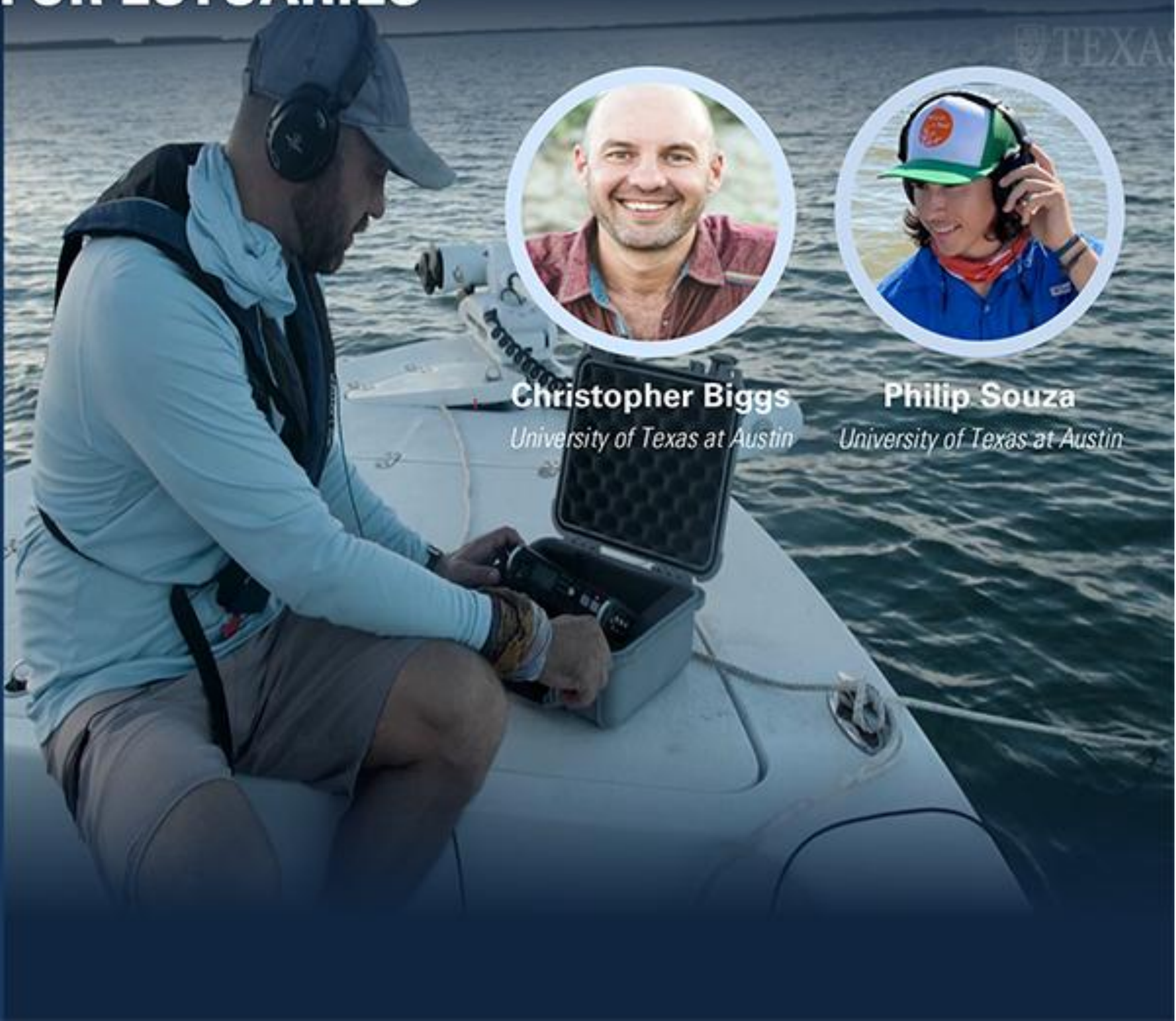
COLLABORATIVE SCIENCE FOR ESTUARIES

WEBINAR SERIES

Acoustic Monitoring of Estuarine Communities Facing Ecosystem Change



Date: Thursday, July 14, 2022
Time: 2:00-3:00 PM ET

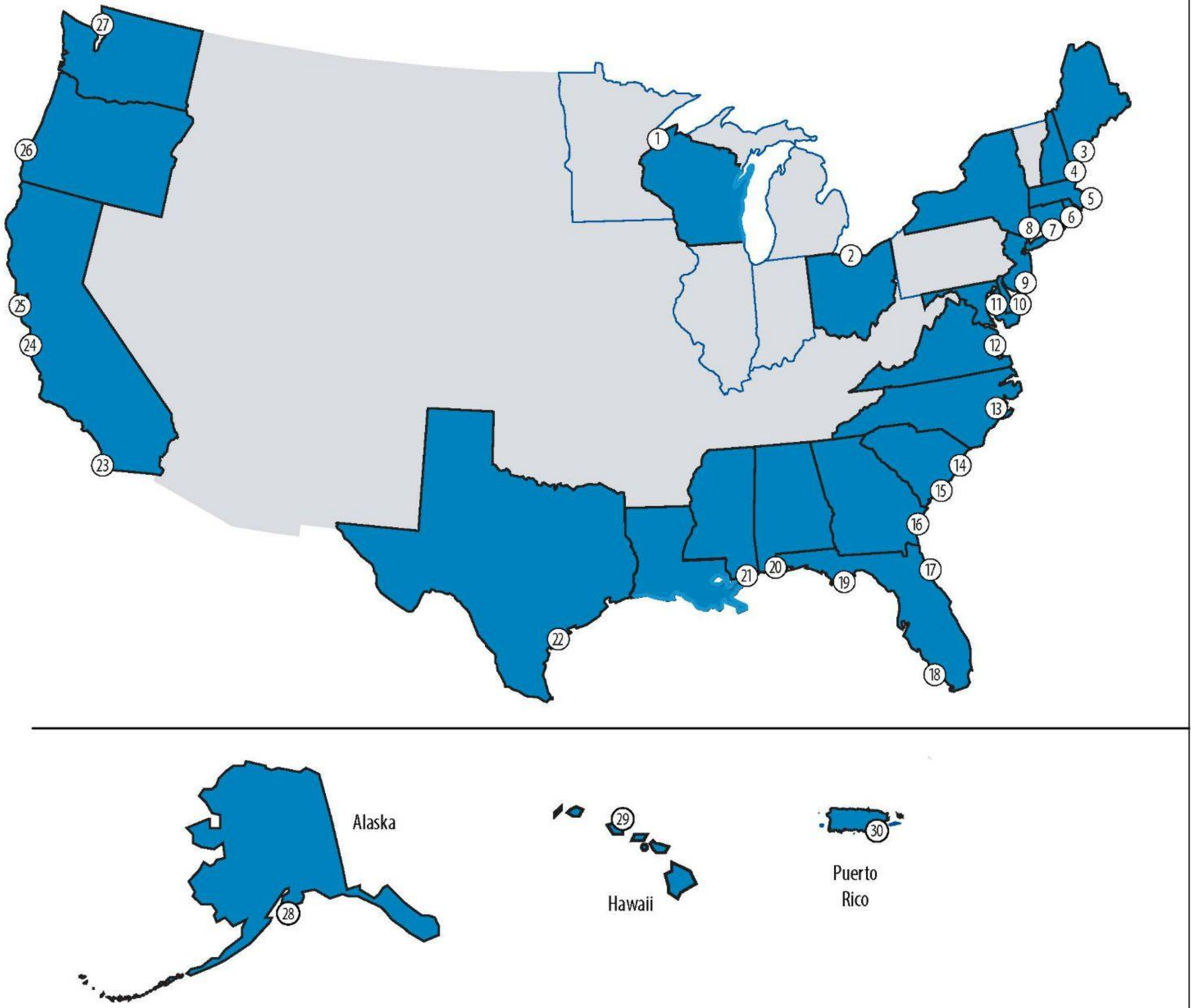
National Estuarine
Research Reserve System
Science Collaborative

NATIONAL ESTUARINE RESEARCH RESERVES

The National Estuarine Research Reserve System (NERRS)

- NOAA Program
- Place-based collaboration with a local partner, e.g.:
    - State Agency
    - University
    - Nonprofit
- Reserve programs:
    - Stewardship
    - Research and scientific monitoring
    - Training
    - Education

The NERRS Science Collaborative supports science for estuarine and coastal decision-makers.



Great Lakes
1. Lake Superior, Wisconsin
2. Old Woman Creek, Ohio

Northeast
3. Wells, Maine
4. Great Bay, New Hampshire
5. Waquoit Bay, Massachusetts
6. Narragansett Bay, Rhode Island
7. Connecticut

Mid-Atlantic
8. Hudson River, New York
9. Jacques Cousteau, New Jersey
10. Delaware
11. Chesapeake Bay, Maryland
12. Chesapeake Bay, Virginia

Southeast
13. North Carolina
14. North Inlet-Winyah Bay, South Carolina
15. ACE Basin, South Carolina
16. Sapelo Island, Georgia
17. Guana Tolomato Matanzas, Florida

Gulf of Mexico
18. Rookery Bay, Florida
19. Apalachicola, Florida
20. Weeks Bay, Alabama
21. Grand Bay, Mississippi
22. Mission-Aransas, Texas

West
23. Tijuana River, California
24. Elkhorn Slough, California
25. San Francisco Bay, California
26. South Slough, Oregon
27. Padilla Bay, Washington
28. Kachemak Bay, Alaska

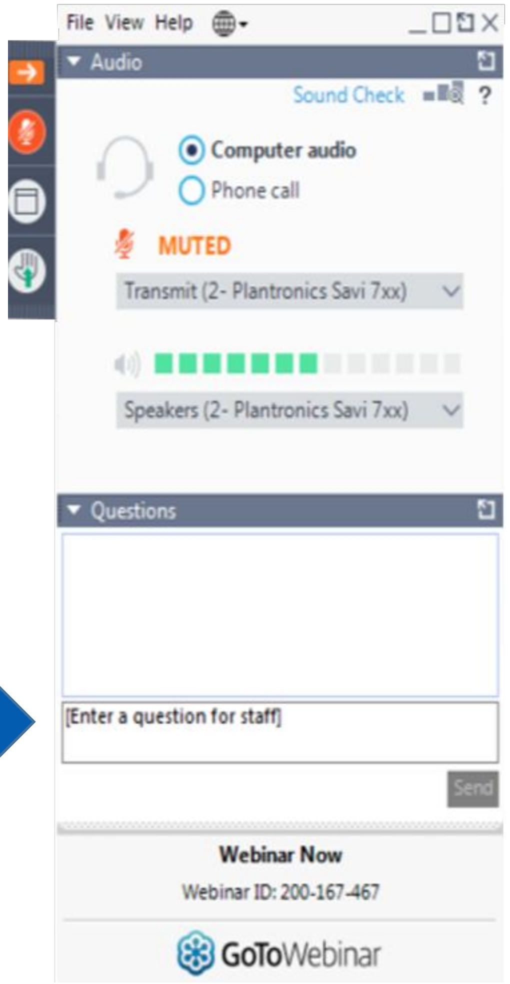
Pacific
29. He'eia, Hawai'i

Caribbean
30. Jobos Bay, Puerto Rico

PROPOSED
Bay of Green Bay, Wisconsin
Louisiana

Have a question?

Use the “Questions” function to pose questions throughout the webinar.



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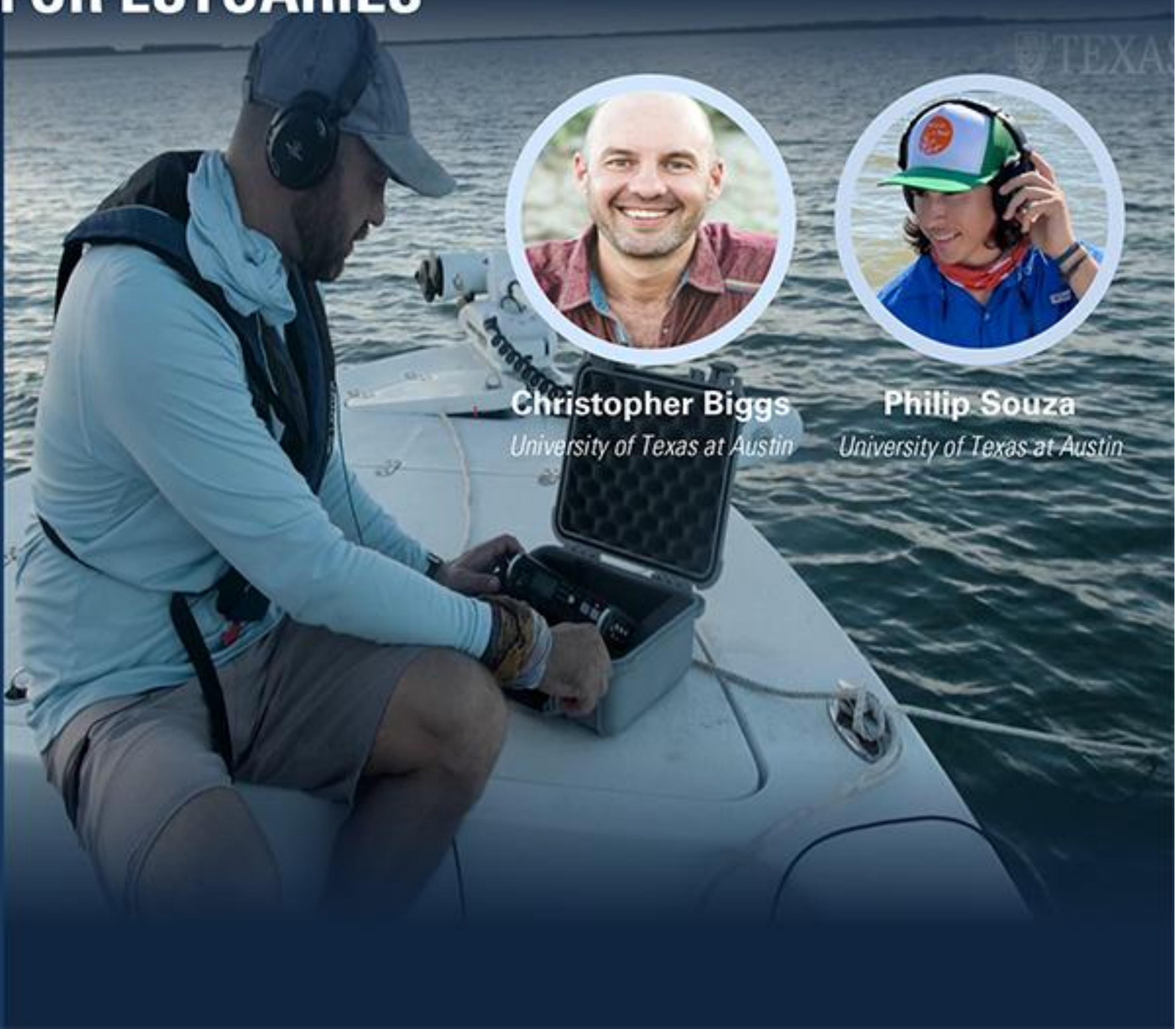


National Estuarine Research Reserve System

Science Collaborative

Christopher Biggs
Robert Dunn, Matthew Kimball
Eric Montie, Kevin Boswell

Marine Science Institute
University of Texas at Austin

July 14, 2022

National Estuarine
Research Reserve System
Science Collaborative

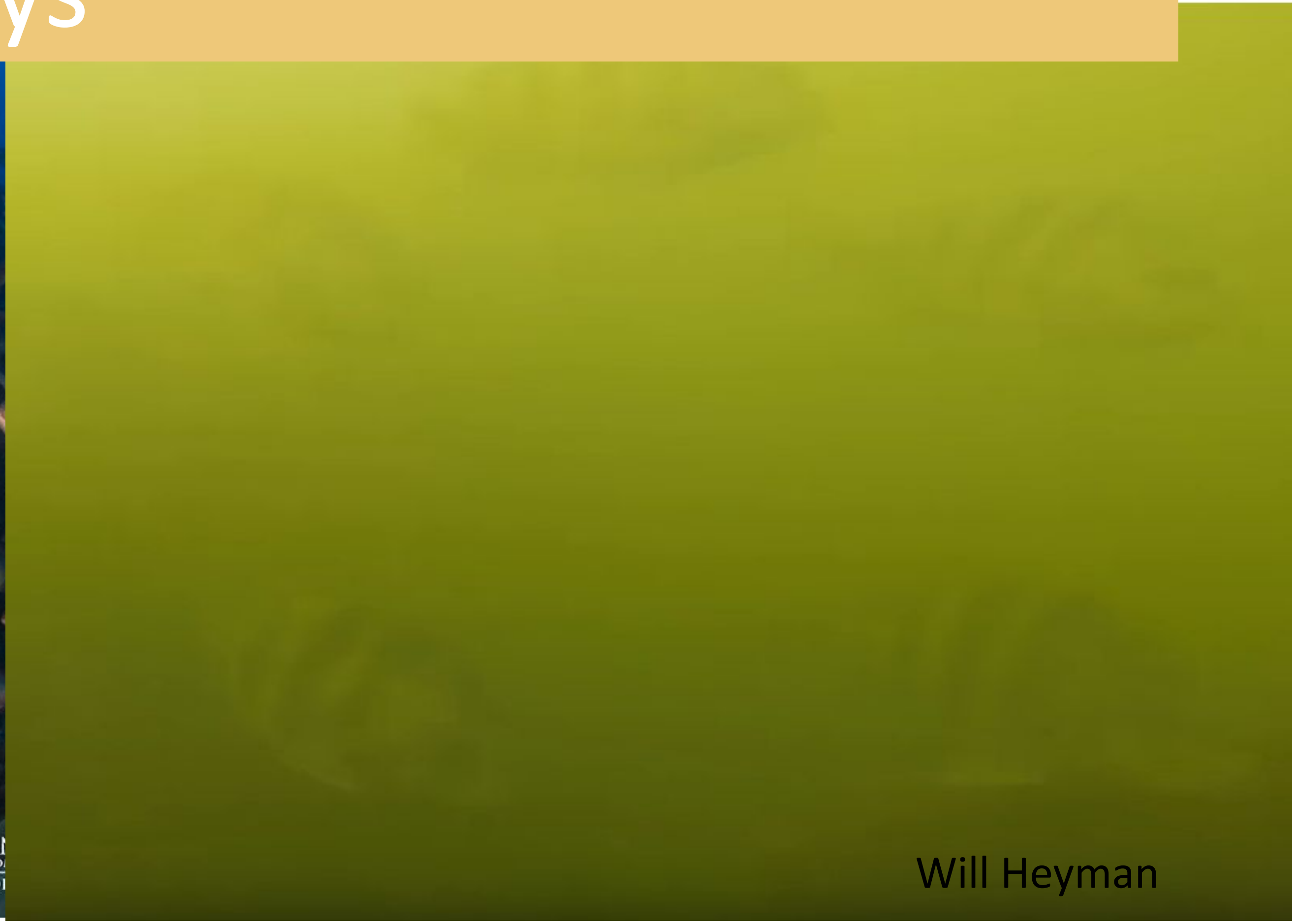
National Estuarine Research Reserve System Science Collaborative

