A Multi-Pronged Approach to Investigate the Offshore Migration and Habitat Use by Southern Flounder

PRELIMINARY RESULTS

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East Carolina University, Department of Biology

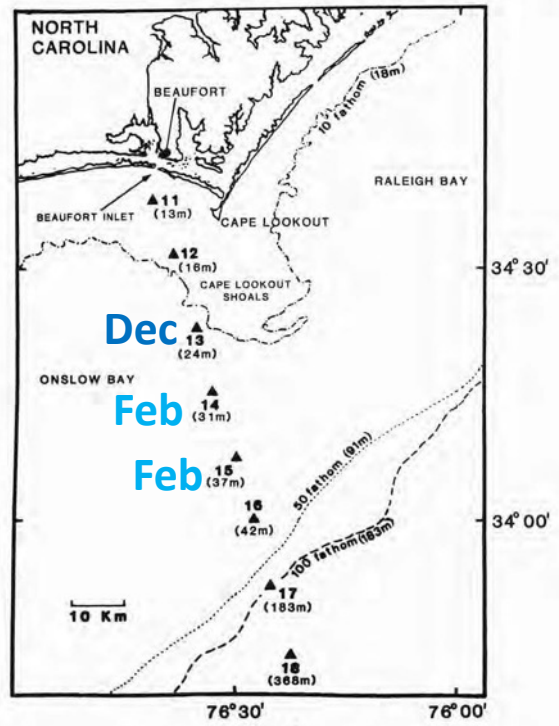
Background Information

- Life history of North Carolina (NC) fishes characterized by seascape connectivity between estuaries, sounds, inlets, and offshore habitats
- Flounder fishery has historically been the largest finfish fishery in NC
- Currently classified as overfished and experiencing overfishing
- Likely intermixing of fish populations between states
- Spawning locations unknown throughout its range

Multi-pronged approach

Acoustic tagging
Larval dispersal modeling
Egg surveys & DNA barcoding
Otolith microchemistry
Age, growth, and maturity

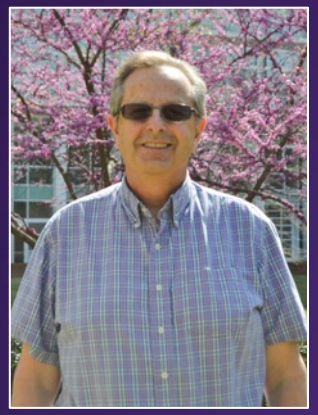
Larvae Detected on Continental Shelf



Map from Powell & Robbins (1994)

