What's All that Racket! Estuarine Soundscapes in South Carolina

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College of Charleston

USCB Marine Sensory and Neurobiology Lab
USCB Lowcountry Dolphin Conservation

- Acoustic communication & soundscape ecology
- Environmental monitoring of estuaries
- Diversity and abundance of invertebrates & fish
- Bottlenose dolphin population monitoring

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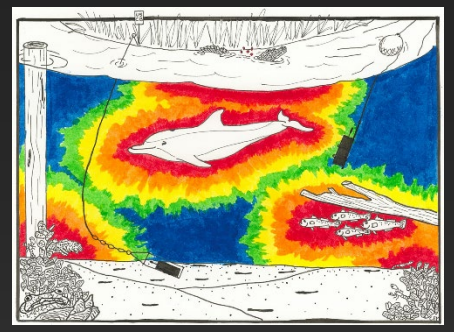
https://www.facebook.com/MarineNeuroLabAtUSCB/

USCB Marine Sensory and Neurobiology Lab

Past Lab Manager	Current Lab Manager	Field Manager
(Agnieszka Monczak)	(Alyssa Marian)	(Bradshaw McKinney)

CoC Graduate Students
(Jamileh Soueidan, Lindsey Transue, Caroline Tribble)

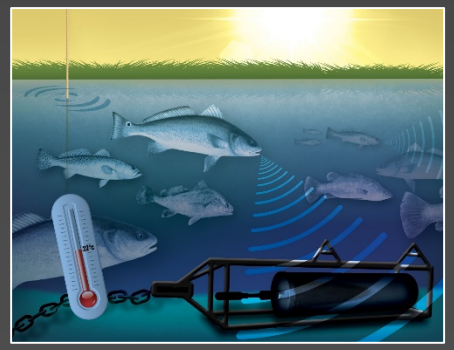
USCB Students
Evan Bowman, Anneau Cappelmann



1. The Soundscape of the May River Estuary

2. Soundscape Phenology and Biodiversity

3. Fish Courtship Sounds Correlate with Juvenile Fish Appearance



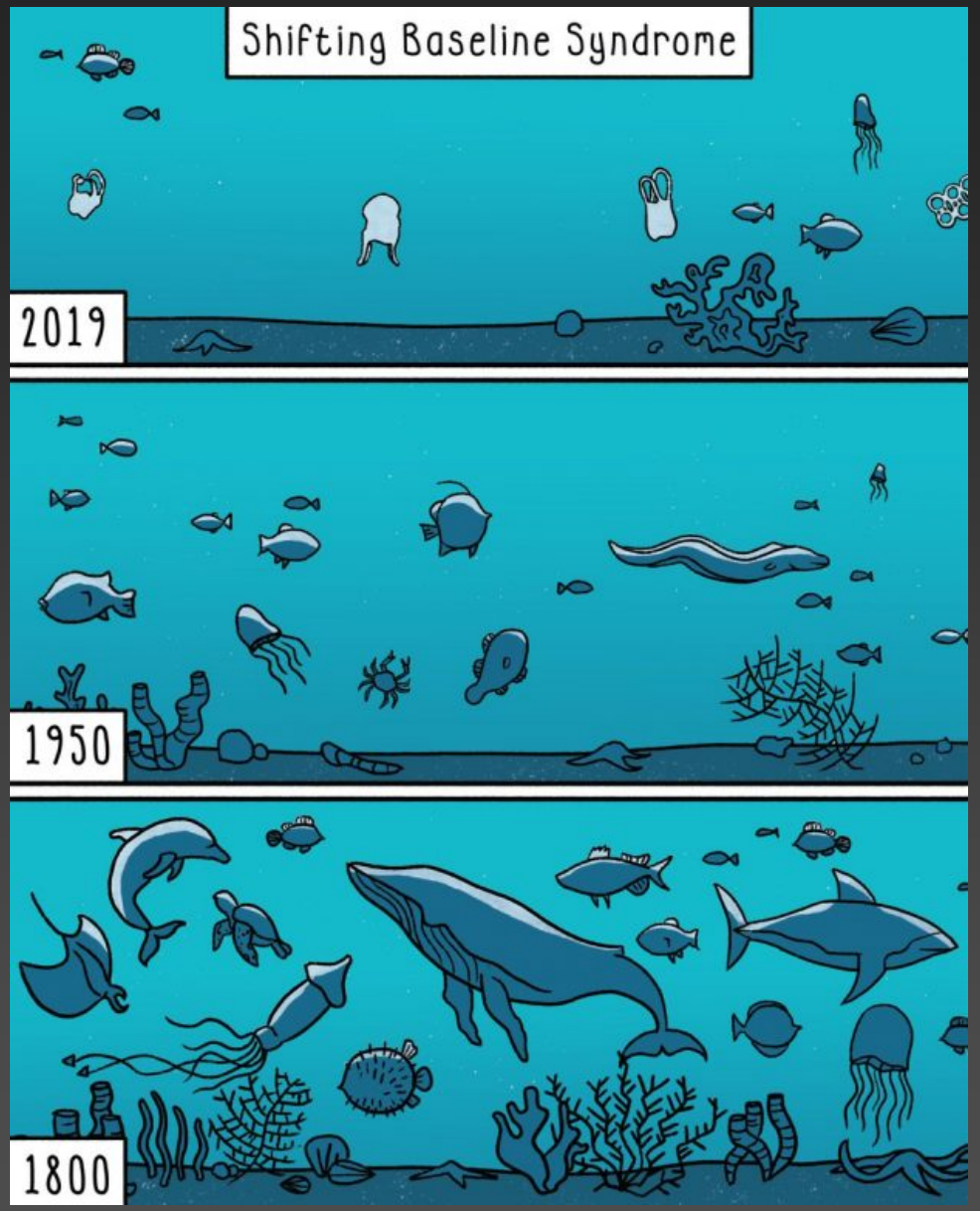
4. Estuarine Soundscape Observatory Network of the Southeast (ESONS)

Why Is Long-term Monitoring So Important?

Shifting Baseline Syndrome

"Each person evaluates the condition of the environment based on its state when they first experienced it, so changes to the environment are evaluated from this initial baseline. Thus, each generation accepts the environment in its degraded form as if it were normal, overlooking the changes the environment has undergone before their lifetime". Ian McHarg & Daniel Pauly

Natural Rhythms?
Natural Disturbances?
Noise Pollution?
Nutrients?
Chemical Pollution?
Invasive Species?
Habitat Alteration?
Ocean Acidification?
Warming Climate?
Whaling?
Overfishing?



University of Victoria, "Stories of Our Era"

Soundscape Ecology? A Useful Tool in Monitoring Marine Ecosystems

Natural Rhythms?
Natural Disturbances?
Noise Pollution?
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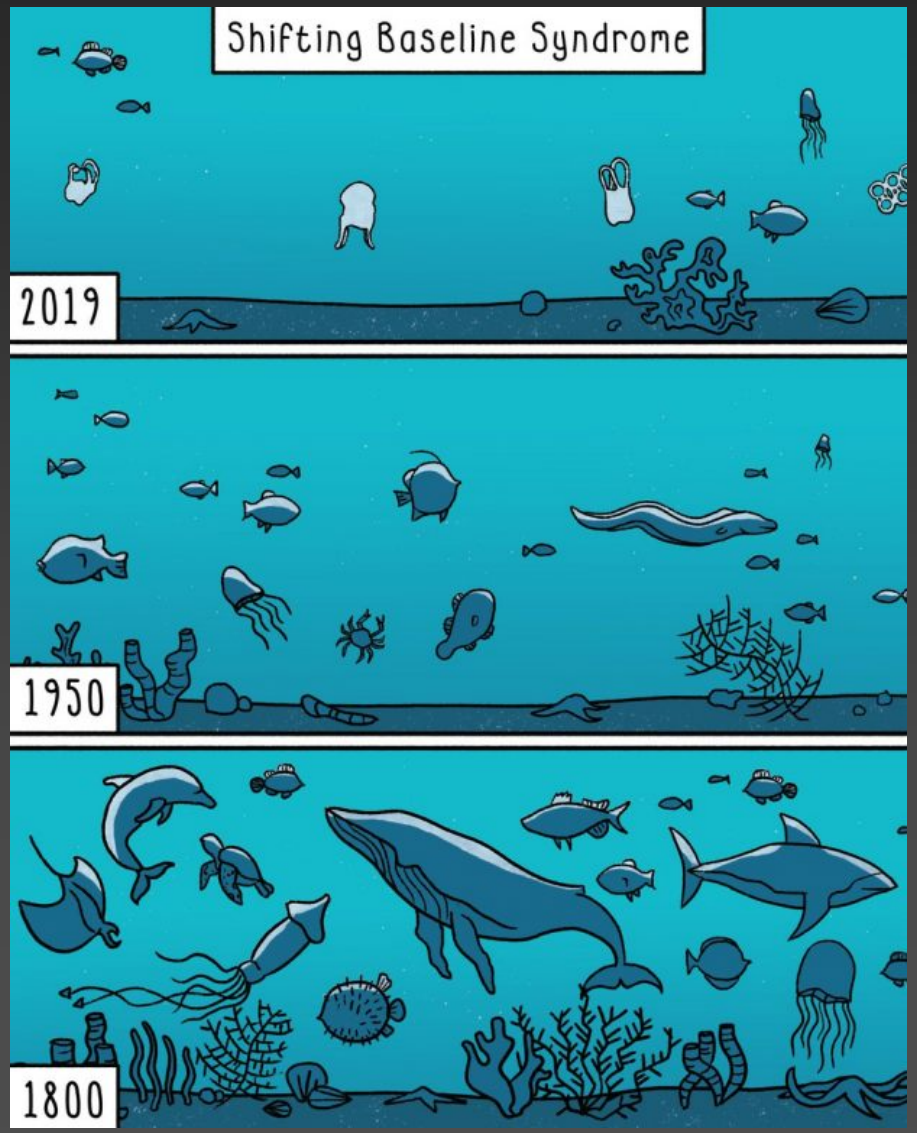


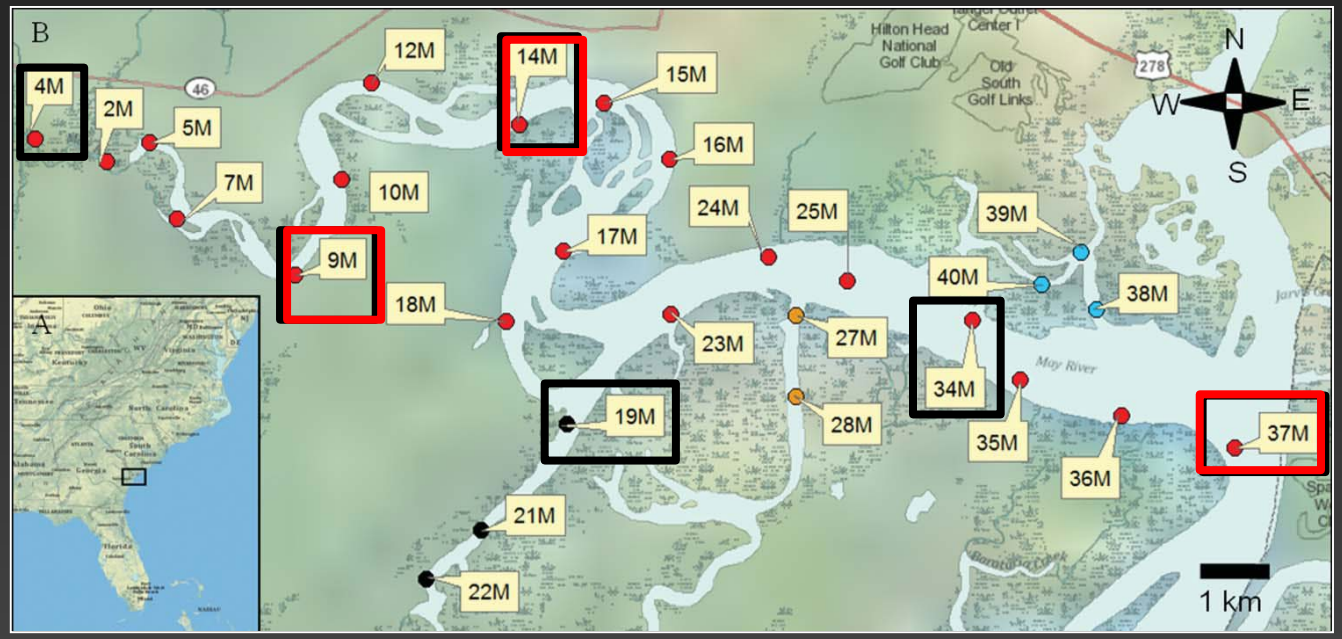
Technology Allows High Temporal Resolution

Useful in Estuaries Where Visibility Is Limited

Eavesdrop on Animal Behavior at Multiple Levels of Biological Complexity

Many Aquatic Organisms Produce Sound

Monitoring the Soundscape of the May River Estuary



2012 → short-term acoustic recordings at 27 stations.

2013 & 2014 → DSG-Oceans at 6 stations (2 minutes every 20 minutes); HOBO temperature & depth loggers; March to December.

2015 to present → DSG-Oceans at 3 stations; year round; 2 minutes every 1 hour.

Snapping Shrimp Snaps

- Big claw → air bubble → collapse → snap
- Snaps are vertical and broadband
- Territory, communication, and foraging?

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https://doi.org/10.3354/meps12813
MARINE ECOLOGY PROGRESS SERIES
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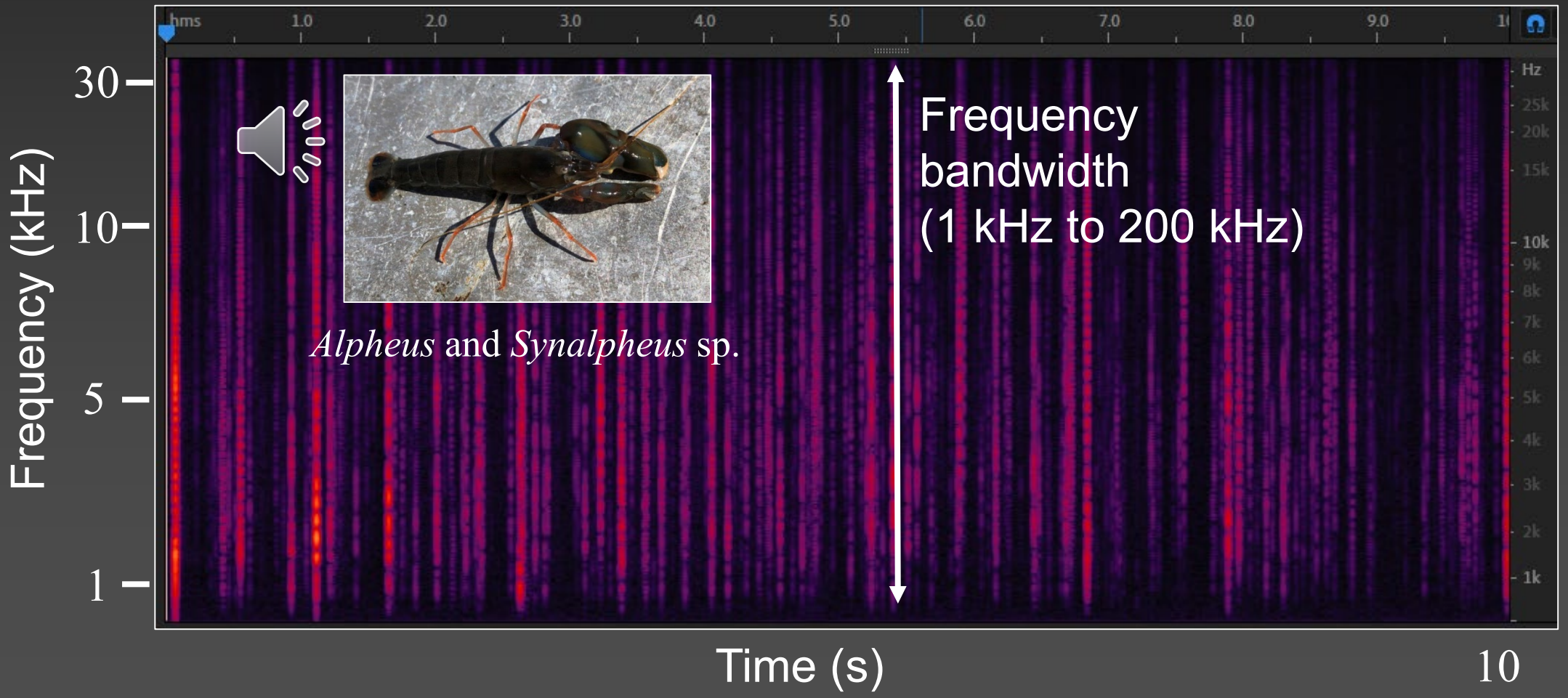
Published January 17

