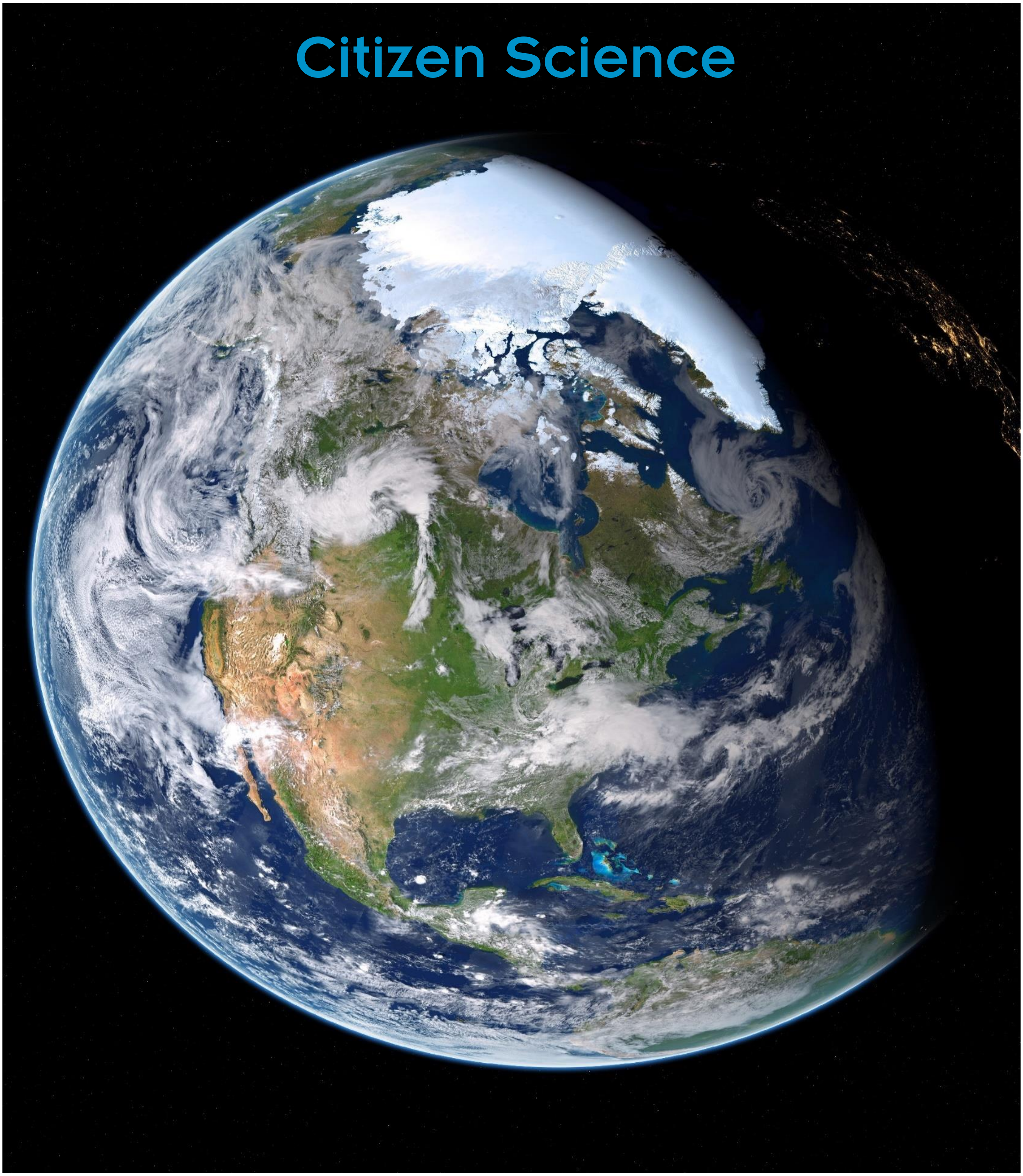
Citizen Science

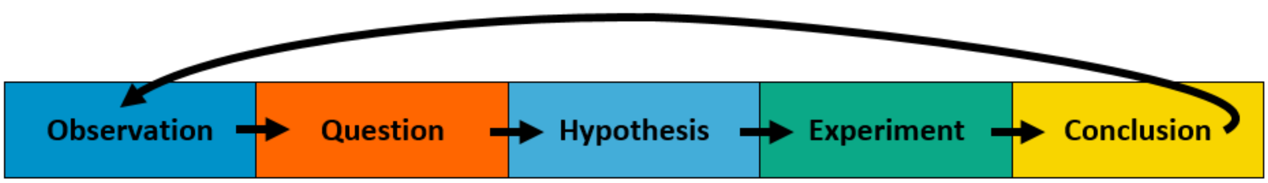


“Somewhere, something incredible is waiting to be known.”-Dr. Carl Sagan, a world-renowned astrophysicist

Dr. Sagan was talking about planets and galaxies, but this statement can easily be applied to our coastal waters, oceans, and fisheries. Right here in our backyards, Florida's reefs, beaches and estuaries support some of the greatest **biodiversity** on the planet. In the very waters we play in, something incredible is waiting for one of us to discover. Even as a student, you could be that discoverer, or one of a team of discovers. You can become a "citizen scientist."

Your Qualifications

Whether you realize it or not, you've engaged in science since before you could crawl. You figured out that certain actions, such as crying or smiling, elicited certain responses from your parents that were no less important than them feeding you or putting you down for a nap. Maybe when you were little older you dug in the sand along the beach chasing pink and purple and yellow coquina clams, or observed little fish darting in and out of seagrasses while snorkeling. Maybe you were fascinated with insects, or flowers, or had a telescope to view the stars. By cataloguing the world around you, you are always discovering our world and using the **scientific method**.



The scientific method is considered a linear process, starting with an observation and ending with a conclusion. In reality, experiments often lead to new questions, and hypotheses are often wrong! There are many ways to approach the scientific method.

The scientific method is a way of using evidence to answer questions, and is often thought of as a sequence of events: observation, question, hypothesis, experiment, conclusion. Without even realizing it, you have probably worked through this process by yourself when asking a question about the world around you.

As you matured and your powers of observation expanded, naturally you wanted to begin testing the world around you. You even may have thought that something you saw was caused by something else. In scientific terms, this is called cause and effect. For example, you stopped watering your house plant (the "cause"), and shortly after the plant leaves turned brown (the "effect"). After witnessing many of these cause-and-effect relationships, you may start to think that these relationships are always the same. But this is not necessarily true; there may be variation in the cause-and-effect relationships. Other things could have caused the leaves of your houseplant to turn brown. You can't assume that your poor plant-watering habits caused the plant leaves to turn brown without some sort of test.