Teamwork Makes the Dream Work

Rebecca Asch, Lead PI



Roger Rulifson, PI

Pat Harris, PI

Caitlin McGarigal, Research associate

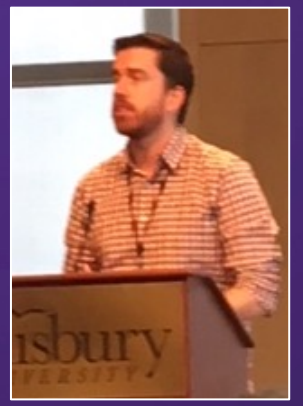
Tyler Peacock, PhD student

Paul Salib, MS student

Joe Luzckovich, PI

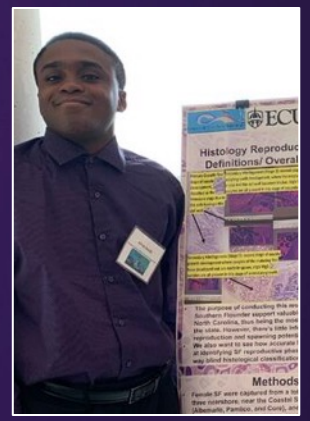
Mark Sprague, PI

Eric Diaddorio, Investigator



Brian Bartlett, PhD student

Justin Mitchell, MS student



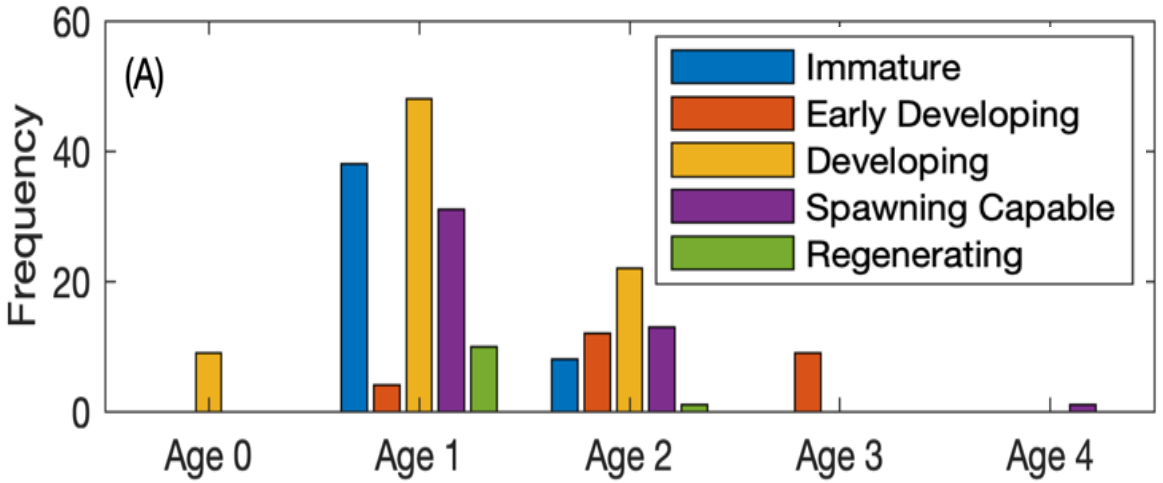
Jevon Smalls, Undergraduate

ECU

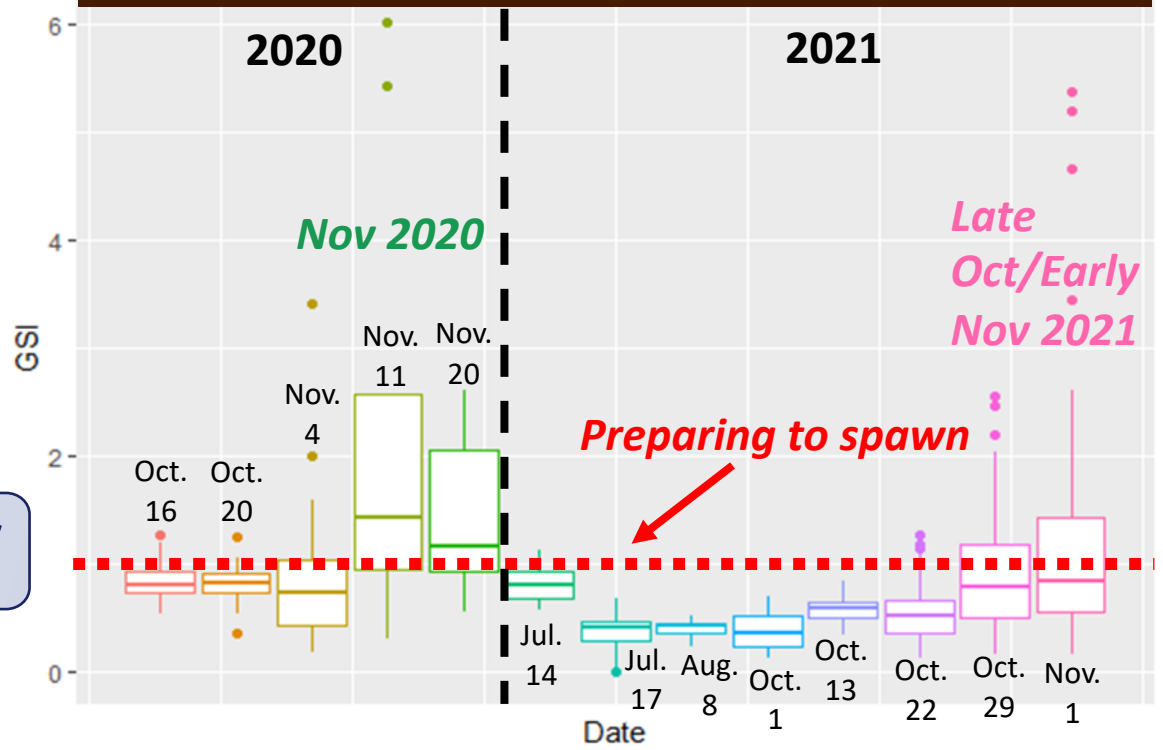
Age, Size, and Maturity Provide Biological Context