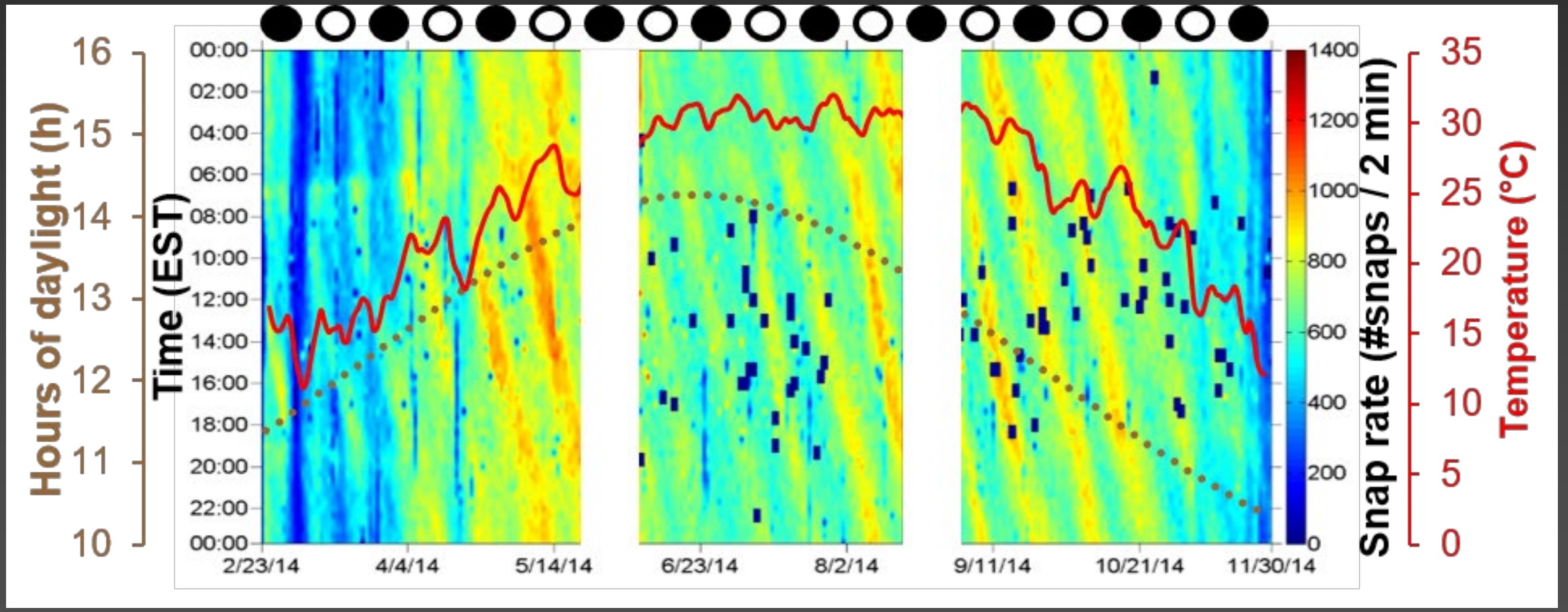
Sound patterns of snapping shrimp, fish, and dolphins in an estuarine soundscape of the southeastern USA

Agnieszka Monczak[1,2,*], Claire Mueller[1], Michaela E. Miller[1], Yiming Ji[3], Stephen A. Borgianini[1], Eric W. Montie[1,*,**]



Temporal Rhythms of Snapping Shrimp Acoustic Behavior

Station 9M: Snap rate (# snaps / 2 min)



Spring - Silver Perch Evening Chorus

- Male sonic muscle beats → swim bladder → calling
- Low frequency pulses: 300 to 2000 Hz
- Courtship and spawning behavior

Vol. 581: 1–19, 2017
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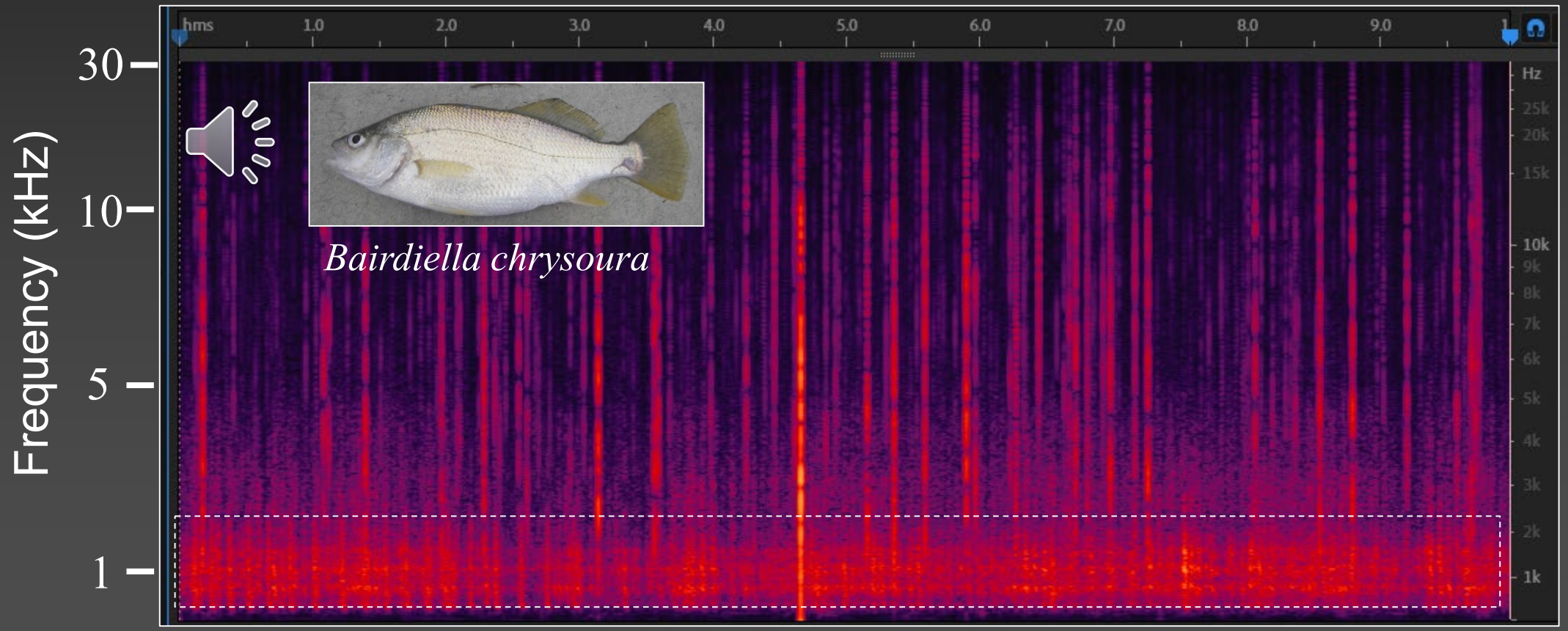
FEATURE ARTICLE

Long-term acoustic monitoring of fish calling provides baseline estimates of reproductive timelines in the May River estuary, southeastern USA

Agnieszka Monczak[1,*], Andrea Berry[2], Chris Kehrer[3], Eric W. Montie[1,*,**]



Summer – Spotted Seatrout Nightly Chorus Dominates the May River

- ‘Grunts’, ‘drums’, & ‘staccatos’ ~ peak 100 to 700 Hz
- Courtship and spawning behavior

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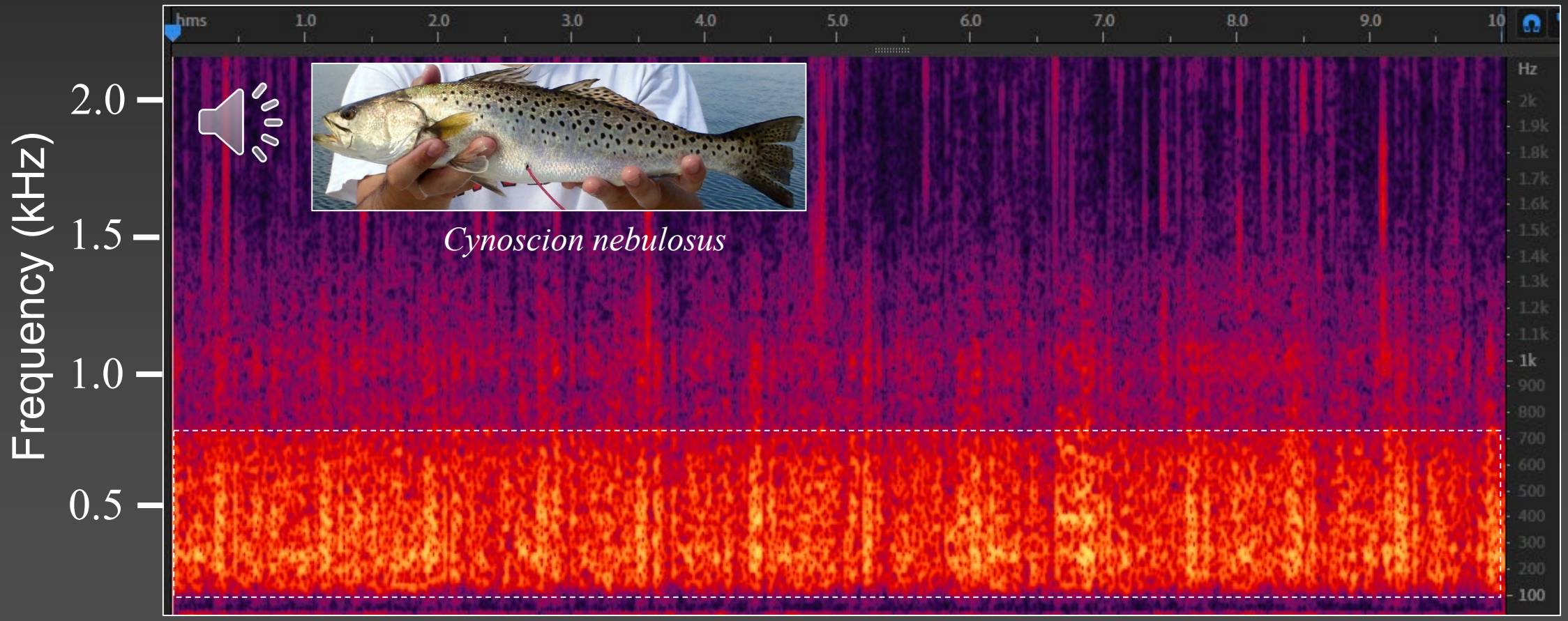

Fall – Late Afternoon Chorus of Red Drum at the Mouth of the May River

- Low frequency pulses: 100 to 600 Hz
- Courtship and spawning behavior

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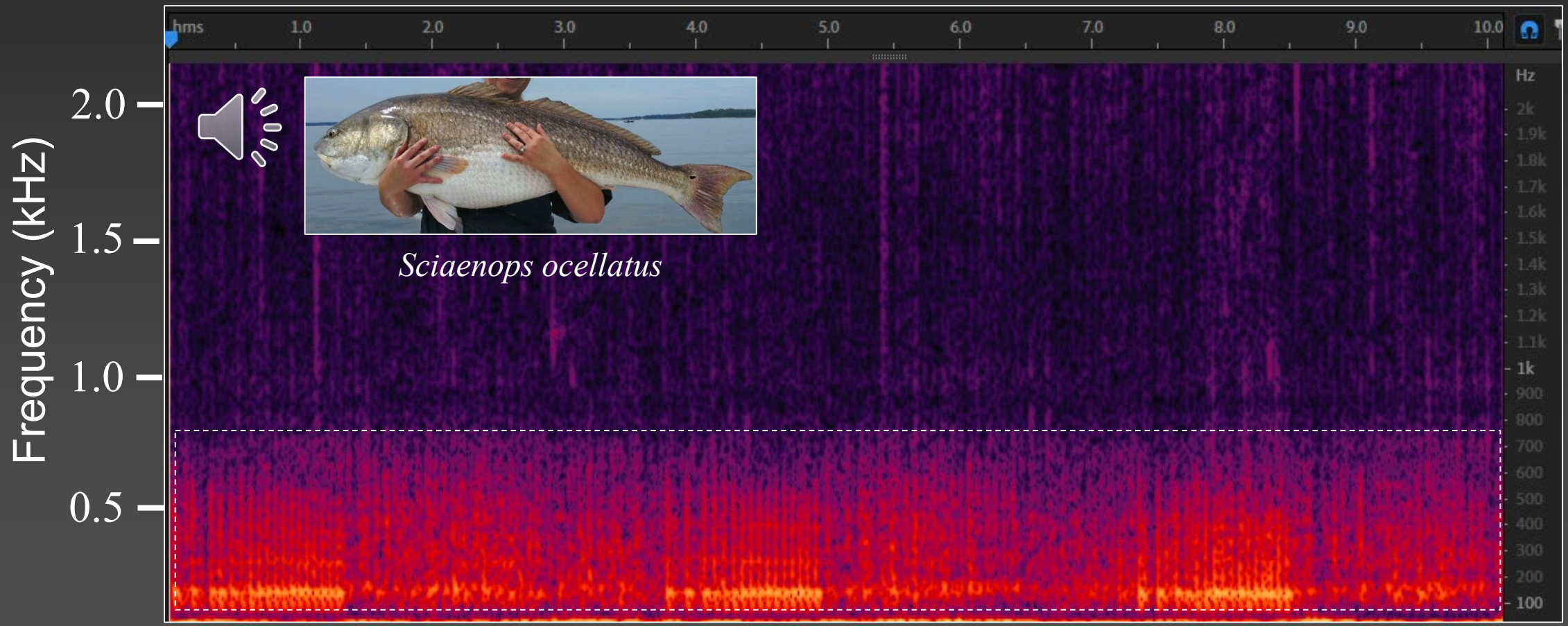
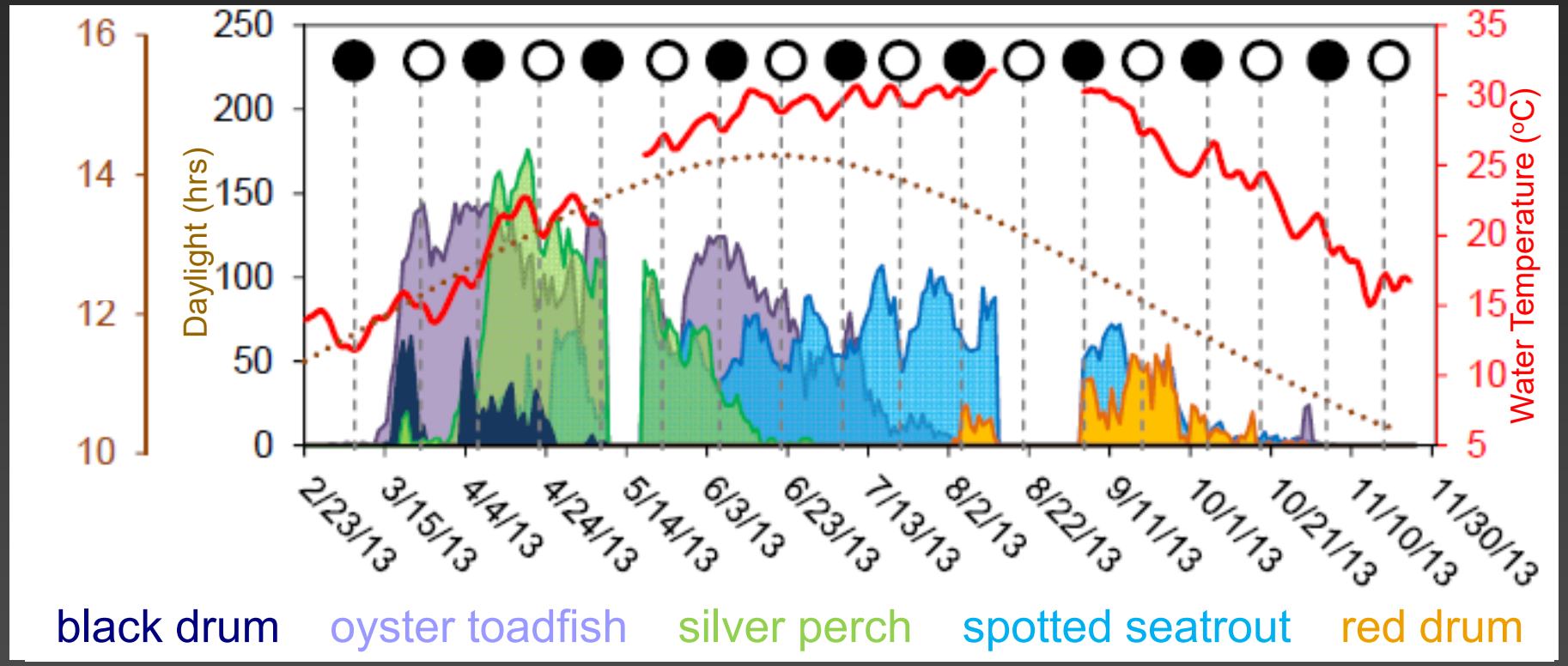
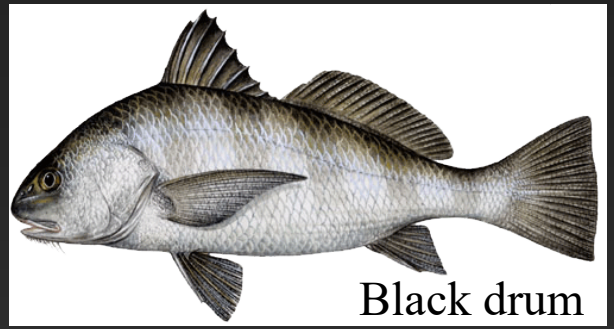


