SHELF

SPAWNING HABITAT & EARLY-LIFE LINKAGES TO FISHERIES

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SPAWNING HABITAT & EARLY-LIFE LINKAGES TO FISHERIES

Work Completed	Planned Work

SPAWNING HABITAT & EARLY-LIFE LINKAGES TO FISHERIES

Work Completed	Planned Work

2017-2018

|

SHELF I
Pilot Study

SHELF

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SHELF I
Pilot Study

2019-2023

SHELF II
Egg Monitoring Begins;
Barcoding Methods

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Egg Monitoring Begins; Barcoding Methods

2023-2026

SHELF III
Egg Monitoring Cont.; Targeted Studies

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2017-2018	**2019-2023**	**2023-2026**	**2026-2035**
SHELF I **Pilot Study**	**SHELF II** **Egg Monitoring Begins; Barcoding Methods**	**SHELF III** **Egg Monitoring Cont.; Targeted Studies**	**SHELF IV-VI** **LT Egg Monitoring TS; Targeted Studies; Respond to Needs**

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SHELF I **Pilot Study**	SHELF II Egg Monitoring Begins; Barcoding Methods	SHELF III Egg Monitoring Cont.; Targeted Studies	SHELF IV-VI LT Egg Monitoring TS; Targeted Studies; Respond to Needs

SHELF I (2017-2018): followed on success of prior FLRACEP funding to DNA barcode fish eggs

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ORIGINAL ARTICLE

WILEY FISHERIES OCEANOGRAPHY

DNA barcoding reveals clear delineation between spawning sites for neritic versus oceanic fishes in the Gulf of Mexico

Makenzie Burrows | Jeremy S. Browning | Mya Breitbart | Steven A. Murawski | Ernst B. Peebles

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Funding information
Florida RESTORE Act Centers of Excellence Program (FLRACEP)

Abstract

We combined research-vessel cruises of opportunity with DNA barcoding to survey planktonic, percomorph fish eggs at 40 stations distributed across and around the Gulf of Mexico (GoM). The objectives were (a) to determine whether eggs of fishes that are potential candidates for the daily egg production method (DEPM) can be readily barcoded, (b) to identify taxa that are spawning in the GoM, (c) to determine encounter rates for eggs of economically valuable taxa, and (d) to characterize individual egg taxa as being primarily neritic, primarily oceanic, or primarily mixed (i.e., both neritic and oceanic). Of the 1,144 eggs that were individually barcoded, 709 (62%) were definitively identified to species (62 species from 42 families), with an additional 20 taxa identified to genus or subfamily level. The eggs of 15 economically important species were identified, most of which had intermediate encounter rates and moderately dispersed spatial distributions, as indicated by an index of aggregation. SIMPROF analysis of stationwise cluster analysis identified eight significant groups within the 35 stations that yielded percomorph eggs; a corresponding specieswise analysis identified six groups of stations as having a neritic egg community and two groups as having an oceanic community, with a community transition located at the shelf break. Although the neritic and oceanic stations did not share important species, it remains possible that coastal pelagic species have mixed neritic–oceanic distributions. Together, these results indicate DEPM fish-egg surveys based on DNA barcoding are feasible at the large marine ecosystem scale.

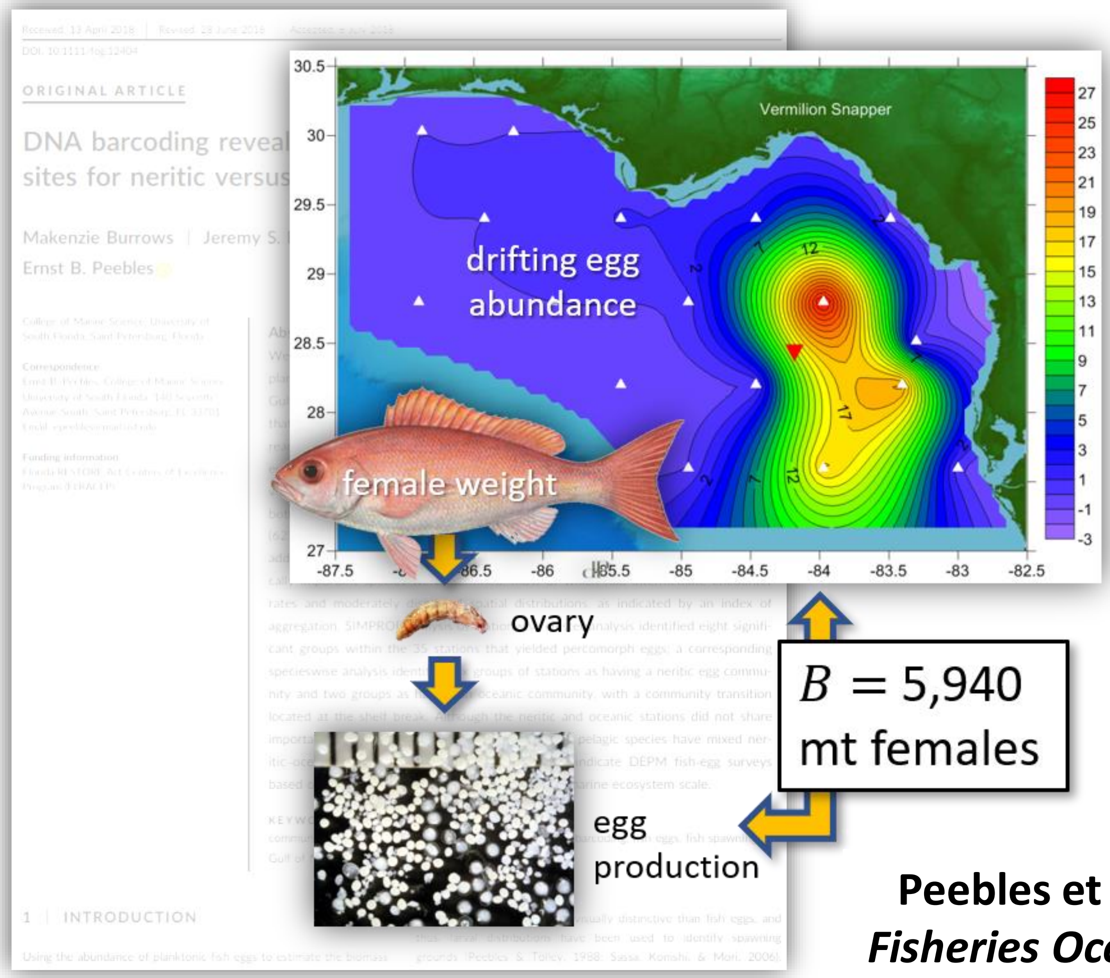
KEYWORDS
community transition, daily egg production method, DNA barcoding, fish eggs, fish spawning, Gulf of Mexico, large marine ecosystems

1 | INTRODUCTION

Using the abundance of planktonic fish eggs to estimate the biomass

Fish larvae are usually more visually distinctive than fish eggs, and thus, larval distributions have been used to identify spawning grounds (Peebles & Tolley, 1988; Sassa, Konishi, & Mori, 2006).

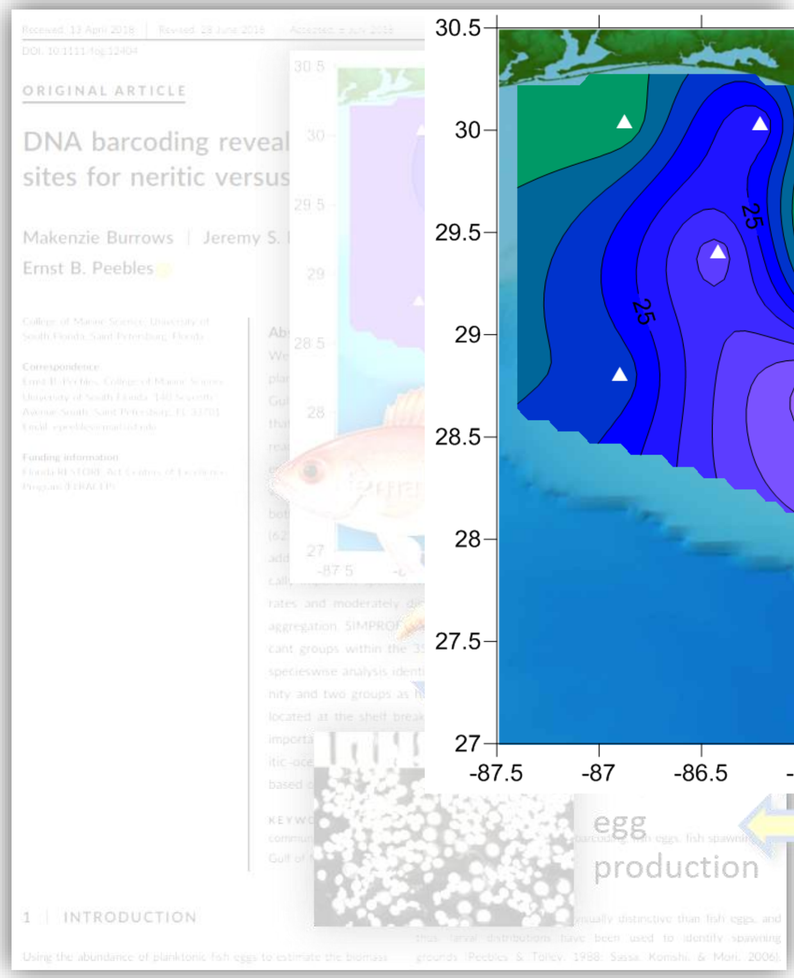
SHELF I (2017-2018): focused on the Daily Egg Production Method to estimate SSB