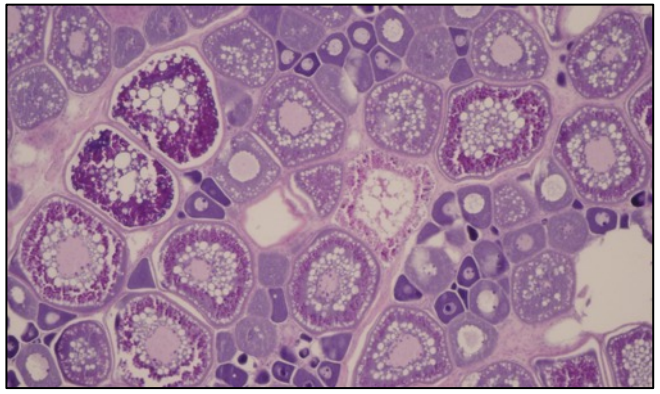
- Microscopic examination of southern flounder ovaries indicates batch spawning
- Fall preparation for spawning seen each year
- 50% of flounder mature by age 1

PRELIMINARY RESULTS



Gonadosomatic index (GSI) by Date





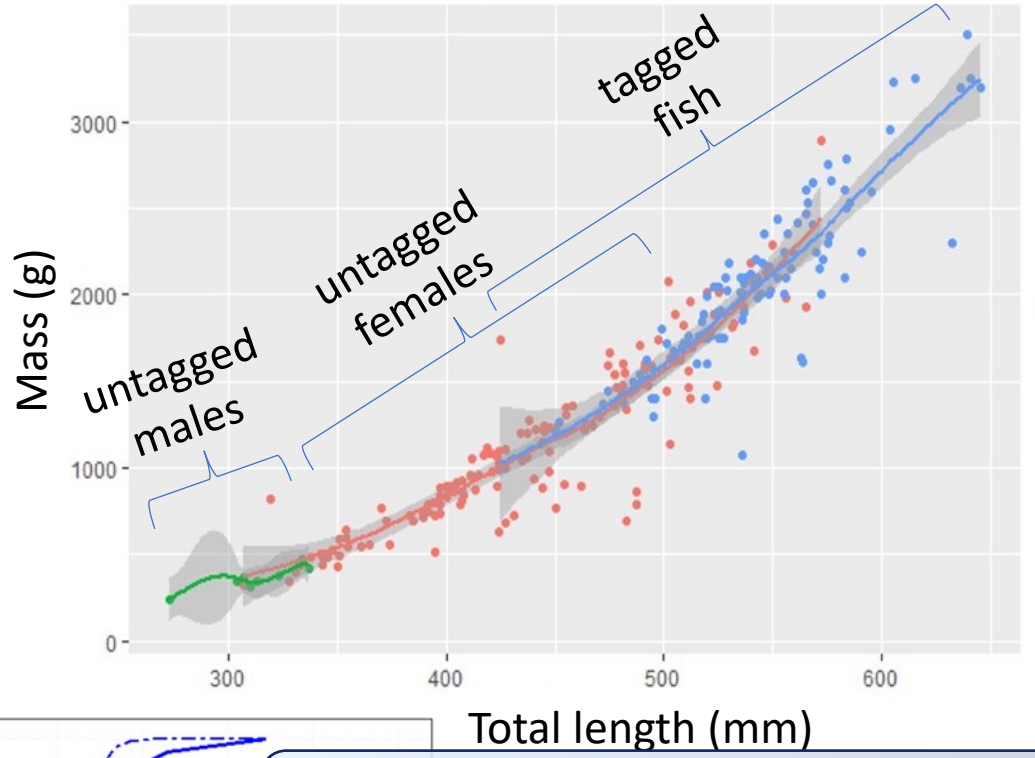
Justin Mitchell

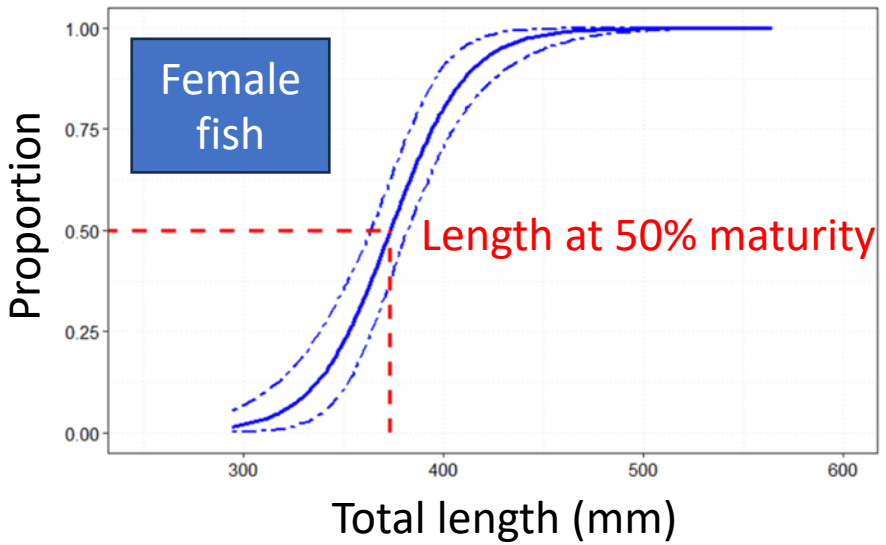