When you first witness something happening, or make an **observation**, you often **question** why it may have happened. You then start to form **hypotheses**, informed explanations, about what you observed. Hypotheses come in the form of "because" statements. For example, the plant leaves turned brown *because* you stopped watering the plant.

Next, you need to test your hypothesis by creating an **experiment**. If you stop watering a different house plant and the leaves also turn brown, there is a chance your hypothesis has some truth. But if you stop watering 10 house plants and all their leaves turn brown, you have real evidence that supports your hypothesis. In this scenario, that is not what happens – you stop watering another house plant, but the leaves stay green. You can now **reject** your hypothesis about the lack of water, and create a new hypothesis based on a new observation. Looking closely at the leaves of the plant, you see small bugs around the brown leaves. Your new hypothesis is that the leaves turned brown *because* of the bugs on the leaves. You pull some of the bugs off of the leaves, place them gently onto other leaves that are green, and within days those leaves have turned brown. You now have evidence that supports your new hypothesis, and can use this evidence to form a **conclusion.**

The scientific method can change with the question being asked – in the scenario above, the hypothesis had to be created twice, after the first experiment showed that poor watering did not turn all the plant leaves brown. Sometimes, you may have to form many different hypotheses before reaching a conclusion. Some questions are harder to answer than others.

Even before formally learning the steps that make up the formal scientific method, unwittingly you would ask yourself questions and work through them in scientific ways. The scientific method is part of what makes us human. It is the most precise way that we search for meaning in the physical world. We make observations, form a hypothesis and test it to better understand the world around us. The beauty of the scientific process is that it provides everyone access to the natural world – and its willingness to reveal its secrets – to anyone willing to ask the right questions, test the proper conditions, and challenge preconceived notions or unanswered questions.