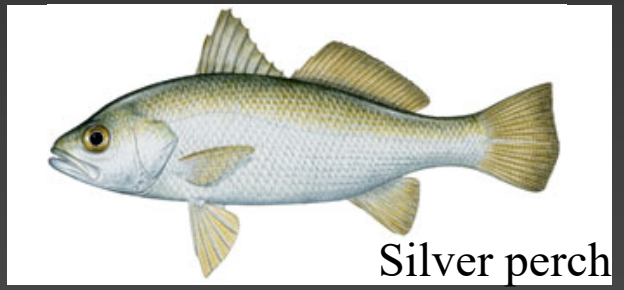
Patterns of Fish Courtship Sounds

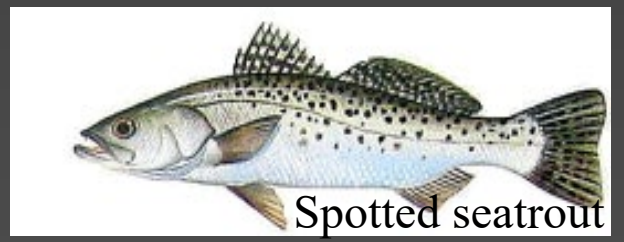
Station 37M (mouth of May River)

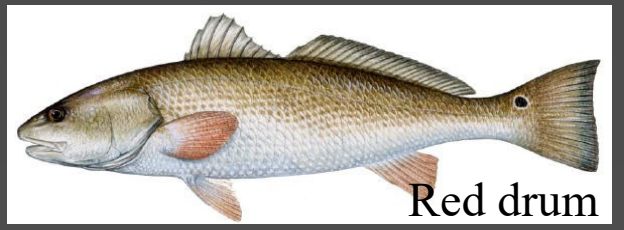


- Calling intensity score: 0=no calls; 1=one call; 2=multiple calls; 3=chorus.
- Sum calling intensity score per evening.
- Spawning timelines = exact start & end dates for calling and chorusing.
- Reproductive / spawning potential = number of hours chorusing per year.









Bottlenose Dolphin Sounds - Mouth of the May River

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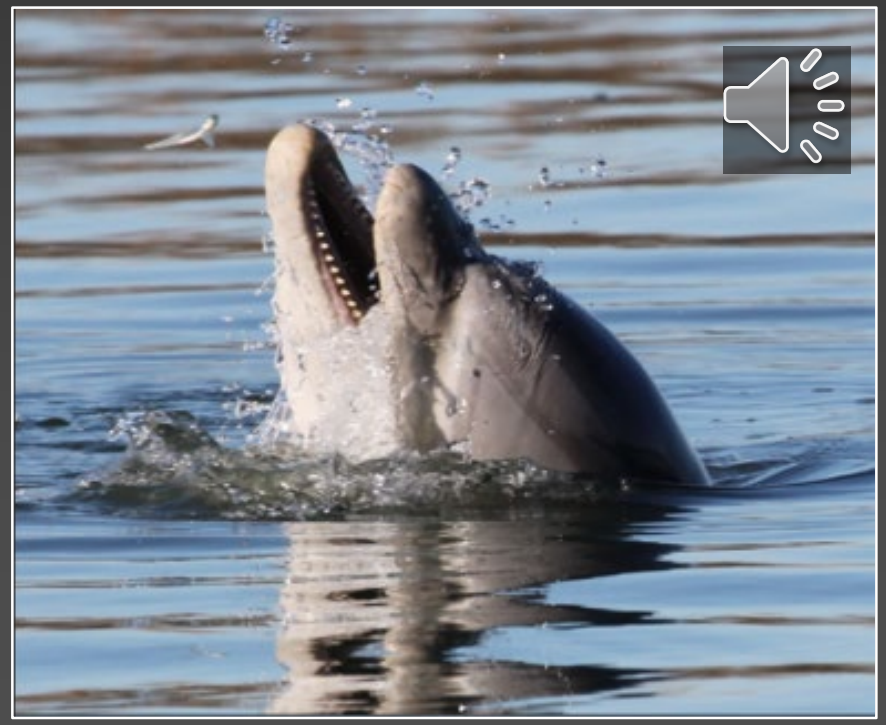
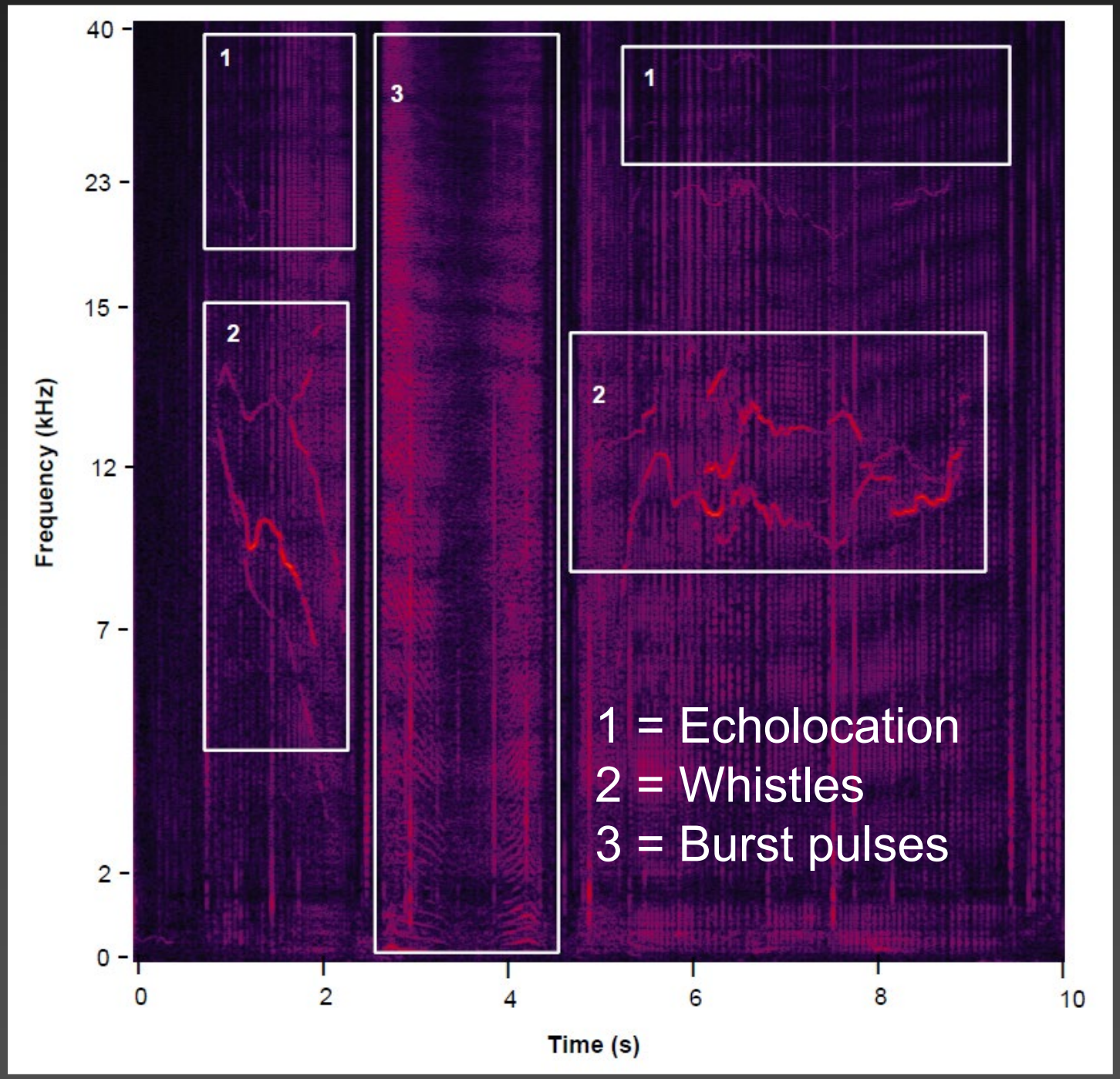
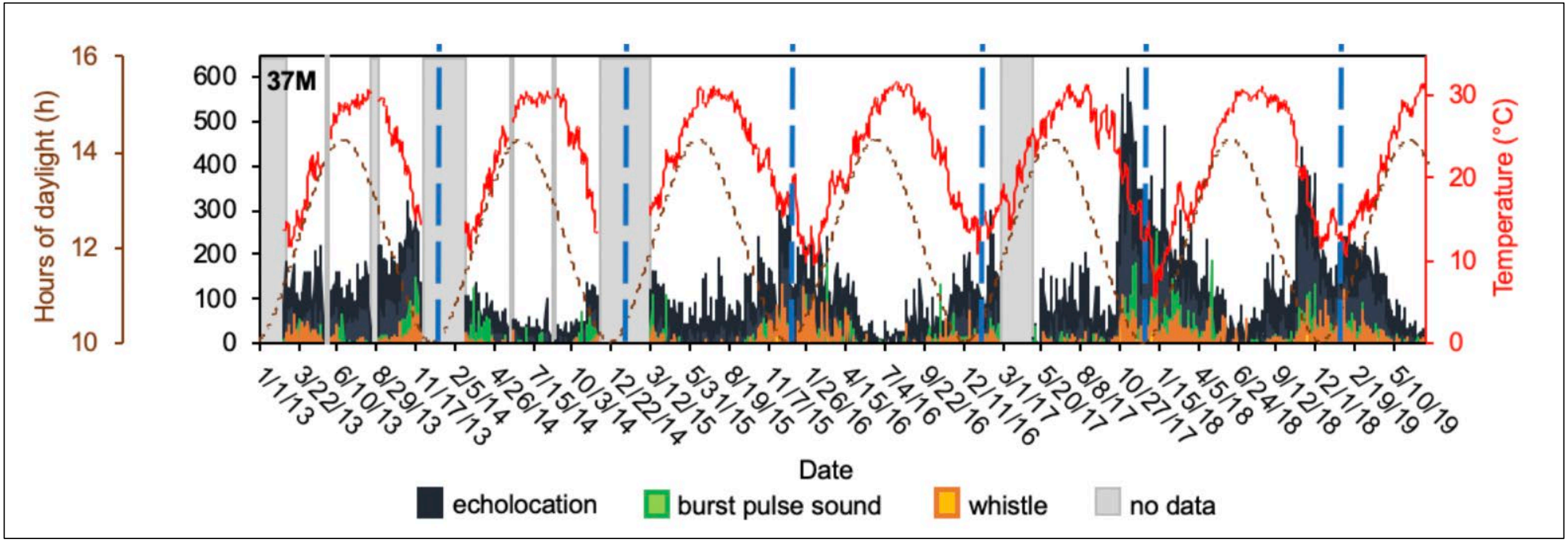




Seasonal Increases of Dolphin Vocalizations Detected at the Mouth of the May River



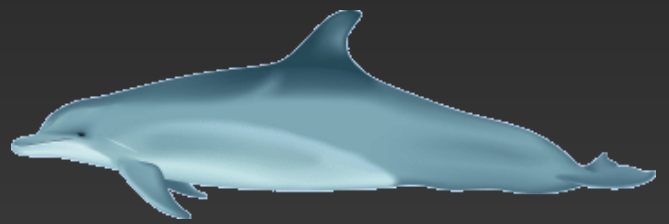
Water temperature (red line) and hours of daylight (brown dotted line).
Marian et al. 2020 resubmitted to *Marine Mammal Science*

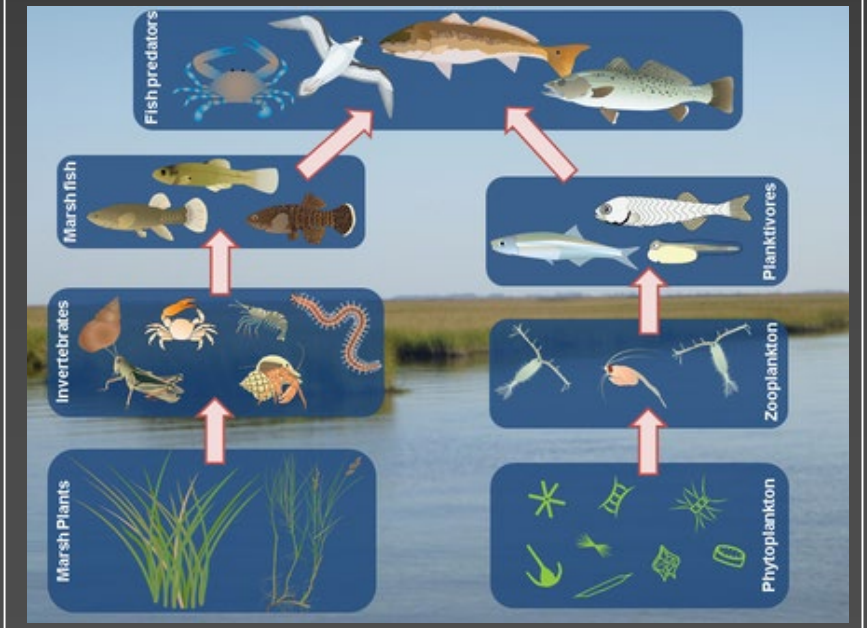
We integrate traditional visual surveys with our passive acoustics monitoring