Age, Size, and Maturity Provide Biological Context

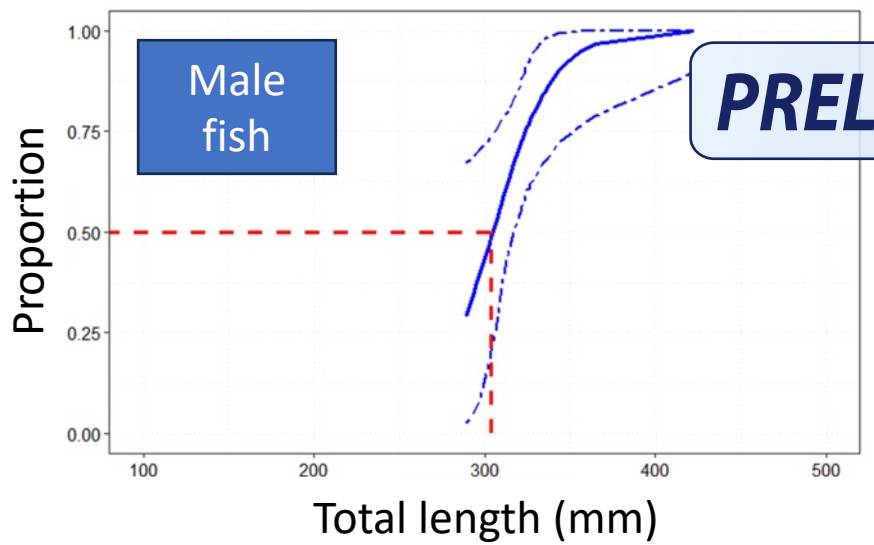
- Female fish are larger than males; all tagged fishes were very likely female

- We identified 50% of female fish were mature at 374 mm TL
  - → 345 mm – Monagahn & Armstrong (2000) – Different methodology
  - → 451 mm – Midway & Scharf (2012)
  - → 402 mm – Flowers et al. (2019)