The Nature of Discoveries

Many discoveries and inventions happened by accident – others by casual observation. Often in coastal and oceanic ecosystems, discoveries are made with help from people profoundly connected to an ecosystem, such as an indigenous tribe member, or a fisherman who spends a great deal of time on the water. We, as citizens, can help scientists and fisheries managers collect the information they need to manage our natural resources for health and abundance.

The process of everyday people engaging in science is called "citizen science." In this lesson, you will learn:

- What is considered citizen science
- How you can engage in practicing citizen science
- Where you can discover science projects to engage with
- Examples of citizen science

- Examples of social and ecological improvements thanks to citizen science

An angler assists in citizen science by helping scientists catch fish in a seine net. The fish are tagged, and DNA samples are taken to better understand the life cycle of the fish.

What is Citizen Science?

Citizen science is a great opportunity for everyday people to get involved in the scientific process. Citizen science is also called amateur science, cooperative research, crowd-sourced science, volunteer science, or public scientific participation. Citizen science reaches across all disciplines such as astrology, biology, conservation science, ecology, zoology, and every other science field you can imagine. Citizen science is encouraged so widely because of its **co-benefits**. These include:

- Larger **datasets**
- Lower research costs
- Community education
- Faster pace of knowledge gain

Science can be expensive and there are not that many trained scientists. When government agencies, research universities and **non-governmental organizations** (NGOs) lack the funds for personnel to research, they team up when possible with communities of interested citizens. Organizations may provide **grants** to fund scientists to work with lay people on research initiatives. This partnership is the core of citizen science—professional scientists reaching out to the community to engage in the process.

When scientists work with the communities affected by their science, this provides scientists an opportunity to learn more about their topic from experienced groups such as commercial fishermen, fishing guides, and recreational fishermen (also known as anglers) who may have witnessed something important about the study subject. Teaming up with interested people allows scientists to learn things about the surrounding environment that they may not have had the opportunity to observe themselves, such as changes to animal behavior, losses of habitat, or other imbalances in the ecosystem. Community involvement gives scientists "insider" information that can increase the understanding of the area. This perspective is critical for developing a better understanding of the place or system being studied, and contributes to the more traditional principles of science. It is sometimes called, "local knowledge," or more formally as "**traditional ecological knowledge**."

Anglers do the hard work in a research effort involving catching fish in seine nets and landing the fish so they can be tagged, sampled, and released.

Example: The Demand for Tarpon Data

Atlantic Tarpon, with their large, powerful bodies and athletic jumps, are very popular among anglers. Their popularity and abundance makes them tremendous economic drivers in most coastal regions around Florida, and in many other tropical and temperate regions. In the United States, some anglers exclusively target tarpon, and almost all fish are released alive. That's because tarpon aren't very good eating, and are much more valuable alive as part of a catch-and-release fishery so they can reproduce more tarpon for anglers to catch.

Atlantic tarpon are a **migratory species**, targeted as far north as the Chesapeake Bay, throughout the Gulf of Mexico, throughout the Caribbean, and in northern Atlantic waters of South America. People from all over the world travel to these regions and spend lots of money in hopes of hooking a 6 foot (or larger!) tarpon and seeing one of its spectacular jumps. Many people are infatuated with the tarpon's great power and beauty.

Given the ecological and economic importance of the species, it is extremely important that we understand the tarpon's biology, life cycle, and needs. Here's what we know and what you can help us discover:

Tarpon are an ancient species – far older than most other bony fishes alive today. These ancestors of eels date back to a time at least 100 million years ago when our oceans were warmer, more acidic, and very clear. Adult tarpon make migrations offshore to spawn, but we don't know exactly where. That's a problem. Exploration for oil and gas continues to expand offshore, and the potential for another major disaster like the 2010 Deepwater

Horizon oil spill in the Gulf of Mexico increases as more wells are tapped. Other industries that may or may not be a problem for tarpon – such as offshore aquaculture and wind energy development – are becoming more common in ocean waters. Meanwhile, because of climate change, our oceans are becoming warmer and more acidic. Major ocean currents such as the Gulf Stream could be affected, and food sources could become more limited. All of these changes could cause shifts in spawning locations as well as impact food sources for tarpon larvae. We need to discover the spawning locations and protect them.

