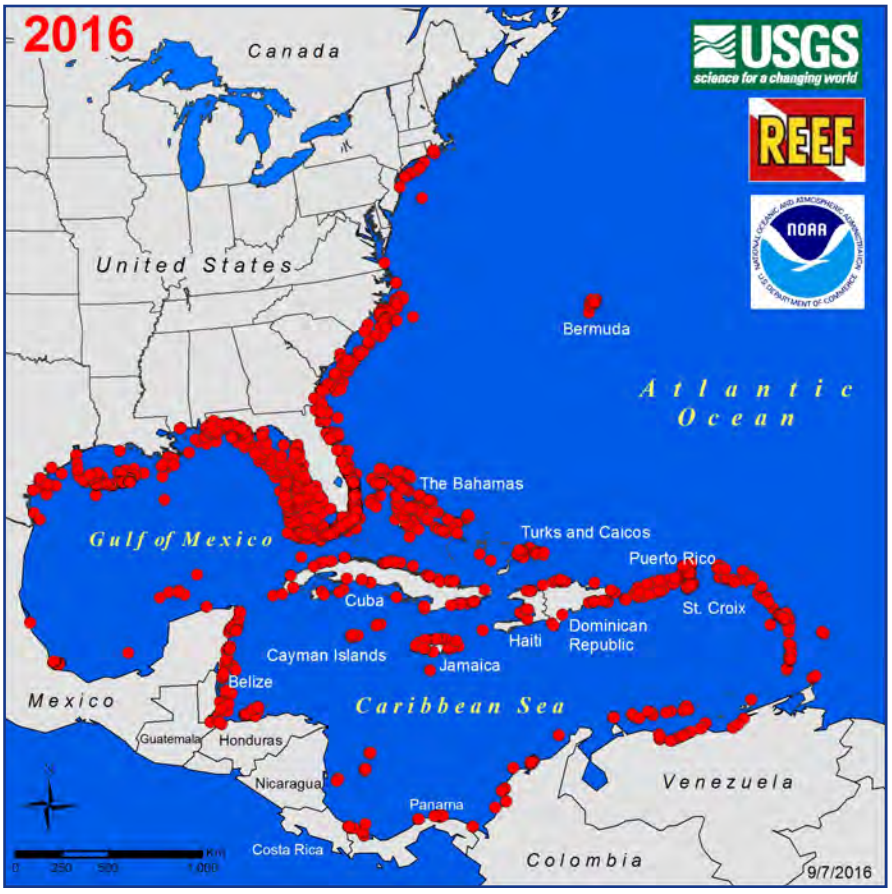


Figure 4. Indo-Pacific lionfish, originally found in the Indo-Pacific region, have been seen in the northwestern Atlantic Ocean, the Caribbean Sea, and the Gulf of Mexico. The red dots on the map indicate sightings of lionfish. Map courtesy of Pam Schofield.

Figure 5. The native habitat of lionfish is the Indo-Pacific region, which includes the Indian Ocean, the western and central Pacific Ocean, the seas of Indonesia which connect those two oceans, and the Red Sea. Map by Carey Burda and Stephanie Pfeiffer.