- Create a collaborative network of scientists, managers, and educators
- Co-develop acoustic monitoring framework

Mission-Aransas NERR, TX

Passive acoustic monitoring provides an alternative to visual surveys

Koror, Palau

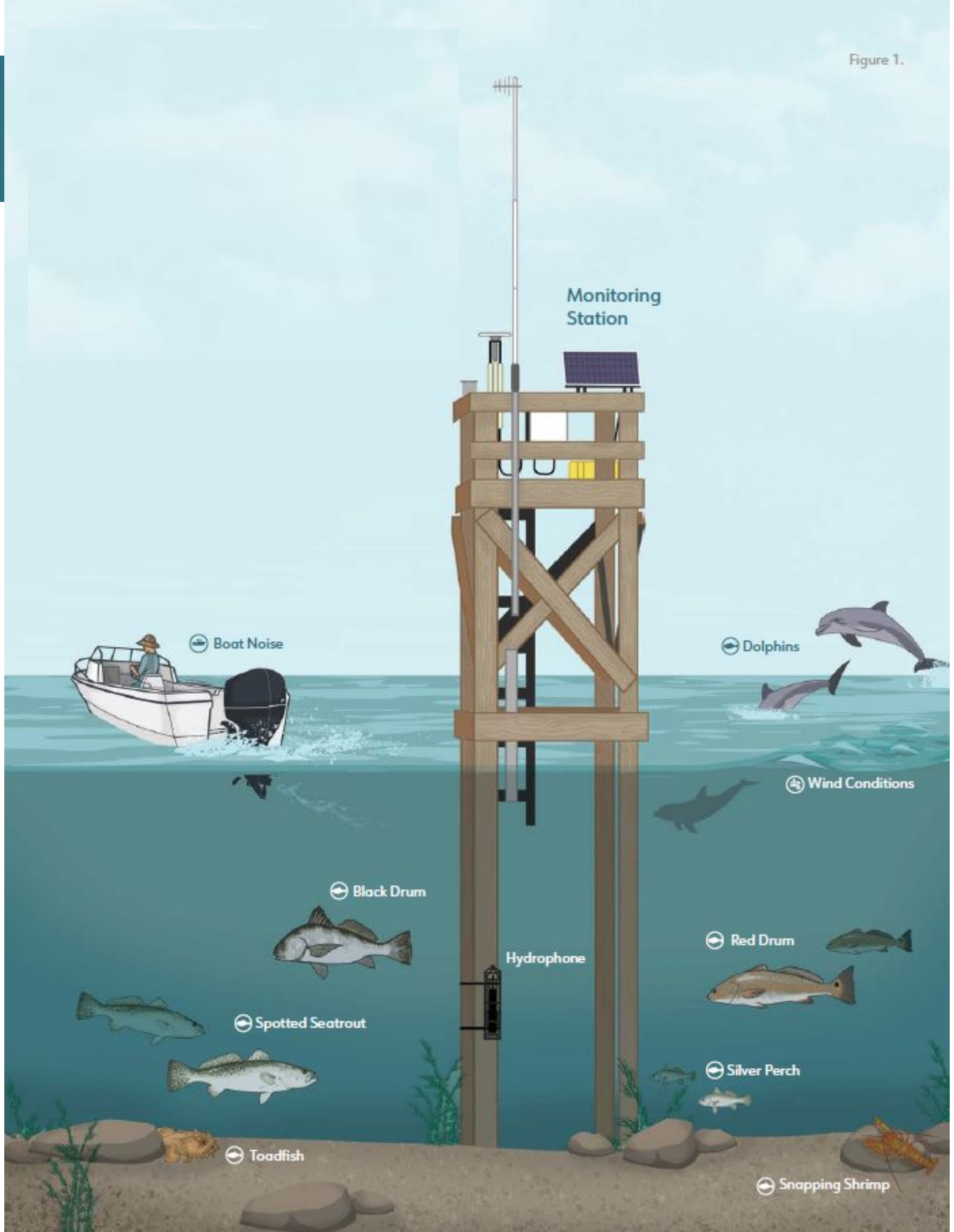


Port Aransas, Texas

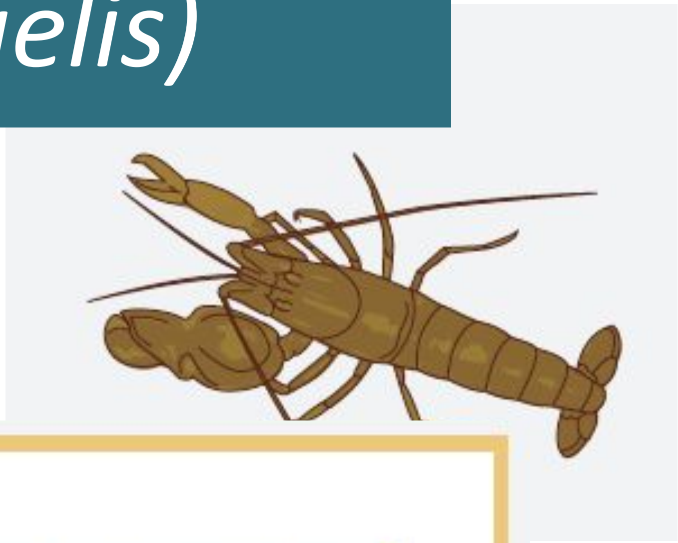
Soundscapes

SOURCES OF SOUND

- BIOLOGICAL SOUND
- GEOPHYSICAL SOUND
- ANTHROPOGENIC SOUND



Snapping Shrimp (*Alpheus heterochaelis*)



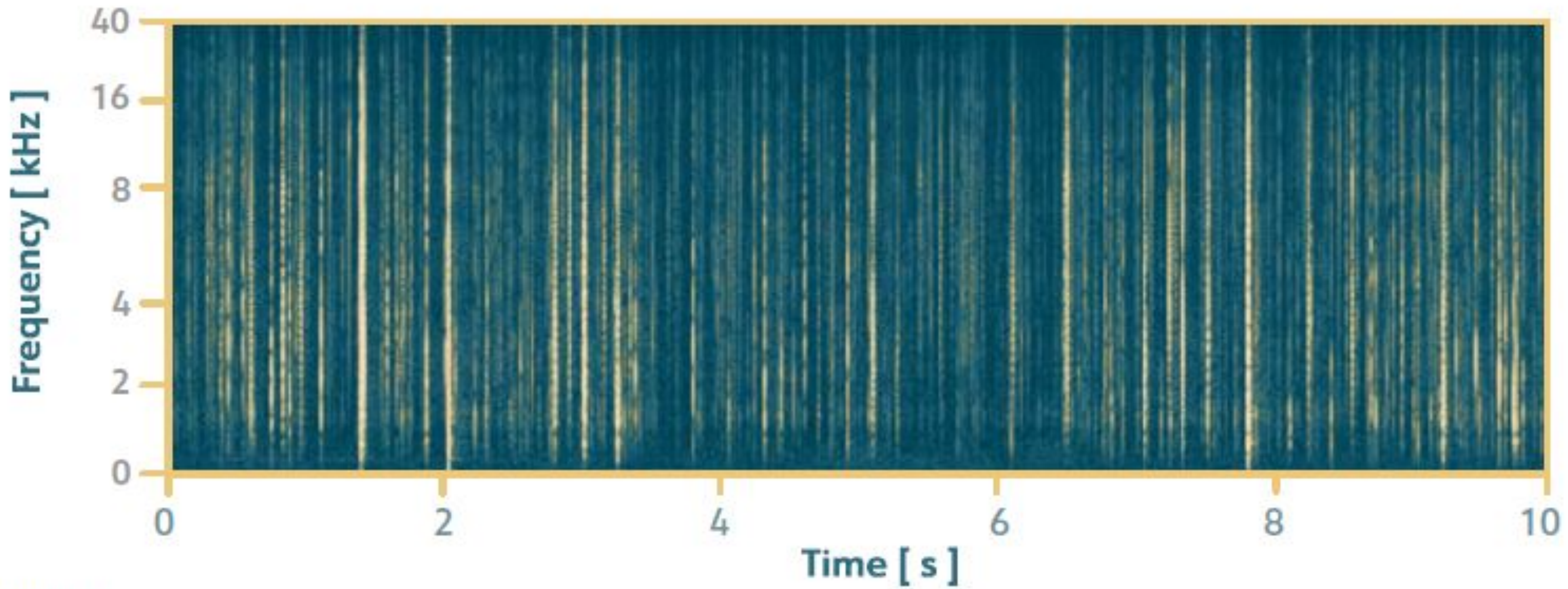
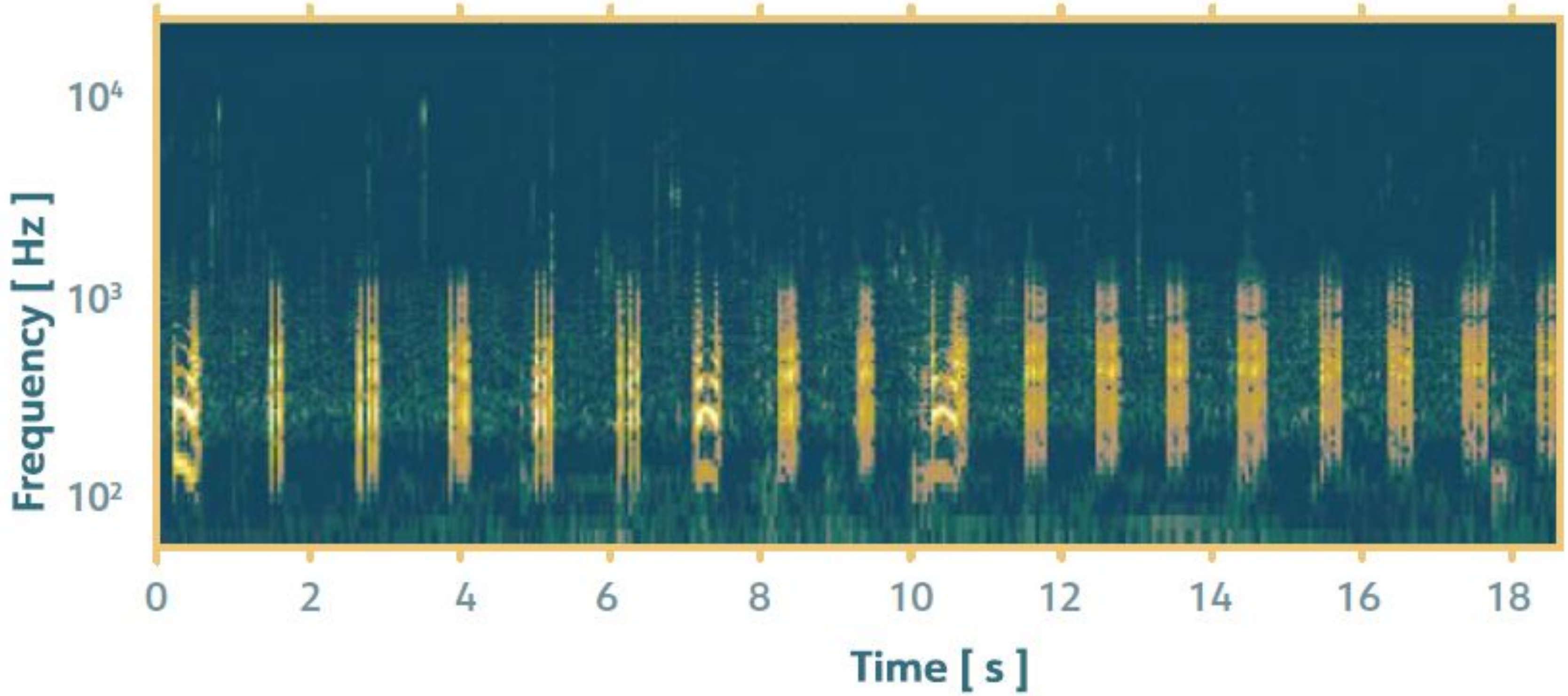


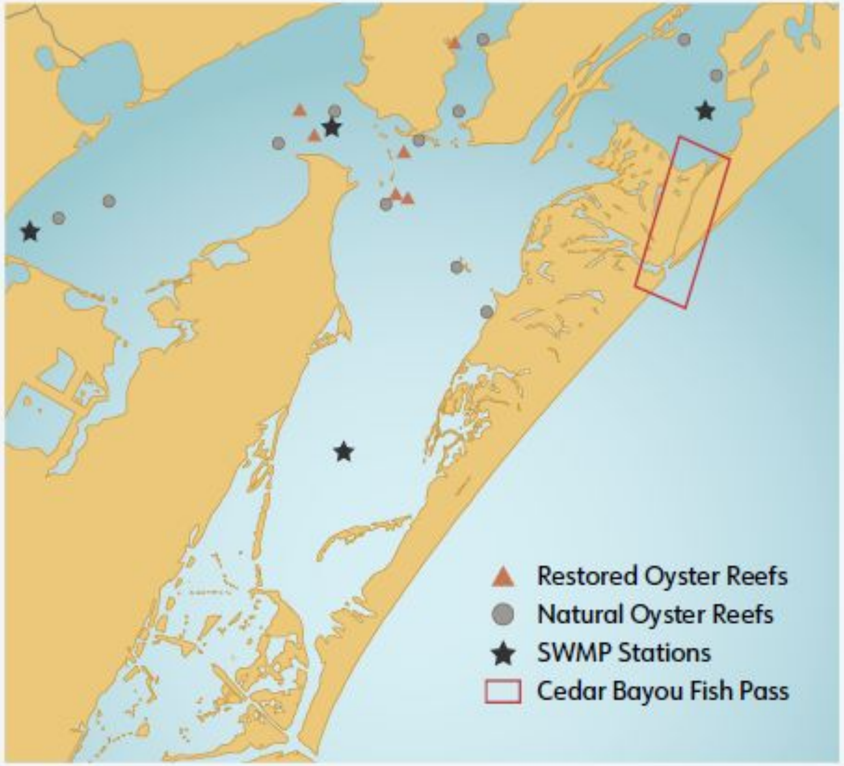
Figure 5:

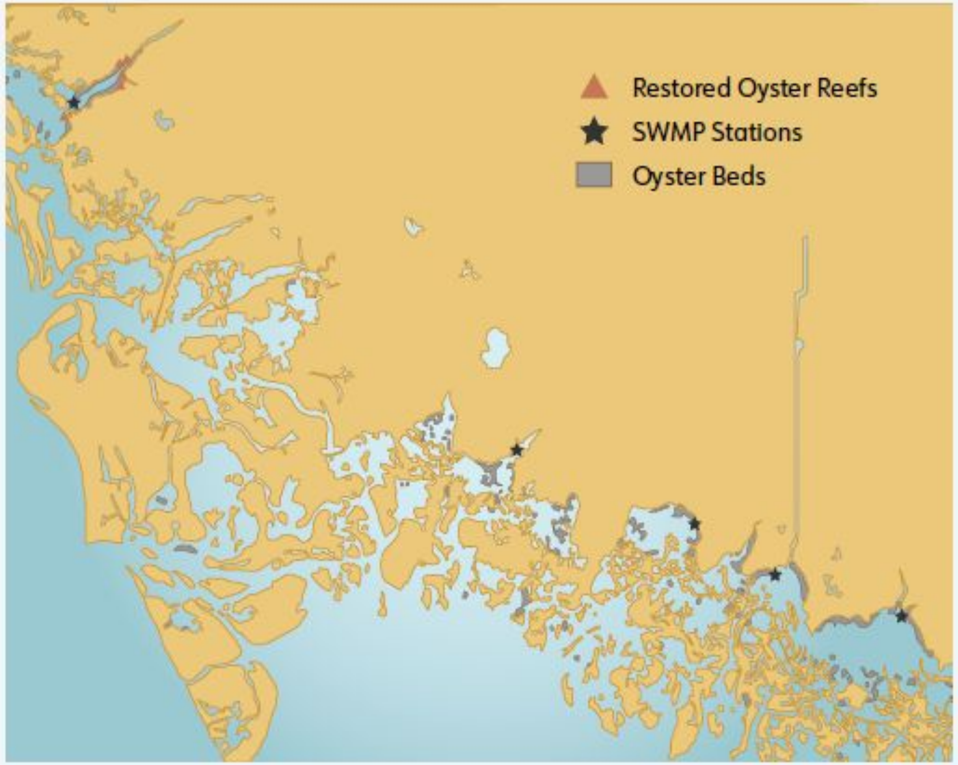
Spotted Seatrout (*Cynoscion nebulosus*)

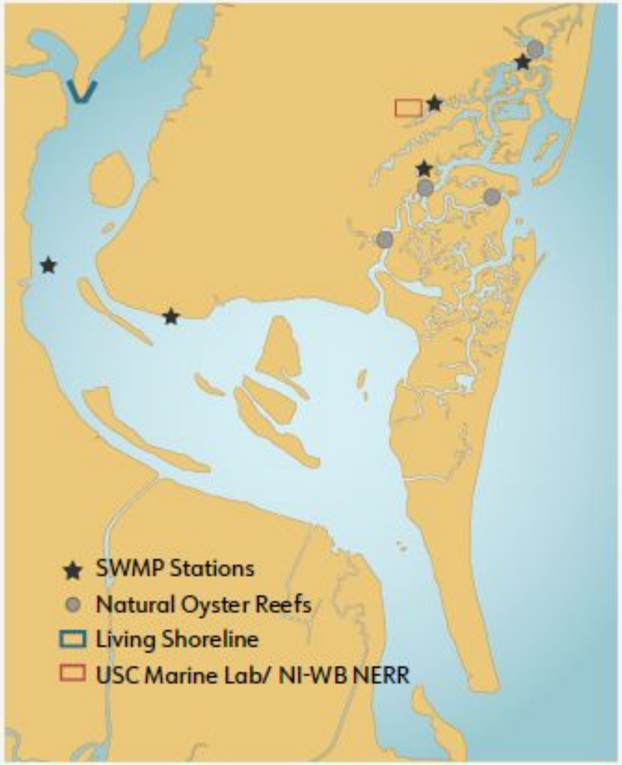
Figure 2:



Designing a research framework that addresses management priorities of NERRs







MISSION • ARANSAS NATIONAL ESTUARINE RESEARCH RESERVE

Rookery Bay National Estuarine Research Reserve

North Inlet – Winyah Bay National Estuarine Research Reserve

Management priorities of end-users

TEXAS PARKS & WILDLIFE

The Nature Conservancy

SOUTH CAROLINA DEPARTMENT OF NATURAL RESOURCES

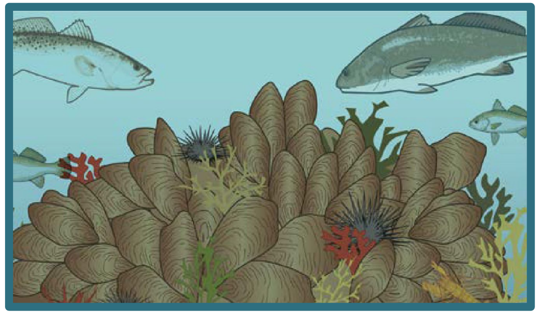
Sea Grant Florida

Anthropogenic Noise Impacts

Oyster Habitat

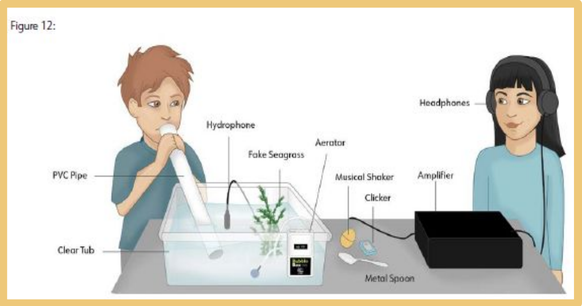
Visitor Use

Integrating acoustic monitoring across sectors



Research

Stewardship

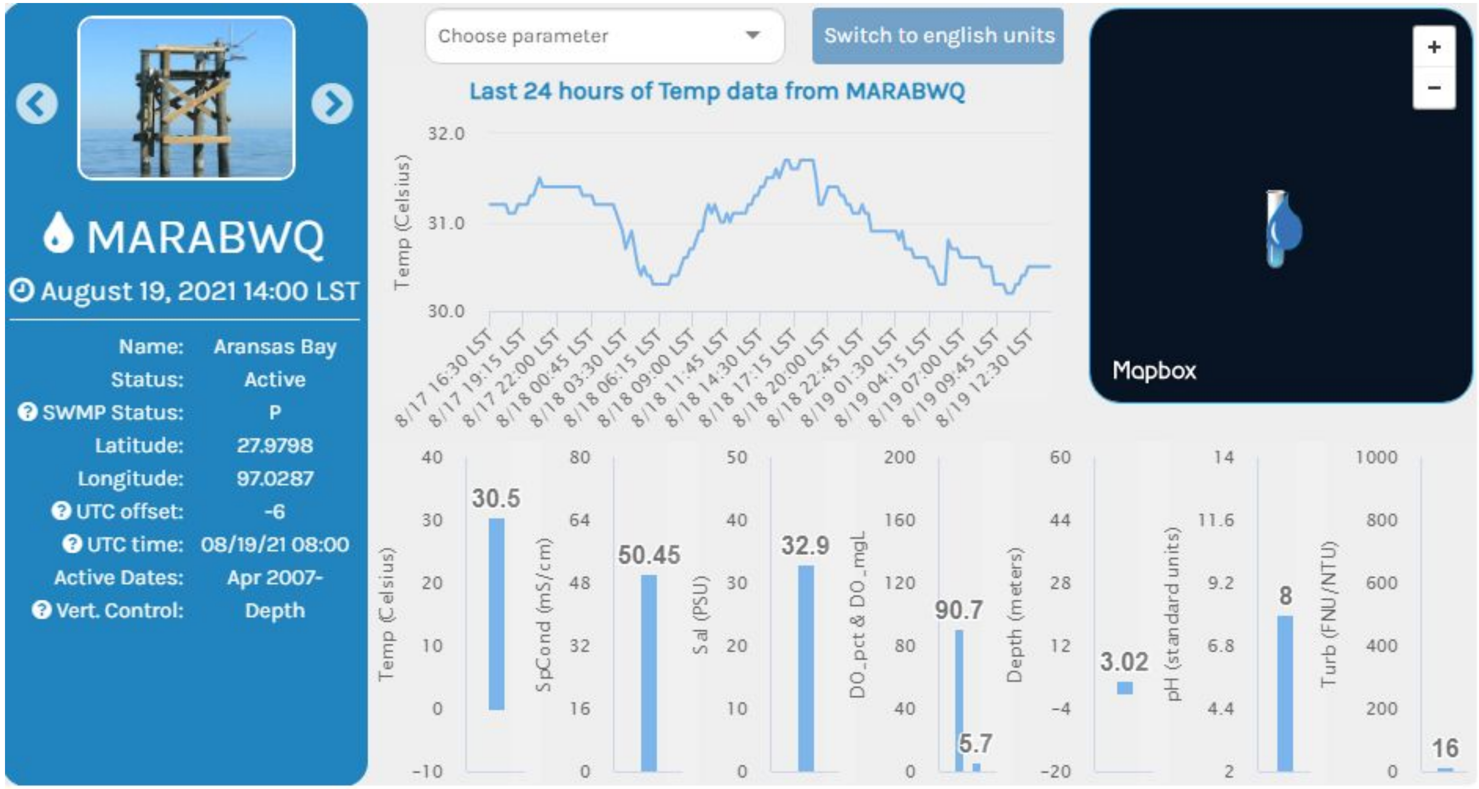


Education

https://nerrssciencecollaborative.org/media/resources/LISTEN_IN_%20Acoustic_Monitoring_booklet.pdf

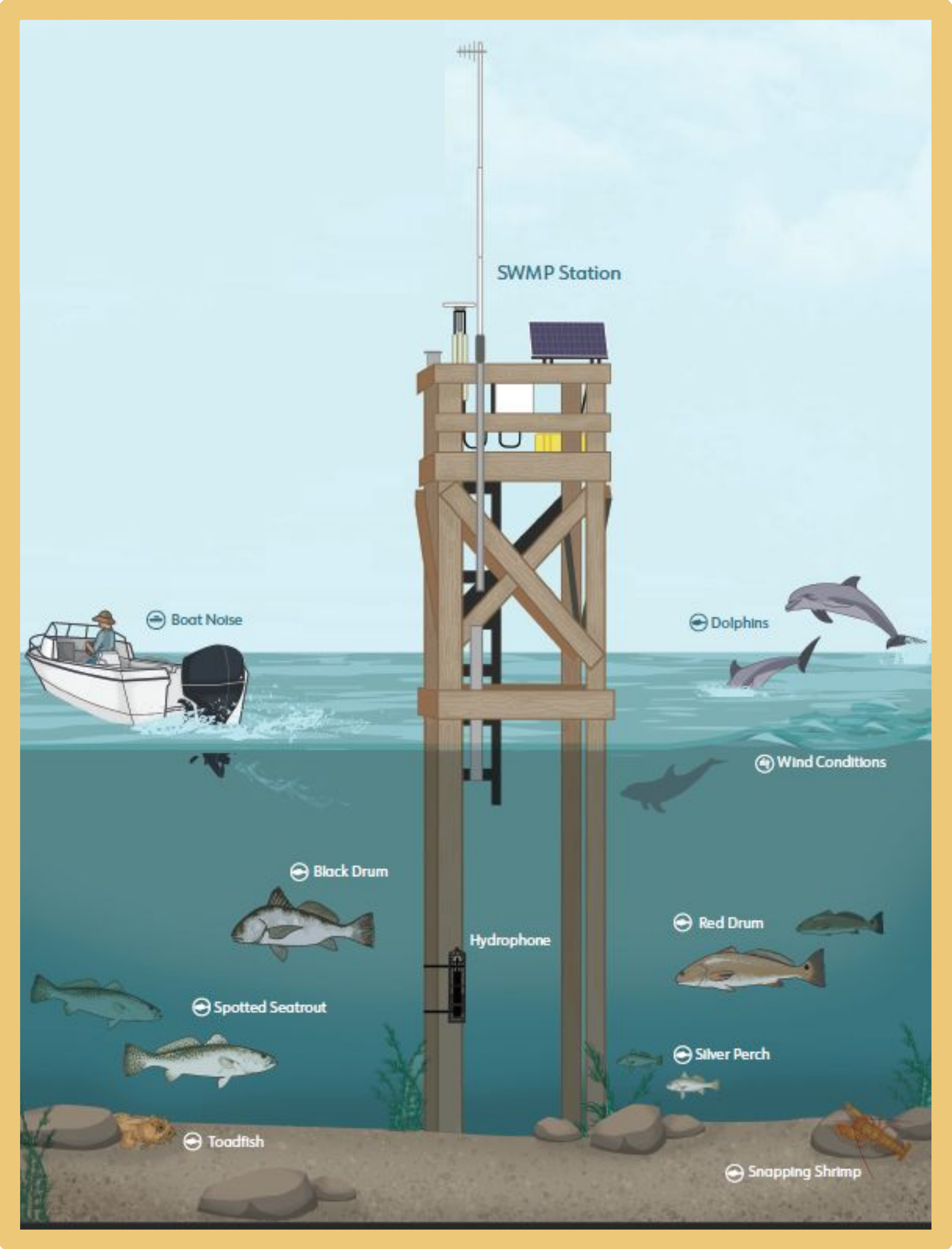
Passive acoustic monitoring can enhance current monitoring efforts

System Wide Monitoring Program



Passive acoustic monitoring can enhance current monitoring effor

Biological activity

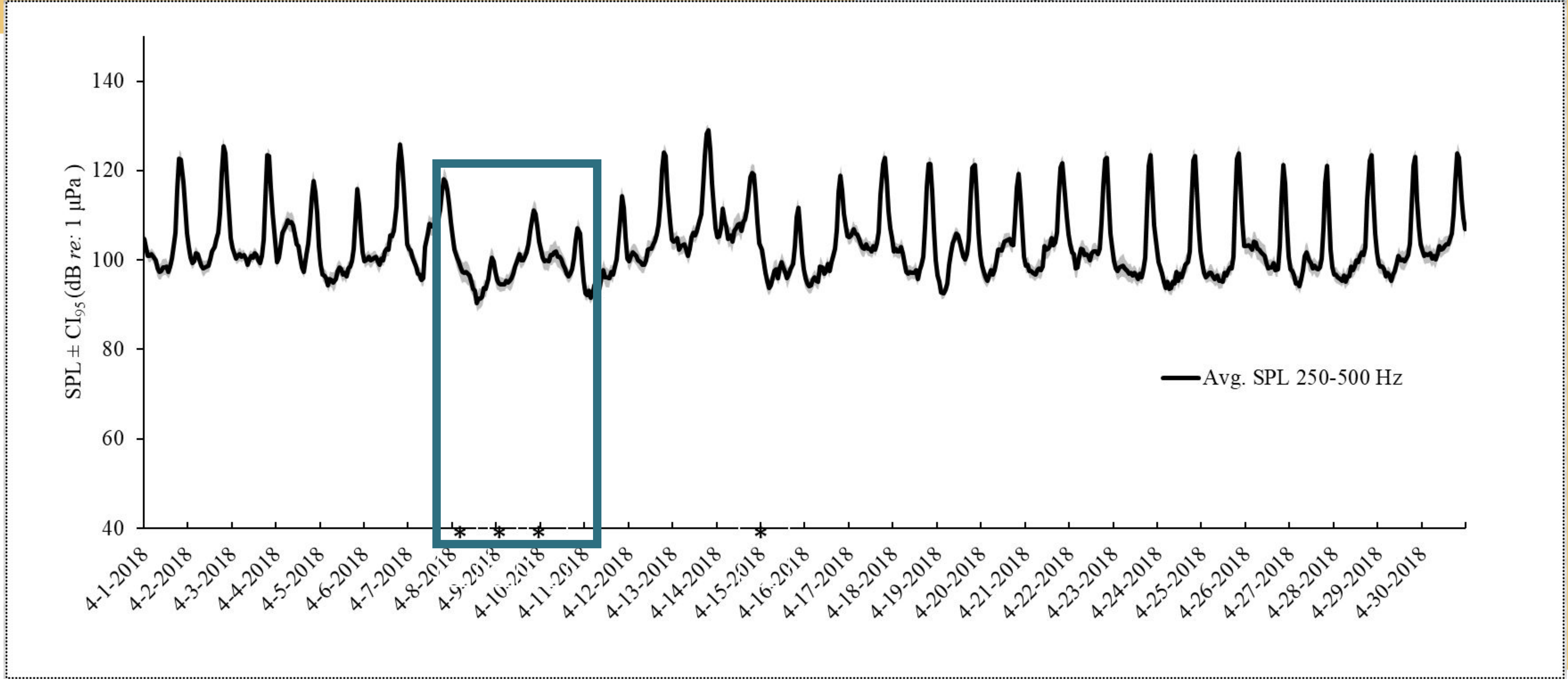


Passive acoustic monitoring can enhance current monitoring effor

Biological activity

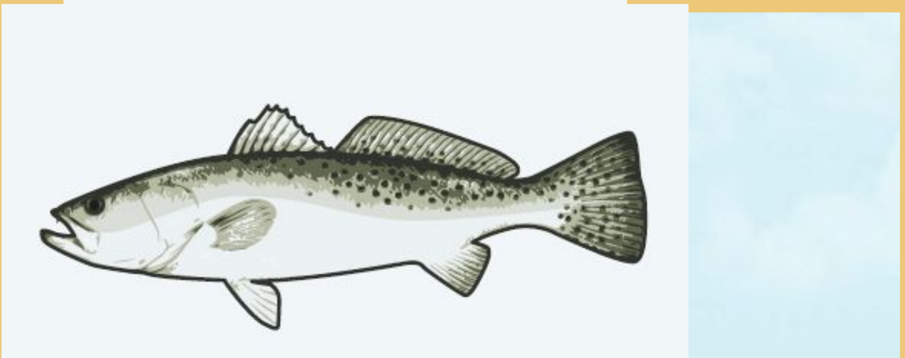
Biggs et al. 2019

Spawning Activity



Passive acoustic monitoring can enhance current monitoring efforts

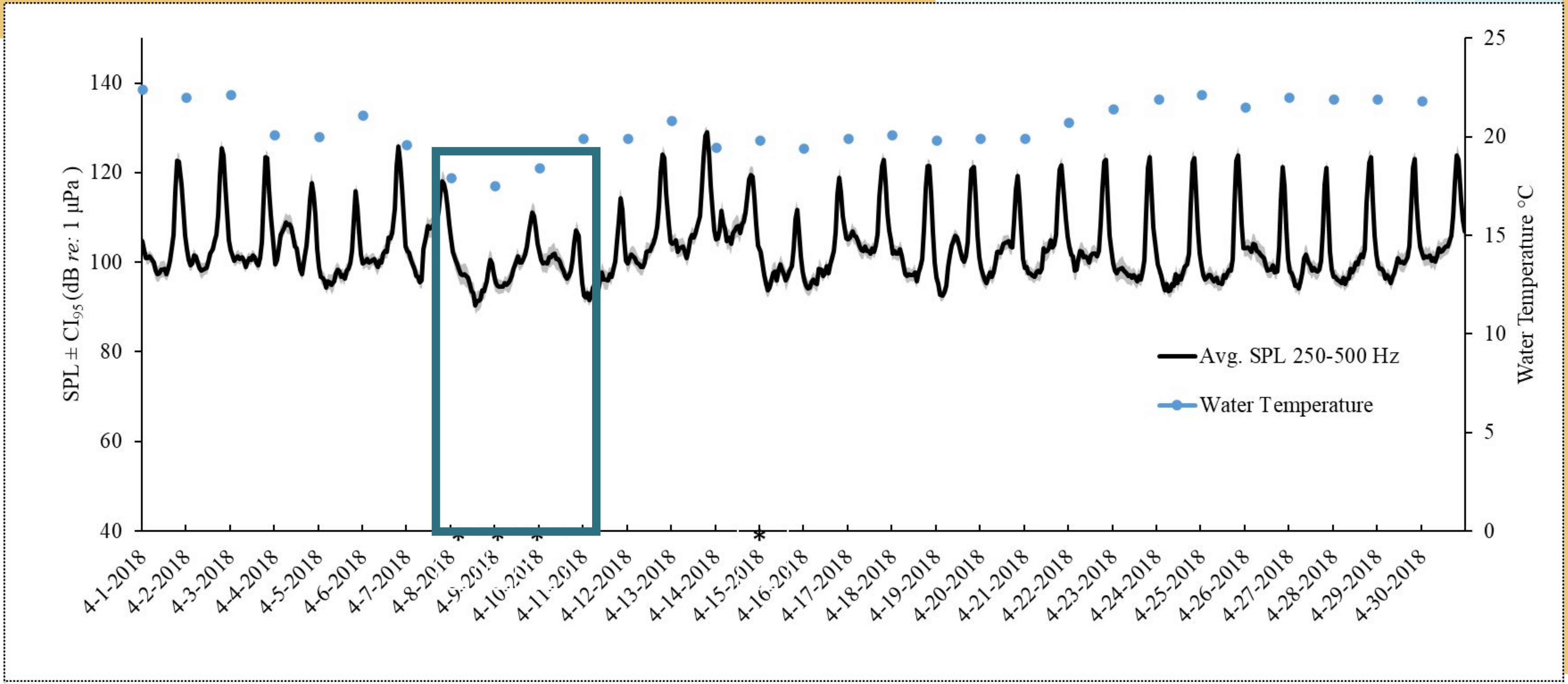
Spotted Seatrout



Biological activity

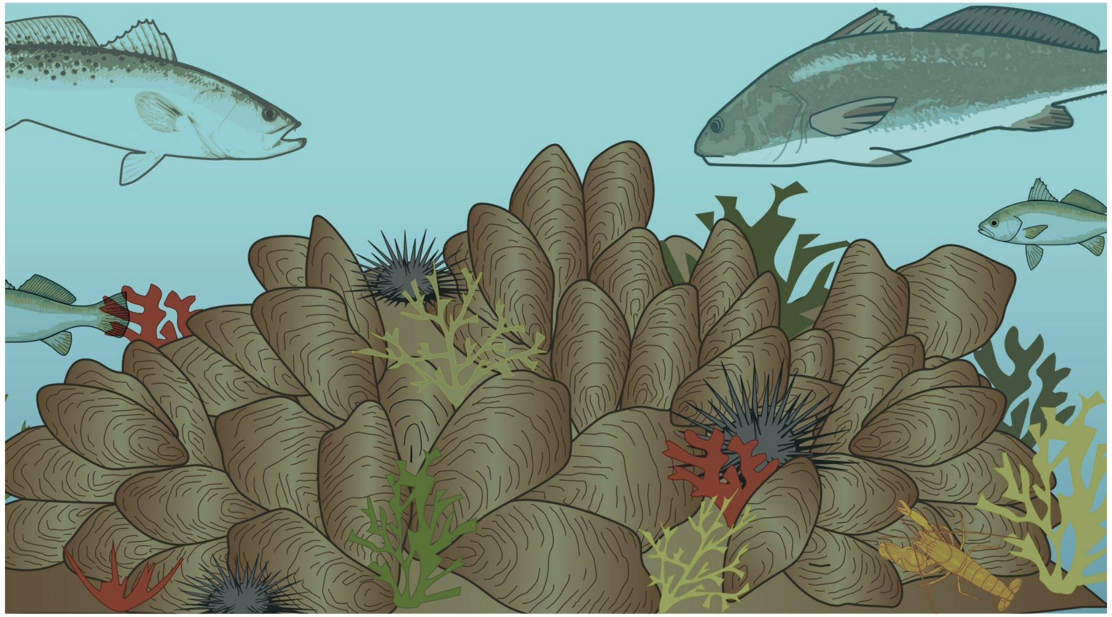
Biggs et al. 2019

Spawning Activity



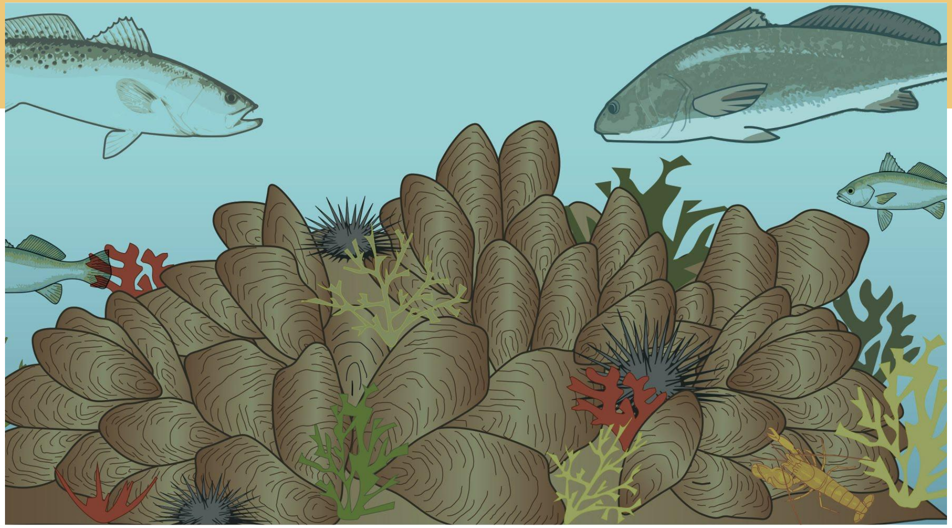
Passive acoustic monitoring can enhance current monitoring efforts