NMFS Permit #20066
Date: 7/10/2020
Photographer: A. Marian

By listening, we can understand key behaviors in organisms that occupy different trophic levels at a high temporal resolution

"Healthy Estuary"





"Healthy Soundscape"

Signal	Key Behavior
Echolocation	Foraging
Whistles	Communication
Burst pulses	Mating
Calls & choruses	Spawning Silver perch Black drum Oyster toadfish Spotted seatrout Red drum
Snaps	Foraging snapping shrimp

Noise Pollution

Marine Pollution Bulletin 133 (2018) 246–260

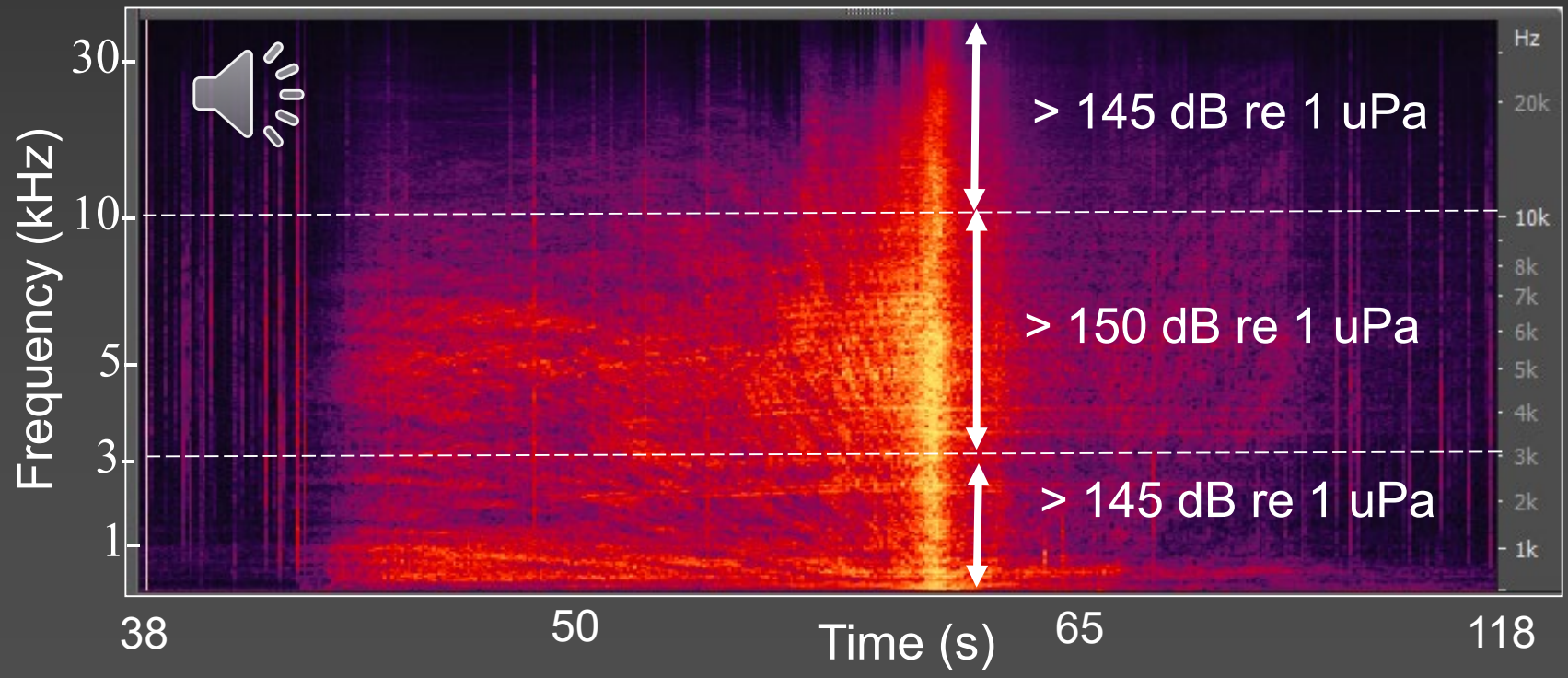
Contents lists available at ScienceDirect

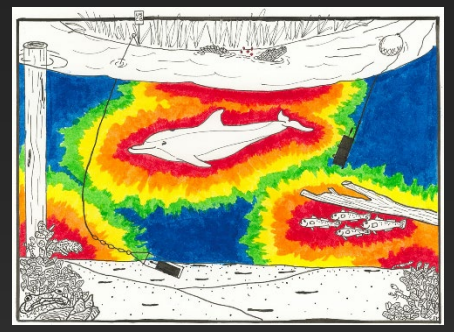
Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Boat noise in an estuarine soundscape – A potential risk on the acoustic communication and reproduction of soniferous fish in the May River, South Carolina

Somers Smott[a,b,1], Agnieszka Monczak[b], Michaela E. Miller[b], Eric W. Montie[b,*,1]





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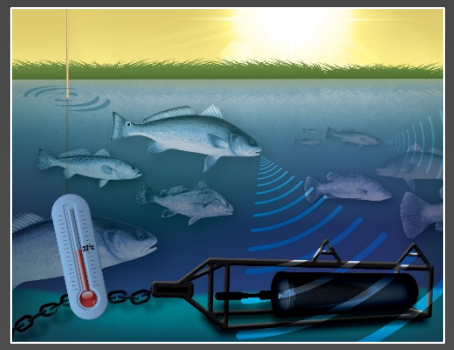


4. Estuarine Soundscape Observatory Network of the Southeast (ESONS)

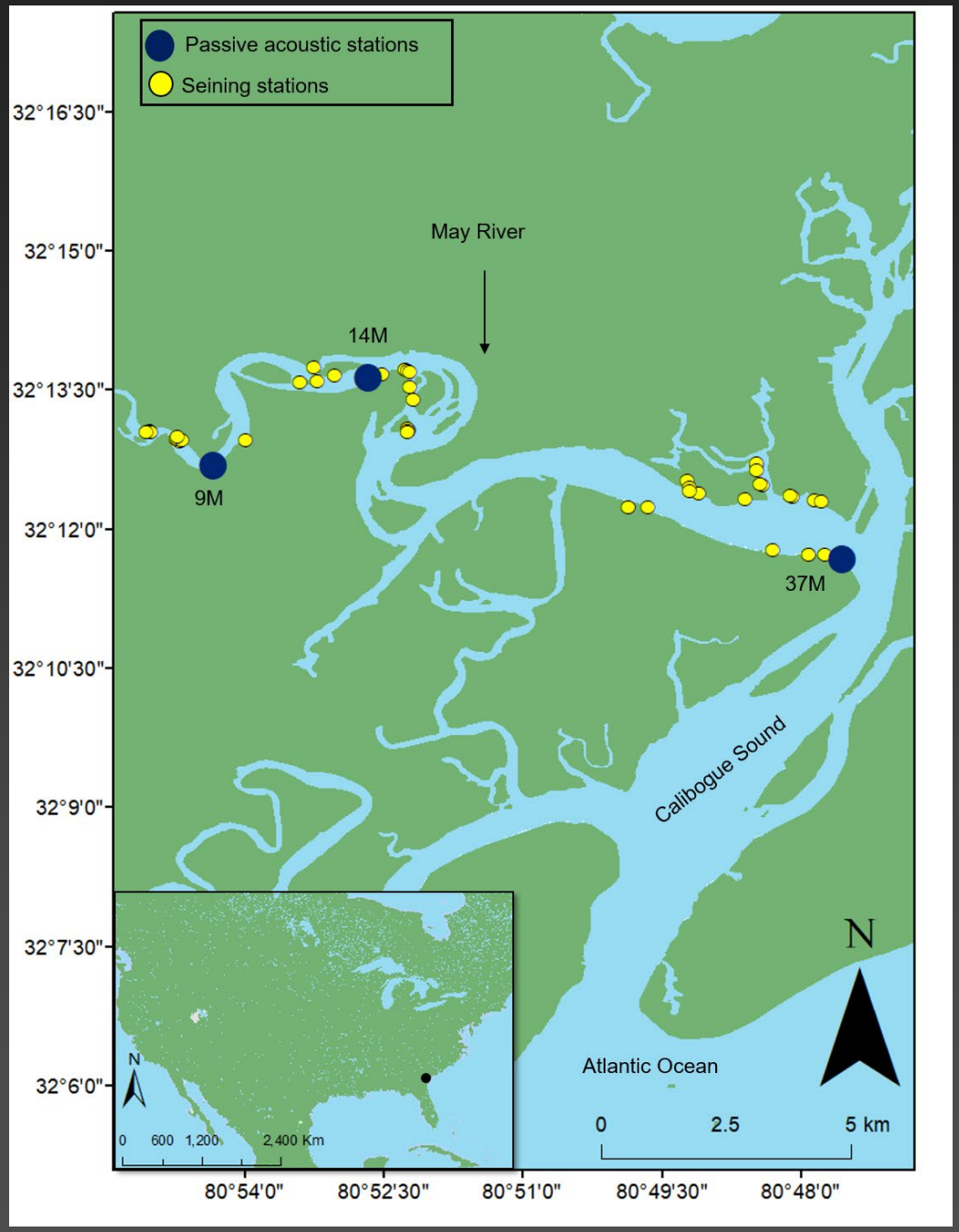
Specific Objectives

RESEARCH ARTICLE

What's all that racket! Soundscapes, phenology, and biodiversity in estuaries

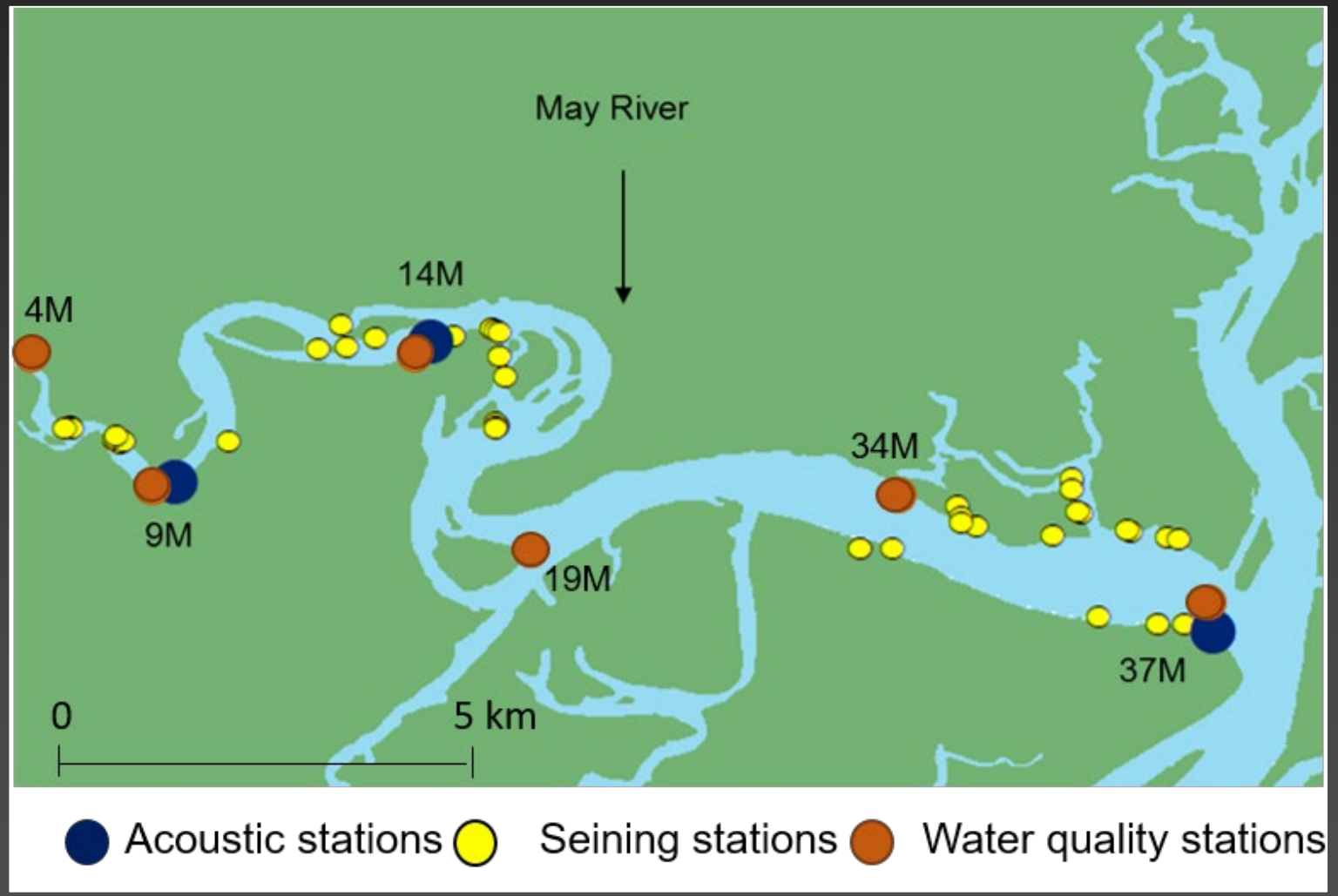
Agnieszka Monczak[1,2☯], Bradshaw McKinney[1], Claire Mueller[1], Eric W. Montie[1☯*]

1. Determine temporal patterns of high, low, and broadband frequency sound pressure levels (SPLs) over a six year time span (2013 to 2018) in the May River estuary.
2. Determine how certain environmental factors influence SPLs.
3. Examine phenology of acoustic activity of snapping shrimp and fish.
4. Determine temporal patterns of species richness and abundance and examine how these indices correlate with the soundscape.