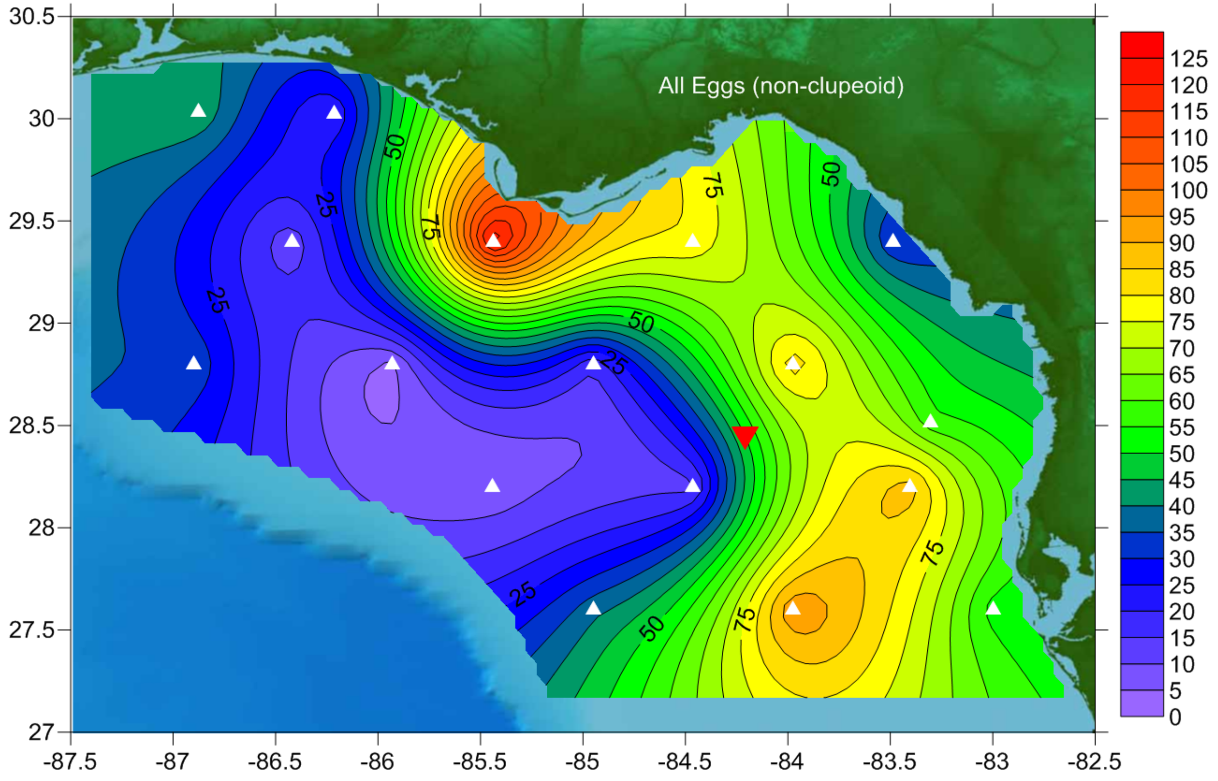


Peebles et al. In Prep

Fisheries Oceanography

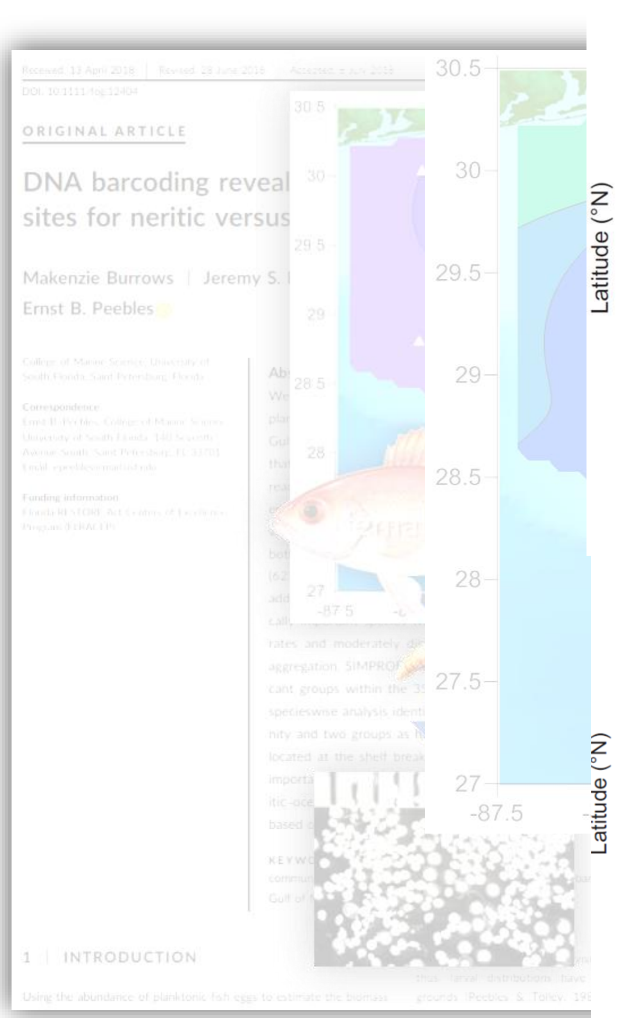
SHELF I (2017-2018): also identified spatial distributions of fish eggs on the WFS

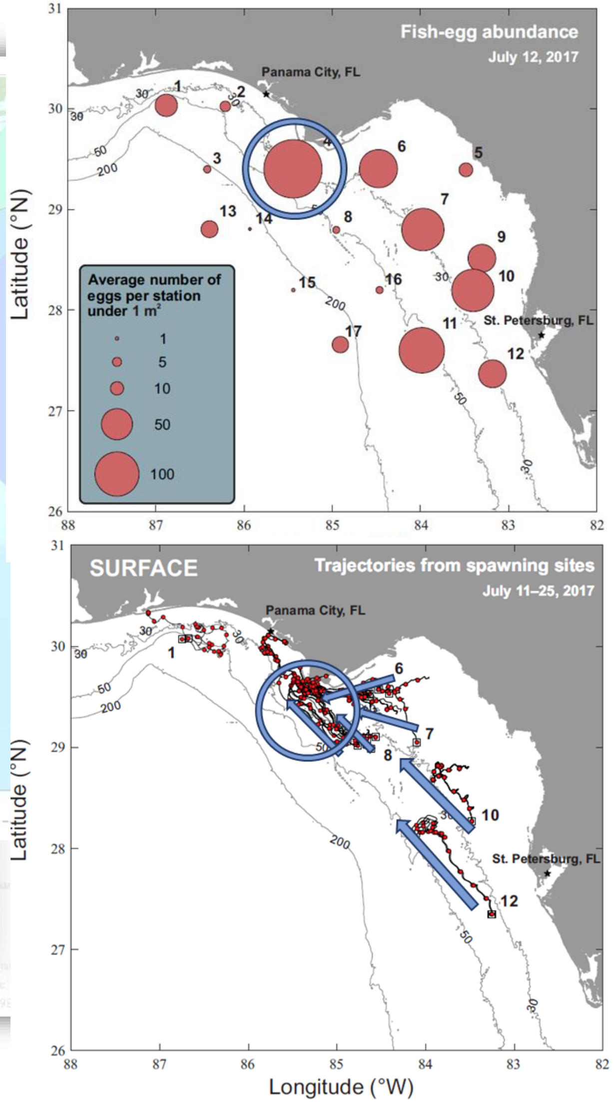




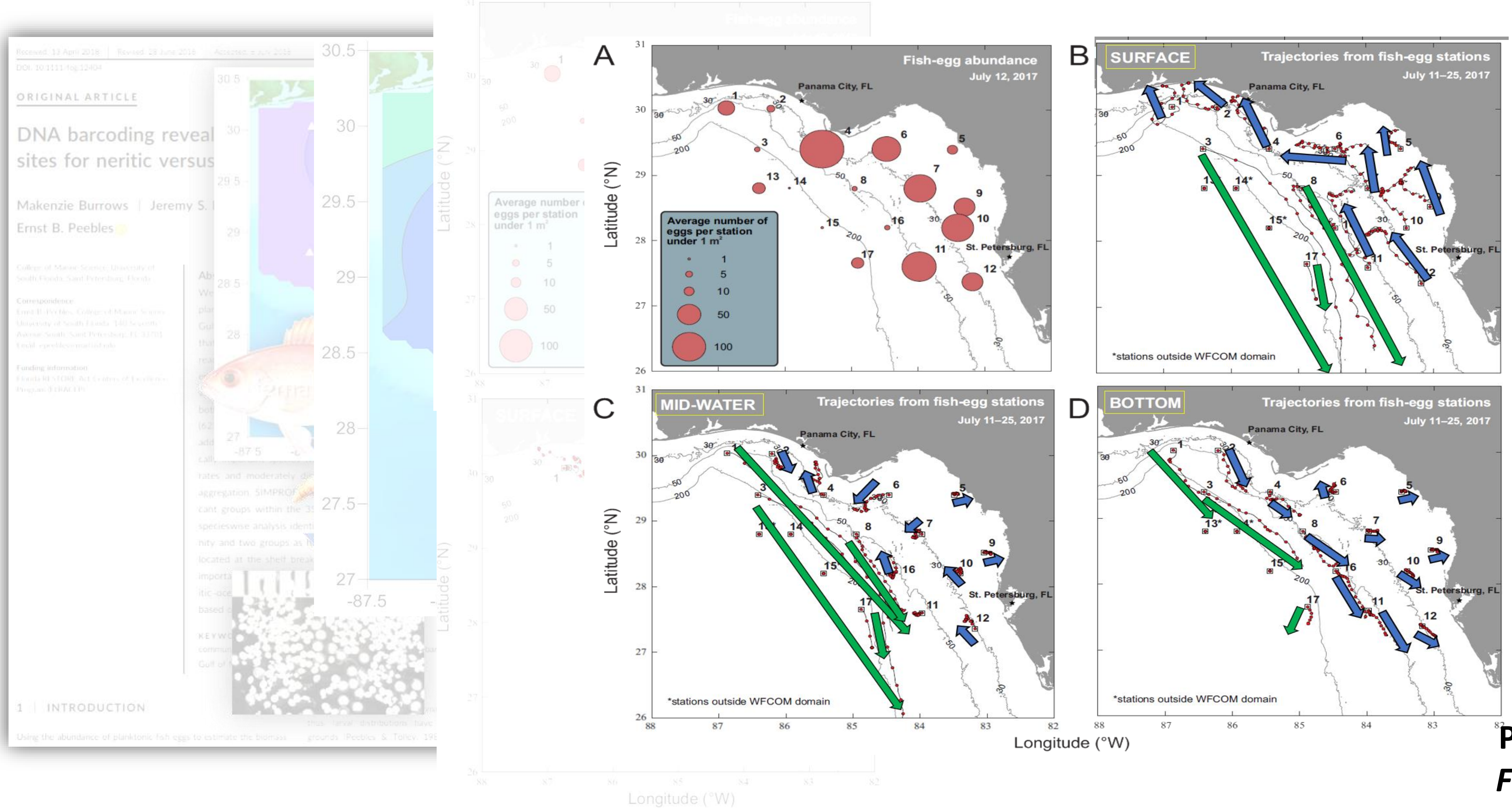
Fish eggs were found to be generally most abundant near shore, with a possible "hot spot" near Cape San Blas (unit is number of eggs under one square meter of sea surface).