Code Red

Tarpon larvae are eel-like organisms called, "**Leptocephalus**." They float around on the open ocean for approximately 30 days until currents push them into shallow creeks and wetlands in estuaries, where they will live as juveniles and metamorphose (change shape) into fishlike form. Meanwhile, as coastal development increases and wetlands are damaged or destroyed, we still don't know which creeks are the most important to juvenile tarpon so we can protect these areas from development, pollution, and sea-level rise. Though scientists are working hard to learn how juvenile tarpon interact in certain habitats and what habitats they prefer, they need extra eyes to find where these animals live. The Bonefish and Tarpon Trust (BTT) is a non-governmental organization (NGO) that uses its coalition of members and supporters to provide scientists with the needed extra eyes to monitor juvenile tarpon habitats as part of its **Juvenile Tarpon Habitat Program**.

The need to understand juvenile tarpon habitat is critical to their survival. Loss of habitat is the single greatest threat to tarpon populations – not just here, but across the world. The International Union for Conservation of Nature (IUCN), a coalition of scientists and concerned citizens, have "**red-listed**" tarpon populations as "vulnerable" – meaning that there has been at least a 30-percent decrease in tarpon populations worldwide.

Mapping, understanding, and protecting juvenile tarpon habitat helps protect the entire population. Citizen scientists now play critical roles in filling in the understanding of what habitats juvenile tarpon prefer. It would require a colossal investment in time and resources for just trained scientists to search so much geography and habitat types for juvenile fish. By teaming with scientists, citizens can vastly expand the reach and observation of the species and their habitats.

Anglers on their boats or even in their neighborhood now report where they find tarpon under twelve inches. As citizens across the state report these juvenile tarpon sightings, this information helps to fill out a map of where we find these fish. Reports of these sightings give the scientists at BTT a low-cost way to create a map of juvenile tarpon habitats. Using this map, they can look for characteristics shared by habitats where juvenile tarpon are found. This helps scientists understand what characteristics are most important for juvenile tarpon habitat. So far, they have learned that mangrove creeks with access to freshwater or **hypoxic** areas seem to be important because they provide protection from predators that cannot enter or survive in such shallow, oxygen-poor environments. These are the types of habitats that need protection from fishing, pollution, and development if tarpon populations are going to recover. This is important information that citizen scientists helped to figure out.

By participating in this study, citizens are more likely to fight to protect the places that support the juveniles of a species they are so passionate about. Citizens, along with attorneys and other professional advocates, can find funds to purchase and protect lands surrounding these essential habitats, and work with developers and polluters on project designs and pollution mitigation plans. If necessary, they can challenge the pollution and development permits at the agencies that issue them, or via lawsuits in courts.

Also, once preferred habitats are identified, scientists and citizens then work together to identify special areas of concern that may require additional protections or are ripe for habitat restoration. Restoring habitats is the next level of citizen science that allows citizens to actually get dirty and rebuild lost or degraded habitats, fully participating in protecting species and the waters where they live.

Anyone who finds a juvenile tarpon can report the location and date, which helps scientists figure out juvenile habitats and learn about spawning seasons.

These are the ways that communities can become involved in science that provides information to help protect ecosystems that provide goods and services such as fisheries production, economic value, and which guard against flooding during hurricanes. But it all begins with sound science, and citizen science is often the most practical and effective way to figure out what must be protected and restored.

Science Experiments

Understanding how species interact and move between essential habitats can be a great, deep mystery. The problem with observing fish movements is that many species occupy many different habitats within their life cycle as they move underwater where humans cannot stay for very long. Permit are one of those species of fish with a very complicated life cycle – plus, they have powerful bodies that allow them to travel very far, very quickly, away from the curious eyes of the human observer.

Permit are another fish that is targeted by anglers for thrill. As adults, permit hunt for small crabs and invertebrates in shallow waters around seagrasses and even in bubbling surf on the beach, but swim offshore to wrecks and coral reefs as well. Anglers can often spot them in shallow water as the fish dig around in the sand, making it both exciting and infuriating as they watch the fish avoid their fishing hooks in favor of crabs and worms. When finally hooked, permit show their true strength and agility as they put up a fight the angler will not soon forget. Similar to tarpon, permit are an important economic staple around Florida and Caribbean waters.