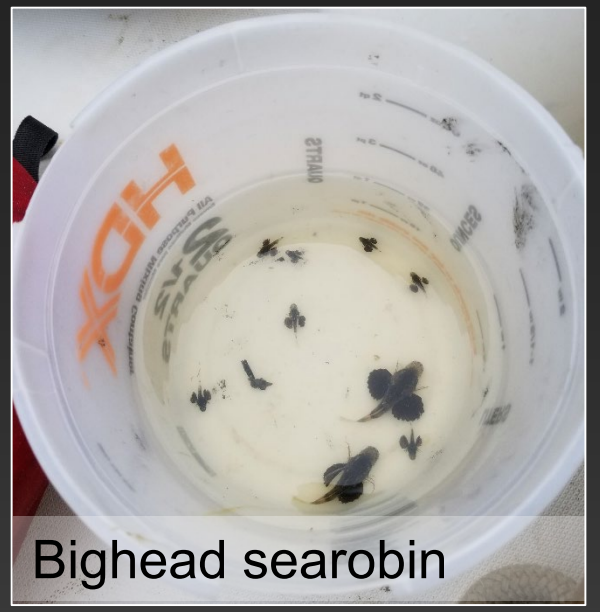
Seining Program Design

- Seining 2016 – 2020 (4 yrs)
- Seined 6 to 12 tidal pools, creeks, or shoreline habitats monthly on low tide
- Selected randomly from pool of 50 sites near listening stations from headwaters to mouth
- Monthly water temperature, salinity, dissolved oxygen, pH
- Species abundance / m^2 & lengths



440 Seines!

5/11/2016 – 1/8/2020

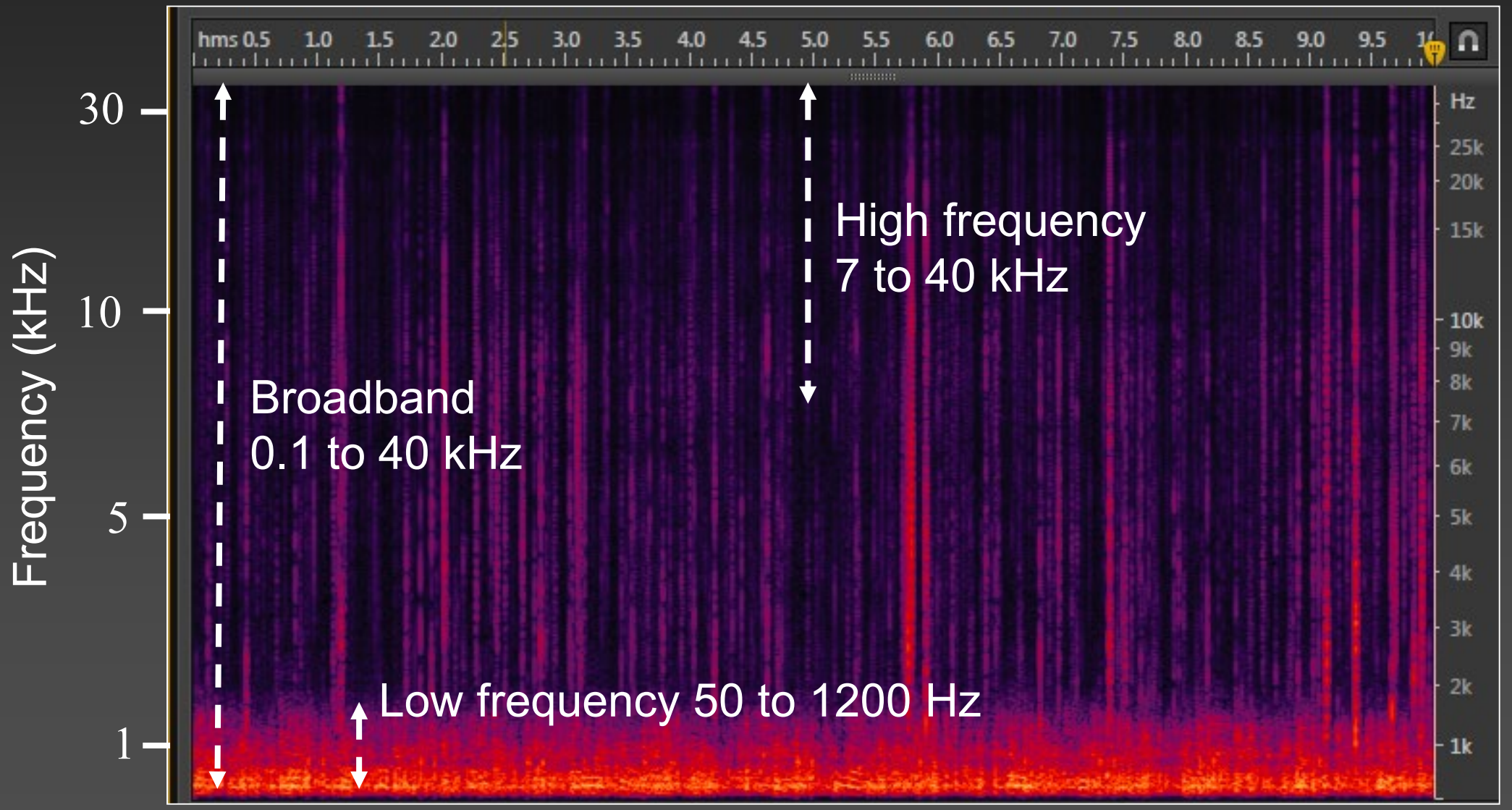


Bighead searobin

Southern flounder

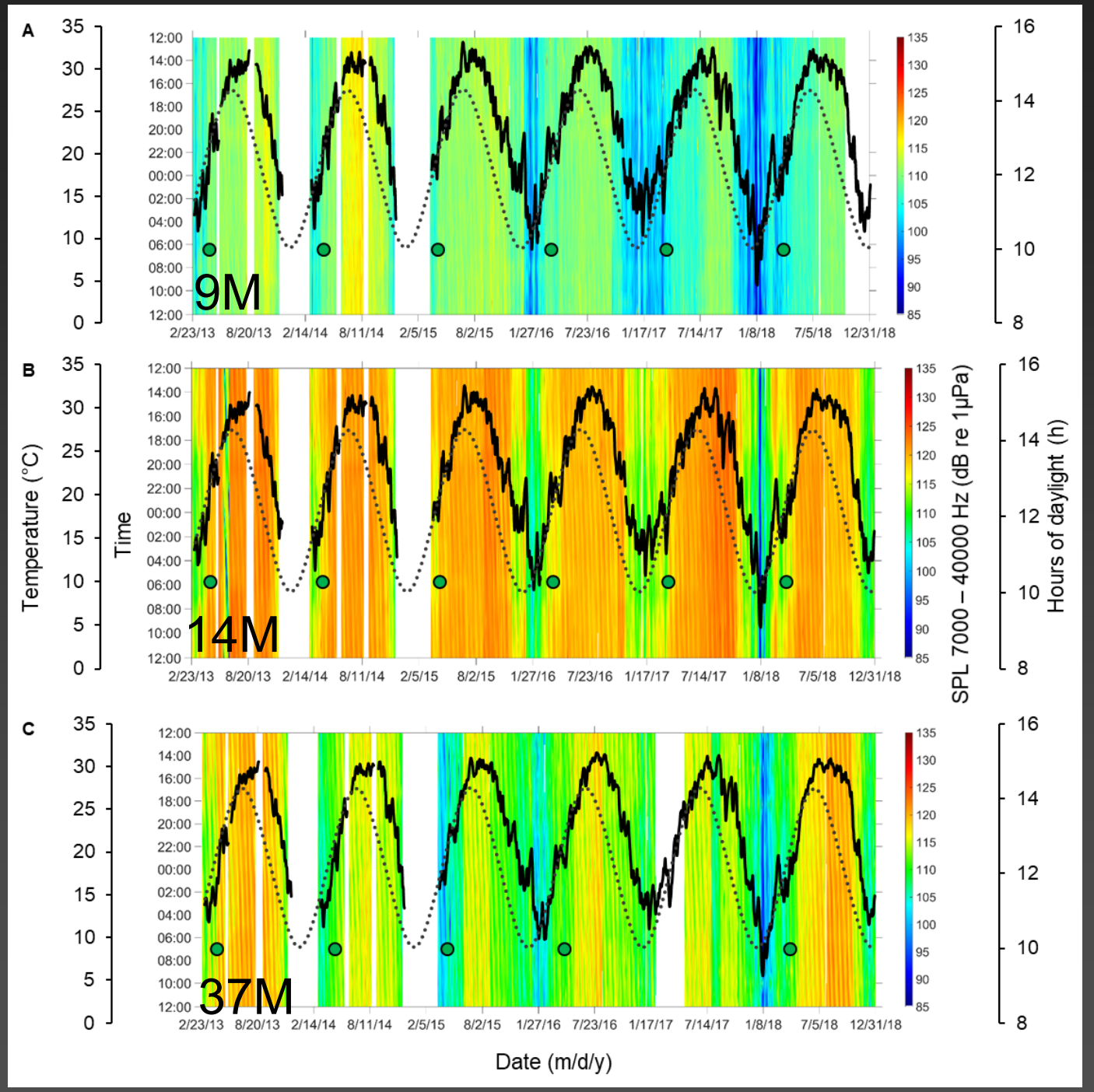
Planehead filefish

Objective 1: Measuring Sound Levels - Bandwidths that Represent Snapping Shrimp and Fish Courtship Behavior

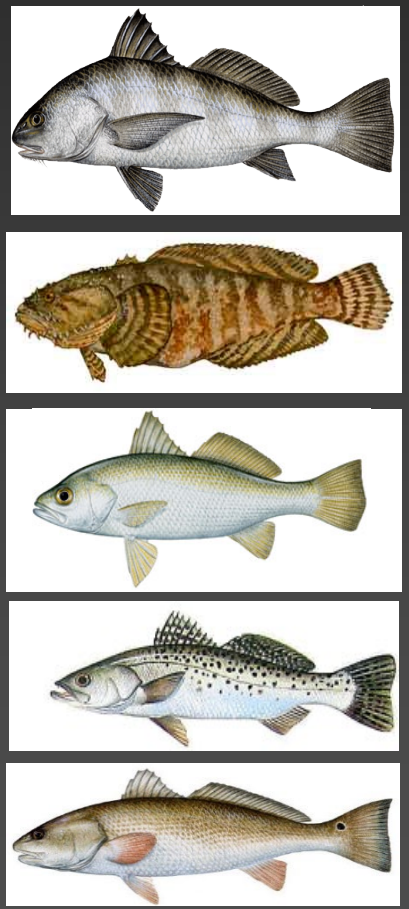


Time Series of High Frequency SPLs from 2013 to 2018

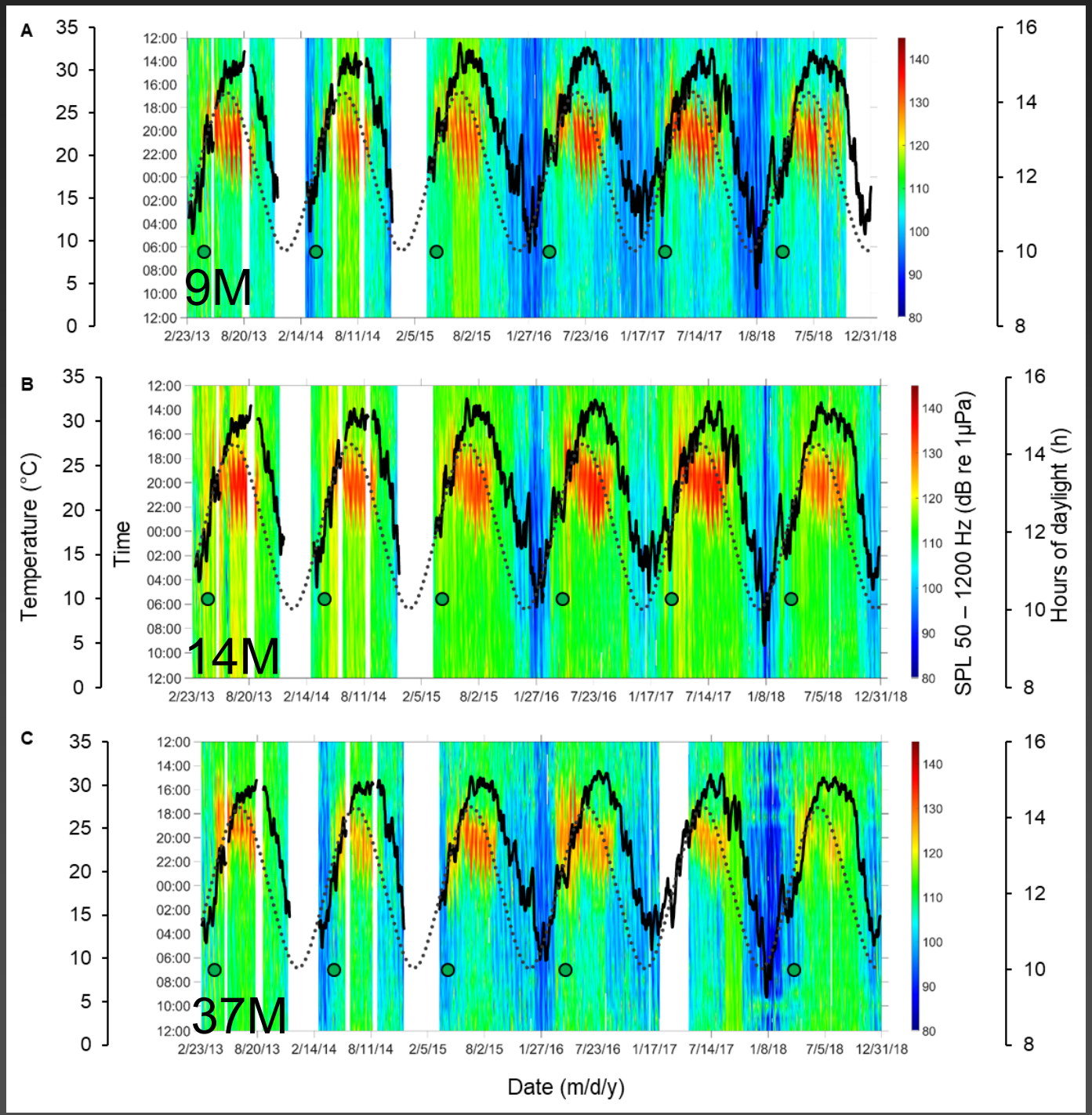
- 7 to 40 kHz rms SPLs = snapping shrimp snaps
- SPLs increased & decreased with the seasonal temperature changes
- 2018 coldest winter, lowest SPL
- Phenology: green dots = 1st posterior probability change ≥ 0.5 detected during spring



Time Series of Low Frequency SPLs from 2013 to 2018

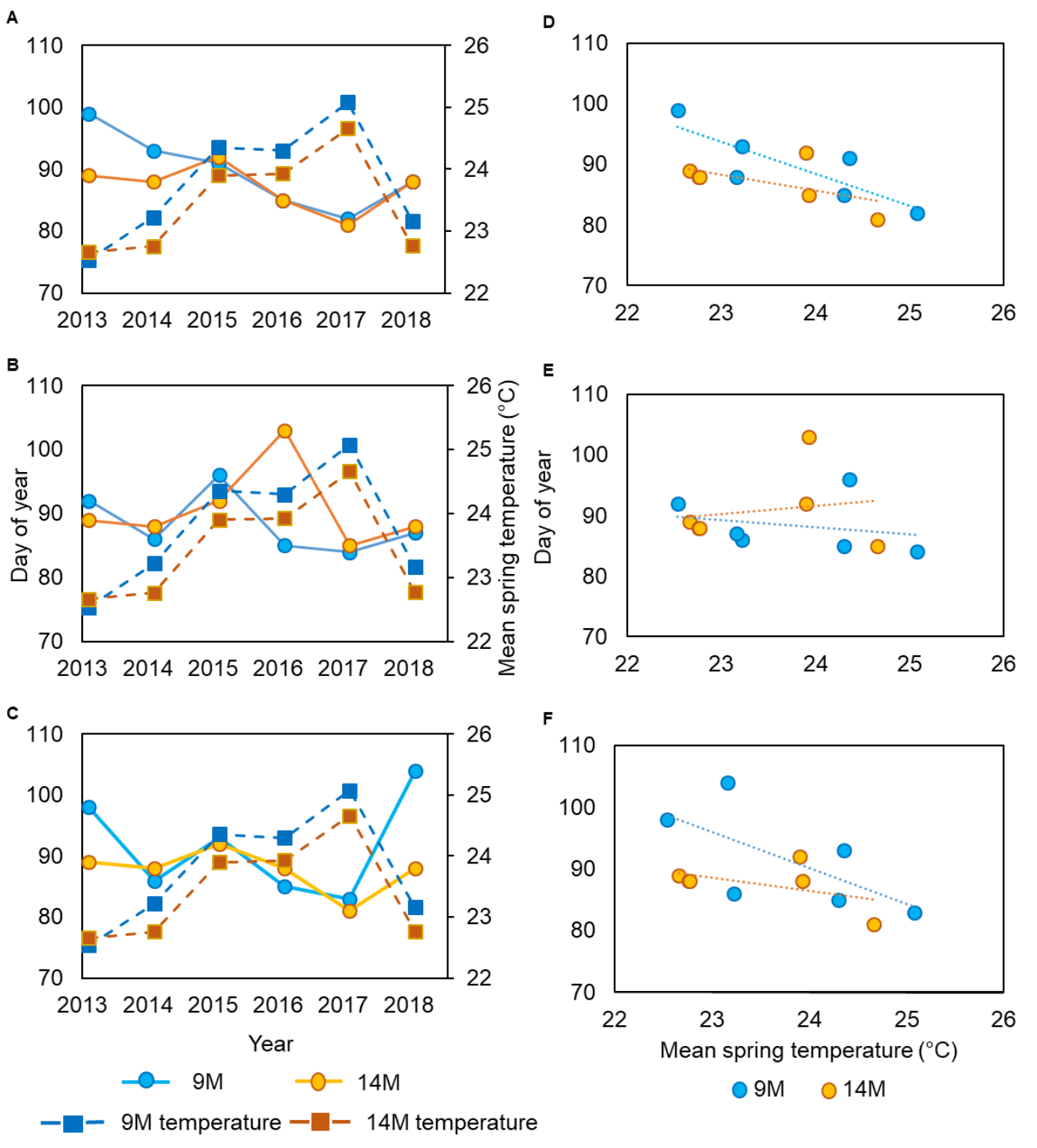


- 50 to 1200 Hz rms SPLs = fish courtship
- SPLs increased spring/summer evenings
- SPLs fluctuate with the seasonal temperature changes
- 2018 coldest winter, lowest SPL
- Phenology: green dots = 1st posterior probability change ≥ 0.5 detected during spring



Objective 3: Soundscape Phenology

- Phenology of acoustic activity of snapping shrimp (high frequency SPL) and fish (low frequency SPL) by detecting the date of the first abrupt change in SPL.
- In years with higher mean spring water temperatures, the first peak in (A) high, (B) low, and (C) broadband SPL occurred earlier as compared to years with lower mean spring water temperatures.
- Negative correlations occurred between mean spring water temperature and the timing of the first peak in probability of change for (D) high, (E) low, and (F) broadband SPLs.