SHELF I (2017-2018): we were able to explain the distribution of eggs based on PO models





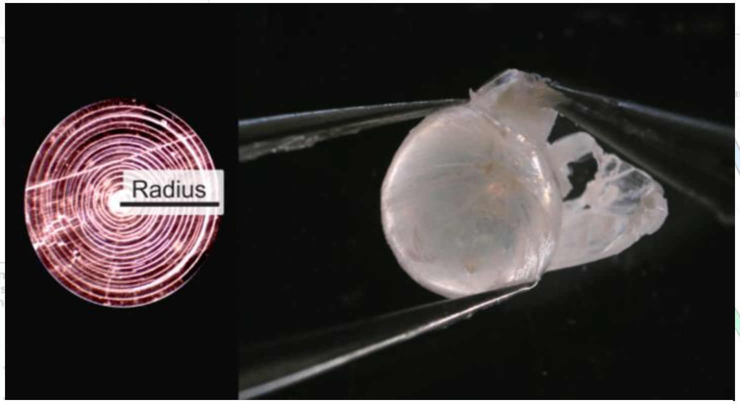
SHELF I (2017-2018): we also used PO models to estimate egg retention and export dynamics



Eggs spawned on the inner and middle WFS tended to be retained, whereas those on the outer WFS tended to be exported.

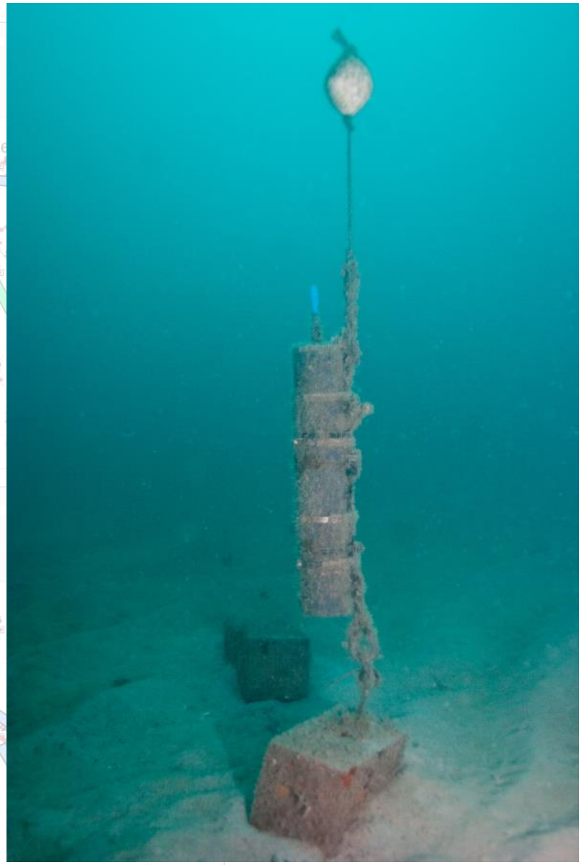
Peebles et al. In Review
Fisheries Oceanography

SHELF I (2017-2018): and we explored the use of various complementary field and lab tools



Stable isotope analysis of fish eye lenses to estimate spawning locations

Towed camera system to estimate fish abundance and distributions



Hydrophones to estimate fish abundance and calls

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- A final report was submitted, and results of the pilot SHELF project were reviewed and revised by FLRACEP's program management team (PMT)
- After reviewing the diverse array of methods and their results, the PMT prioritized:
  - continued funding for the egg-monitoring component of the program
  - with flexibility and funding for targeted studies

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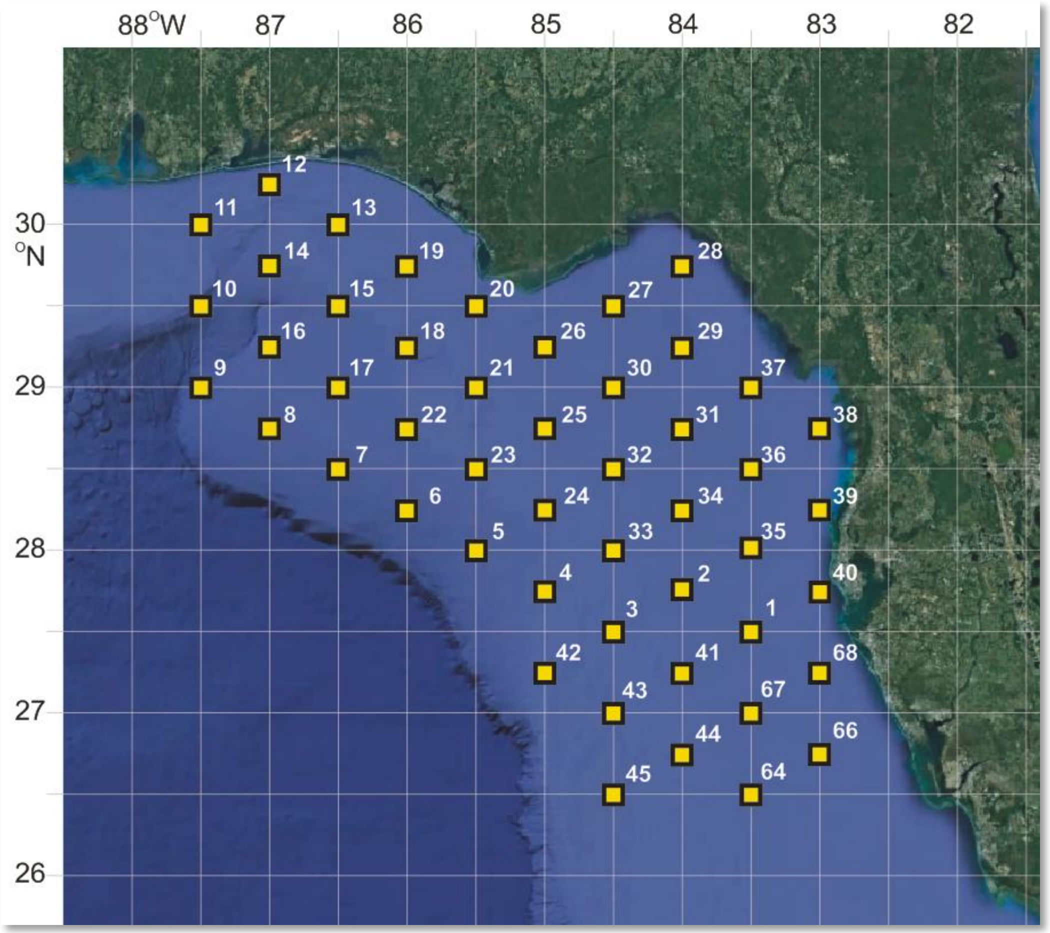
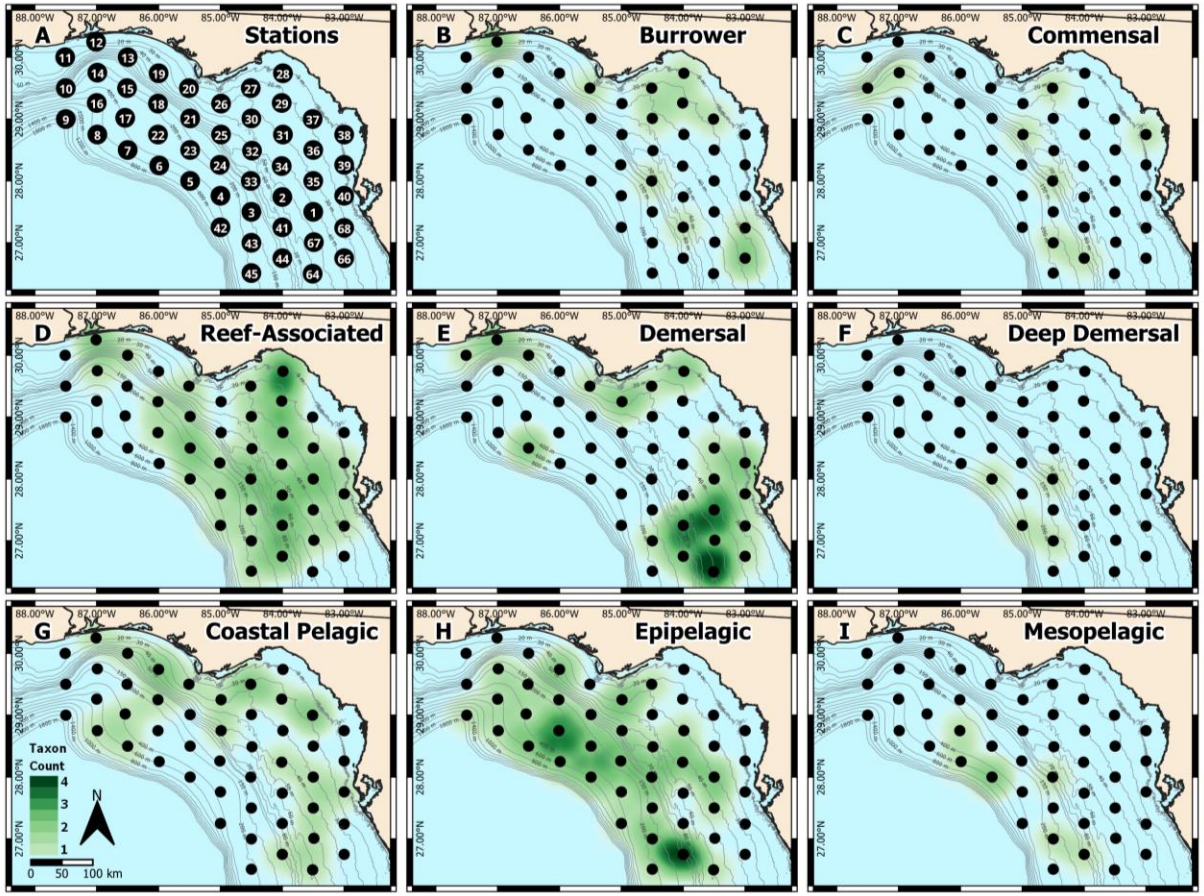
SHELF II (2019-2023): initiation of egg monitoring survey across the WFS