Biodiversity, habitat use, ecosystem health



Passive acoustic monitoring can enhance current monitoring efforts

Biodiversity, habitat use, ecosystem health



Restoration effectiveness

Impacts of harvesting

Recovery rates

Stewardship

Impacts of Anthropogenic Noise

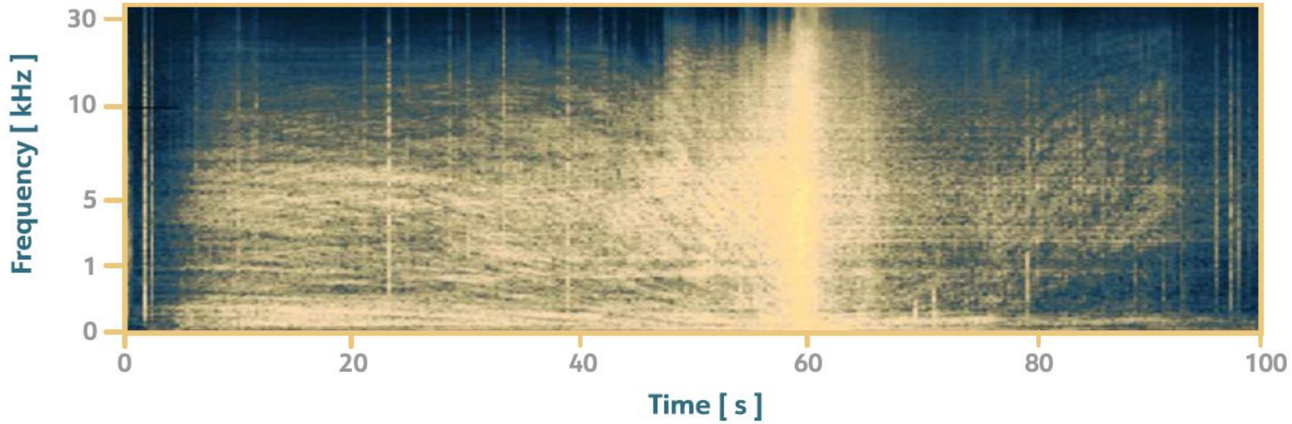
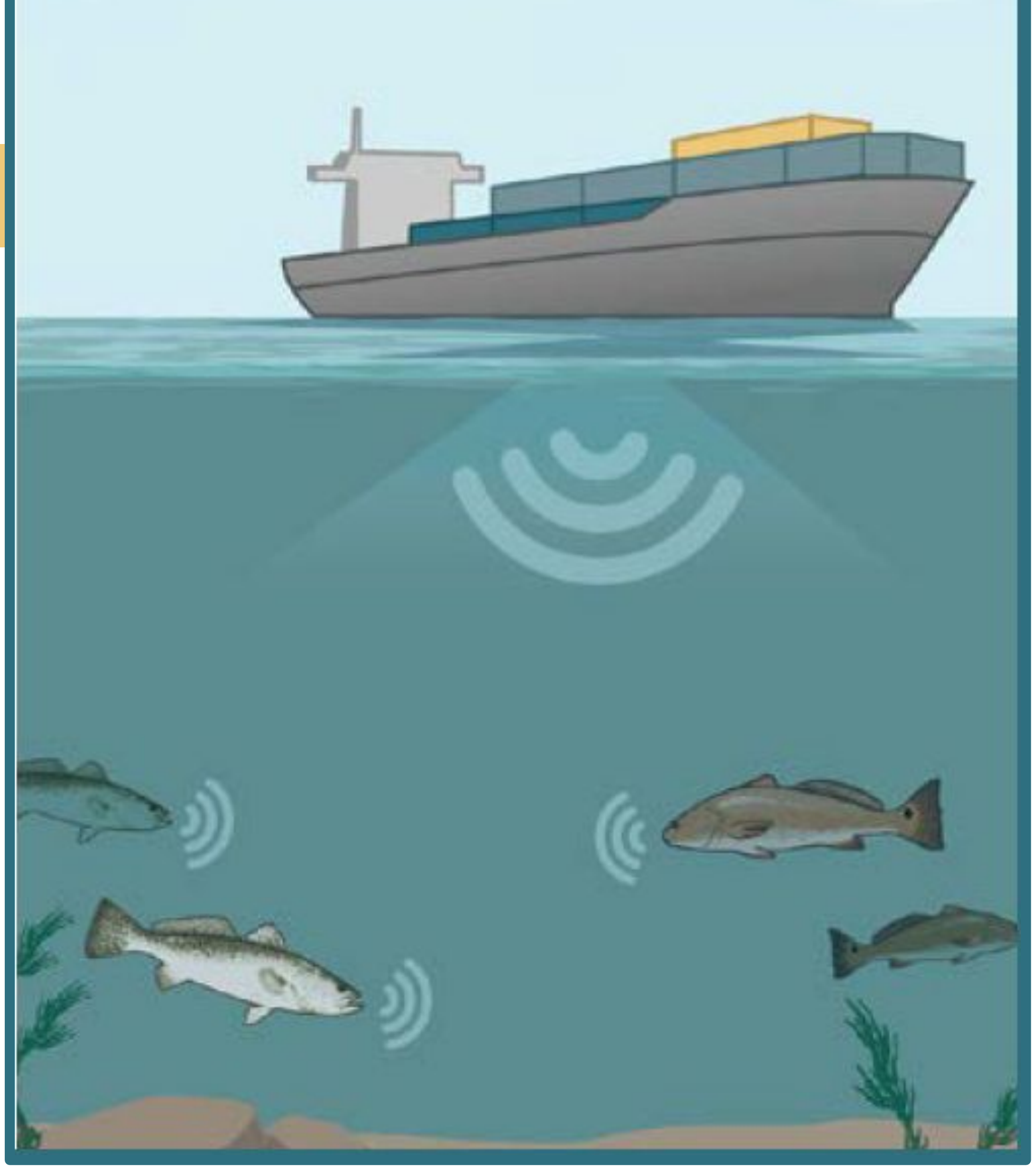


Figure 11:

Figure 10:



Stewardship

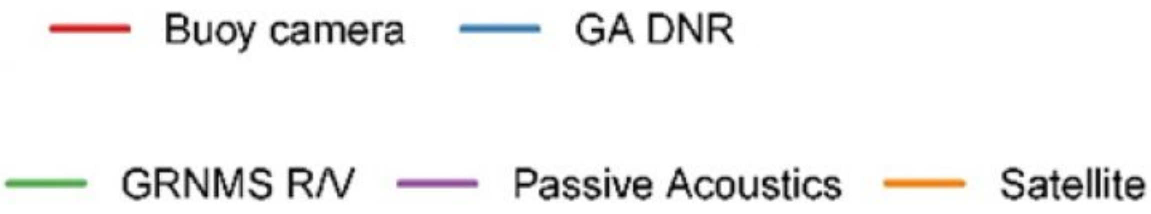
Monitoring Visitor Use to assess ecosystem value or regulation compliance

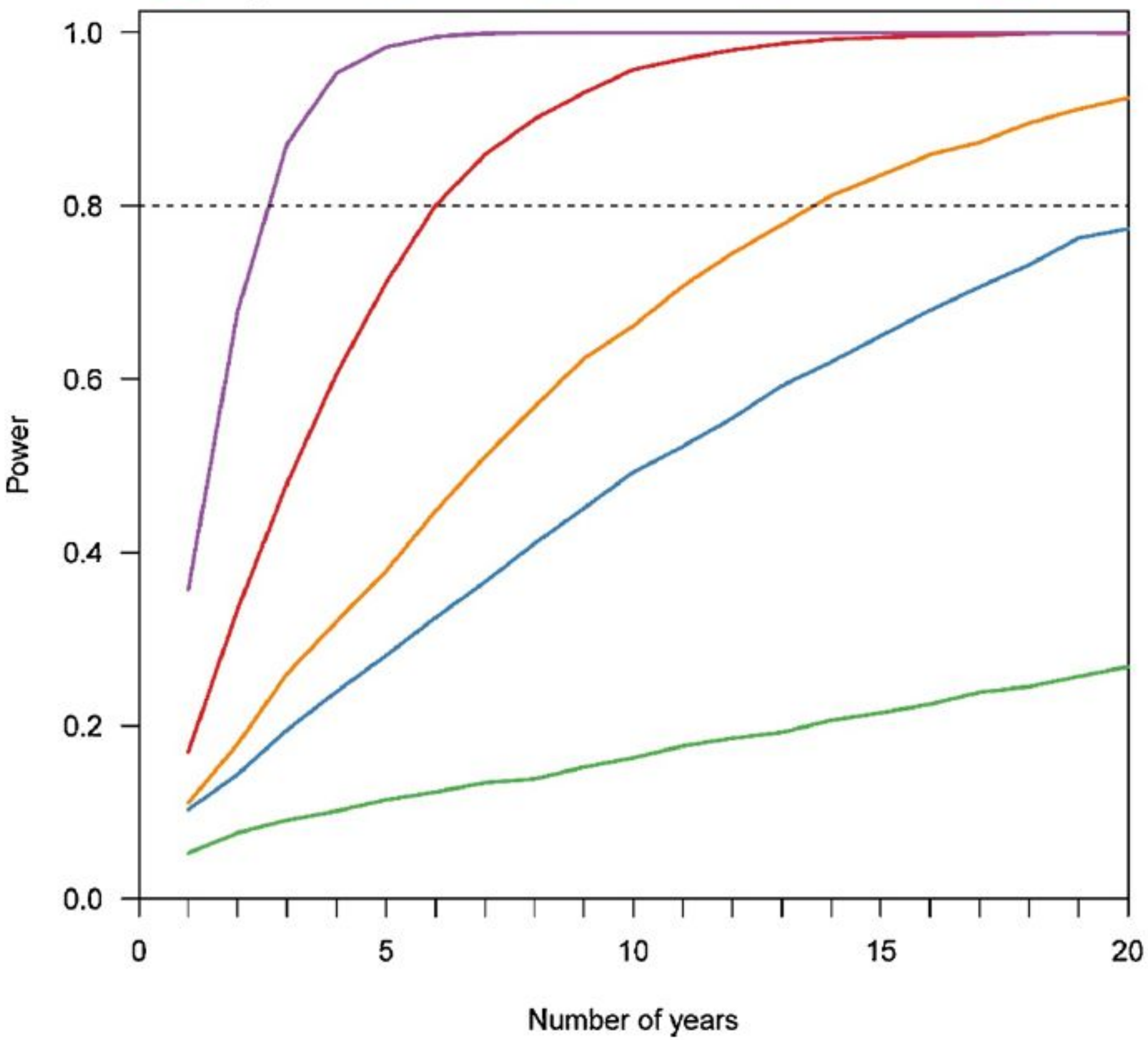
www.gsmfc.org/ann_ms/

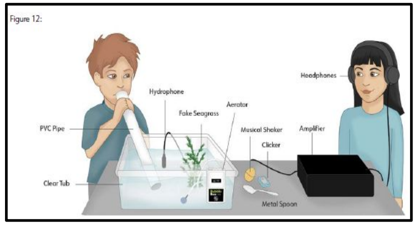
Passive acoustic monitoring is the best remote sensing approach

Monitoring Visitor Use

Kendall et al. 2021



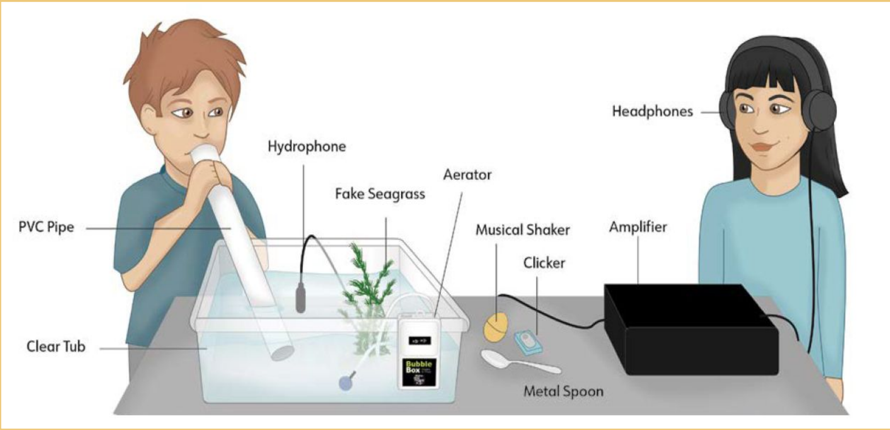




Education

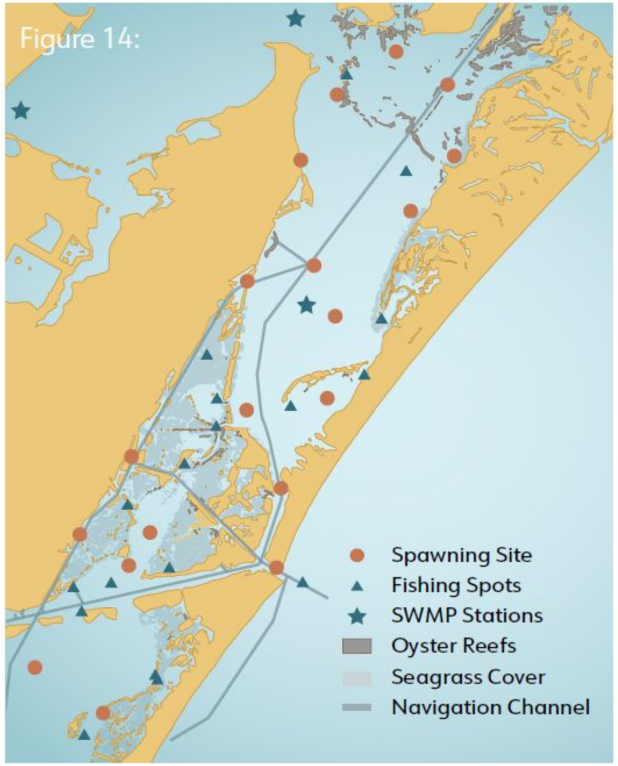
Teachers on the Estuary (TOTE)

Exploring Sound

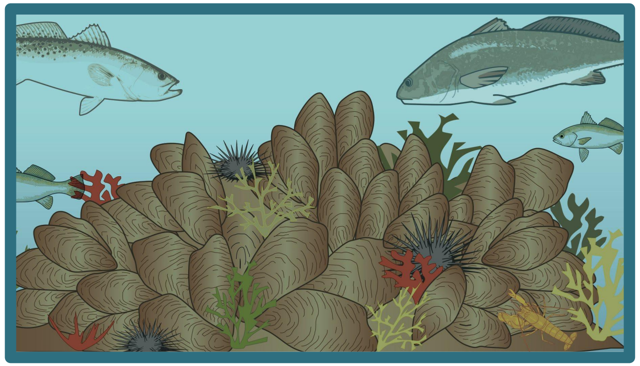


Sounds in the Field

Interpreting data



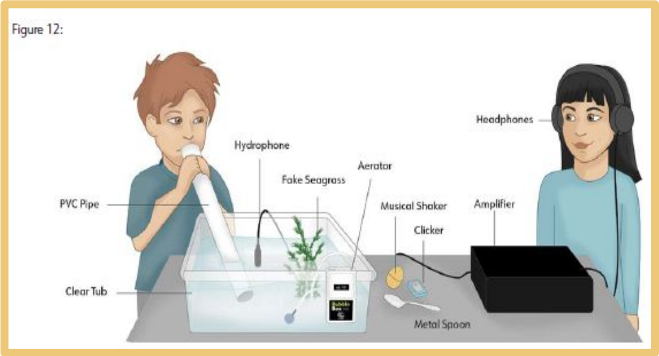
Management needs addressed with acoustic monitoring



Habitat assessment pre/post restoration

Short-term variability & long-term change

Visitor Use & Noise



Education

Research

Stewardship

Education

THE UNIVERSITY OF TEXAS MARINE SCIENCE INSTITUTE

BARUCH INSTITUTE FOR MARINE AND COASTAL SCIENCES
UNIVERSITY OF SOUTH CAROLINA

USCB

FIU
Institute of Environment

NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

National Estuarine
Research Reserve System
Science Collaborative

Rookery Bay
National Estuarine Research Reserve

NORTH INLET – WINYAH BAY
NATIONAL ESTUARINE RESEARCH RESERVE

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TEXAS
The University of Texas at Austin

Acoustic monitoring of oyster reef communities

Philip Souza, Jr.[1, 2]

[1] University of Texas at Austin Marine Science Institute, Port Aransas TX, US

[2] Mission-Aransas NERR (fellow), Port Aransas TX, US


CELEBRATING 75 YEARS
Marine Science Institute
The University of Texas at Austin
Texas

Oyster Reef Communities

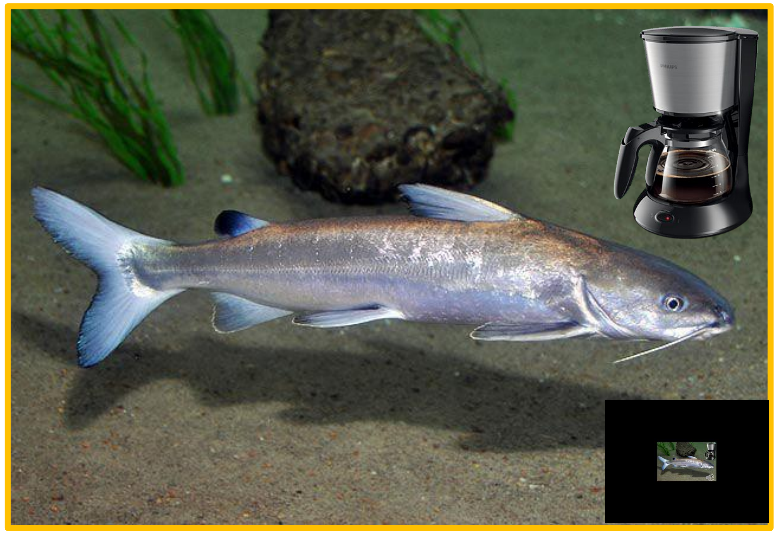
Eastern oysters provide habitat for a diverse assemblage of marine invertebrates and fish[3]