From shallow flats and bubbling surf zones, to deepwater wrecks and reefs, permit can be found almost anywhere in the tropical South Atlantic and Caribbean waters. How they move from these habitats and why is only partially understood. Scientists have informed hypotheses of why this happens, but until tested and validated under real conditions, they do not have real answers.

Permit regularly move between shallow and deep waters for unknown reasons. Scientists have informed hypotheses of why this happens, but until tested and validated under real conditions, they do not have real answers. To better understand permit migratory patterns, scientists have formed a number of questions:

Citizen science has provided scientists with much information about permit, including where they spawn, and how old they are on average at a certain size.

- Do permit stay in relatively small home ranges, or regularly move longer distances?
- While there are special areas around the Florida Keys designed to protect permit, are permit staying in these areas or are they moving further, into unprotected waters where they are likely to be captured and not released?

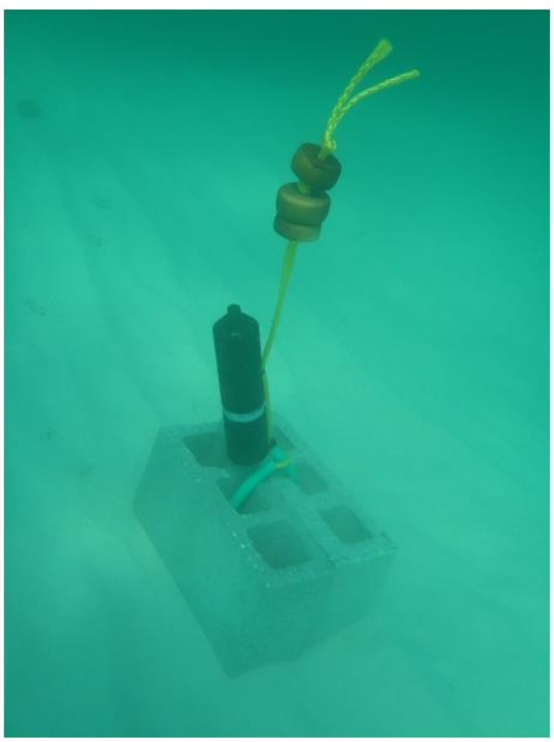
To answer these questions requires the use of scientific method, but just as importantly it requires anglers to help scientists catch these fish. Yes, that's right: catching fish in the name of science. This type of citizen science is often referred to as cooperative research.

As in any scientific research, the project design is critical to the project's success. Scientists typically develop the method, and use citizen help to put the design – and thus the experiment – into action. Tracking the permit's migratory patterns and seeking to find the answers to the questions above requires two steps: 1) inserting **dart tags** and 2) inserting **acoustic tags** into two different groups. Each tag type has a specialized use for scientists, but often citizen scientists help to find and catch the permit and to insert the tags.

Dart tags are simple yellow streamers that are attached to the back of the fish. On a dart tag, the scientist's sponsoring organization will print a phone number, address or webpage with instructions on whom to contact when the fish is caught again. Each tag also has a unique numeric code that identifies the individual fish. If you love to chase permit, dart tagging is a fun, educational way to participate in citizen science. By contacting the Bonefish Tarpon Trust, you can request a dart tag. The organization will send the dart tags with instructions on how to insert the tag into the fish. Usually the organization will ask the angler to take a few measurements of the fish as well. After the fish is released – hopefully in the next few days, months, or years – another angler will come along and catch the fish again. They can report where the fish was caught, how much it grew, and how long it was swimming around in between catches. This is a fun way to collect data, but most importantly, everyone can learn a lot about these important fish.

Based on data that anglers have collected so far, scientists are coming closer to the conclusion that permit usually swim within the same area and do not travel too far. As more fish get tagged and more anglers record recaptured fish, scientists get a better picture of the species' range. Although dart tags can provide a sense of range and migratory pathways, scientists cannot be absolutely sure about their findings until they look at permit movements in more detail. Acoustic tags actually show not only where fish went, but how exactly they got there.