- 49 stations in 10 days at sea (August-September 2019)
- Sample processing was completed Fall 2019
- DNA barcoding was complete by early 2020
- We used DNA metabarcoding...



SHELF II (2019-2023): DNA metabarcoding

- We recovered 37 taxa from 4,719 fish eggs
- Identified taxa corresponded with known habitat types of these taxa



Breitbart et al. 2023
PeerJ

SHELF II (2019-2023): Pros and cons of DNA metabarcoding for long-term monitoring

Parameter	Individual eggs	Metabarcoding
Cost	$5.15 per egg $494.40 per site[a]	$0.78 per egg[a] $64.82 per site

[a] Cost calculated based on 96 eggs per site.

Breitbart et al. 2023
PeerJ

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Quantitative	Yes	No
Ability to return to individual eggs with additional primers	Yes	No
Prevalence of false positives/negatives	Low/None	Frequent; dependent on the application of a threshold

[a] Cost calculated based on 96 eggs per site.

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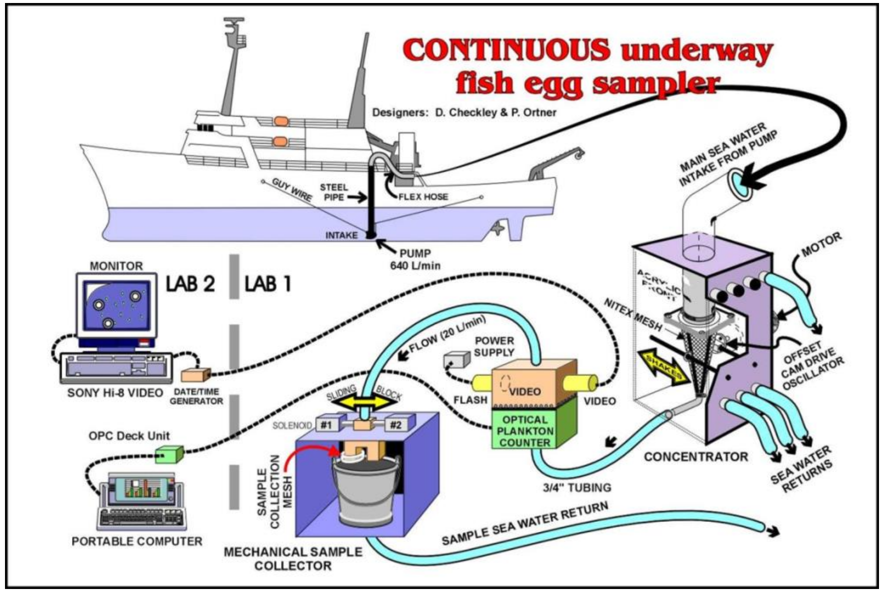
[a] Cost calculated based on 96 eggs per site.

We therefore decided to use individual egg barcoding for the SHELF program

Breitbart et al. 2023
PeerJ

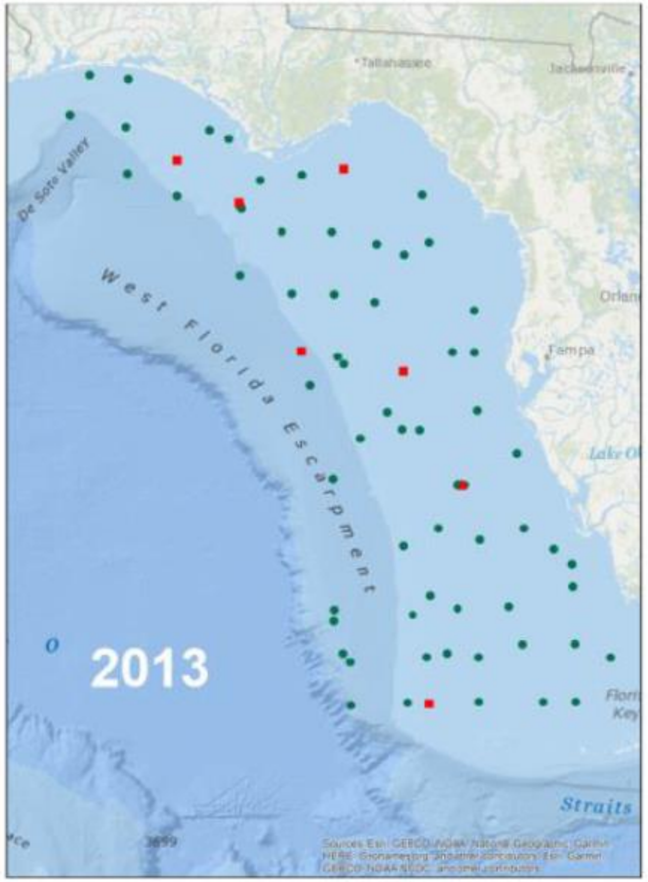
SHELF II (2019-2023): COVID created novel challenges to conduct field work / cruises

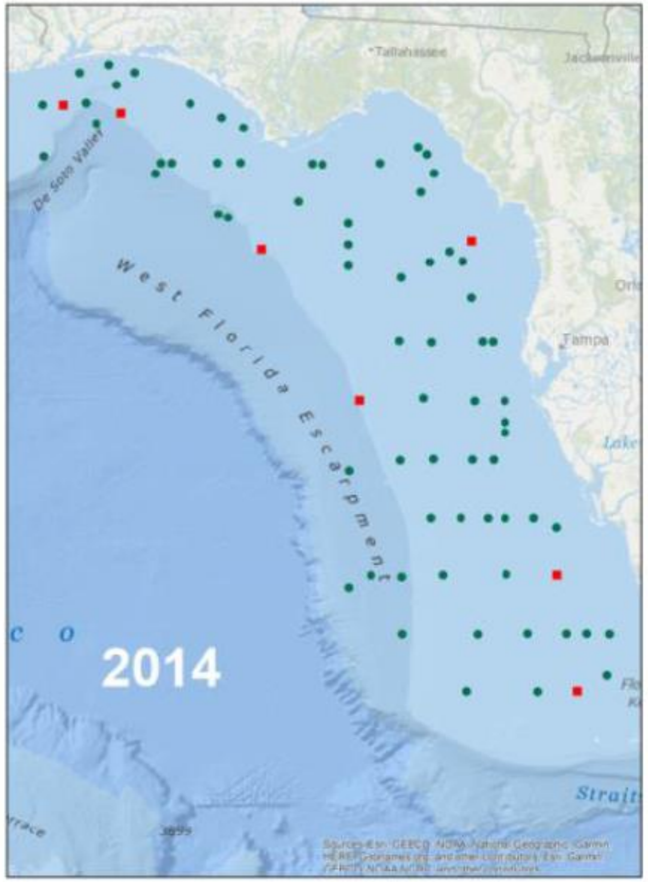
SHELF II (2019-2023): we were able to overcome these challenges with a new collaboration



NOAA's Continuous Underway Fish Egg Sampler (CUFES), with the entire system diagrammed in the middle panel and a photo of the concentrator and mechanical sample collector inside the vessel's lab in the right panel (courtesy NOAA NMFS).