Biodiversity - 7 Invertebrate Species

Grass shrimp (*Palaemonetes vulgaris)*

Big claw snapping shrimp (*Alpheus heterochaelis)*

Brown shrimp (*Farfantepenaeus aztecus)*

Mantis shrimp (*Squilla mantis)*

Blue crab (*Callinectes sapidus*)

Spider crab (*Libinia emarginata)*

Brief squid (*Lolliguncula brevis)*

58 Fish Species, 31 Families

Atlantic silverside (*Menidia menidia)*

Feather blenny
(*Hypsoblennius hentz)*

Ocellated flounder (*Ancilopsetta ommata)*

Atlantic spadefish
(*Chaetodipterus faber)*

Black cheek tonguefish
(*Symphurus plagiusa)*

Atlantic needlefish (*Strongylura marina)*

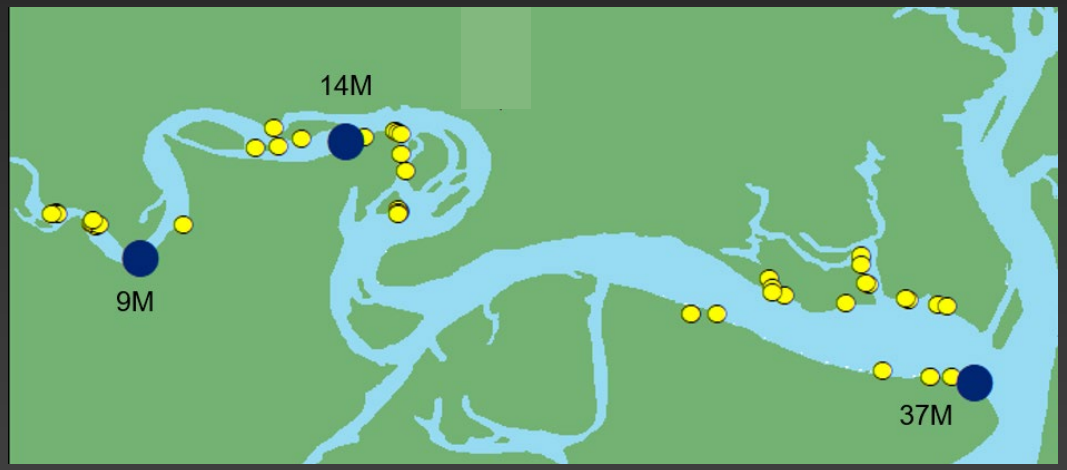
Pigfish (*Orthopristis chrysoptera)*

Bighead searobin
(*Prionotus tribulus)*

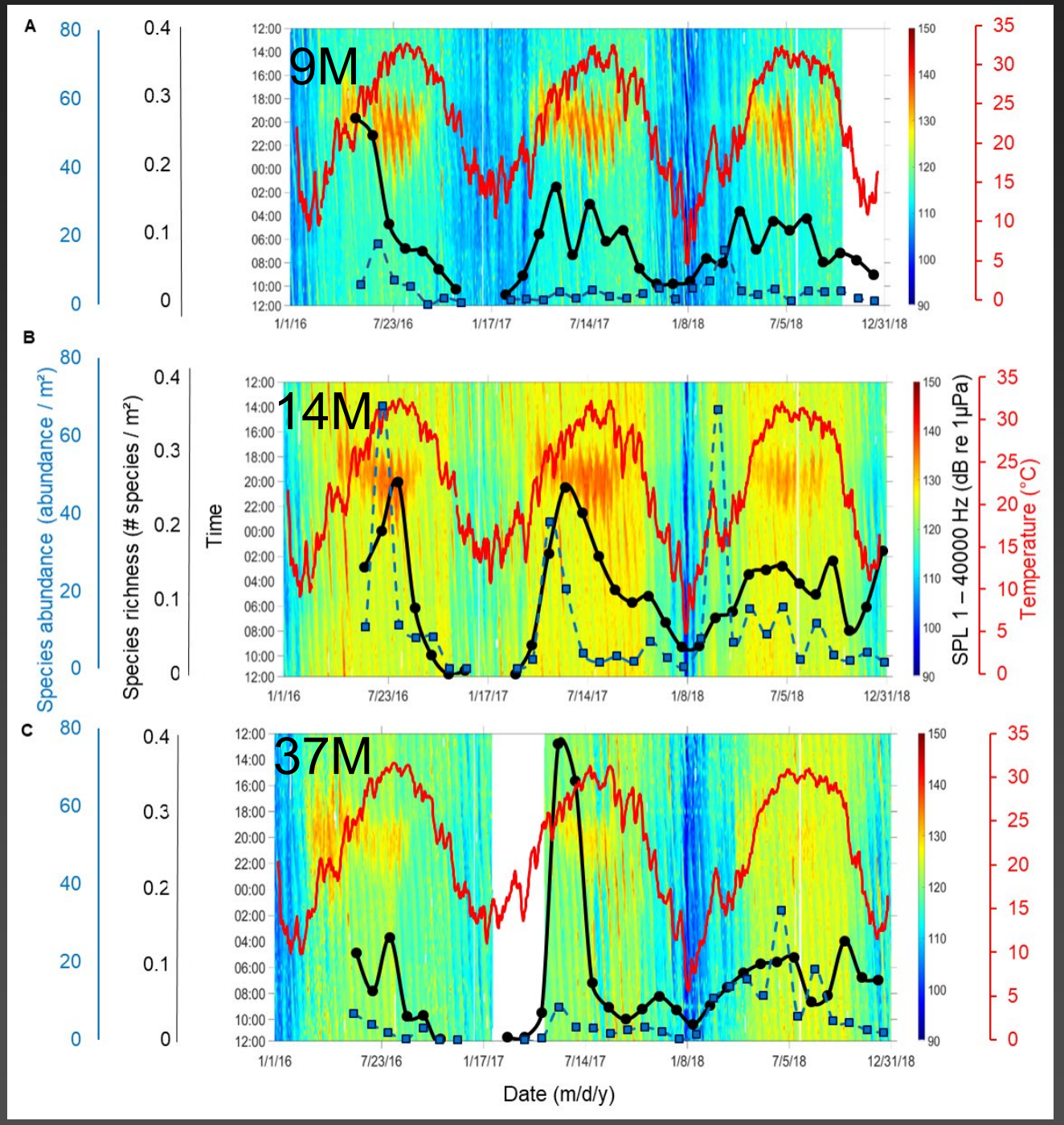
Atlantic cutlass fish (*Trichiurus lepturus)*

Great barracuda (*Sphyraena barracuda)*

Objective 4: Soundscapes, Biodiversity, and Abundance



- Lower species diversity and abundance during winter, and higher species diversity and abundance during spring and summer.
- This temporal pattern of species diversity and abundance followed the warming and cooling patterns of the estuary as well as the oscillating pattern of the biological soundscape.

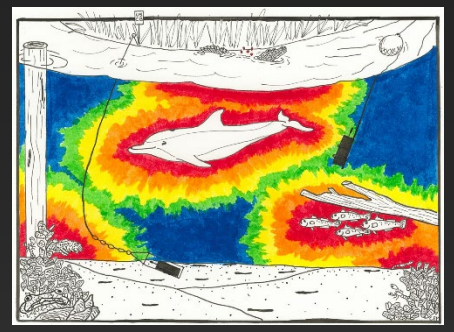


Conclusions

- We showed that the transition between winter and spring is a dynamic time-period with an increase in biological sound during the spring, which mirrors the increase in (phytoplankton), (zooplankton), invertebrates, and fish abundance that drive changes in primary, secondary, and tertiary productivity within estuaries

- In years with warmer spring temperatures, this seasonal transition occurred earlier than in years with cooler spring temperatures

- This means that temperature plays an important factor in initiating certain behaviors (e.g. spawning), and earlier occurrences of these behaviors reflect an organismal response to climate variability



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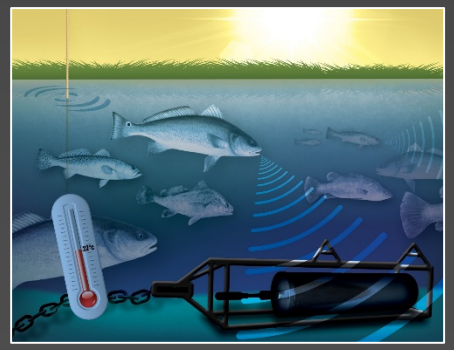
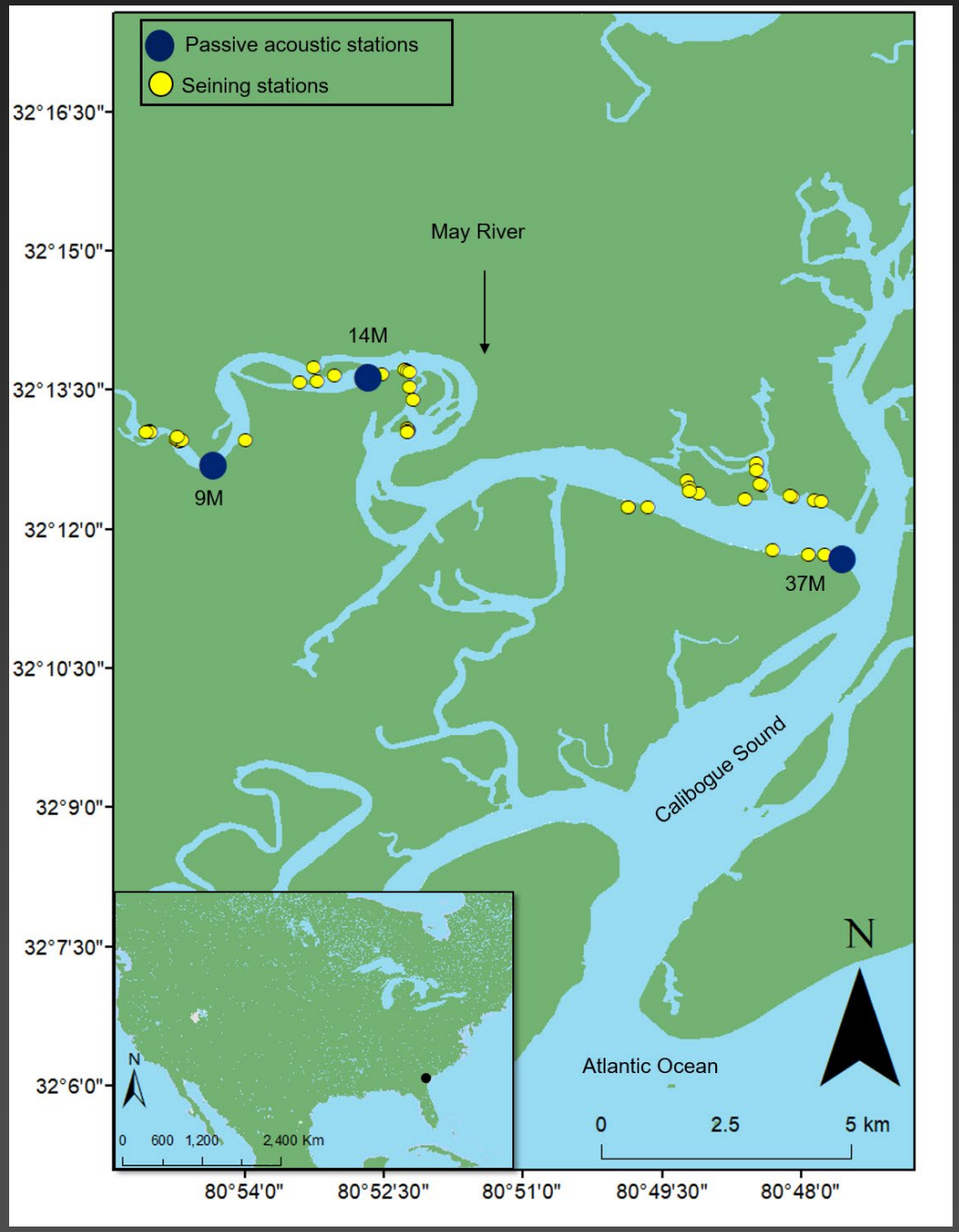


4. Estuarine Soundscape Observatory Network of the Southeast (ESONS)

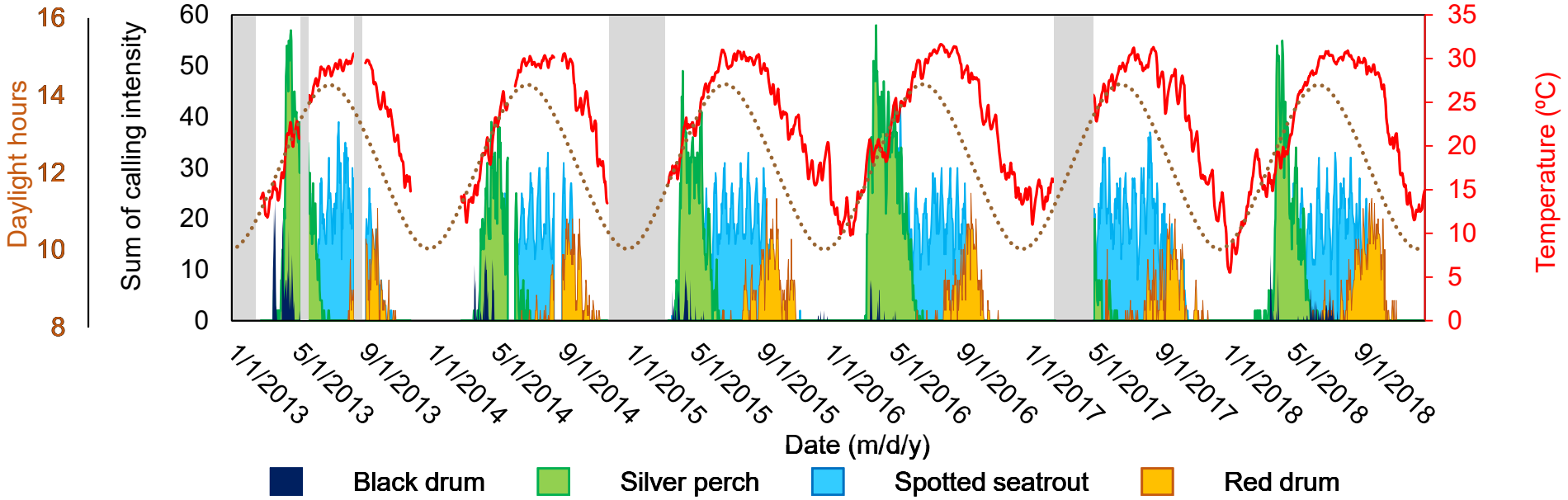
Specific Objectives

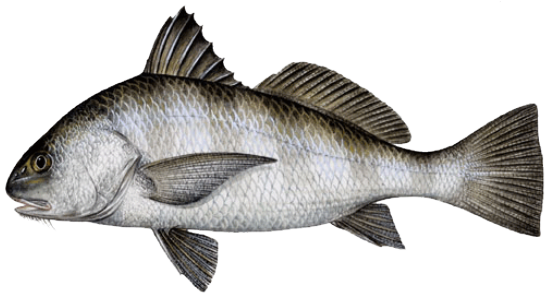
1. Examine the patterns of fish calling in the May River Estuary over a six-year time span from 2013 to 2018.
2. Determine how environmental factors influence fish acoustic activity.
3. Investigate the correlation between fish calling and young-of-the-year (YOY) appearance and abundance from 2016 to 2018.
4. Examine the phenology of fish calling and YOY appearance.