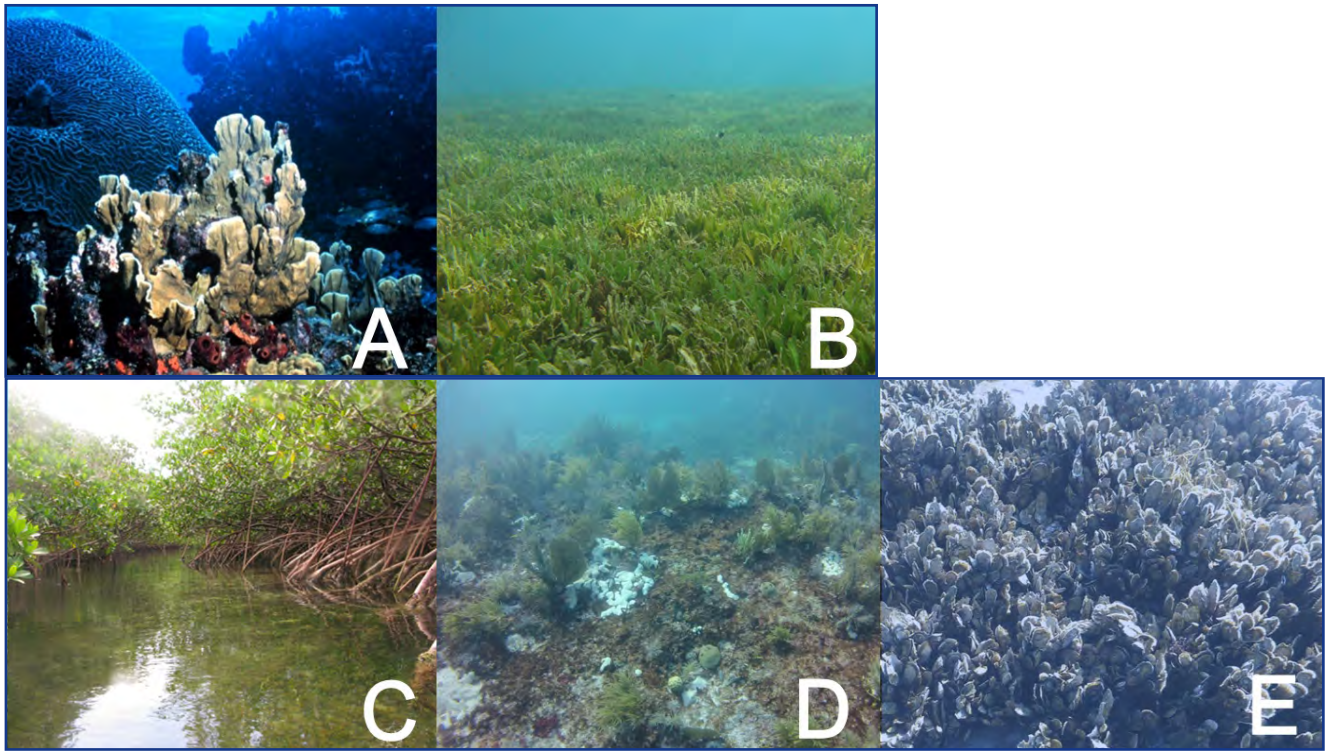


Figure 6. Indo-Pacific lionfish have been seen in coral reefs (A), seagrass meadows (B), mangroves (C), hard bottoms (D), and oyster reefs (E), among other habitats. A coral reef is built by colonies of tiny marine animals. A hard bottom is an area with low diversity, relatively flat, and characterized by hard materials. Photos A, B, C, and D courtesy of Lad Akins, and photo E courtesy of Babs McDonald.