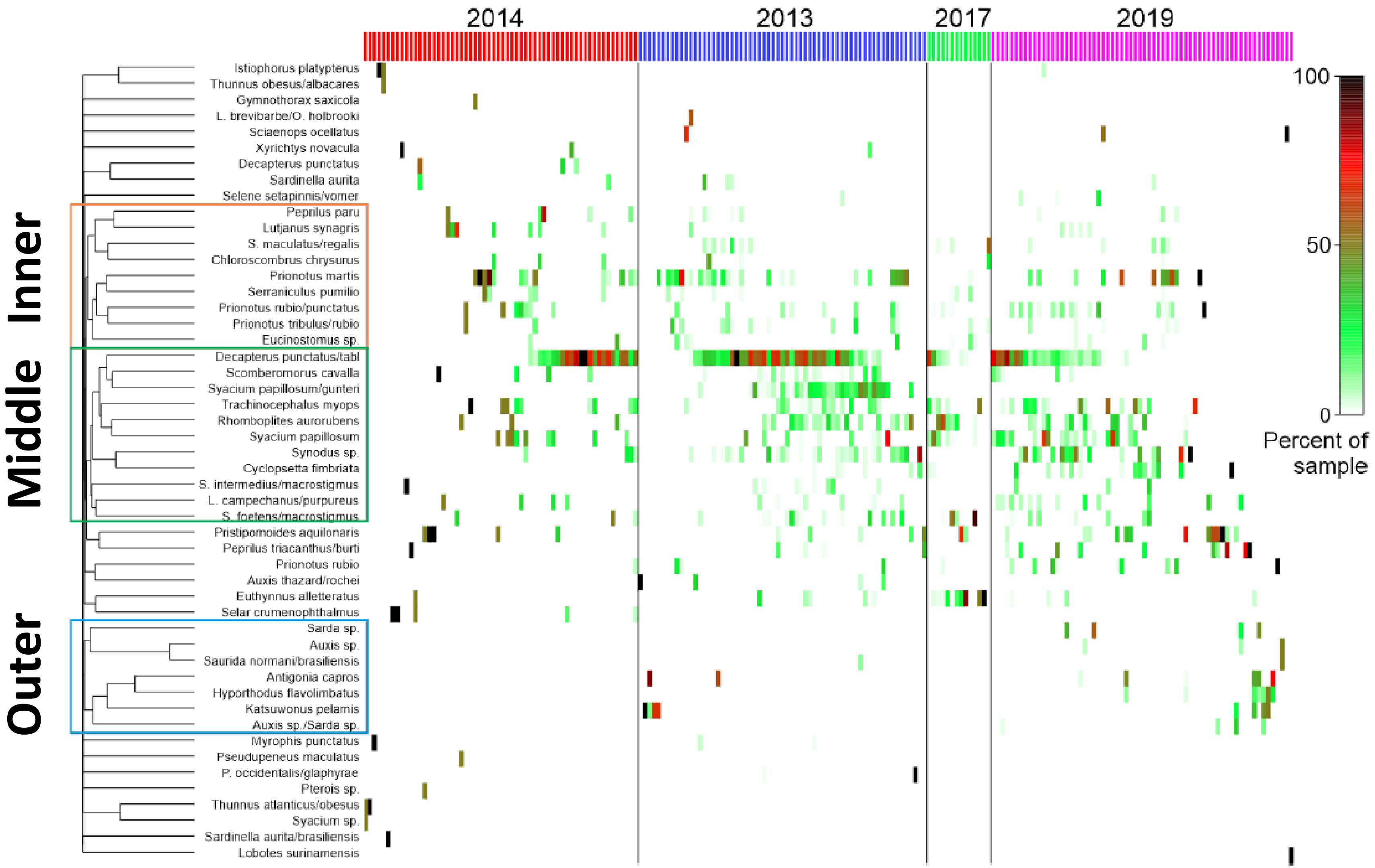
SHELF II (2019-2023): we barcoded three years of archived fish eggs collected by NOAA SEAMAP





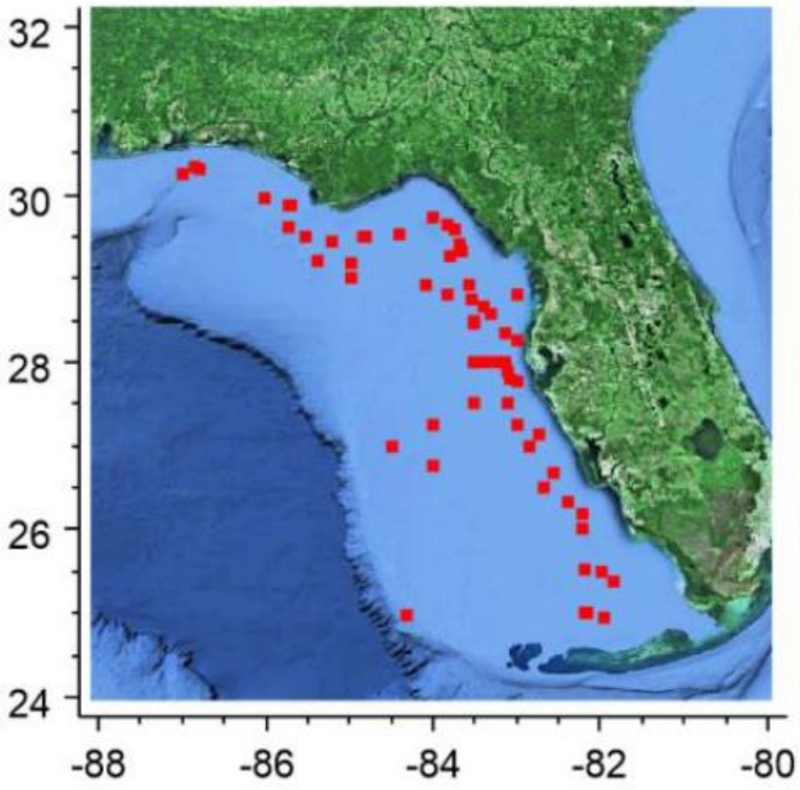
We have barcoded 251 stations, had 80% success rate, and have found 163 taxa.

SHELF II (2019-2023): community structure of fish eggs along an inner-outer shelf gradient

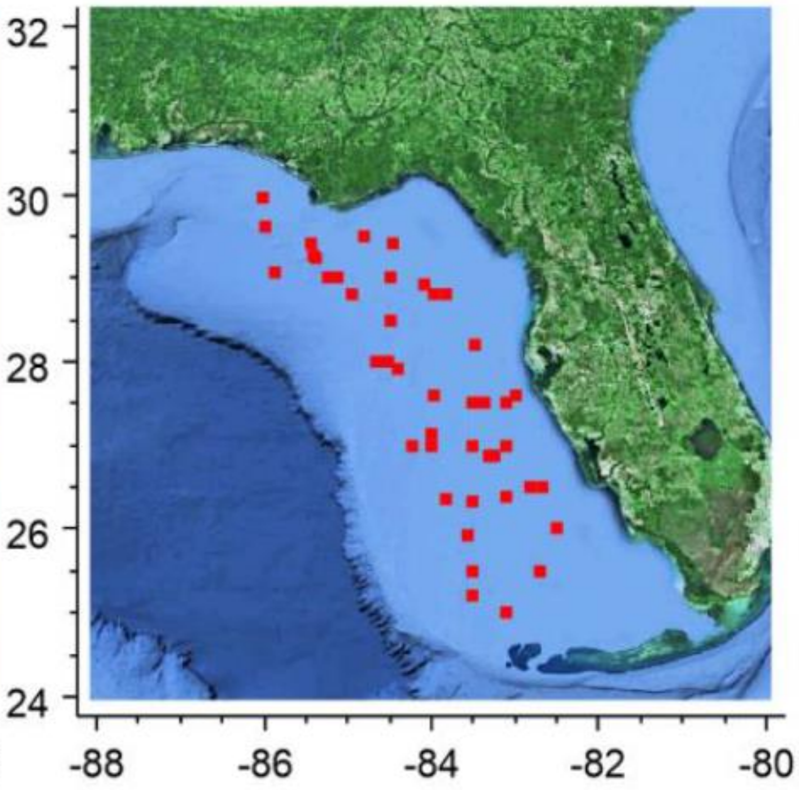


SHELF II (2019-2023): example taxa identified for inner, middle, and outer shelf communities

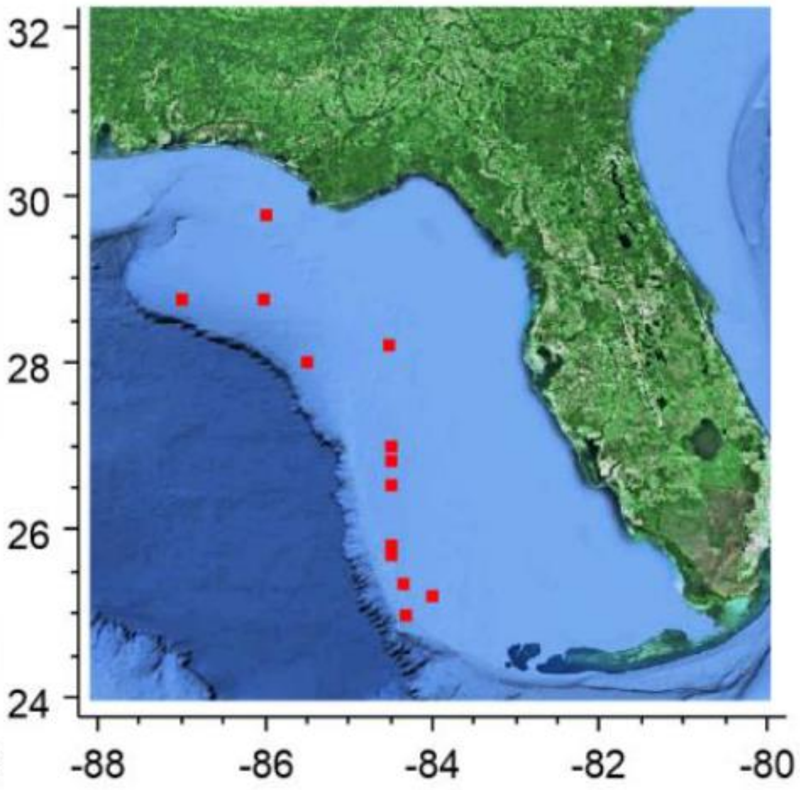
Gulf of Mexico barred searobin (*Prionotus martis*)



vermilion snapper (*Rhomboplites aurorubens*)