Communities provide several ecosystem services[4]

- Fisheries enhancement
- Nutrient and energy cycling

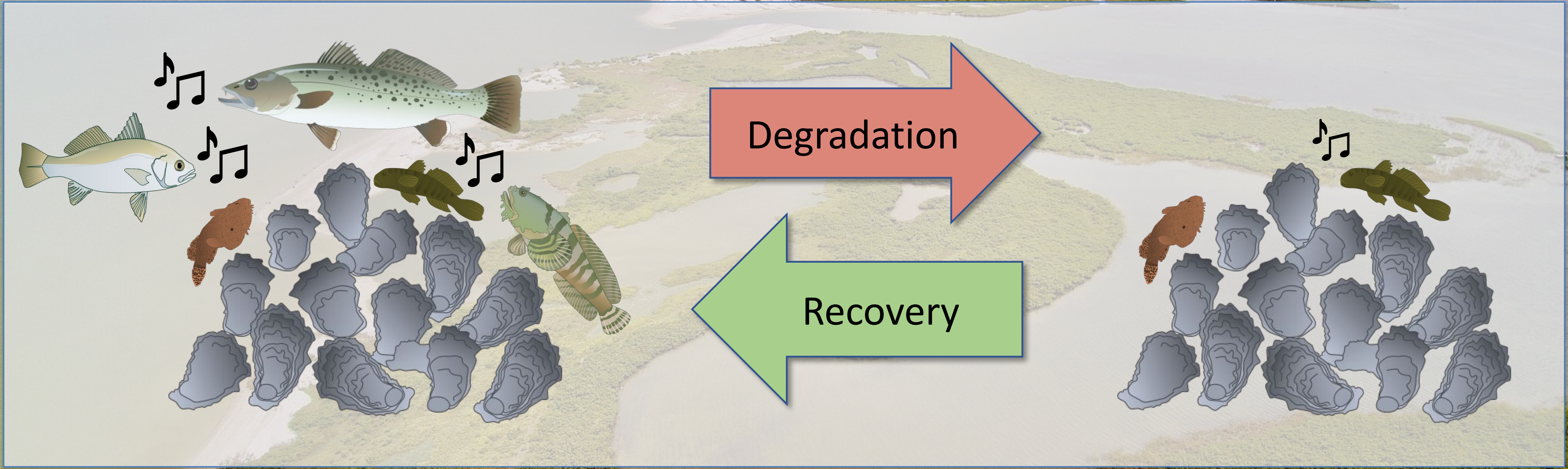
Oyster Reef Sound Producers

Residents

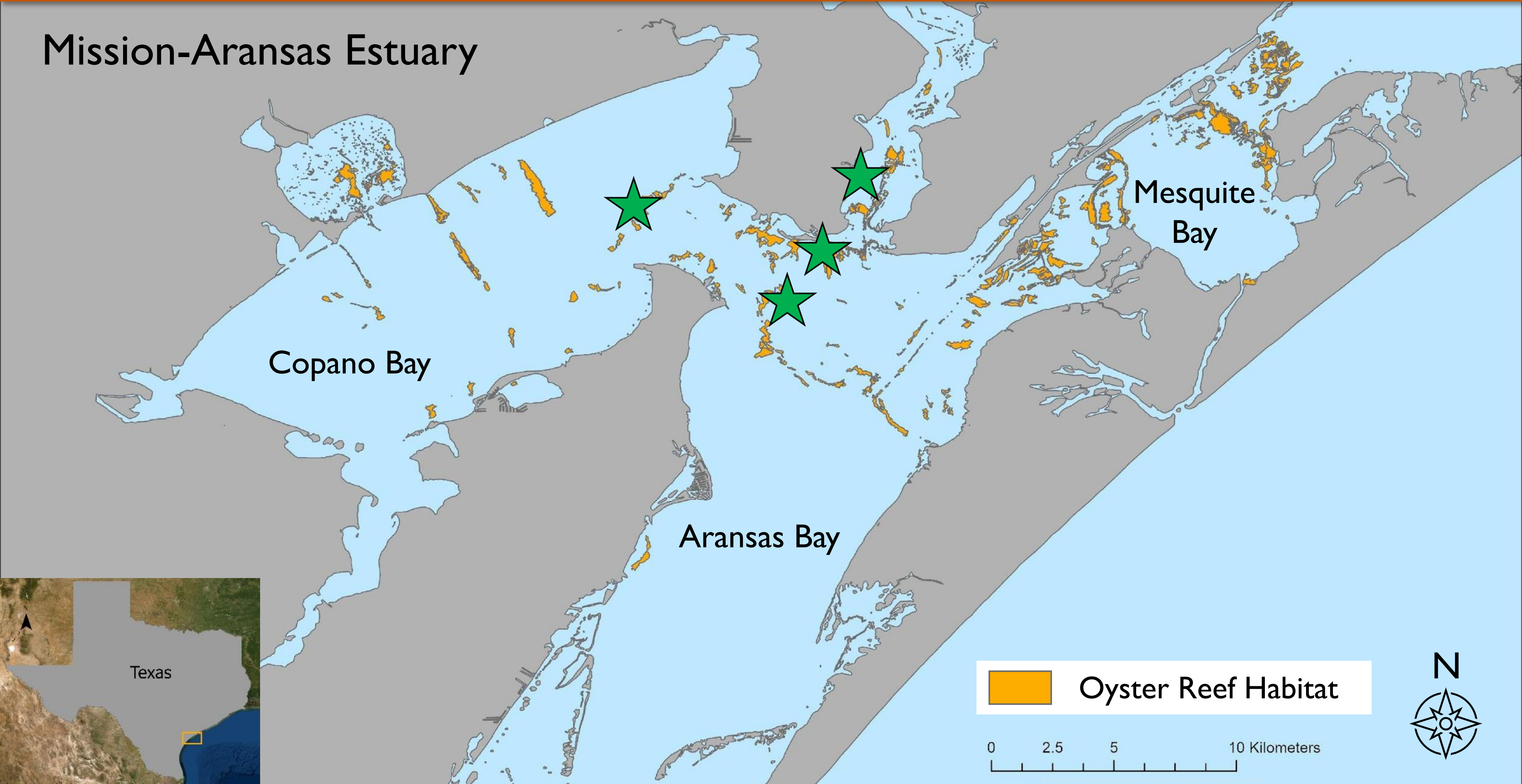


Transients

Can we use these sounds to monitor oyster reef health?



Mission-Aransas Estuary



Methods: Acoustic Monitoring

1 acoustic recorder on each reef site

Recorded 1 min sound file every 10 min

<u>Measures Generated</u>

Sound pressure level (SPL)

Acoustic complexity index (ACI)

Fish calling activity

Community Sampling

9 Oyster sampling units (OSUs) per reef site

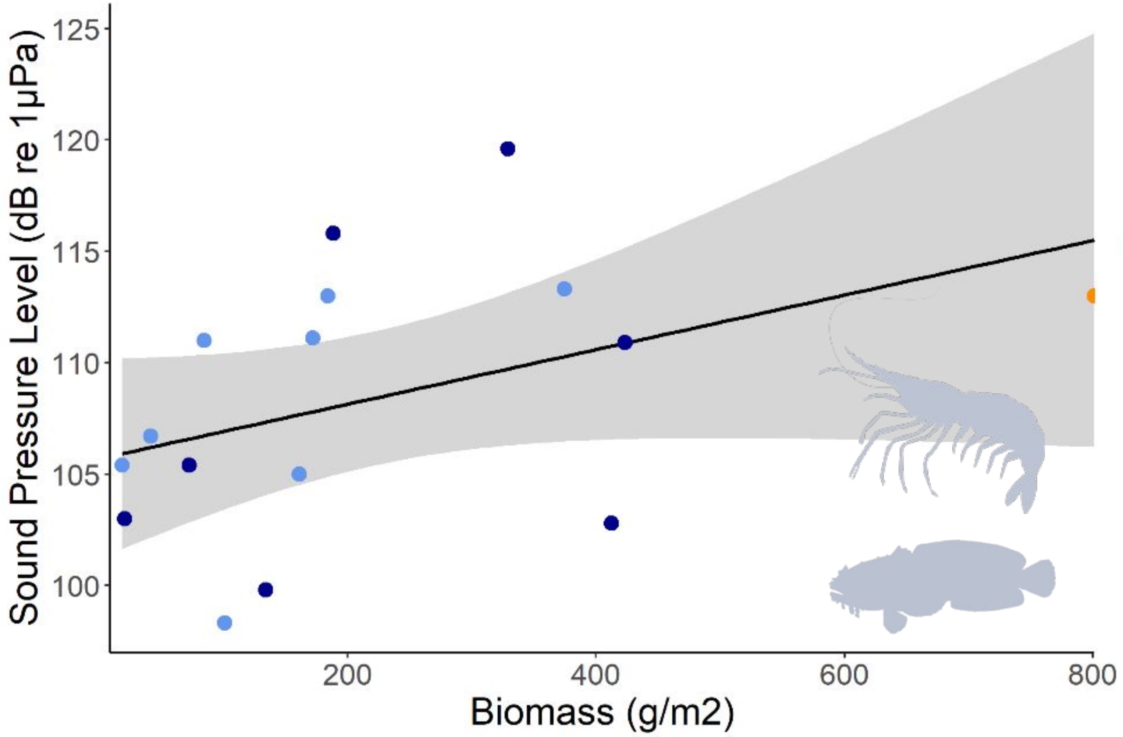
Collected every ~3 weeks

<u>Measures Generated</u>

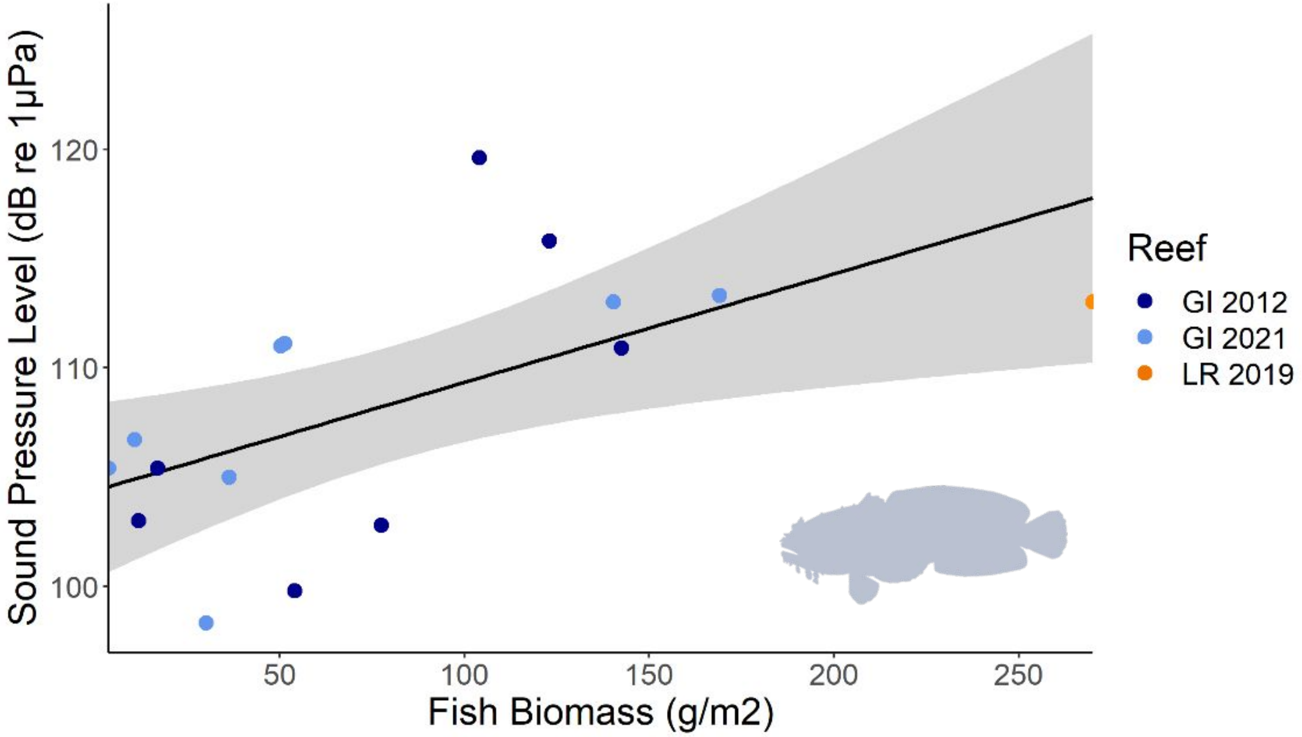
- Abundance
- Biomass
- Species richness