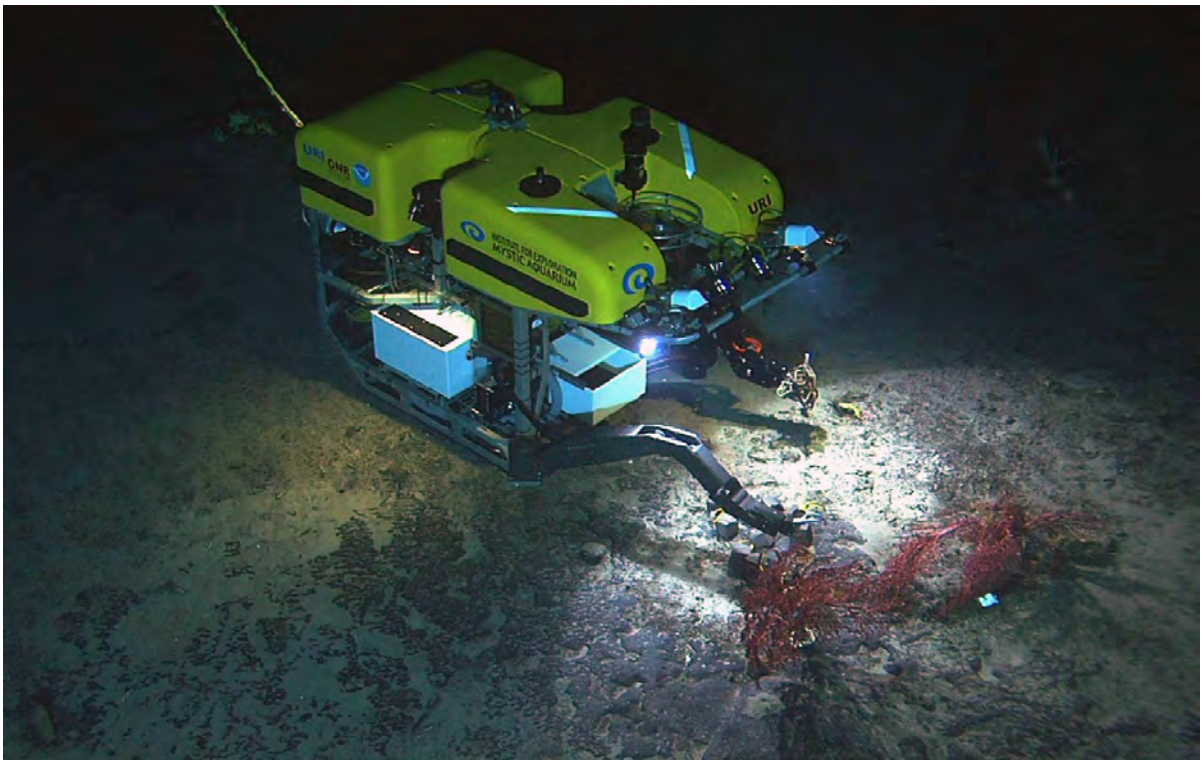


Figure 7. Underwater remotely operated vehicles survey an area by being controlled remotely. Photo courtesy of Mountains of the Sea Research Team, National Oceanic and Atmospheric Administration.

Figure 8. Andy Dehart and Lad Akins tag a lionfish. Photo courtesy of Lad Akins.

Reflection Section

- The scientists wanted to understand how Indo-Pacific lionfish are impacting the Gulf of Mexico ecosystem. To do that, they first needed to ask a different question. What question did the scientists ask in this research? Why did they need to ask this question?
- Describe one challenge of collecting information about the lionfish population in the Gulf of Mexico.

Methods

The scientists identified an area in the Gulf of Mexico where Indo-Pacific lionfish had been sighted. The scientists compared five sources of lionfish **abundance** data collected in this area (**figure 9**). The data collection spanned the time from the first recorded Indo-Pacific lionfish sightings in this Gulf of Mexico area in 2010 through the year 2012.

The first source of lionfish counts was from an underwater **stationary** camera used by the Southeast Area Monitoring and Assessment Program (SEAMAP). The program uses

