

# Citizen Science

Bonefish  
& Tarpon  
TRUST



## Student Reading

**“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 discoverers. 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 applying a version of the **scientific method**.



**Coquina Clams:** Coquina clams (*Donax* spp.) are a vital forage source for permit swimming in the surf. Scientists in Florida and North Carolina began researching the impacts of beach dredge-and-fill projects on *Donax* populations after citizen scientists reported their virtual disappearance post-project.

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 observed was caused by something else. In scientific terms, this is called cause and effect. For example, a strong wind (the “cause”) broke a tree branch (the “effect”). After you’ve witnessed many of these cause-and-effect relationships, you may start to think that these relationships are consistent, 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 tree branch to fall. You can't assume that wind was the cause without some sort of test.

When you first witness something happening, or make an **observation**, you often consider the reasons it may have happened. You are forming a **hypothesis** about what could have caused your observation. Hypotheses come in the form of "because" statements. For example, the tree branch broke because the wind was very strong.

Next, you need to test your hypothesis by going outside and looking at the tree branch. Upon further investigation of the broken branch, you find that a wood-eating beetle weakened the branch to the point that a mere gust of wind could break it off. You can now **reject** your hypothesis about the wind, and create a new hypothesis that the tree branch broke because of the beetles. Some of you may have stopped your investigations here, satisfied by finding the beetles, but others may have continued on to see if all the broken branches nearby had beetles too – further testing your idea.

Even before formally learning the scientific method, unwittingly you would ask yourself questions and work through them in scientific ways. The scientific method or inquiry 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
- To complete one citizen science project for your class.
- Examples of citizen science
- Examples of social and ecological improvements thanks to citizen science



An angler assists in citizen science by helping scientists catch bonefish in a seine net. The fish are tagged, and DNA samples are taken to establish range and population dynamics.

## 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 benefits
- 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 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**.”

In providing local knowledge and in helping to collect data, citizens can help scientists conduct science experiments, make scientific discoveries, and solve management problems.



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

## Example: The Demand for Tarpon Data

Tarpon fisheries are tremendous economic drivers in most coastal regions around Florida, and in many other tropical and temperate regions. This **migratory species** is targeted as far north as the Chesapeake Bay, throughout the Gulf of Mexico, throughout the Caribbean, and in northern Atlantic waters of South America.

In the United States, some recreational 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 fishermen to catch. Anglers from all over the world travel to Florida and other top tarpon fishing locations, spending lots of money, because they are infatuated with the tarpon's great power and beauty. The fish are cautious about biting, and when an angler successfully entices a tarpon to eat a fly, lure or bait, the resulting battle is one filled with electrifying, gill-rattling leaps, and long, fast runs.

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 – especially a species like the permit (*Trachinotus falcatus*) – is that they occupy many different habitats within their life cycle as they move underwater where humans cannot stay for very long.

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.

When forming the hypotheses for understanding permit migratory patterns, scientists have a number of questions regarding the species:





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 act like bonefish and stay in relatively small home ranges, or regularly move longer distances?
- Is the Special Permit Zone in the Florida Keys large enough to protect the fishery, or do Keys permit migrate north into unprotected areas where harvest levels are high?
- Do individual permit go to the same location each time they spawn, or use multiple locations?

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're an angler and 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 fishermen 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 fishermen 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

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 fishermen 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 fishermen have determined are permit travel zones.



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

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

## Websites

**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!**

## Podcasts

**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/>

## Videos

**Get Started with Citizen Science with Sci Starter:**

[https://www.youtube.com/watch?time\\_continue=35&v=yWZ6wybgHl4](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=GJXGBuxN5g>

**TEDx: Can Citizen Science Save us?** <https://www.youtube.com/watch?v=SC2SjkjUK0>

**The Awesome Power of Citizen Science:** <https://www.youtube.com/watch?v=SZwJzB-yMrU>



# Highlighted Vocabulary from Student Reading:

**acoustic tags:**

small sound-emitting devices that allow the detection and/or remote tracking of organisms in aquatic ecosystems.

**biodiversity:**

the variety of life in the world or in a particular habitat or ecosystem.

**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 supposition or proposed explanation made on the basis of limited evidence as a starting point for further investigation.

**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:**

a method of procedure that has characterized natural science since the 17th century, consisting of systematic observation, measurement, and experiment, and the formulation, testing, and modification of hypotheses.