Sound pressure levels ~ Biomass

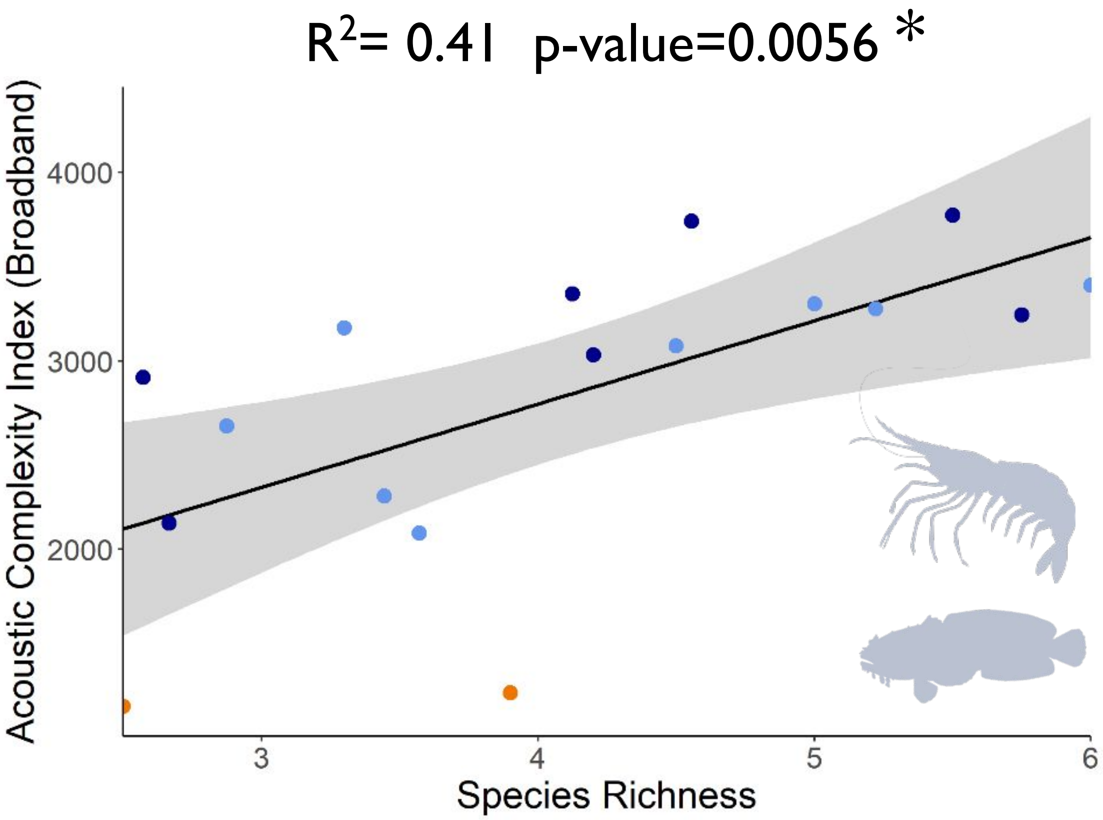
R^2= 0.38 p-value=0.0068 *

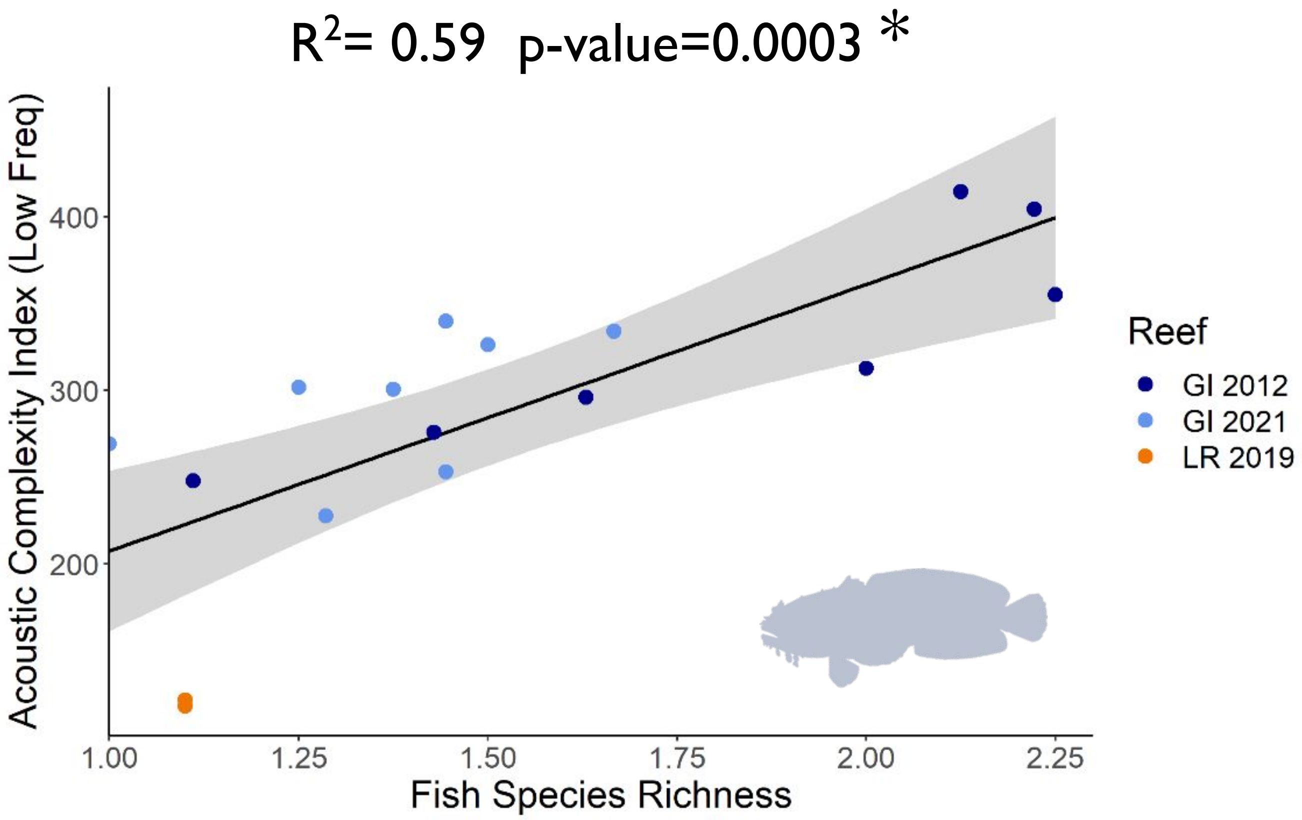


R^2= 0.60 p-value=0.0001 *



Acoustic complexity index ~ Species Richness





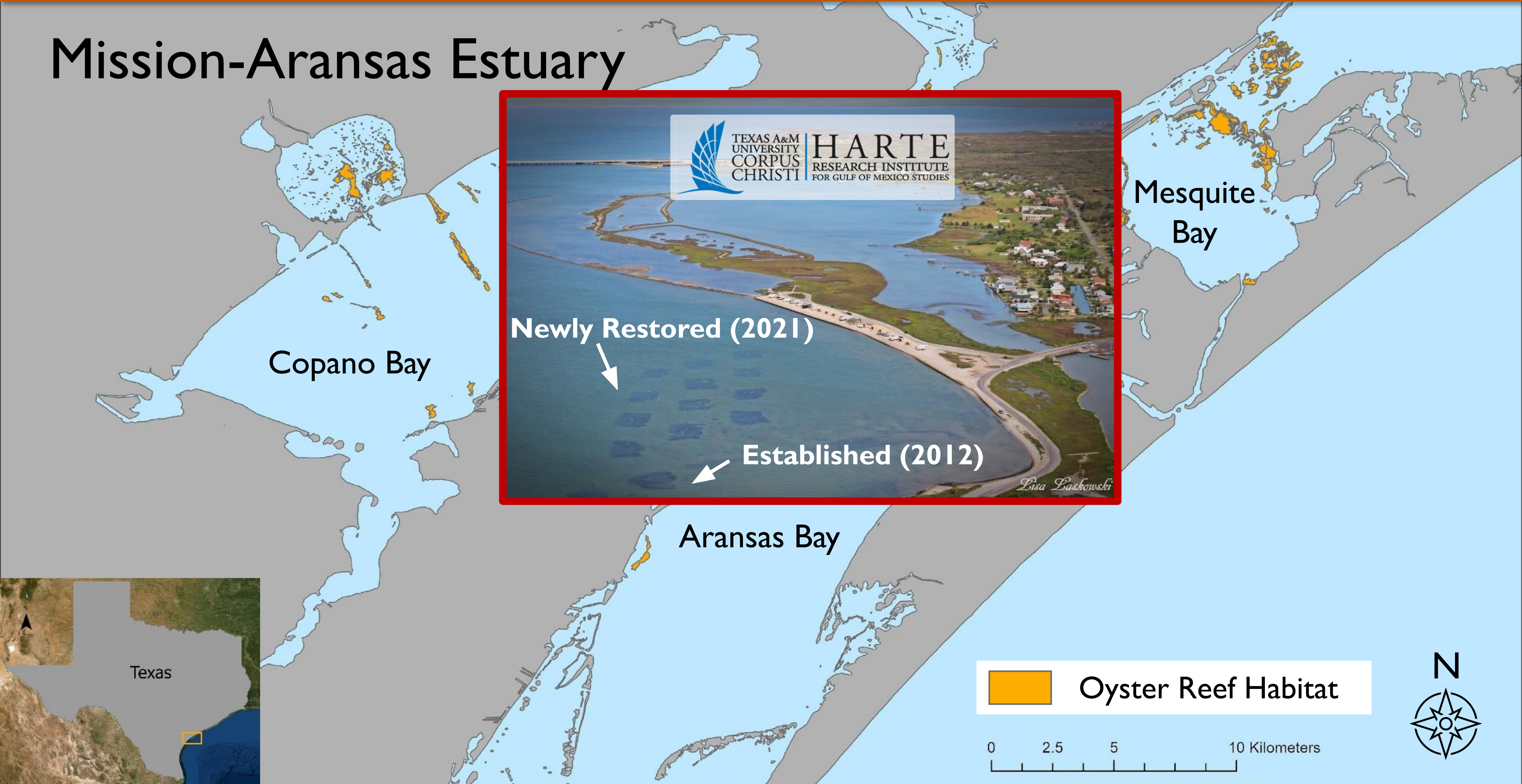
Applied monitoring:

Reef restoration

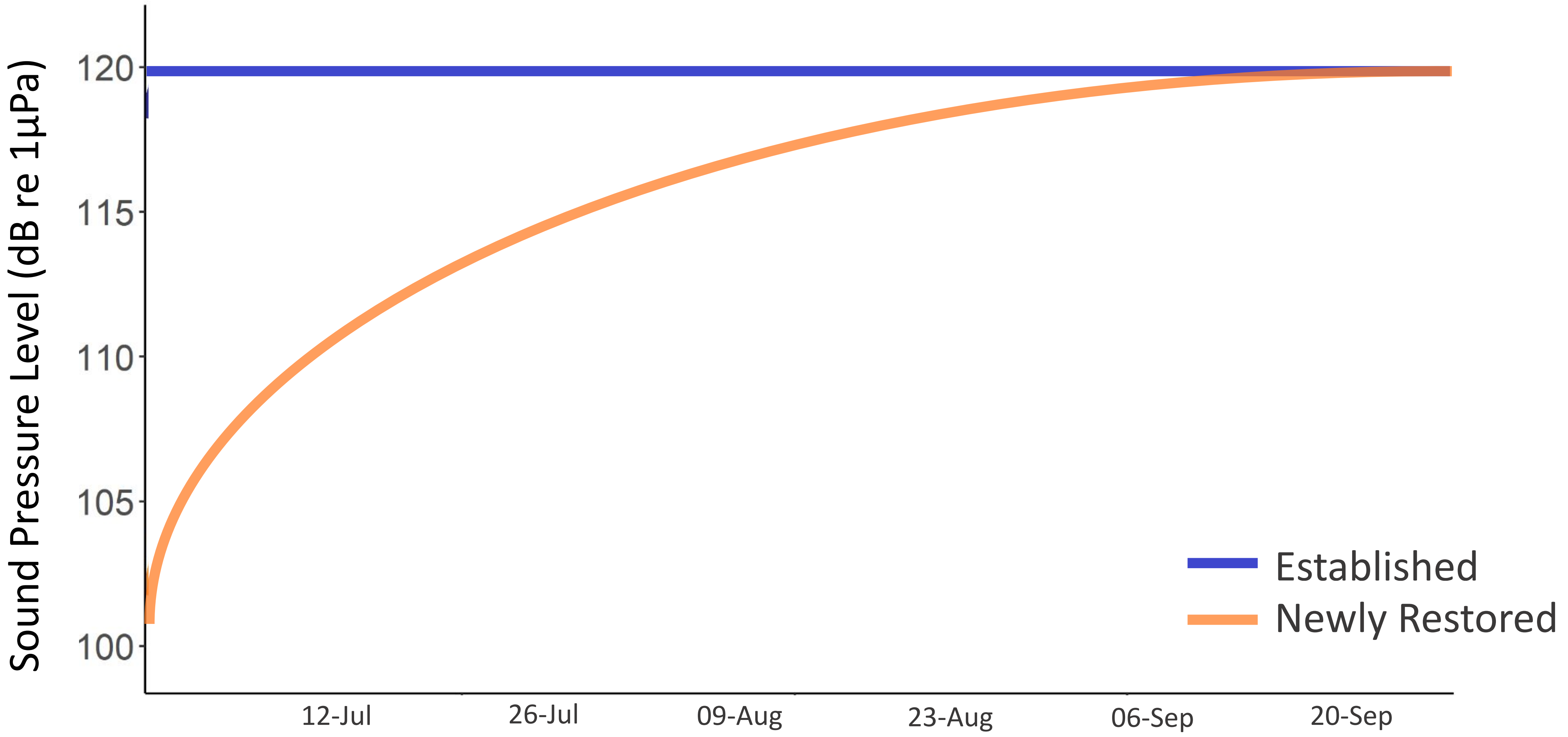
Natural disturbance

Oyster dredging

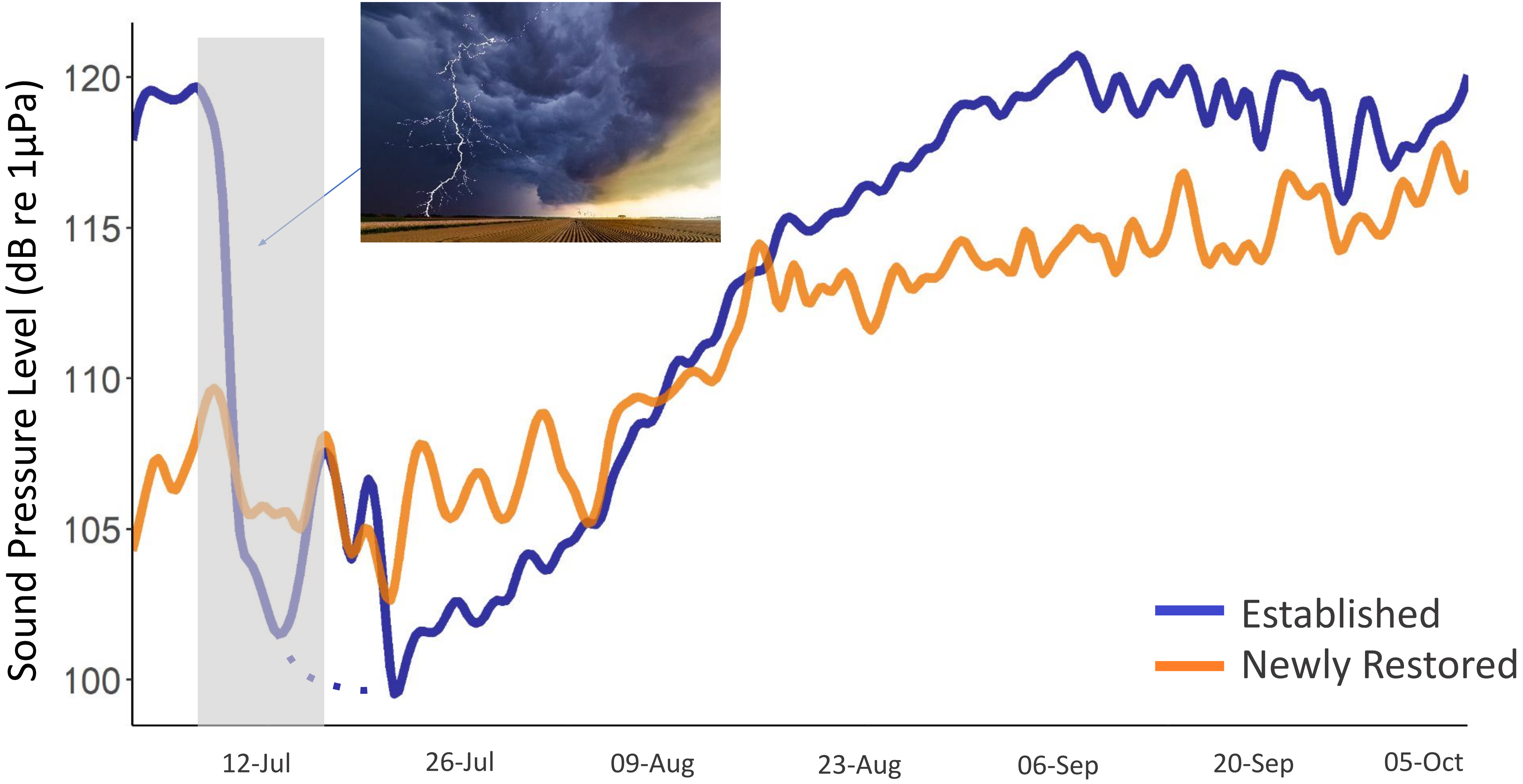
Mission-Aransas Estuary



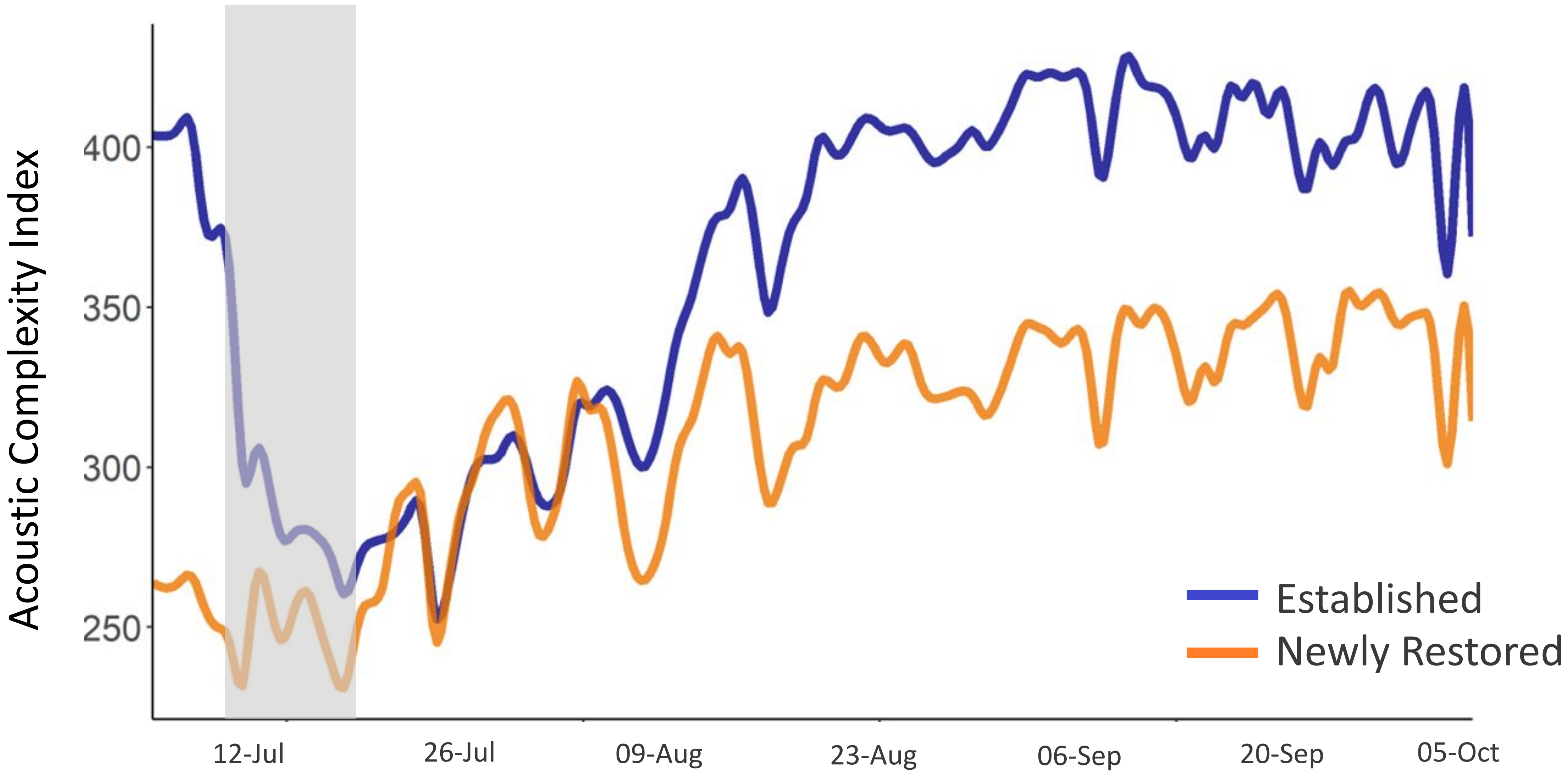
Expectation: Sound Pressure Level



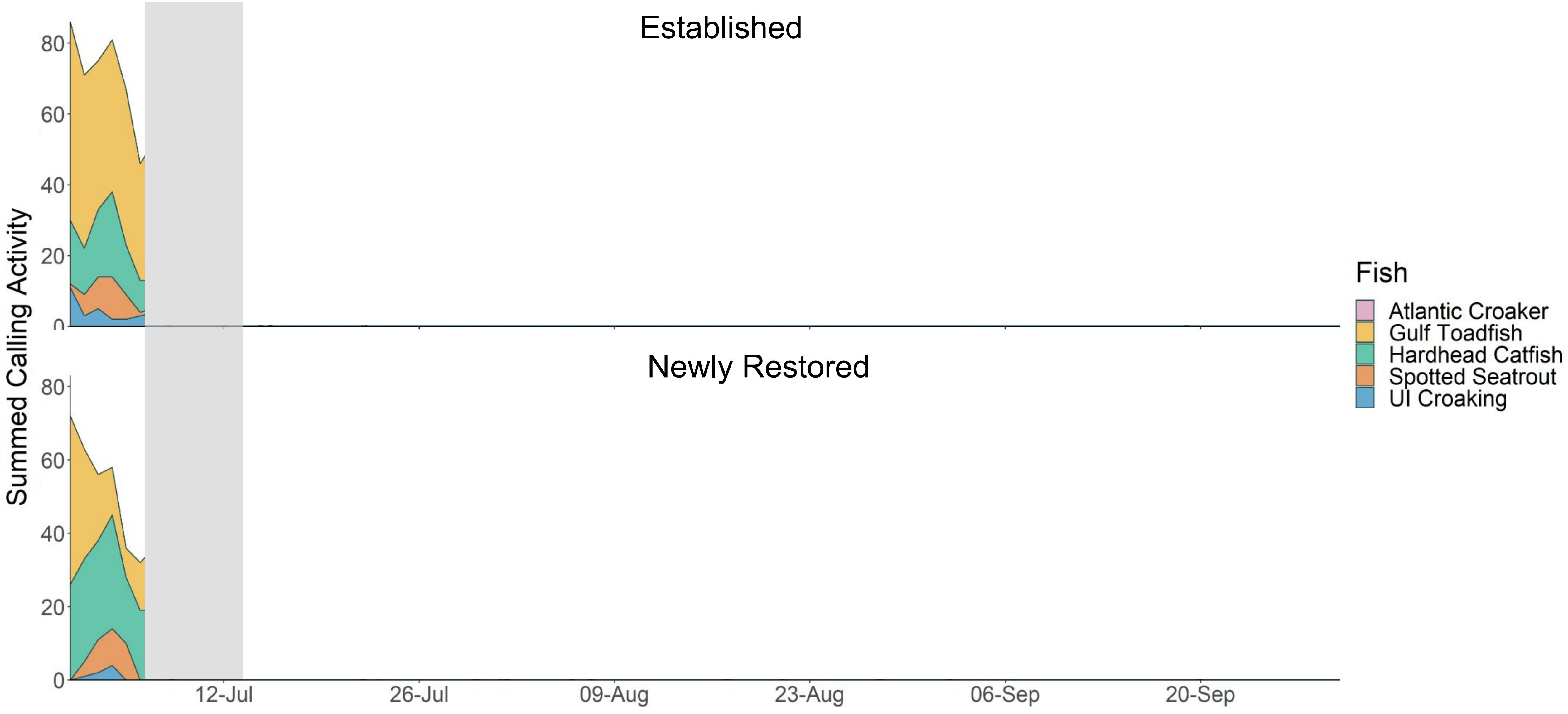
Reality: Sound Pressure Level



Acoustic Complexity Index

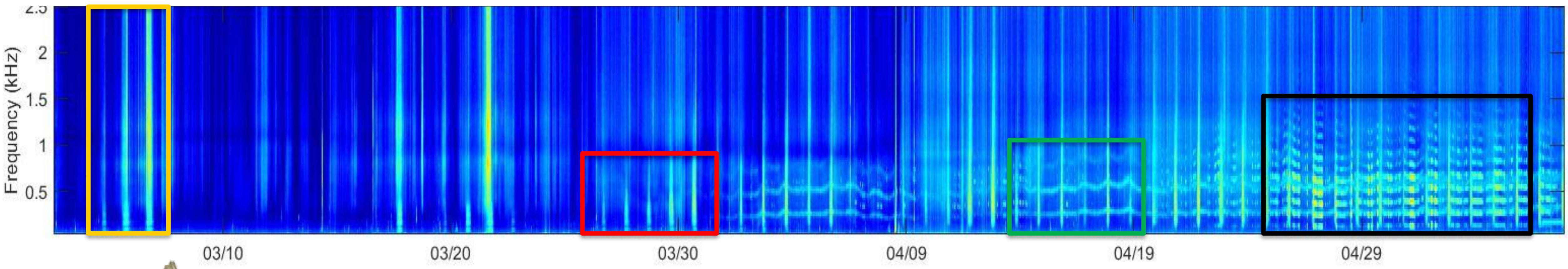


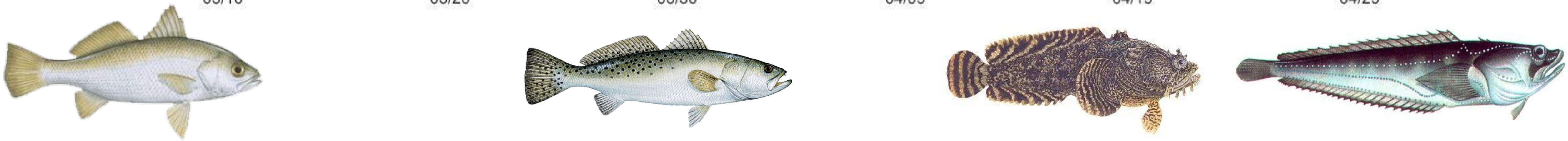
Fish Calling Activity



The University of Texas at Austin

Oyster Communities & Monitoring • Collections • Testing Relationships • **Applied Monitoring**