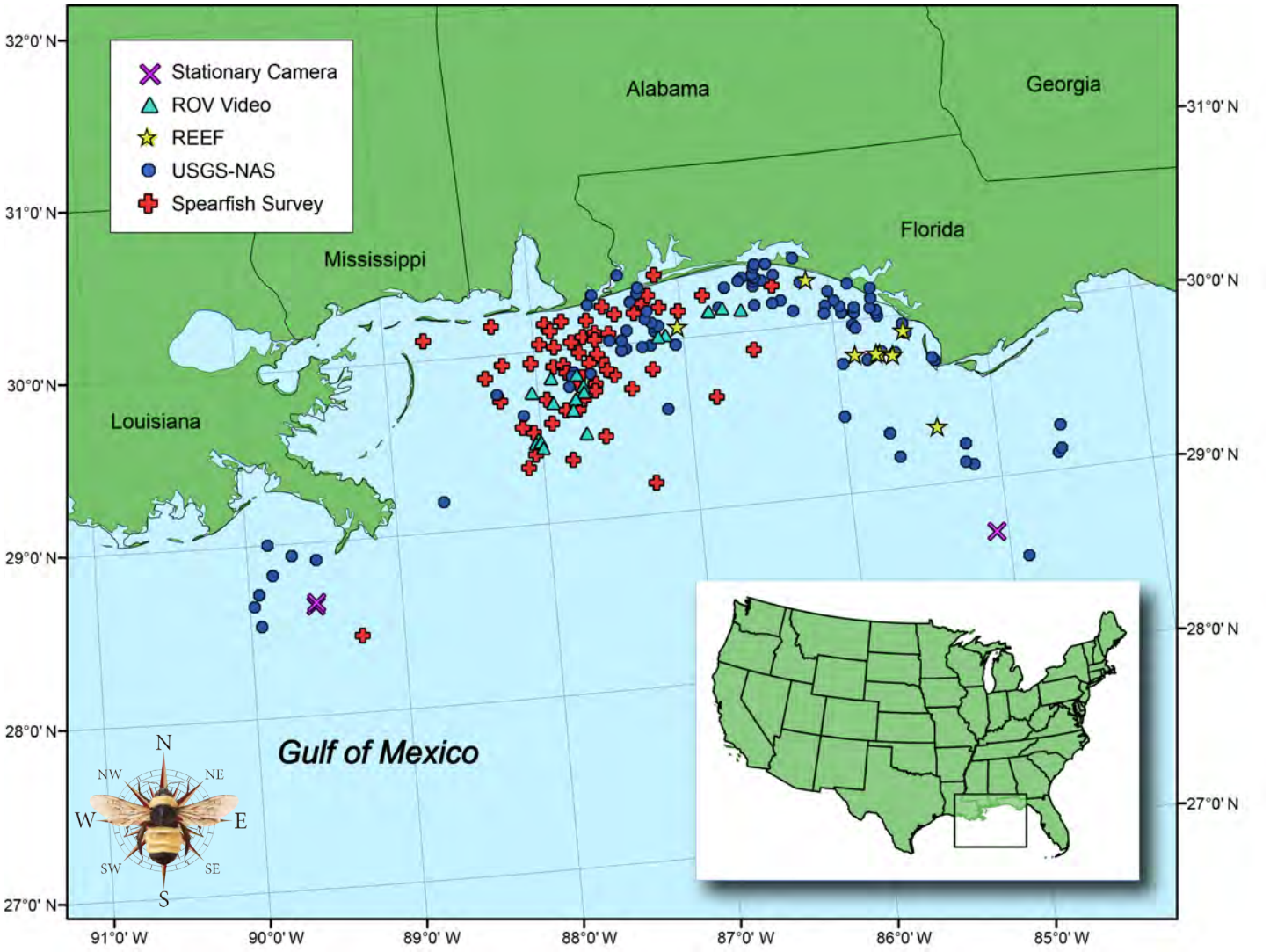


Figure 9. The scientists identified an area in the Gulf of Mexico where Indo-Pacific lionfish had been sighted. Map by Carey Burda and Stephanie Pfeiffer.

underwater photography to identify, count, and understand a range of marine life.

The second source of lionfish counts was from information provided by the Dauphin Island Sea Lab (DISL). DISL uses underwater remotely operated vehicles (ROVs). The ROVs videotape artificial reef structures and the areas around the structures (**figure 10**). A reef is rock, coral, a sandbar, or other structure beneath the water's surface. An artificial reef is a human-built structure meant to provide reef habitat for marine life. Sometimes boats or other materials are purposely sunk to create artificial reefs.

The third source of Indo-Pacific lionfish counts was the U.S. Geological Survey's **Nonindigenous Aquatic** Species (USGS-NAS) **database**. The USGS-NAS database is like an online library where information is stored. This database enables the U.S. Geological Survey to monitor, record, and analyze sightings of nonnative aquatic species throughout the United States. Citizens, as well as scientists, can visit online and report sightings.

The scientists also used data reported into the Reef Environmental Education Foundation (REEF) database. REEF is a

What Is the Southeast Area Monitoring and Assessment Program?

The Southeast Area Monitoring and Assessment Program (SEAMAP) collects, manages, and shares information about fisheries in the Southeastern United States. SEAMAP's goal is to provide managers with the best information possible so that the best decisions can be made. SEAMAP is a partnership between Federal and State Governments and universities.