Acoustic Tags



An acoustic receiver is anchored to the ocean floor and held upright with a couple floats.

Acoustic tags are surgically implanted devices that use technology to track a fish's movements. These tags work similarly to a Sunpass that cars in Florida use as they pass by toll stations on the highway. Each tag has a unique identification (ID) code that is recorded by "scanners" called acoustic receivers that are anchored on the ocean floor all across the U.S. East Coast, throughout the Keys, and around The Bahamas. Every time an acoustically tagged fish swims past one of these receivers, the receiver it passed picks up and records the ID number of the fish,

the date and the time it was detected. For this kind of study, cooperative research allows scientists to hitch rides with anglers to accomplish two things: 1) catch the fish and do a minor and harmless surgical procedure, where scientists make an incision, implant the acoustic tag, and close the incision with a few stitches, and
2) place the receivers throughout the Keys in places that the anglers have determined are permit travel zones.

In this experiment, scientists placed more than 100 tags in permit over a five-year period. Every 6 months, scientists retrieved the acoustic receivers from around the ocean floor, saved all the data that shows which fish swam by and when, and re-anchored the receivers in place. The beauty of this method is that receivers used by scientists doing other projects also detect permit with acoustic tags, so no matter where the permit swims, it has a good chance of being detected. This sharing of data among scientists is a great way to collaborate and to increase the power of their research.

Between dart tags and acoustic tags, scientists are able to get a pretty reliable picture of when and where permit are swimming on a regular basis, and it wouldn't be possible without citizen scientists. Scientists share the collected information, and get a better understanding of the environmental conditions and paths that fish use. Over time, a database creates a picture that can even help scientists understand if there are other things going on that may affect migratory behavior. This information is critical for fisheries managers, so that they can act to ensure enough spawning age fish are protected across enough range to ensure reproduction and a healthy fishery.

Anglers help scientists understand tarpon and permit migrations by inserting dart tags with information about the fish below the dorsal fin.

For example, periodically, the Florida Keys National Marine Sanctuary revises its management plan. This is a process where managers look at human activities in the Sanctuary and consider how humans are affecting the Sanctuary's habitats. By using the data gathered by the tagging programs and learning how fish use these habitats, managers can revise their management plans to protect permit during spawning seasons and even change human activities that may negatively impact the permit population and the habitats they use.

Understanding the habits and the range of permit movements is critical to protecting them. Without citizen science and cooperative research, many of the scientific questions scientists could not be answered. Citizen science helps to keep Florida fisheries healthy, and healthy fisheries means we can all enjoy our local species more often.

Classroom Resources

Sci Starter: **https://www.scistarter.org/**
Citizen Science: **https://www.citizenscience.org**
Woods Hole Oceanographic Institute Citizen Science Projects**: http://www.whoi.edu/main/resources-for-teachers/citizen-science-projects**
Article listing other citizen science projects**: https://reefbites.wordpress.com/2020/01/28/citizen-science-facilitating-ocean-stewardship-and-enabling-widespread-monitoring-of-marine-ecosystems/**
There are a bunch of citizen scientist web sites focused on fisheries. For example: **http:// safmc.net/citizen-science-initiative/**
A Google search on "citizen science fisheries" will get you a bunch more to choose from!

The Naked Scientists Podcast: **http://podbay.fm/show/74171648/e/1379977200?autostart=1**
Science Weekly: **https://www.theguardian.com/science/audio/2012/jun/18/science-weekly-podcast-citizen-science**
TED Radio Hour: **https://podcastbrunchclub.com/citizen-science/**

Get Started with Citizen Science with Sci Starter:
https://www.youtube.com/watch?time_continue=35&v=yWZ6wybgHl4
TEDx: The Crucial Role of Citizen Scientists in Ocean Conservation:
https://www.youtube.com/watch?v=GJXGBuxN_5g
TEDx: Can Citizen Science Save us? **https://www.youtube.com/watch?v=SC2S_jkjUK0**
The Awesome Power of Citizen Science: **https://www.youtube.com/watch?v=SZwJzB-yMrU**

Highlighted Vocabulary from Student Reading:

acoustic tags:
a device that is often implanted in a fish and emits a frequency or "ping" that is detected by receivers as it moves within range, allowing the travel patterns of the fish to be tracked.