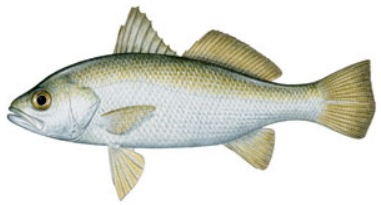
Year-to-year Patterns of Fish Calling at the Mouth of the May River Estuary

37M





Black drum

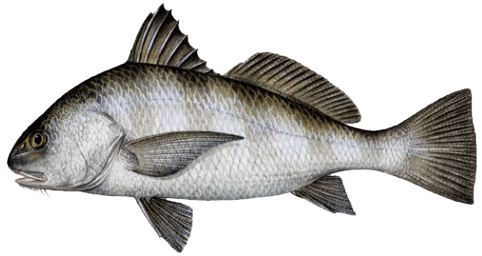


Silver perch

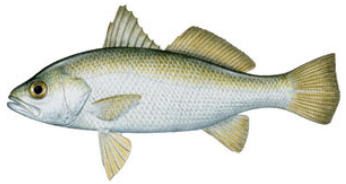
Spotted seatrout

Red drum

Year-to-year Patterns of Fish Calling in the May River

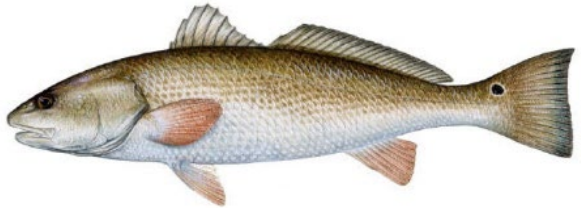


Black drum



Silver perch

Spotted seatrout

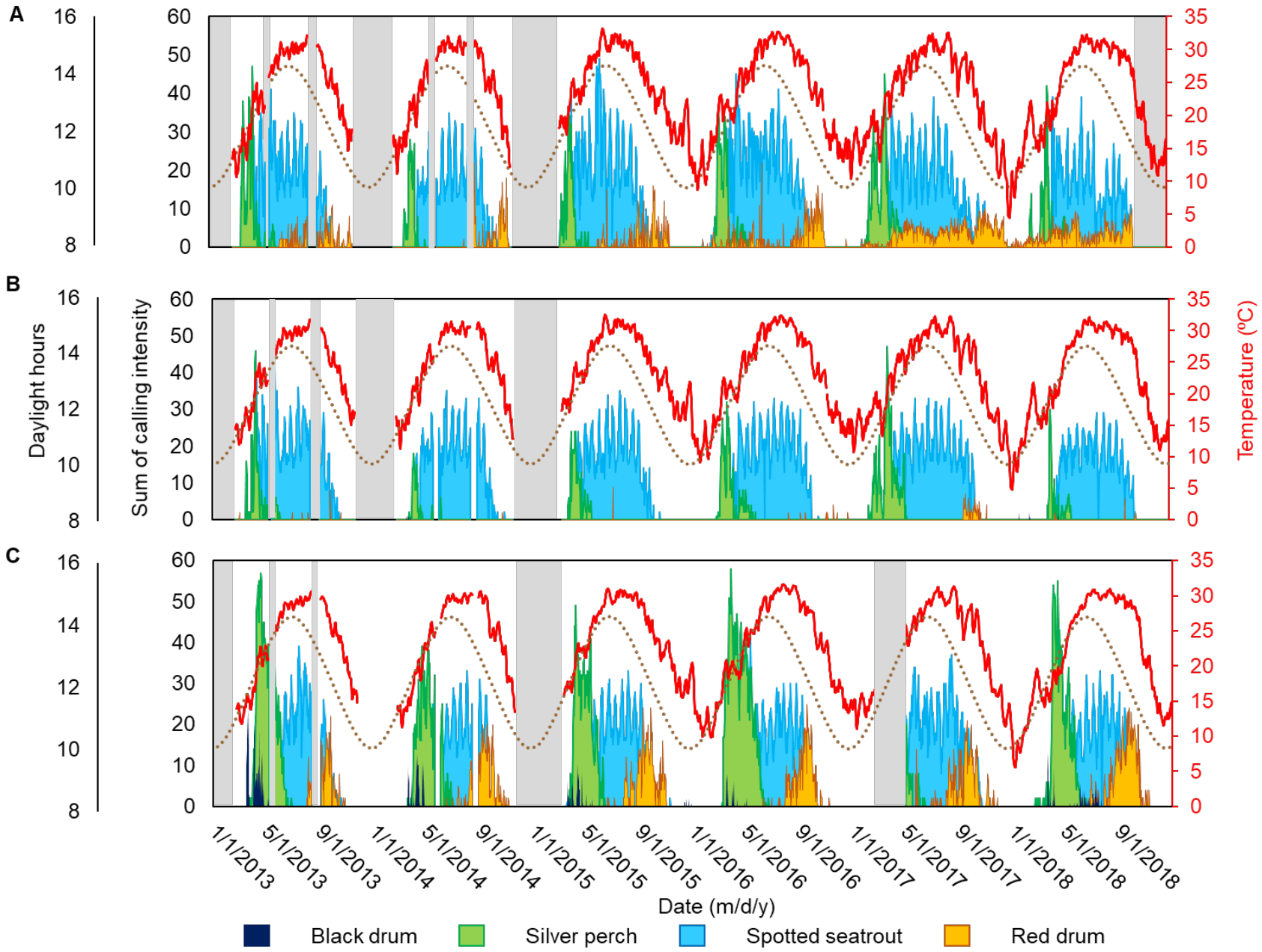


Red drum

9M

14M

37M



From 2016 to 2019, we monitored the abundance of fish using haul seines

Black drum

Spot

Silver perch

Red drum

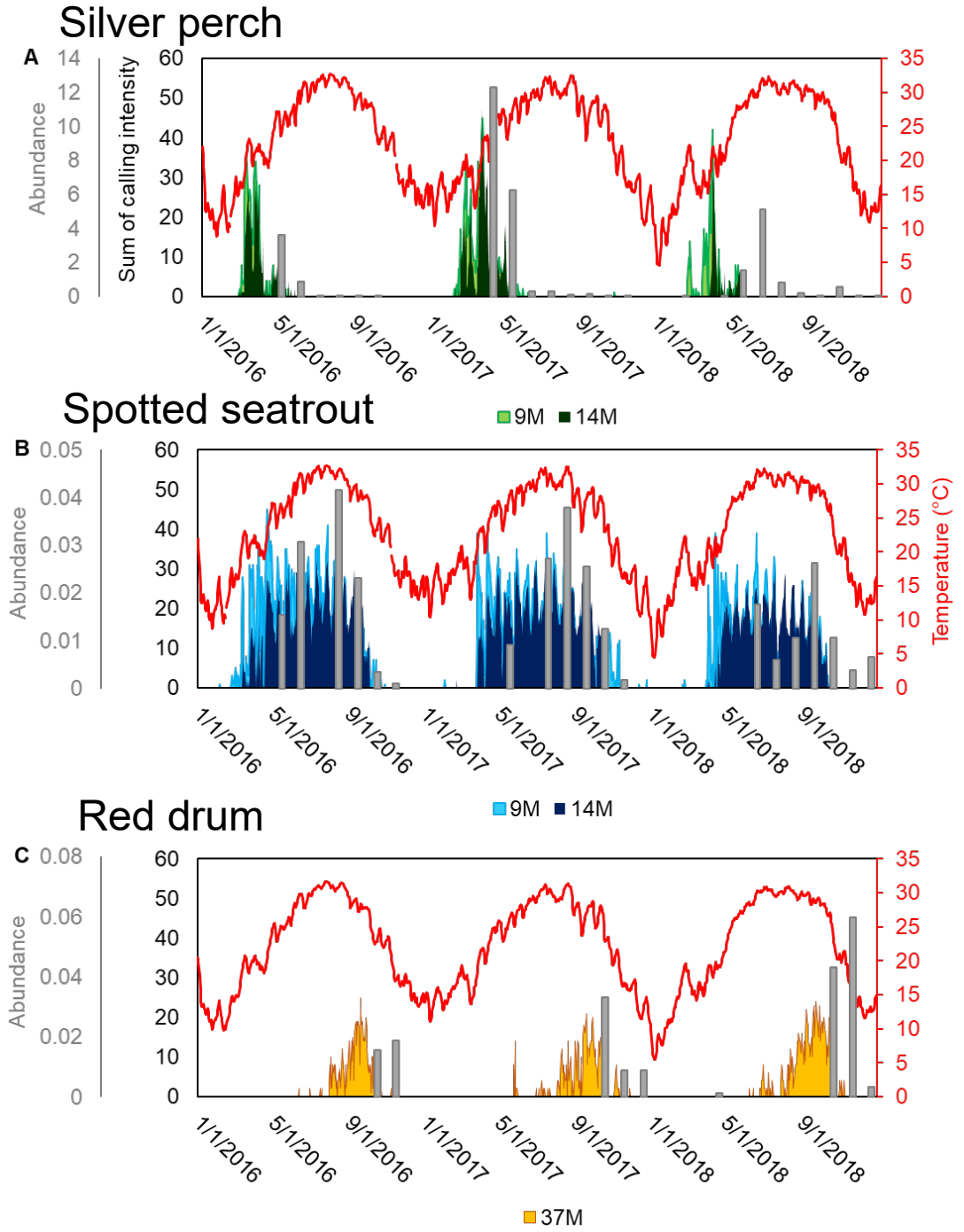
Spotted seatrout

Correlation between Fish Calling and Young-of-the Year(YOY) Appearance

Silver perch

Spotted seatrout

Red drum

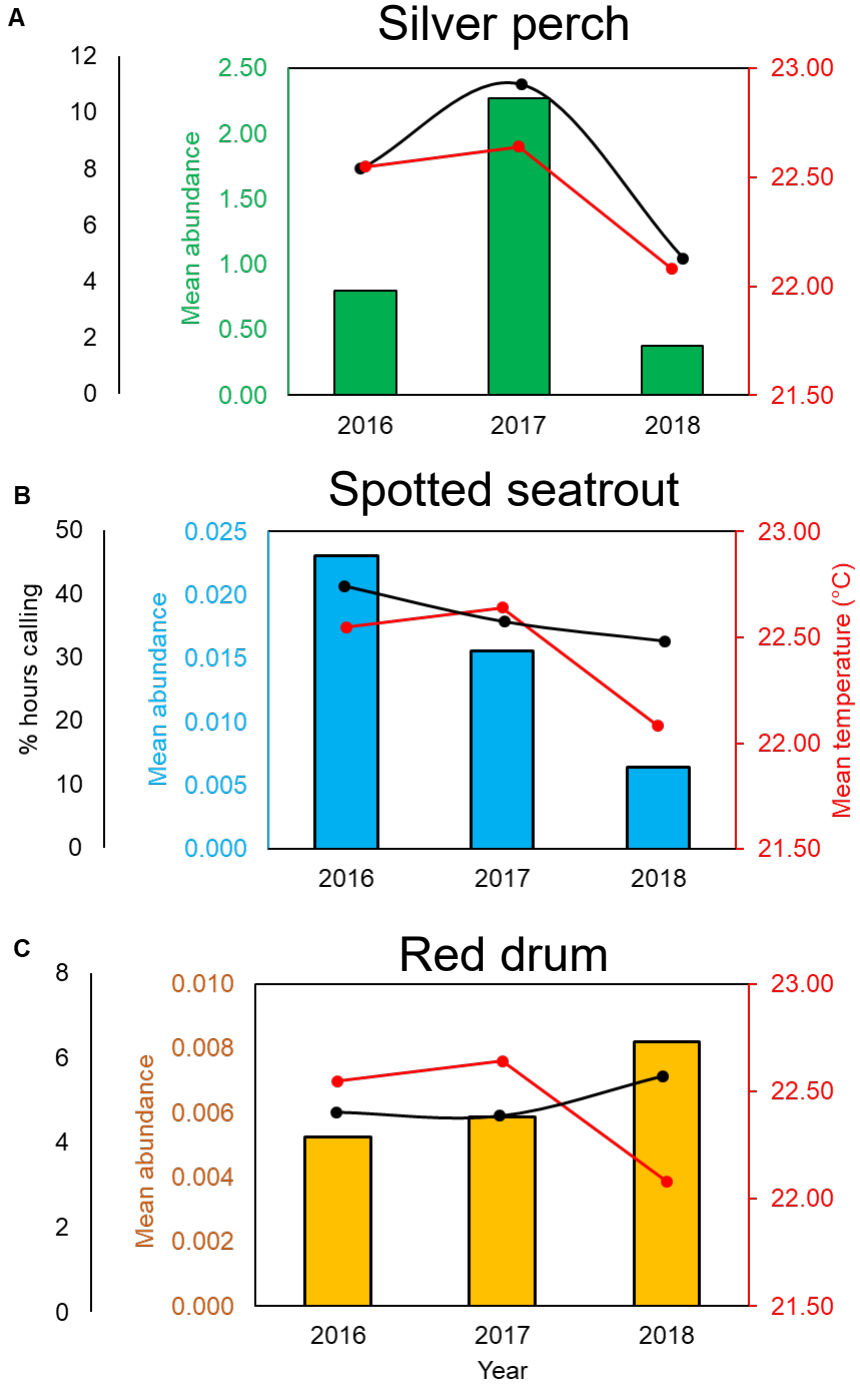


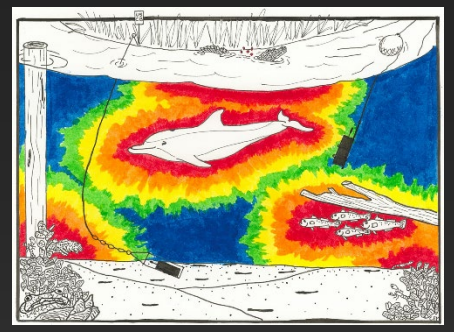
Correlation between Fish Calling and Young-of-the Year Abundance

Silver perch

Spotted seatrout

Red drum

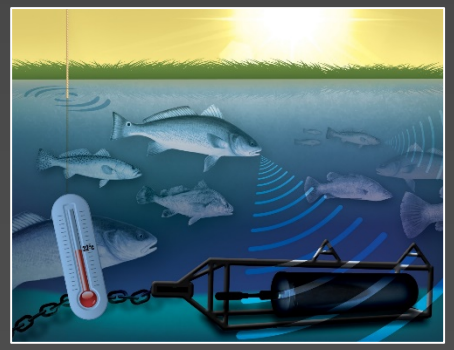




1. The Soundscape of the May River Estuary

2. Soundscape Phenology and Biodiversity

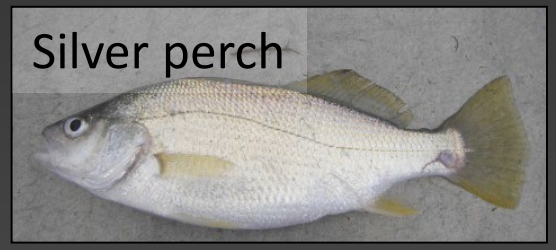
3. Fish Courtship Sounds Correlate with Juvenile Fish Appearance