Figure 10. This material is an artificial reef that provides habitat for marine animals. Photo courtesy of Lad Akins.

marine conservation organization. REEF trains recreational SCUBA divers as citizen scientists. These citizen scientist SCUBA divers report sightings of marine fish and other marine organisms.

The last source of information came from an online **questionnaire**. The questionnaire asked 232 licensed Alabama spearfishers to report the number and location of their dives. The questionnaire also asked spearfishers to report any sightings or experiences with lionfish, to provide any photographs they had taken, and to describe their encounters in detail.

What Is a Spearfisher?

A spearfisher is a person who, while swimming below the water's surface, captures fishes using a spear. For many of the spearfishers in this study, the spear is propelled mechanically or shot using the tension of a large rubber band to propel it forward. Spearfishing is not legal in some places.

What Is the Dauphin Island Sea Lab?

The Dauphin Island Sea Lab (DISL) conducts research and provides marine education opportunities to Alabama colleges and universities. Most of DISL's research is about **nearshore** and **estuarine** (es chə **rēn**) processes in the northern Gulf of Mexico. (See the sidebar on page 38 to learn more about estuaries.)

Reflection Section

- Why did the scientists identify a specific area to study?
- The scientists wanted to compare information from citizen scientists with information collected by marine scientists' ongoing survey efforts. Which of the five data sources were provided by citizen scientists?

Photo courtesy of http://www.iStockphoto.com.

Findings

The scientists examined 1,411 photographs and videos recorded by the stationary cameras and the ROV (**table 1**).

Data Source	Pre-2011		2011		2012	
	Attempts	Total Lionfish	Attempts	Total Lionfish	Attempts	Total Lionfish
Stationary Camera	710	0	247	0	189	4
ROV Video	29	0	144	1	92	50
USGS-NAS	Not Applicable	15	Not Applicable	76	Not Applicable	244
REEF	86	0	48	2	57	13
Spearfisher Questionnaire	14,802	230	3,559	1,073	Not Applicable	Not Applicable

Table 1. Yearly number of attempts to observe Indo-Pacific lionfish and numbers of lionfish sighted for each data source. Notice the numbers of total lionfish counted in each year.

The USGS-NAS database first recorded lionfish sightings in the Gulf of Mexico in 2010. However, lionfish were seen off the southeast coast of Florida as early as 1985. Reports indicated that most sightings were of 1 to 4 lionfish, although some reports showed up to 50 lionfish per sighting. Lionfish were observed between 2 meters in depth in shallow seagrass meadow habitats and up to 40 meters in depth in offshore and artificial reef habitats. The REEF database did not have any lionfish sightings in the Gulf of Mexico before 2011.

Fifty-seven licensed spearfishers answered the questionnaire. These 57 spearfishers had participated in more than 14,000 dives. These SCUBA divers had an average of 13 years of experience and an average of 17 dives every year in the northern Gulf of Mexico. One-third of the spearfishers reported seeing lionfish during a dive. In total, spearfishers saw 1,303 individual lionfish. Of these, 82 percent were observed in 2011.

Although some of the lionfish sightings were spread out across the study area, most of the sightings occurred within the same area (see figure 9 on page 47).

Number Crunches

- How many individual lionfish were observed by spearfishers in 2011?
- What was the average number of dives per spearfisher?

Citizen Science Connections

iCoast is a project aimed at improving scientific knowledge of coastal erosion issues. Coastal erosion is the process or state of washing away land in coastal areas. Coastal erosion is a common issue following extreme storm events, such as hurricanes. Extreme storms can change or damage the natural environment and human-made structures.

Scientists have taken more than 140,000 photos of coastal areas before and after 24 different extreme storms. However, the scientists are unable to compare and contrast all the photos by themselves. Scientists are asking citizen scientists to use iCoast to identify changes and damage to coastal areas using the photos.

iCoast lets citizen scientists:

- Learn about coastal erosion issues;
- Compare and contrast coastal erosion photos;
- Submit data about coastal erosion following extreme storm events;
- Contribute to science.
-

iCoast is a project created by the U.S. Geological Survey. More than 1,000 citizen scientists assist scientists with the iCoast project. To learn more, visit http://coastal.er.usgs.gov/icoast/about.php.