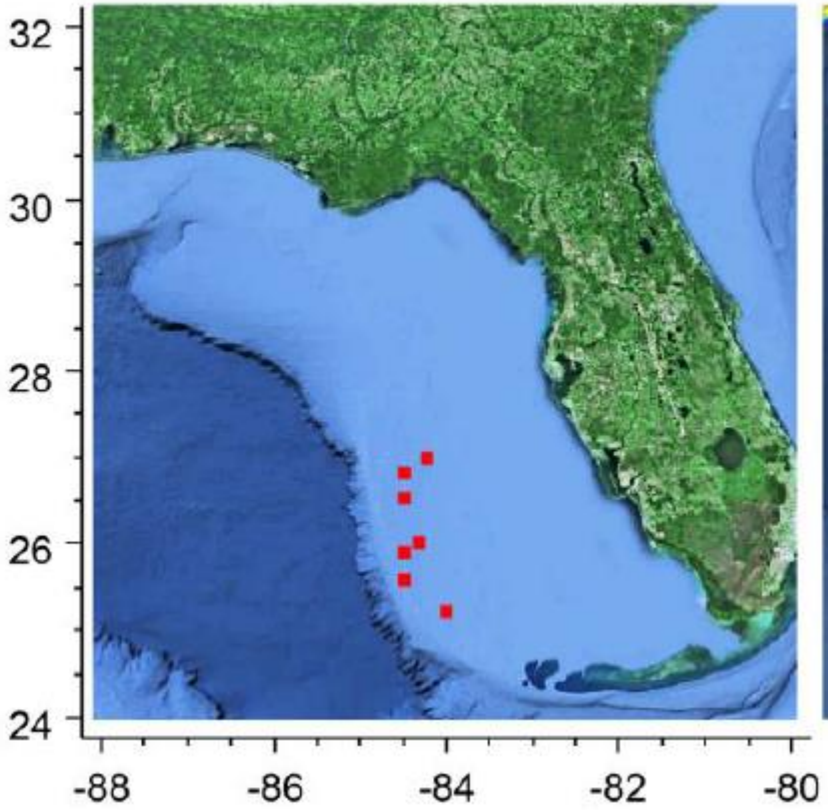


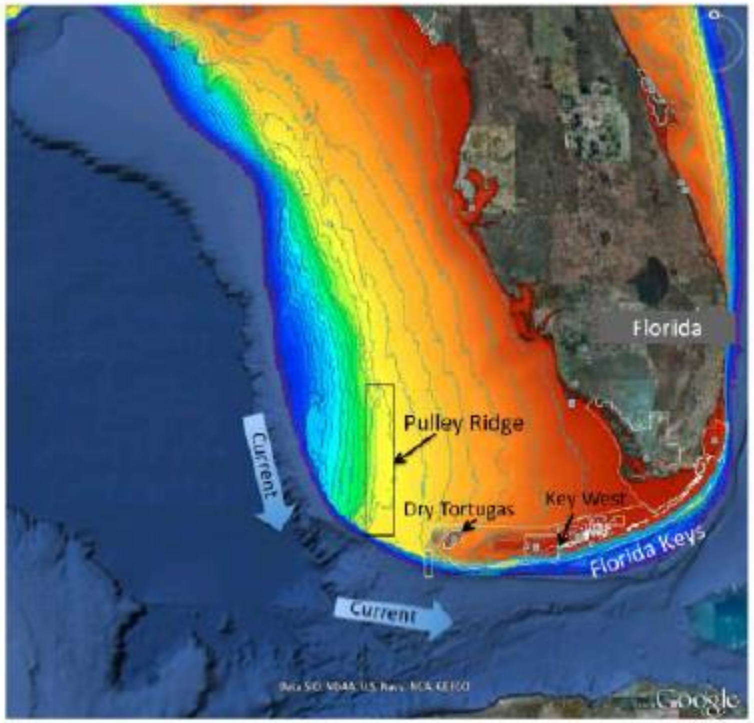
skipjack tuna (*Katsuwonus pelamis*)



SHELF II (2019-2023): distribution of yellowedge grouper eggs relative to Pulley Ridge HAPC

yellowedge grouper
(*Hyporthodus flavolimbatus*)





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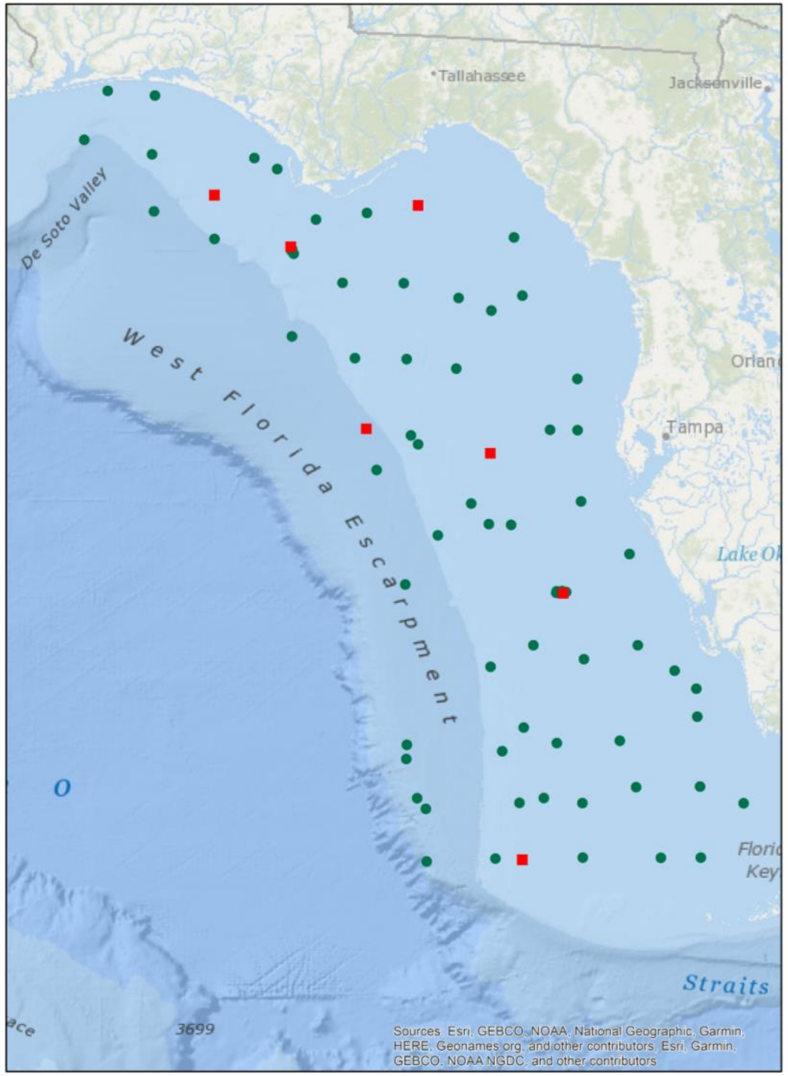
SHELF III (2023-2026): continue long-term egg monitoring times series and targeted studies



Year eggs collected	SHELF Phase	Status
2013	SHELF II	Completed
2014	SHELF II	Completed
2019	SHELF II	Completed
2022	SHELF III	To do
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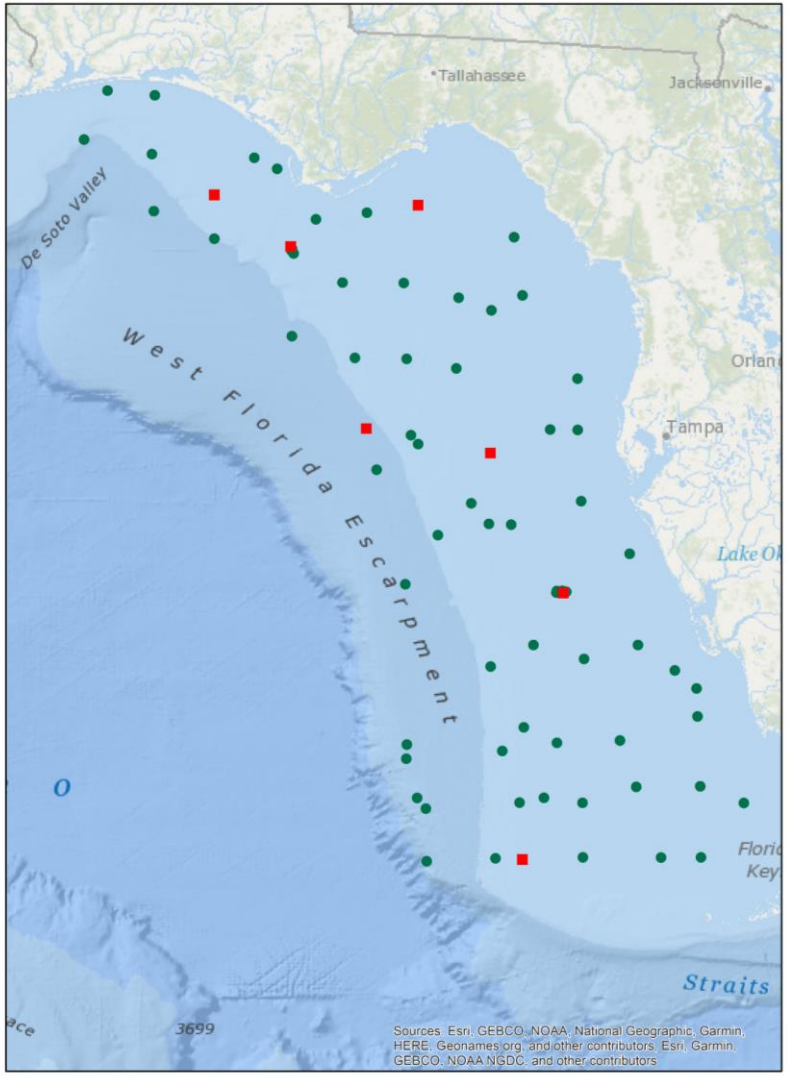