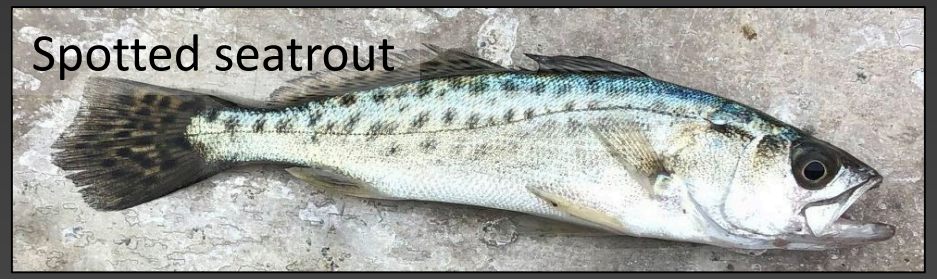


4. Estuarine Soundscape Observatory Network of the Southeast (ESONS)

Estuarine Soundscape Observatory Network in the Southeast (ESONS)

We monitor the sounds of four estuaries in South Carolina using long-term passive acoustic recorders





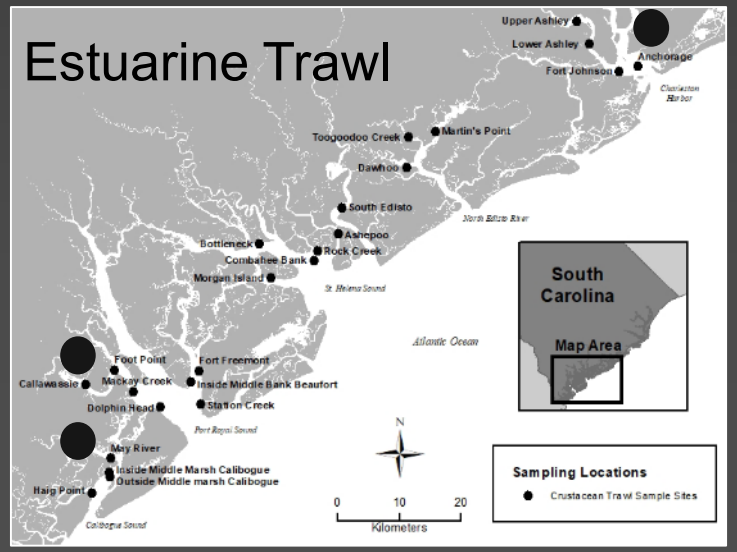
ESONS Overlaps in Space with Fishery Independent Surveys Performed by SCDNR

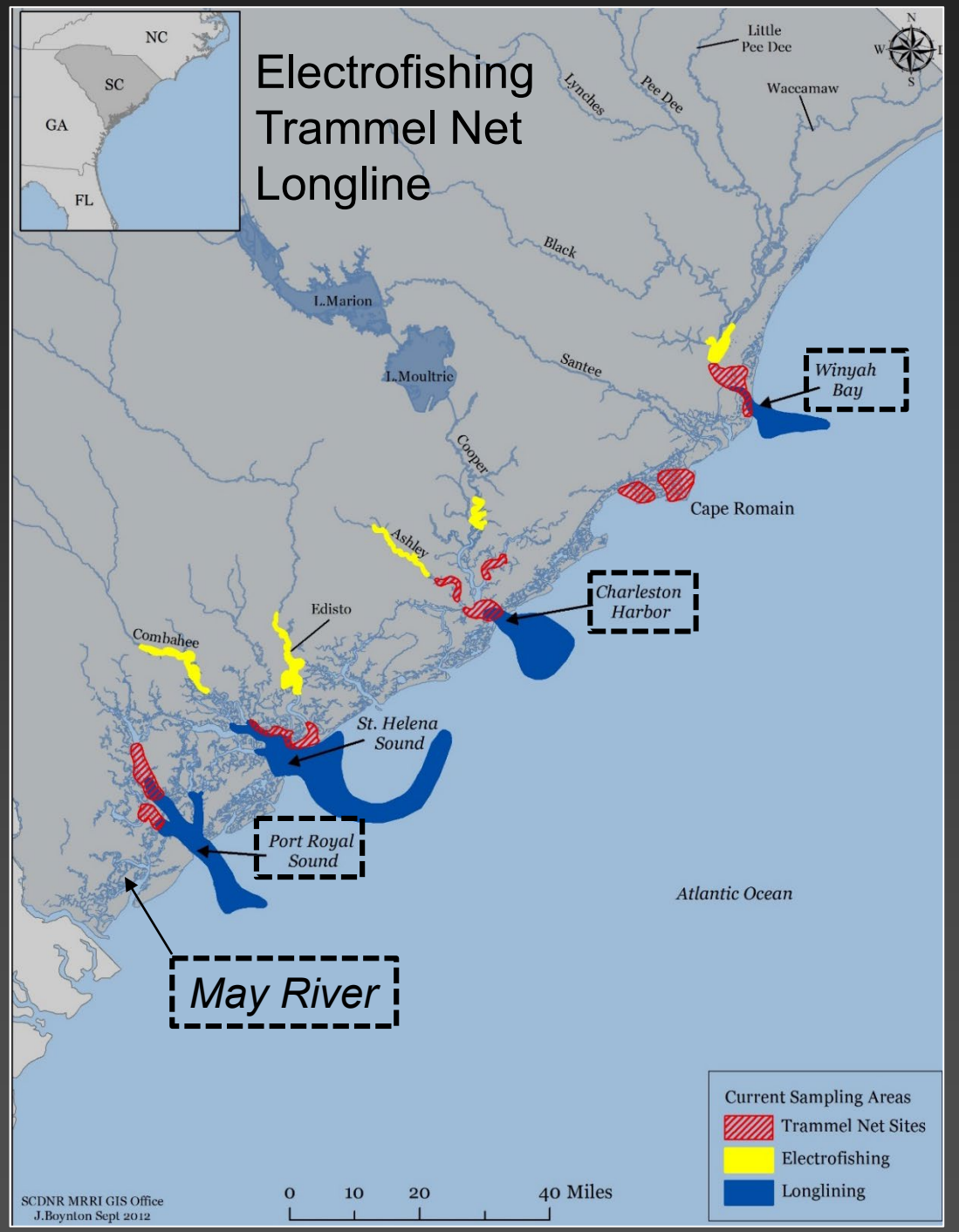
Four Estuaries

1. May River Estuary
2. Chechessee Creek / Colleton River in Port Royal Sound
3. Charleston Harbor
4. North Inlet-Winyah Bay NERRS

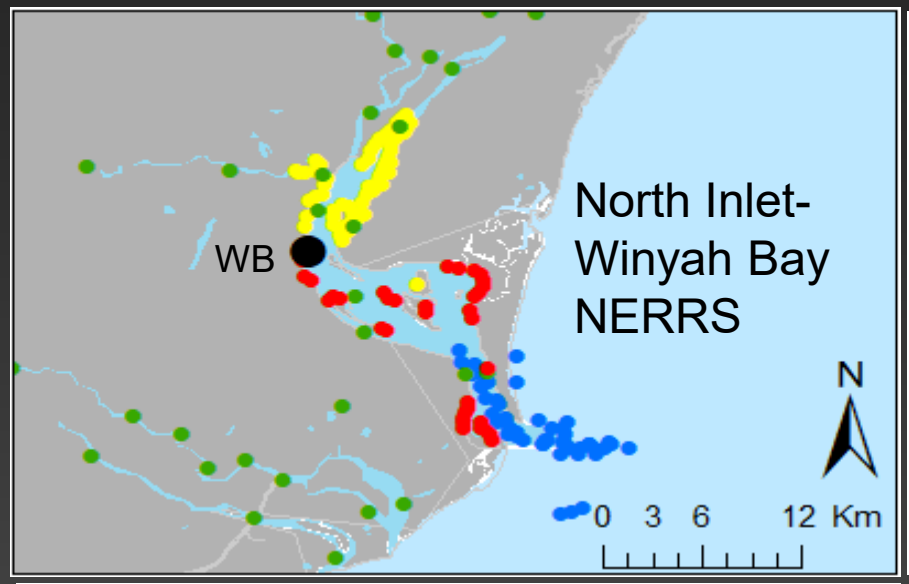
SCDNR Surveys

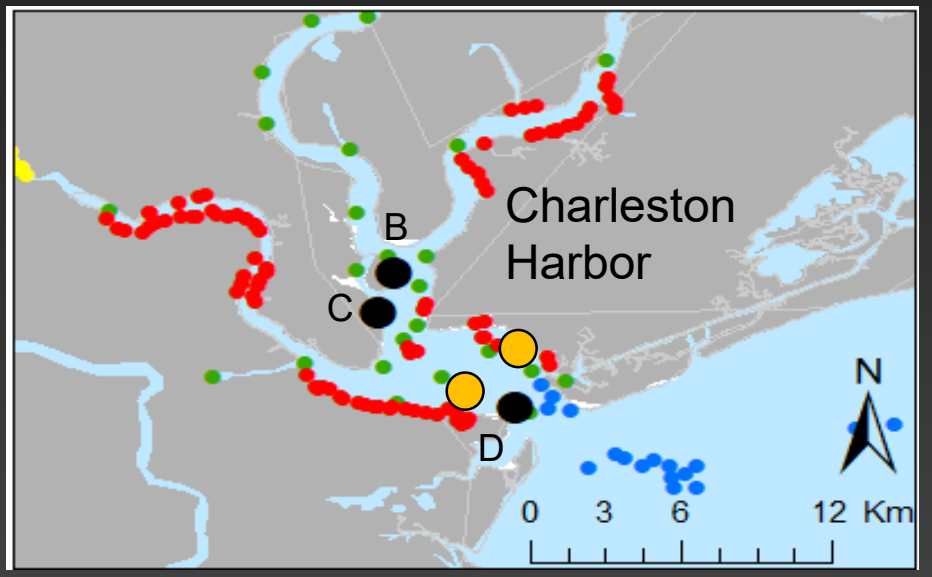
1. Estuarine Trawl Survey
2. Electrofishing
3. Trammel Net
4. Longline

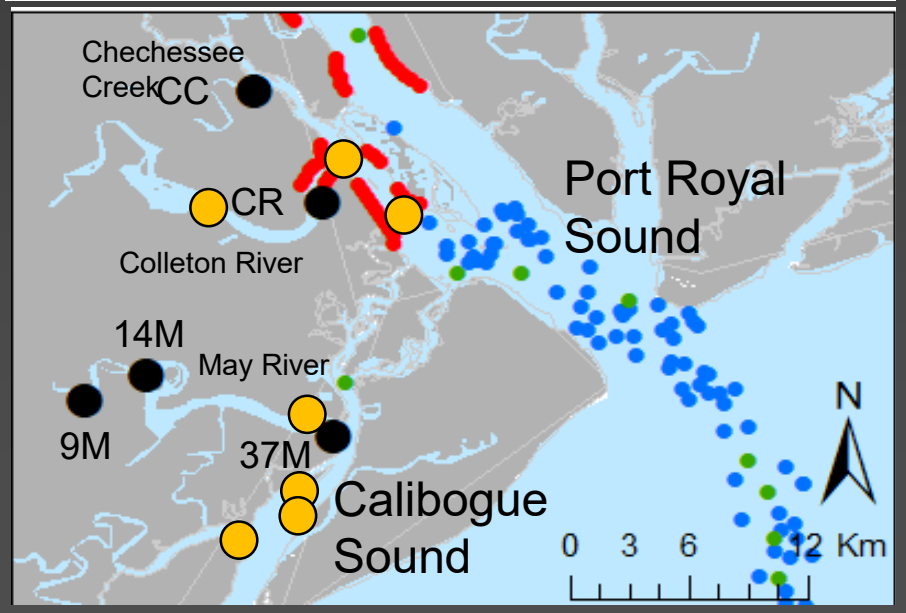




Future Goals: Correlate Soundscape Endpoints with Biodiversity and Abundance from SCDNR Surveys







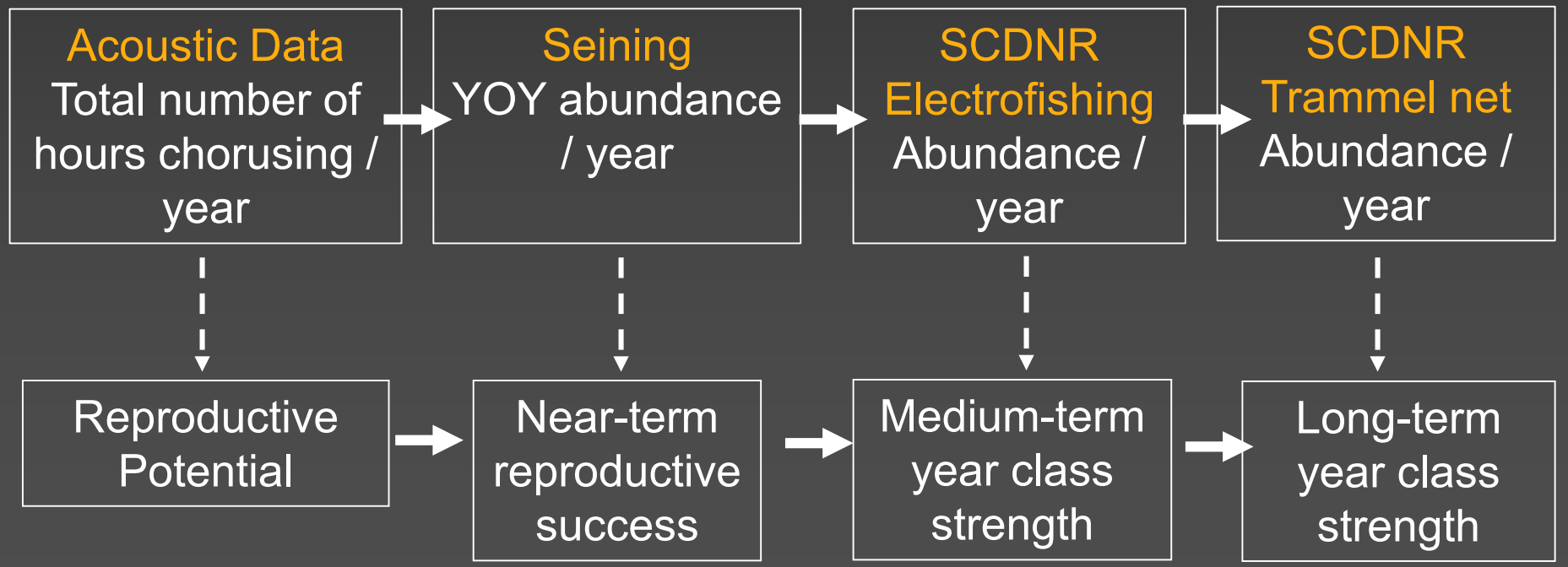
- ESON recorders
- Longline
- Electrofishing
- Trammel net
- Estuarine Trawl Surveys
- Acoustic Telemetry Network

Climate Variability ~ Courtship Calls ~ Reproduction ~ Year Class Strength?

Silver perch
(spring spawner)

Spotted seatrout
(summer spawner)

Red drum
(fall spawner)



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Palmetto Bluff Conservancy

SECOORA
Southeast Coastal Ocean Observing Regional Association

The Lowcountry Institute

National Oceanic and Atmospheric Administration
NOAA
U.S. Department of Commerce

IOOS
Integrated Ocean Observing System

Sea Islands Institute
University of South Carolina Beaufort

Community Foundation of the Lowcountry

Port Royal Sound Foundation

National Institutes of Health

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Questions?
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