USGS
science for a changing world

Reflection Section

- Observe table 1. What is the general trend in lionfish sightings shown by this table?
- Which source of lionfish sightings provided the most information? Why do you think this source might have provided the most information?
- Observe figure 9 on page 47. What patterns do you observe in the sighting locations by the source of the sighting?
- What does the map on page 47 tell you about lionfish location in the study area?

Discussion

The scientists noted that spearfishers, SCUBA divers, and other citizen-based sources of lionfish counting were effective at documenting the rapid movement of lionfish into the study area. Therefore, citizens could play an important role in providing an early warning of other **nonnative** species as they move into new ecosystems.

All of the sources of lionfish counting examined by the scientists showed a similar pattern. Most sources showed lionfish moving into the study area in 2010 and their numbers increasing every year through 2012. The USGS-NAS database relies on volunteers and does not include a measure of effort. The scientists do not know how many times volunteers tried to observe lionfish as compared with the numbers they reported. This lack of information limited the usefulness of the USGS-NAS database.

The survey of spearfishers enabled the scientists to compare effort with lionfish abundance. From this survey of spearfishers, the scientists learned that information provided by a small group of people can provide important additional information about lionfish abundance.

The scientists noted that this particular project is just one example of how citizen scientists can assist scientists with understanding ecosystem changes. In this case, the scientists were better able to understand the rate and locations of nonnative fishes' movement into a new ecosystem. Understanding other events, such as the impact of oil spills or hurricane damage, may also benefit from the involvement of citizen scientists. The popularity and improvement of mobile applications (apps) will provide even more ways for citizen scientists to report their observations. With improved mobile technologies, citizen scientists may become even more effective as contributors to science.

Reflection Section

- The scientists said that citizen scientists could be an early warning system for the movement of other nonnative species into new ecosystems. Name at least two other situations in which citizen scientists might provide information before scientists could collect it.
- How might the popularity and improvement of mobile apps enable citizen scientists to be more effective at contributing to scientific knowledge?

Adapted from Scyphers, S.B.; Powers, S.P.; Akins, J.L.; Drymon, J.M.; Martin, C.W.; Schobernd, Z.H.; Schofield, P.J.; Shipp, R.L.; Switzer, T.S. 2015. Rapid expansion of an invasive species documented through a social-ecological network. Conservation Letters. 8(4): 242-250. DOI: 10.1111/conl.12127, http://www.reef.org/reef_files/2014_Scyphers_etal_ConLetters_Lionfish.pdf

Glossary

abundance (ə **bən** dən(t)s): Degree of plentifulness.

aquatic (ə **kwä** tik): Growing or living in or upon water.

conserve (kən **sərv**): To avoid wasteful or destructive use of something.

database (**dā** tə bās): A comprehensive collection of related data organized for convenient access, generally in a computer.

endangered (in **dān** jərd): Being in danger or peril.

invertebrate (in **vər** tə brət): An animal lacking a backbone (spinal column). About 95 percent of all animals are invertebrates. These include all animals except mammals, birds, reptiles, amphibians, and fish.

native (**nā** tiv): Living or growing naturally in a particular region.

nearshore (**nir** shȯr): The nearshore region includes water from a lake, bay, or ocean shoreline to 30 meters in depth.

nonindigenous (**nän** in **dij** ə nəs): Growing, living, or occurring in a region or environment which is not native to the organism or thing.

nonnative (**nän nā** tiv): Not naturally occurring in an area.

predator (**pre** də tər): An animal that lives by killing and eating other animals.

questionnaire (**kwes** chə ner): Printed or written form of questions used to gather information.

stationary (**stā** shə ner ē): (1) Not moving; (2) staying in one place or position.

unique (yu **nēk**): (1) Being the only one; (2) Unusual.

venomous (**ve** nə məs): Capable of putting venom into another animal's body usually by biting or stinging it.