Silver Perch

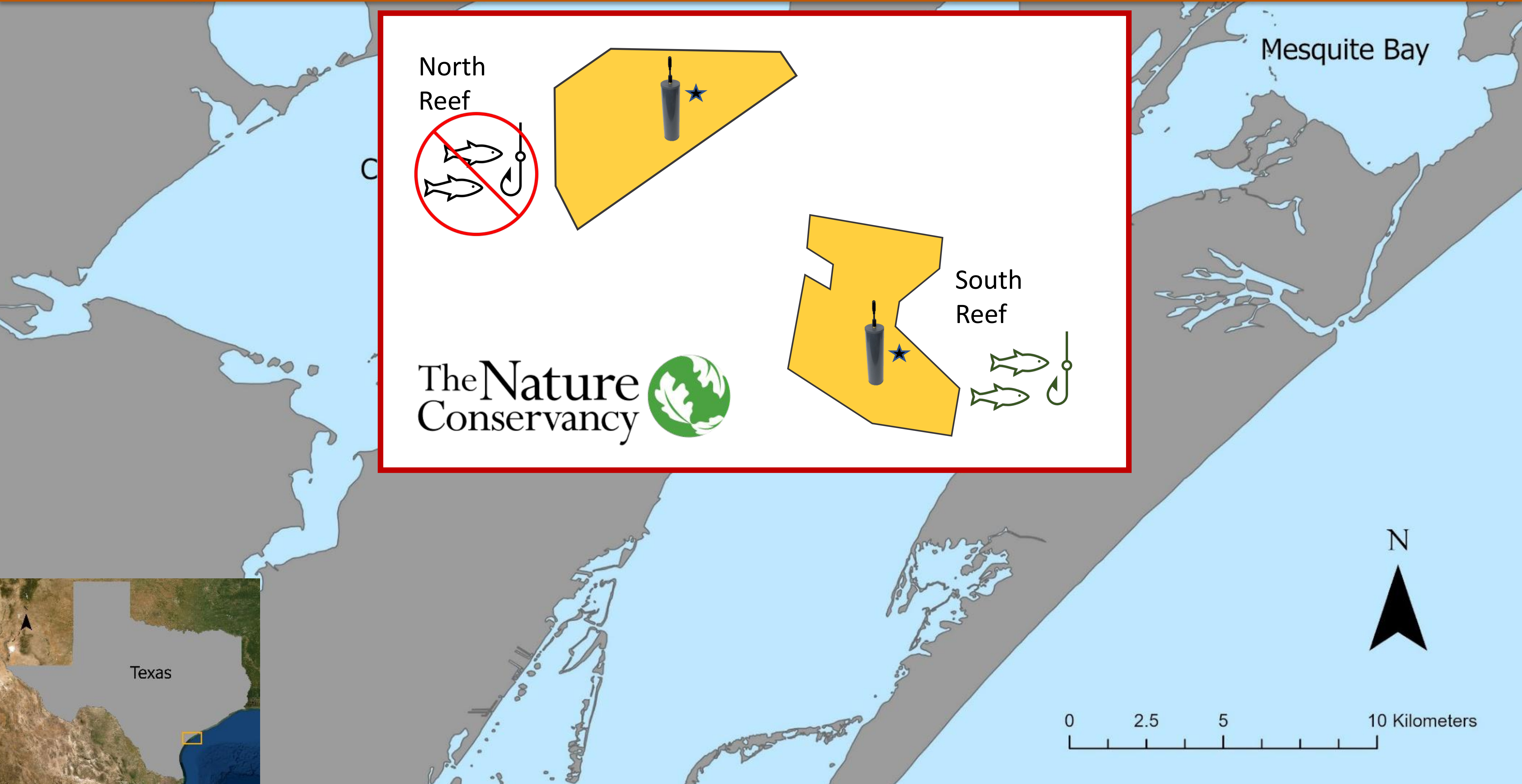
Spotted Seatrout

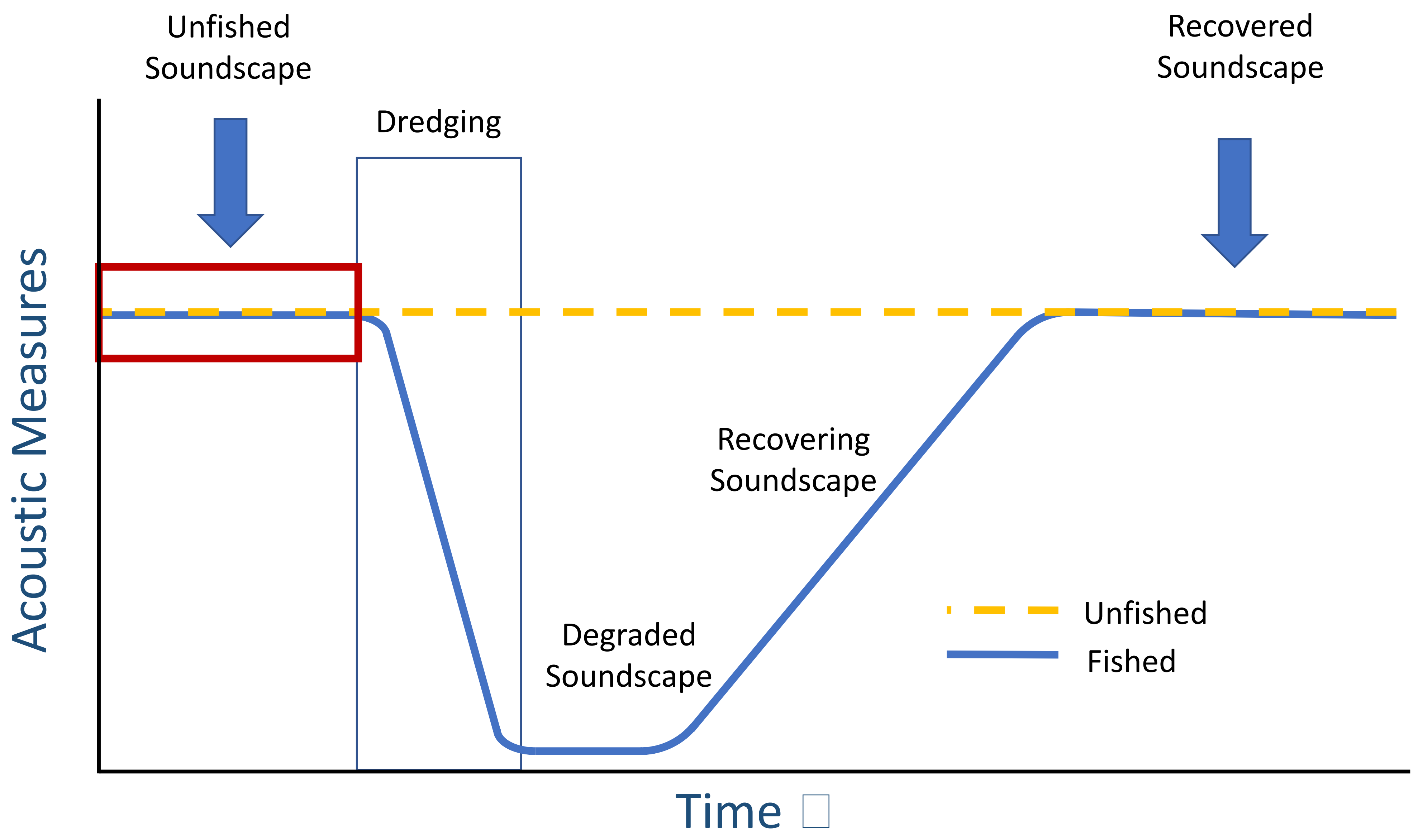
Gulf Toadfish

Atlantic Midshipman

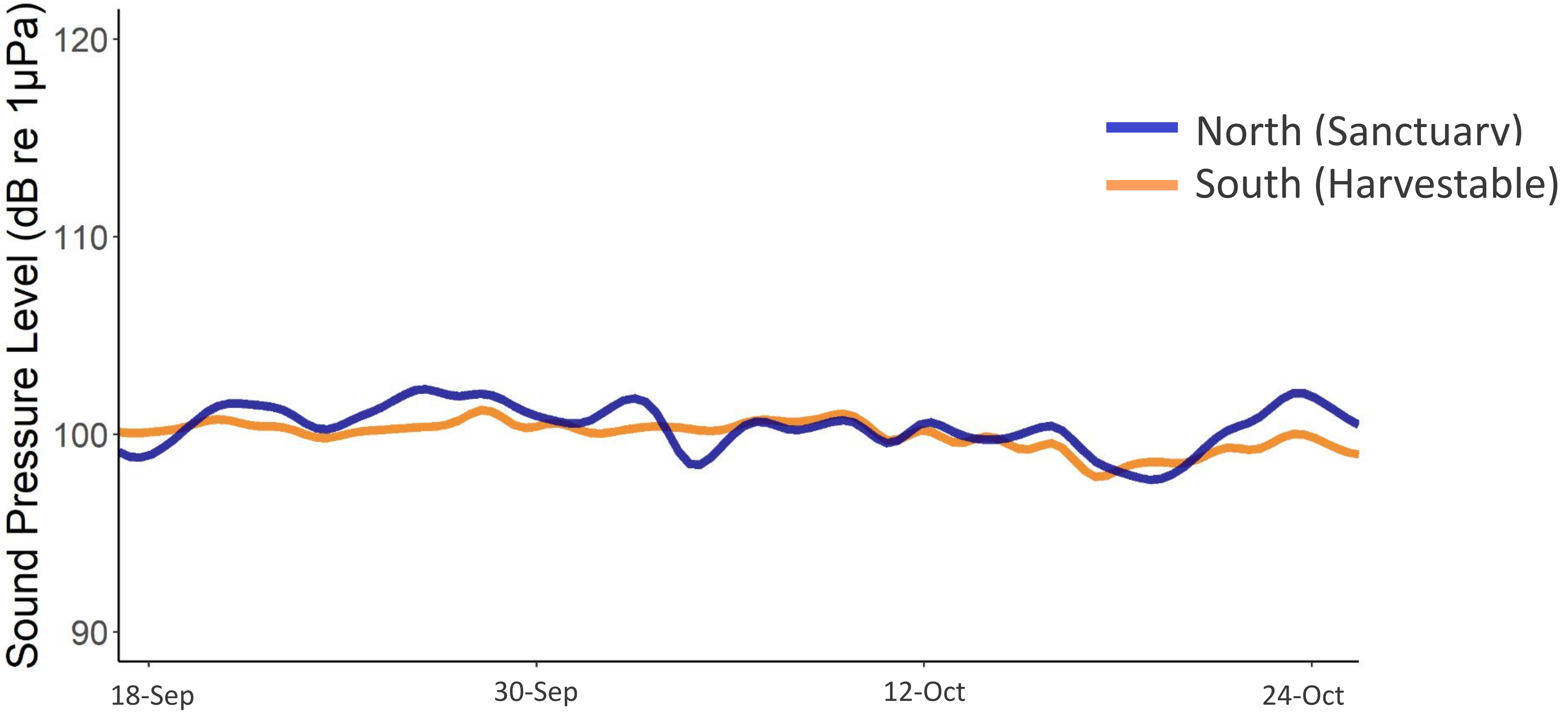
Applied monitoring:

- Reef restoration
- Natural disturbance
- Oyster dredging

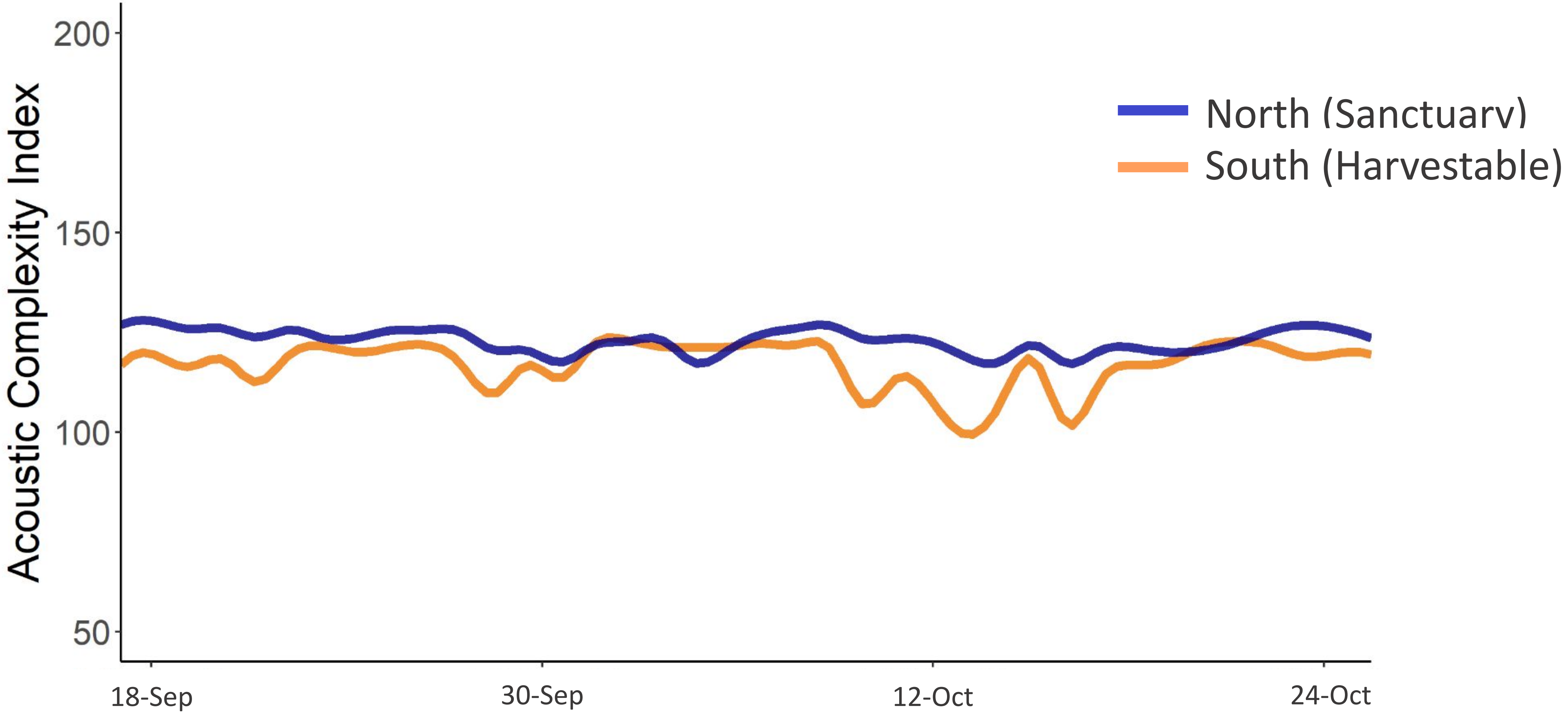

North
Reef
The Nature Conservancy
South
Reef
Mesquite Bay
N
0
2.5
5
10 Kilometers
Texas


Unfished
Soundscape
Dredging
Recovered
Soundscape
Recovering
Soundscape
Degraded
Soundscape
Unfished
Fished
Acoustic Measures
Time

Sound Pressure Level (Loudness)