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2025	SHELF III	To do

Targeted Studies

1. **Better understand spawning dynamics on the WFS**
2. **Examine key assumptions of our methods**

SHELF III (2023-2026): examine eggs collected across seasons on the WFS

FMP category	Common name	Family	Scientific name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Coastal Migratory Pelagics	King Mackerel	Scombridae	*Scomberomorus cavalla*												
Coastal Migratory Pelagics	Spanish Mackerel	Scombridae	*Scomberomorus maculatus*												
Red Drum	Red Drum	Sciaenidae	*Sciaenops ocellatus*												
Reef Fish	Gray Triggerfish	Balistidae	*Balistes capriscus*												
Reef Fish	Greater Amberjack	Carangidae	*Seriola dumerili*												
Reef Fish	Almaco Jack	Carangidae	*Seriola rivoliana*												
Reef Fish	Speckled Hind	Epinephelidae	*Epinephelus drummondhayi*												
Reef Fish	Goliath Grouper	Epinephelidae	*Epinephelus itajara*												
Reef Fish	Red Grouper	Epinephelidae	*Epinephelus morio*												
Reef Fish	Nassau Grouper	Epinephelidae	*Epinephelus striatus*												
Reef Fish	Yellowedge Grouper	Epinephelidae	*Hyporthodus flavolimbatus*												
Reef Fish	Warsaw Grouper	Epinephelidae	*Hyporthodus nigritus*												
Reef Fish	Snowy Grouper	Epinephelidae	*Hyporthodus niveatus*												
Reef Fish	Black Grouper	Epinephelidae	*Mycteroperca bonaci*												
Reef Fish	Yellowmouth Grouper	Epinephelidae	*Mycteroperca interstitialis*												
Reef Fish	Gag Grouper	Epinephelidae	*Mycteroperca microlepis*												
Reef Fish	Scamp	Epinephelidae	*Mycteroperca phenax*												
Reef Fish	Yellowfin Grouper	Epinephelidae	*Mycteroperca venenosa*												
Reef Fish	Hogfish	Labridae	*Lachnolaimus maximus*												
Reef Fish	Mutton Snapper	Lutjanidae	*Lutjanus analis*												
Reef Fish	Red Snapper	Lutjanidae	*Lutjanus campechanus*												
Reef Fish	Cubera Snapper	Lutjanidae	*Lutjanus cyanopterus*												
Reef Fish	Vermilion Snapper	Lutjanidae	*Rhomboplites aurorubens*												
Reef Fish	Tilefish	Malacanthidae	*Lopholatilus chamaeleonticeps*												
Not Federally Managed	Southern Flounder	Paralichthyidae	*Paralichthys lethostigma*												
Not Federally Managed	Spotted Seatrout	Sciaenidae	*Cynoscion nebulosus*												
Not Federally Managed	Black Drum	Sciaenidae	*Pogonias cromis*												
Not Federally Managed	Sheepshead	Sparidae	*Archosargus probatocephalus*												
			Number species (all)	11	13	13	19	19	20	16	18	15	9	7	5
			Number species (peak)	3	5	10	9	8	8	8	7	4	2	1	3
					Q1			Q2			Q3			Q4	

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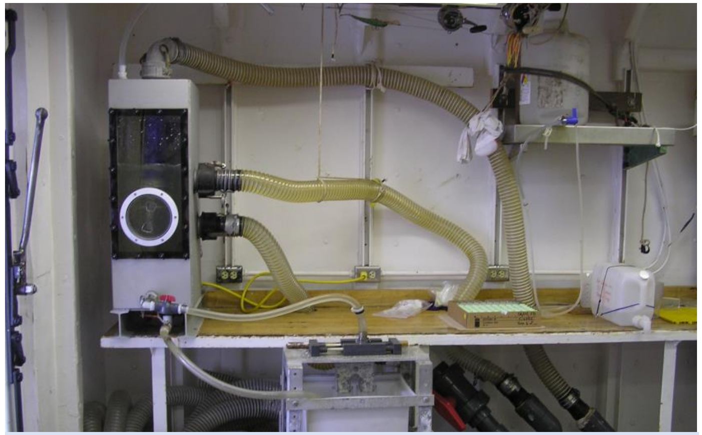
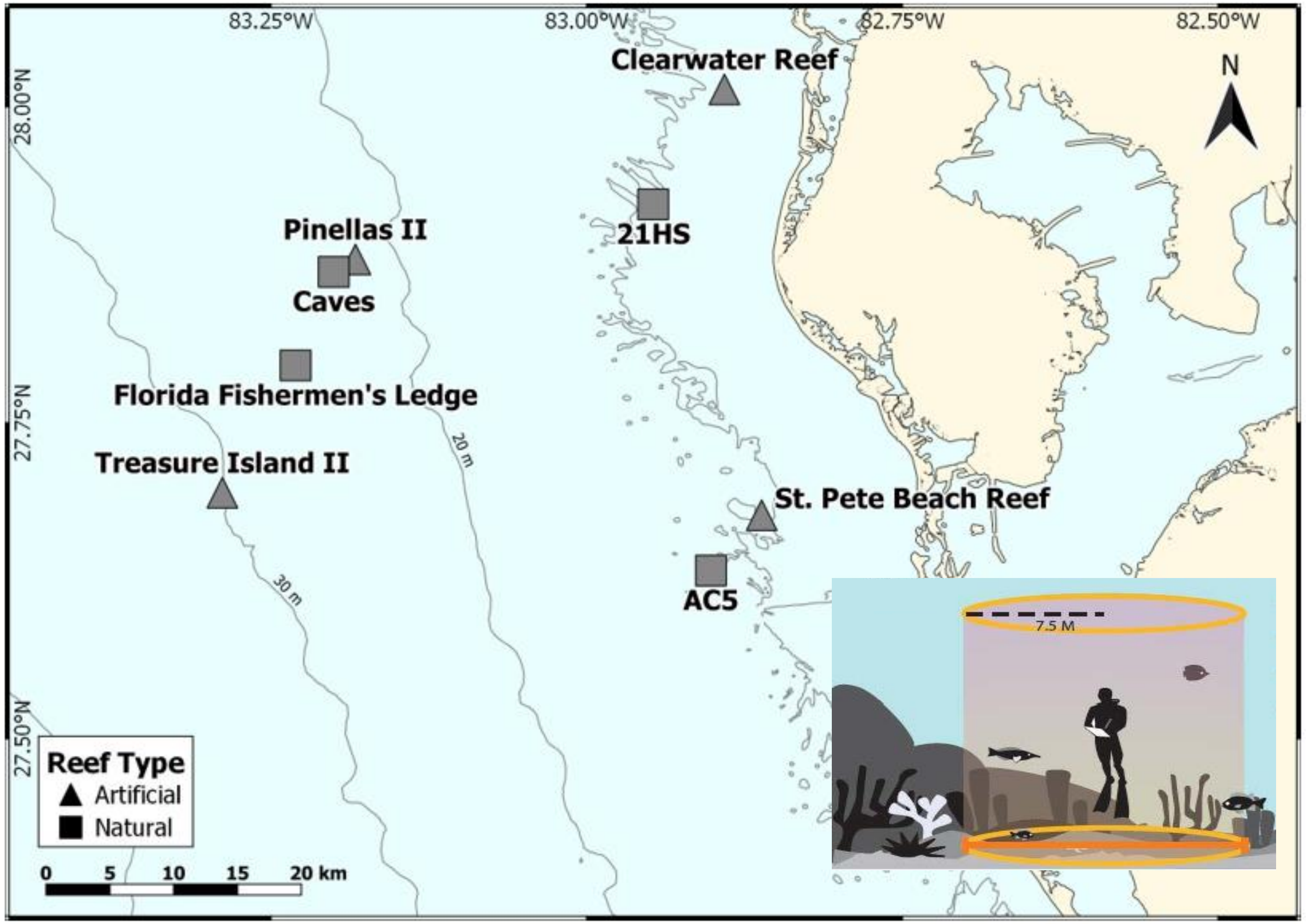
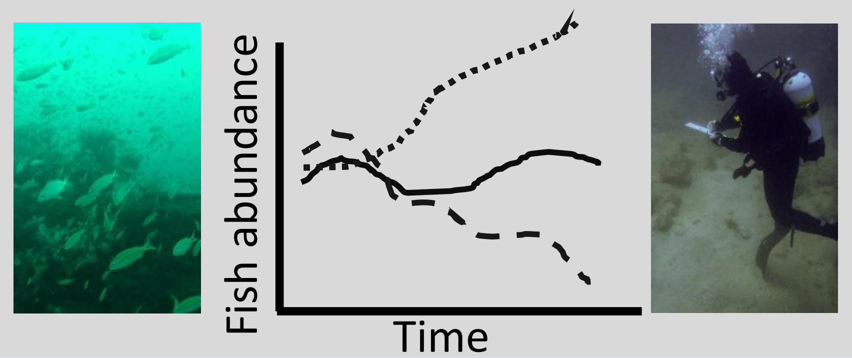


We will build a CUFES to be placed on FIO vessels

SHELF III (2023-2026): test whether we can link adult fish abundances to egg production