Accented syllables are in **bold**. Marks and definitions are from http://www.merriam-webster.com. Definitions are limited to the word's meaning in the article.

FACTivity

Time Needed

20 minutes to organize
Up to 2 days to collect data
30-40 minutes to discuss FACTivity exercise

Materials

- 2 cameras per group (phone cameras, tablet cameras, or point and shoot cameras)

The question you will answer in this FACTivity is: How does the information you collect vary when you use different ways to collect the same information?

Methods

Divide your class into groups of four students each. Make sure each group has access to two cameras, such as those listed in the "Materials" section. For this FACTivity, your group is curious about the popularity of different types of shoes. Your group would like to conduct a research project to determine the abundance of a certain type of shoe in your school.

First, your group will decide what type of shoe you are interested in counting. You could select, for example, a particular brand, a particular type of shoe, a particular shoe color, or any combination.

Each member of your group will be responsible for collecting data about the abundance of this shoe in your school. When you count, you will count a pair of shoes as one.

Two group members will conduct their own observational survey. Each member will count the number of pairs of the particular shoes he or she observes in school over 2 days.

Another group member will identify a busy location, such as the building or cafeteria entrance. This group member will take a photo of all the passing shoes every 5 seconds for 2 minutes during a time when many students are passing. For example, the time could be at the start or close of school, or at the lunch hour. The camera should be pointed at the same location for every photograph. Use a tripod if possible.

One group member will take 24 photos of students' shoes during a busy time, such as during lunch or as students are getting ready for their day. This student can move freely and can photograph any shoes she or he wants to photograph. If a pair of the selected shoes is seen, it should be photographed.

All group members will record their counts in the graphic organizer on page 55.

Lion in Wait FACTivity Graphic Organizer

Group members: _____

_____

Shoe Description		
Group Member Data Collection Method	**Date and Time**	**Number of Shoes Counted**
Survey #1		
Survey #2		
Stationary Camera		
Roving Camera		

After all data have been collected, your teacher will hold a class discussion based on the following questions:

1. How did the number of chosen shoes counted vary by data collection method?
2. What are the similarities between the data collection methods?
3. What are the differences between the data collection methods?
4. What are the advantages of each data collection method?
5. What are the disadvantages of each data collection method?
6. How does each data collection method compare with each similar source of lionfish abundance data in this article? (See Graphic Organizer to Compare Methods on page 56.)
7. Which of the group's members are most like the citizen scientists in this article?

Lion in Wait FACTivity Graphic Organizer to Compare Methods

	Use the space below to compare the methods.
ROV Video (Lion In Wait) vs. Roving Camera (FACTivity)	
Stationary Camera (Lion In Wait) vs. Stationary Camera (FACTivity)	
Questionnaire (Lion In Wait) vs. Surveys (FACTivity)	

If you are a trained Project Learning Tree educator, you may use "Did You Notice?" and "Improve Your Place" as additional resources.

Web Resources

U.S. Geological Survey-NAS Animated Map of Lionfish Spread
https://nas.er.usgs.gov/queries/SpeciesAnimatedMap.aspx?speciesID=963

U.S. Geological Survey-NAS Point Map of Lionfish Sightings
https://nas.er.usgs.gov/viewer/omap.aspx?SpeciesID=963

Dauphin Island Sea Lab
http://www.disl.org

Southeast Area Monitoring and Assessment Program
https://sero.nmfs.noaa.gov/operations_management_information_services/state_federal_liaison_branch/seamap/index.html

U.S. Geological Survey Nonindigenous Aquatic Species Program
https://nas.er.usgs.gov/

Reef Environmental Education Foundation
https://www.reef.org/

Reef Environmental Education Foundation Lionfish Page
https://www.reef.org/lionfish

Reef Environmental Education Foundation Free iPhone Mobile App for Lionfish Sightings:
Search for "REEF Lionfish Sightings"

Marine Advanced Technology Education Center (teaching resources for marine technology, including ROVs)
http://www.marinetech.org/