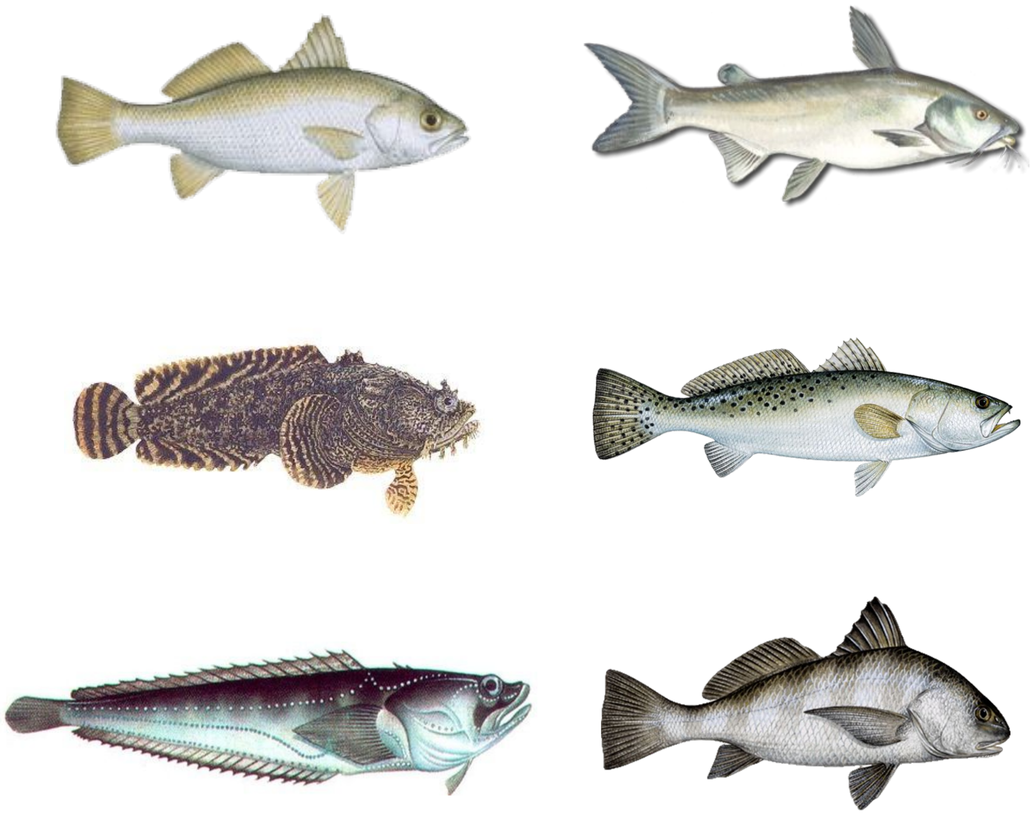


Acoustic Complexity Index

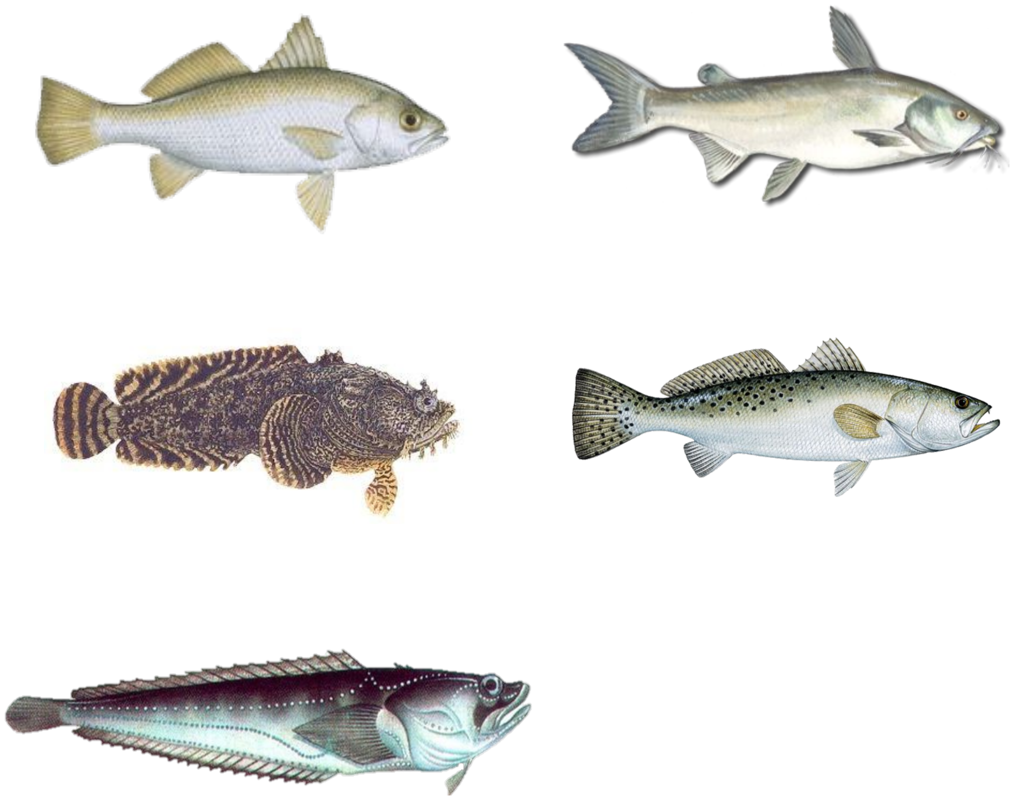


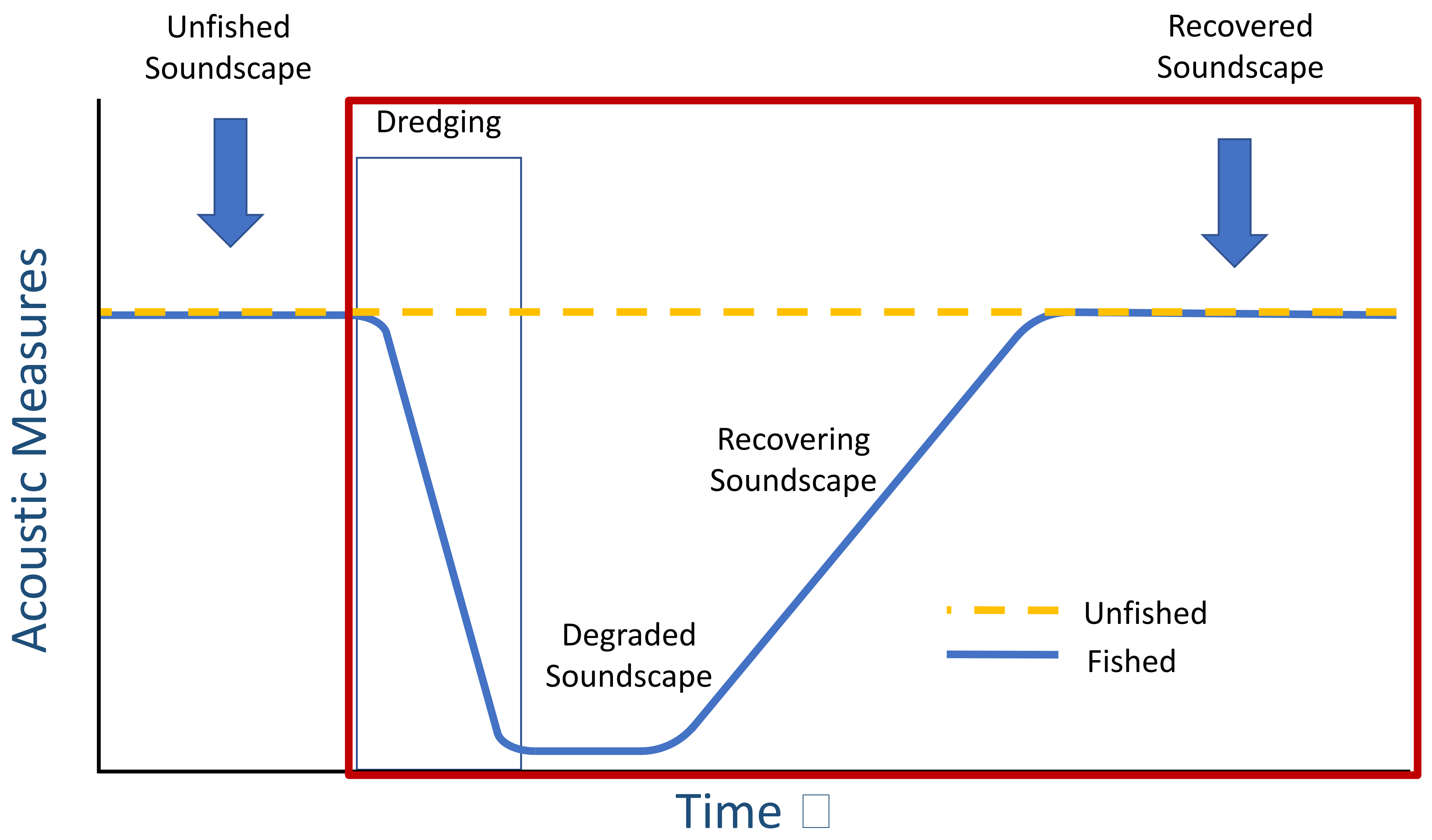
Fish Calling activity (Before)

Sanctuary



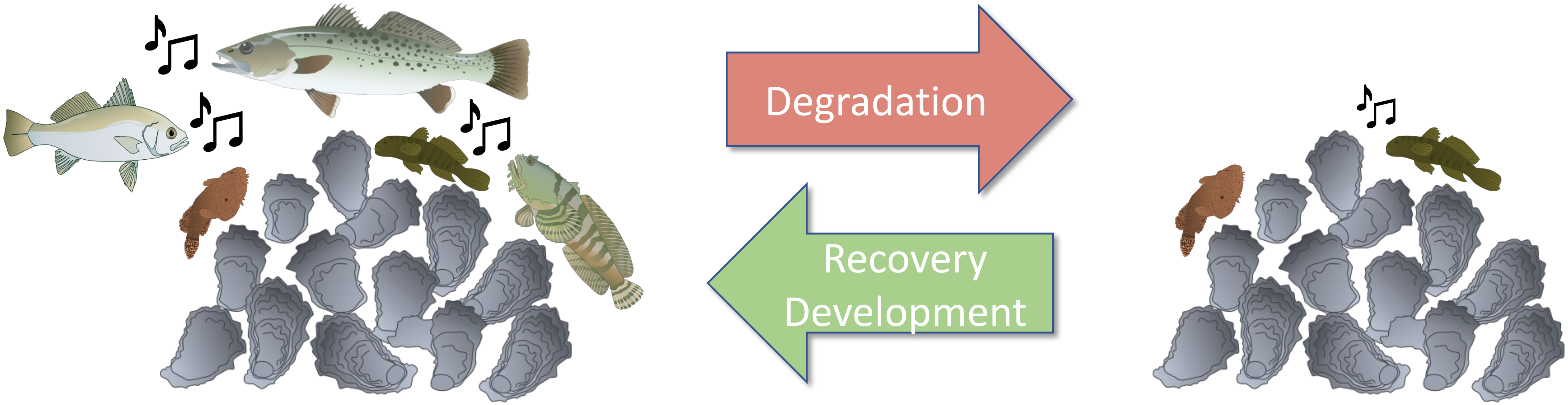
Harvestable




Unfished
Soundscape
Recovered
Soundscape
Dredging
Acoustic Measures
Recovering
Soundscape
Degraded
Soundscape
Unfished
Fished
Time

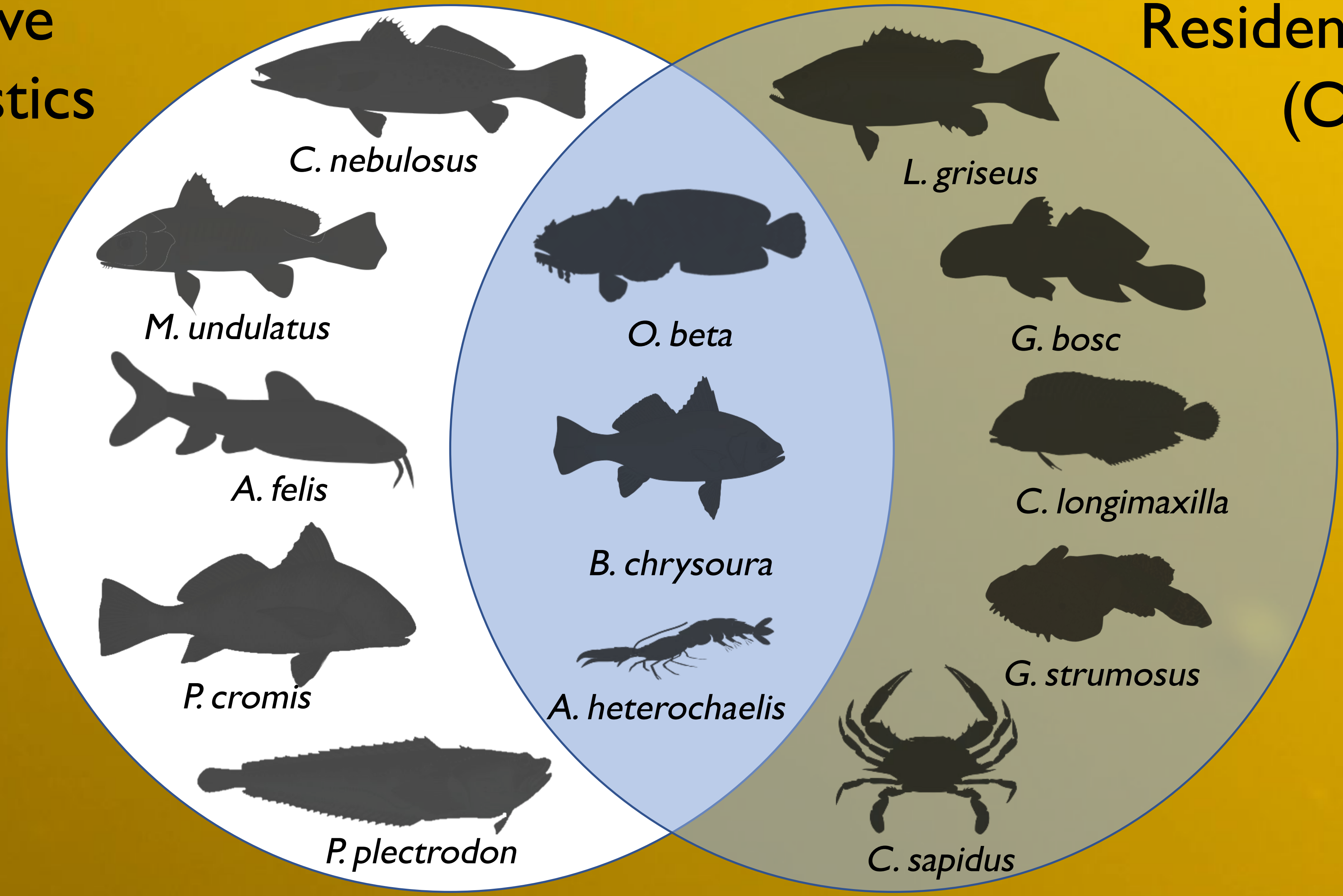
Findings

1. Oyster reef soundscapes are louder with increased resident biomass
2. Soundscapes are more complex with increased resident biodiversity
3. Acoustic monitoring may be useful for detecting acute local disturbances



Passive Acoustics

Resident Sampling (OSUs)



Acknowledgements

- **Funding:** Margaret Davidson Fellowship (NOAA)
- **Collaborators:** T. Palmer (HRI), J. Pollack (HRI), L. Williams (TNC)
- **Fieldwork Help:** C. Marconi, M. McCaffery, K. Savage, K. Capistrant, D. Bolser, H. Bailey, D. Frasier, S. Cunningham, M. Birgisson, J. Majoris

Q&A

Q: Looking back on the project, what was the most surprising finding?

- **A**: One of the biggest hurdles with acoustic monitoring is still the analysis. At this point it is still a rapidly developing field, but much of the analysis depends on manual listening and reviewing of files, which takes a lot of time. That aspect of acoustic monitoring is a limiting factor of how big of a project you can do. There is a lot of work being currently focused on developing AI and machine learning to accurately identify these sound sources underwater, but one of the problems is that we get a lot of fish and other organisms that are calling at the same frequency. When the calls overlap it is really hard to distinguish which organism it is, and this was one of the most surprising challenges from this project. As machine learning develops, that will advance the field a lot more.
- **A**: One thing I have been really surprised about in doing these projects is just how productive these oyster reef soundscapes are and how many different species of fish are vocalizing. I always get really excited when we find a new species that pops up on the reefs. Another surprise is how rapidly the soundscape evolves on these reefs. On the newly restored reef at Goose Island the sound levels were approaching those on the established reef within a few months of their installment. It's very rapid how quickly things are seemingly colonizing those reefs and making noise there.

Q: Are there only a certain selection of species you have recorded and therefore can detect? If not, how do you identify any new species you record?

- **A:** The hydrophones aren't set to record certain species, they will detect any species within range and that are loud enough. There are a lot of challenges associated with trying to figure out what species you're actually hearing. The sounds do have unique characteristics, for example, the frequency band that they're communicating in or the duration of the calls. You can also look at what time of day you're hearing the calls and then you can dig into literature and try to figure out what sound you're hearing because there is a lot of documentation out there for sound producing animals. There are also a couple of good libraries with fish sounds that you can check into, but sometimes you're not able to get to the bottom of what's calling. There are still some sounds that are left a mystery, but one thing we're hoping to do is get some of these animals into tanks and put a hydrophone in there and see if we can solve some of those mysteries.
- **A:** There are a couple efforts right now to help develop a global sound library. There's the Discovery of Sound in the Sea website which is a great resource that has a really nice sound library, and a Bioacoustics Stack Exchange that's just getting started up and being supported by Loggerhead Instruments, which makes a lot of the hydrophones we use.

Q&A

Q: What advice would you give yourself if you were to participate in this project again?

- **A**: There's so many opportunities and so many ways you can take this research, and at some points it can be overwhelming. In some ways it matters less getting the perfect combination of things than just getting something. It's a form of analysis paralysis, of which way do we take this because there's so many options.
- **A:** The advice I would give myself is to try to train up on machine learning techniques and try to use it for automated detection, because it is very time consuming to manually review these sound files for fish calls.

Q: Is there any way that you are measuring how the distance between the established and newly restored reefs influences the colonization of the new reefs?

- **A:** I am not looking into that, but I would imagine that the distance would be influencing recruitment on the reefs. Those sites are about 250-300 meters apart, so I'm sure there's a lot of recruitment going back and forth between those reefs. It seems like there is a little bit of a stagger, where if a species shows up on one reef, a month or two later they start showing up on the other reefs. I'm not looking into this, but I'm sure there is a lot of connectivity between the reefs that we are looking at.

Q: Do you ever anticipate using active and passive acoustics in tandem to understand biological community dynamics? Would this be helpful for getting a holistic understanding of a site?

- **A:** Yes, that is a great idea and a great approach that we have thought about a lot and done a little bit. With passive acoustics you can listen and see which organisms are there, and with active acoustics you can get measures of biomass and start to try and figure out how many individuals are present, because that's hard to get with just sound alone. The two theoretically compliment each other really well. Some members on our team have done some of this work. Kevin Boswell is an expert in active acoustics and has worked with Robert Dunn and Matt Kimball in South Carolina. They've done some active acoustics to look at movements of predator-prey species, but it's often limited by the depth of the water. In so many of the estuaries we're working in it's so shallow that active acoustics doesn't work or becomes very challenging. That has been what's kept us from trying to do that, and why we go to other sampling methods, like Phil's sampling units.
- **A:** The main thing is that it is very logistically challenging to get that type of equipment on some of the shallow reefs, but I do think that it would shed a lot of light. One thing I have been trying to do is relate sound levels on the reef to biomass. We're not sampling a lot of the more mobile species with our oyster sampling units, so I do think active acoustics would provide a more complete picture and the relationships would probably be even stronger.

Q&A

- **Q: Is there a good way to use citizen science for data analysis? If so, how would you train?**
- **A:** I think there is a way to use citizen science for data analysis, but there is still a big learning curve for identifying sounds. It would involve a lot of the same ways that you train machine learning. For example, you get a nice library of examples of what Sea Trout sound like and all the different habitats and group numbers, and you use that as your template to compare to. You have to have some degree of a verification process from experts, too. It takes a while to get your ears and eyes trained in to differentiate what you're hearing and seeing in those recordings. Also, there are more advanced analysis techniques that we utilize when we really get stuck. We're using programming and MATLAB to look at the power spectrum density, which is telling us exactly what frequencies the sound is composed of, which helps us zero in on certain species. That's a little bit more challenging for a citizen science setup.
- **A:** There's certainly a learning curve to figuring out exactly what you're listening to, but we've worked on projects with a couple of undergraduate students at this point. It's really just a matter of giving them an acoustic library of sounds we typically hear on the reefs and a few examples of each species, and then having them listen to as many sound files as possible. It's a lot of back and forth of "Is this what I'm hearing here?", and you tell them, and typically, next time they hear that species they know what they're listening to.