biodiversity:
the variety of different organisms that live in the same habitat or region.

co-benefits:
benefits to (in this context) both the scientist and to the citizen scientist.

dart tags:
thin, streamer-like tags that are attached to the back of a fish, and have contact information of the scientists and a unique identification code.

datasets:
collections of many scientific data points.

grants:
a sum of money given by a government or other organization for a particular purpose.

hypothesis:
a proposed explanation for an observation, often in the form of a "because" statement.

hypoxic:
very little oxygen.

migratory species:
species that travel away from their home range either to feed or to reproduce.

non-governmental organizations (NGOs):
not belonging to or associated with any government. Typically works as a non-profit, not making or being conducted primarily to make a profit.

scientific method:
the process of answering questions based on evidence, as it has been characterized since the 17^{th} century; the process of observation, question, hypothesis, testing or experimenting, and reaching an informed conclusion.

Citizen Science

Turning curiosity into scientific research

Grade Level: 9th – 12th

Lesson Summary:

Citizen science is a critical component to many different scientific studies, and gives citizen scientists the opportunity to better understand the research and the process. In some studies, citizen scientists assist in major scientific discoveries that can change or create legislature. Students will participate in ongoing citizen science projects to learn more about the scientific method.

Standards:

SC.912.N.1.1 – Define a problem based on a specific body of knowledge, for example: biology, chemistry, physics, and earth/space science, and do the following: Pose questions about the natural world.

SC.912.N.1.2 – Describe and explain what characterizes science and its methods.

SC.912.N.4.1 – Explain how scientific knowledge and reasoning provide an empirically-based perspective to inform society's decision making.

LAFS.910.RST.1.1 – Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.

LAFS.910.RST.1.3 – Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.

LAFS.WHST.3.7 & LAFS.1112.WHST.3.7 – Conduct short as well as more sustained research projects to answer a question or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding

Project Activity Assessment

Here is your chance to engage in citizen science. These cool projects will engage your students in discovering projects that inspire and motivate them. Most of these projects may be geared to general education students and advanced placement students. Have students pick out cool and interesting projects that stokes their intellectual curiosity, and let them find their own if those below do not interest them.

Procedure:

- Students should read the "Citizen Science" document prior to class, taking notes and referring to the vocabulary listed at the bottom of the reading.
- Students will be participating in citizen science projects. These projects may be long term, resulting in a more substantial report or presentation, or they may be done over the course of the next few weeks. Give them the option of picking one of the projects listed below, or let them find one themselves and have it approved by you.
- **Cyanobacteria Monitoring Collaborative:** A timely citizen science project sponsored by the Environmental Protection Agency to track and manage water quality and the occurrence of harmful algal blooms that may hurt bonefish, permit, and tarpon essential habitats. By collecting water samples, citizen scientists help scientists build baselines of cyanobacteria blooms and predictive models that may allow water quality experts determine when and where the next bloom will occur. This is a long-term project for students.
- **iNaturalist:** An observation-based project that can be accomplished as individuals or in groups. In this project, students are seeking out biodiversity in their communities. This may be accomplished in any ecosystem: wetlands, tidal, coastal, forest, grass field, or even the school yard. Findings reported through the iNaturalist app are shared with the Global Biodiversity Information Facility.

Bonefish & Tarpon TRUST

Citizen Science

Turning curiosity into scientific research

Resources:

- https://cyanos.org/cyanomonitoring
- https://www.inaturalist.org
- https://www.bonefishtarpontrust.org/conservation/research/projects/juvenile-tarpon-habitat-mapping/
- https://www.nationalgeographic.com/
- https://scistarter.org/
- An article about Citizen Science with 100+ other projects: https://reefbites.wordpress.com/2020/01/28/citizen-science-facilitating-ocean-stewardship-and-enabling-widespread-monitoring-of-marine-ecosystems/

Procedure Continued

Juvenile Tarpon Habitat Mapping Project: Sponsored by the Bonefish & Tarpon Trust, this project is discussed in the student reading. Students may observe and report habitats where juvenile tarpon under 12 inches may be observed. This is a longer lead project and my not be practical for land-based students.