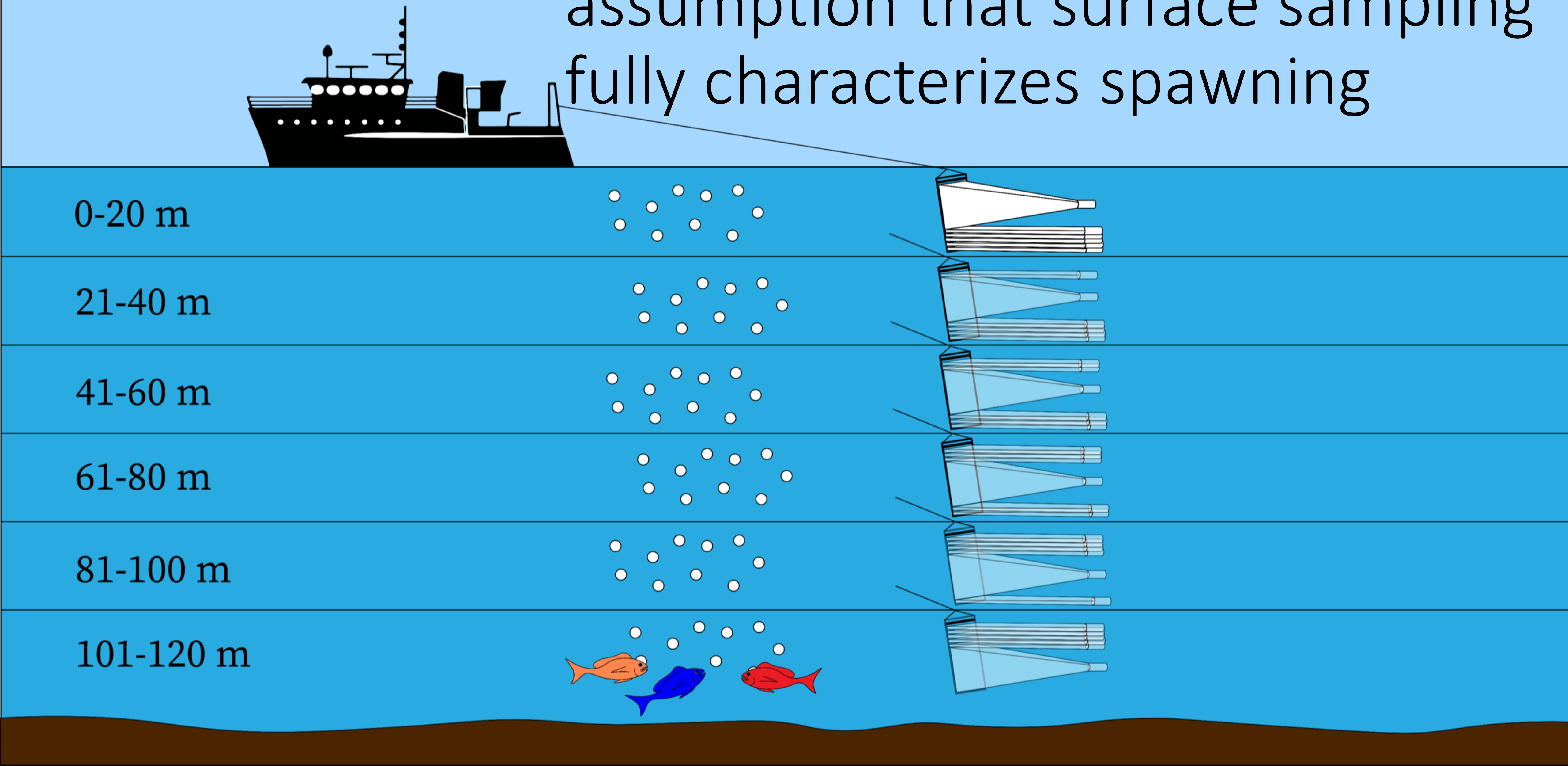




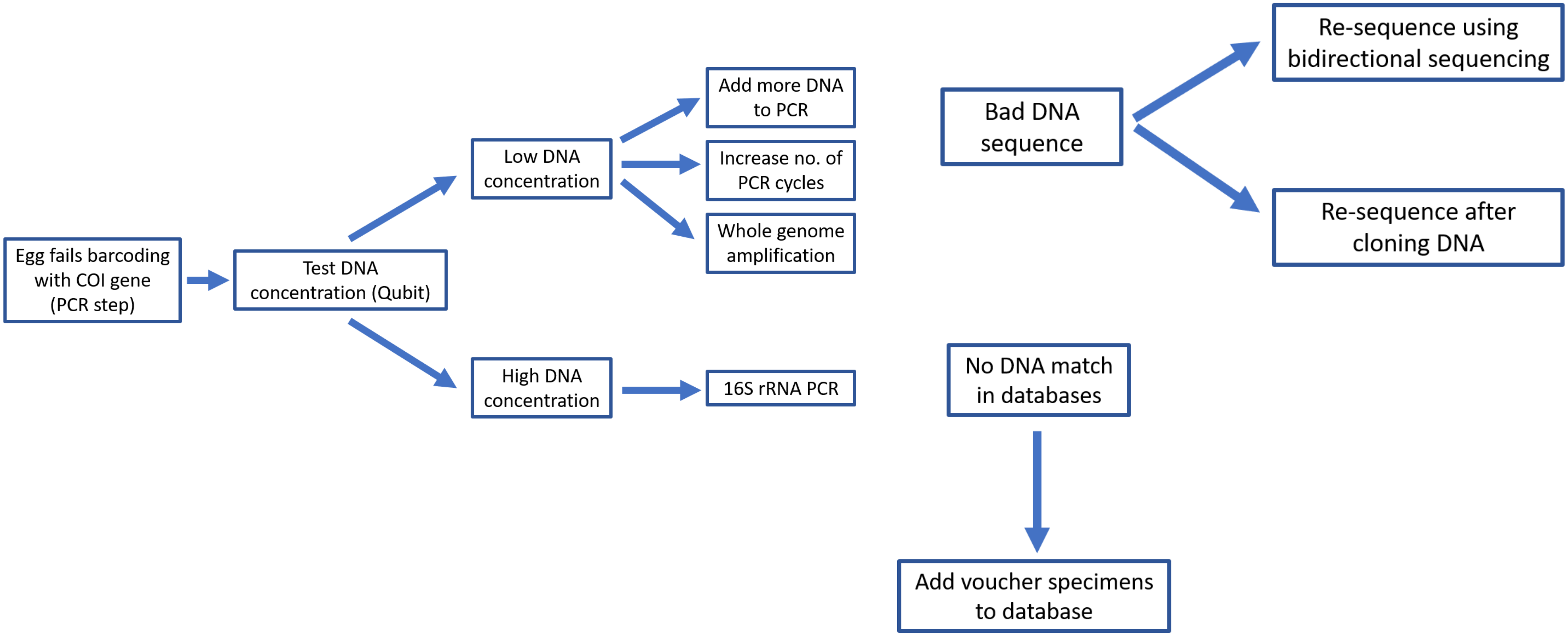
We have over 10 years of continuous reef fish survey data with ~1300 surveys and over 200 taxa

We will build a second CUFES that can be used on our small research vessel

SHELF III (2023-2026): test assumption that surface sampling fully characterizes spawning



SHELF III (2023-2026): determine causes of barcoding failure and improve success rate



Continue existing and develop new collaborations with fisheries scientists

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Disseminate SHELF goals and products to stakeholders

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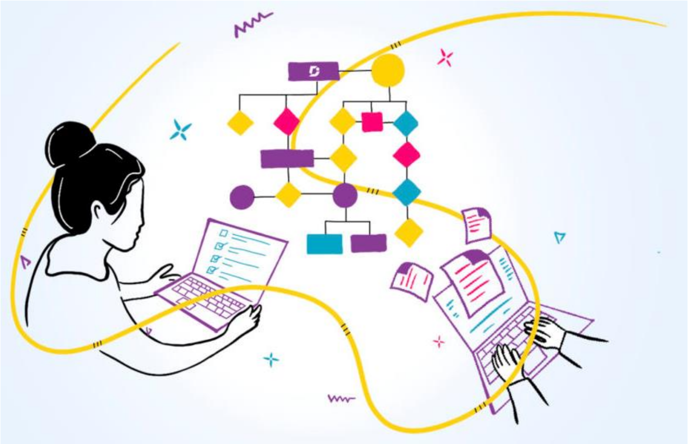
NOAA FISHERIES

Disseminate SHELF goals and products to stakeholders

NOAA Science Seminar Series

Ensure the SHELF program is fully operationalized



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2013	SHELF II	Completed
2014	SHELF II	Completed
2019	SHELF II	Completed
2022	SHELF III	To do
2023	SHELF III	To do
2024	SHELF III	To do
2025	SHELF III	To do
2026	SHELF IV	Pending continued funding
2027	SHELF IV	Pending continued funding
2028	SHELF IV	Pending continued funding
2029	SHELF IV	Pending continued funding
2030	SHELF V	Pending continued funding
2031	SHELF V	Pending continued funding
2032	SHELF V	Pending continued funding
2033	SHELF VI	Pending continued funding
2034	SHELF VI	Pending continued funding
2035	SHELF VI	Pending continued funding

Long-term time series

1. **17 years of identifications across a 23-year span**
2. **Begin to understand long-term dynamics, response to disturbances, recovery of species**
3. **Potential to leverage funding from other sources to continue time series beyond 2036**

Eggs collected	SHELF Phase	Status
2013	SHELF II	Completed
2014	SHELF II	Completed
2019	SHELF II	Completed
2022	SHELF III	To do
2023	SHELF III	To do
2024	SHELF III	To do
2025	SHELF III	To do
2026	SHELF IV	Pending continued funding
2027	SHELF IV	Pending continued funding
2028	SHELF IV	Pending continued funding
2029	SHELF IV	Pending continued funding
2030	SHELF V	Pending continued funding
2031	SHELF V	Pending continued funding
2032	SHELF V	Pending continued funding
2033	SHELF VI	Pending continued funding
2034	SHELF VI	Pending continued funding
2035	SHELF VI	Pending continued funding

Long-term time series

1. **17 years of identifications across a 23-year span**
2. **Begin to understand long-term dynamics, response to disturbances, recovery of species**
3. **Potential to leverage funding from other sources to continue time series beyond 2036**

Flexible to address data needs

1. **Can respond to issues as they emerge to address data needs (e.g., “Great Counts”)**
2. **Potential to incorporate complementary tools and approaches (e.g., PO modeling)**

Thank You!