- Have students report on the following parameters below. Have them perform this in their science journal or create a presentation based upon the data they collected. Assessment should be managed by the rubric below.

Introduction

- Name of Project
- Mission/Goals of Project

Methods

- Dates of Participation
- Steps You Took to Carry Out Research
- How Did You Gather Data?
- How Did You Report/Share the Data?
- Tools Needed to do the Research

Conclusions

- What Did You Learn?
- What Was It Like to Participate in this Project?
- Was It Easy/Hard? Did it inspire?

Expansion:

You may expand this activity by asking the students to write a formal scientific report based on their project. This would include:

- Introduction, including hypothesis and objectives of the study
- Methods followed by the student to collect data
- Results (if applicable/available)
- Discussion of the implications of this data, either based off the results of the study, or based on what they expect they will find.
- Literature cited, including 1 – 2 scientific articles. They may use additional sources such as educational websites.

Citizen Science Project Rubric

AREA	1 Does Not Meet Expectations	2 Partially Meets Expectations	3 Meets Expectations	4 Exceeds Expectations
Science Content	NONE. Student does not understand the concepts of citizen science and did not understand the purpose of their project.	SOME. Student exhibits a basic understanding of citizen science but struggled to understand the purpose of their project.	MOST. Student grasps the concepts of citizen science and understood the purpose of their project but a key component was missing.	**ALL. Student grasps the principles and needs for citizen science and fully understood the purpose of their project.**
Use of Scientific Vocabulary	NONE. Student does not use any introduced concept or use scientific vocabulary to form thoughts and narrative.	SOME. Student attempts to use scientific jargon, but fails to use it properly or in context. Shows some mastery of science language, but fails to use effectively.	MOST. Student uses significant scientific jargon, but fails to identify all principles and concepts. Student exhibits some mastery of scientific concepts and vocabulary.	**ALL. Student effectively communicates using scientific jargon and vocabulary to convey narrative. Student has achieved mastery of vocabulary and concepts.**
Writing Fluency	Writing flow and errors in sentence structure are multiple, distracting from clear communication and narrative lacks thesis-driven structure	Writing flow is broken by ill-defined thesis and awkward sentence structure, making narrative hard to follow. Writing lacks sophistication and higher order thought.	Writing flow is clear and thesis is present. Sentence structure and clear transitions are present.	**Writing flow and thesis are clear and direct. Narrative is easy to follow and author exhibits higher order of thought and understanding of scientific principles.**
Completeness	**Student did not address many of the bullet points on their project report, or did not fully answer many questions.**	**Most points were addressed in the project report, but many answers were incomplete or missing important concepts.**	**All points were addressed in the project report, but not all answers were complete or one important concept was missed.**	**All points were addressed in the project report, and answers were complete and covered all important concepts.**

Citizen Science Presentation Rubric

AREA	1 Does Not Meet Expectations	2 Partially Meets Expectations	3 Meets Expectations	4 Exceeds Expectations
Introduction	Student does not demonstrate understanding of the purpose of the project and does not state what questions are being answered.	Student provides a basic explanation of the purpose of the project but does not clearly specify what questions are being answered.	Student mostly explains the purpose of the research and states the questions being answered, but the explanation is not clear	**Student provides in-depth explanation of why the research was conducted, what the data will contribute to, and what questions are being answered.**
Methods	Student does not provide an adequate description of what data was collected or how it was collected.	Student provides some description of what data was collected OR how it was collected, but does not describe both, and it is unclear how the methods relate to the purpose of the study.	Student provides a basic description of what data was collected and how it was collected, but details are missing OR it is not clear how the methods relate to the purpose of the study.	**Student provides an in-depth explanation of what data was collected and how it was collected, and the connection to the purpose of the study is clear.**
Conclusions	Student did not address all the points for the conclusion section.	Student addressed all the points for the conclusion section but did not provide full answers.	Student addressed all the points for the conclusions section, but did not include some details.	**Student addressed all concluding points clearly and fully.**
Completeness	**Presentation was missing one or more section:** **-Introduction** **-Methods** **-Conclusions**	**Presentation contained all sections, but some sections were missing important information.**	**Presentation contained all sections, all important information was present, but some details were missing.**	**Presentation contained all sections, all important information and all important details.**