- Male fish reached 50% maturity at 304 mm TL





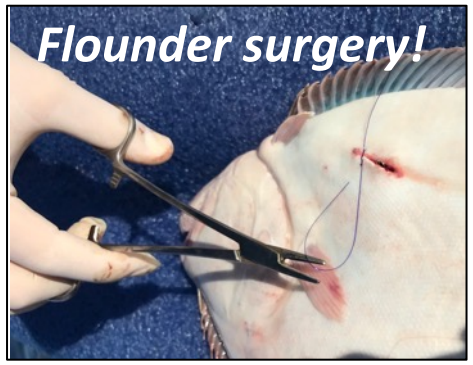


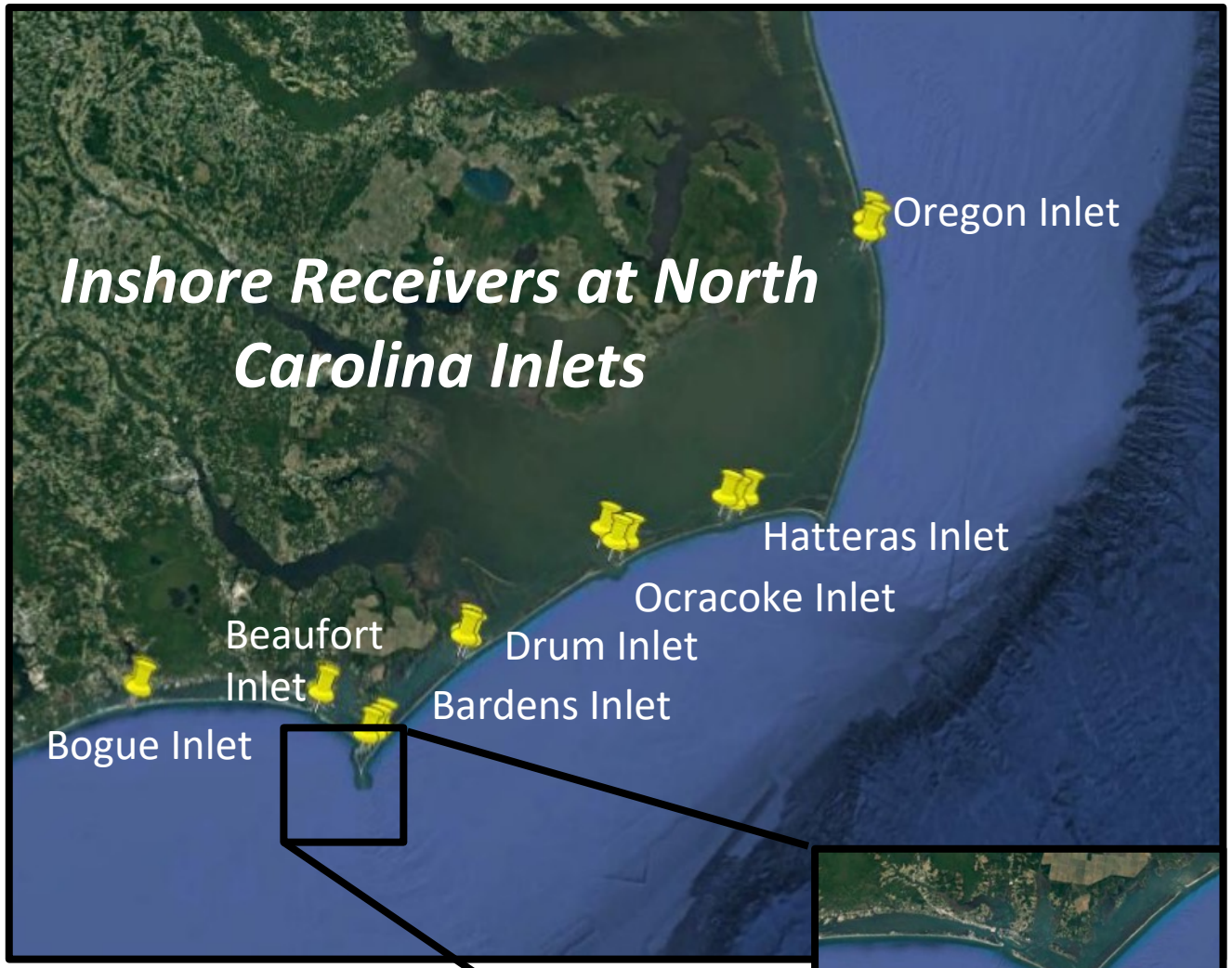
PRELIMINARY RESULTS

Justin Mitchell

Acoustic Tagging Methods

- Tagged 210 fishes in Albemarle, Pamlico, and Core Sounds
- 21 inshore receivers placed at 7 inlets
- 20 receivers in offshore array at Cape Lookout & Frying Pan Shoals (1-km spacing)
- Four wave glider missions: Dec 2020, Jan 2021, Dec 2021, Feb 2022



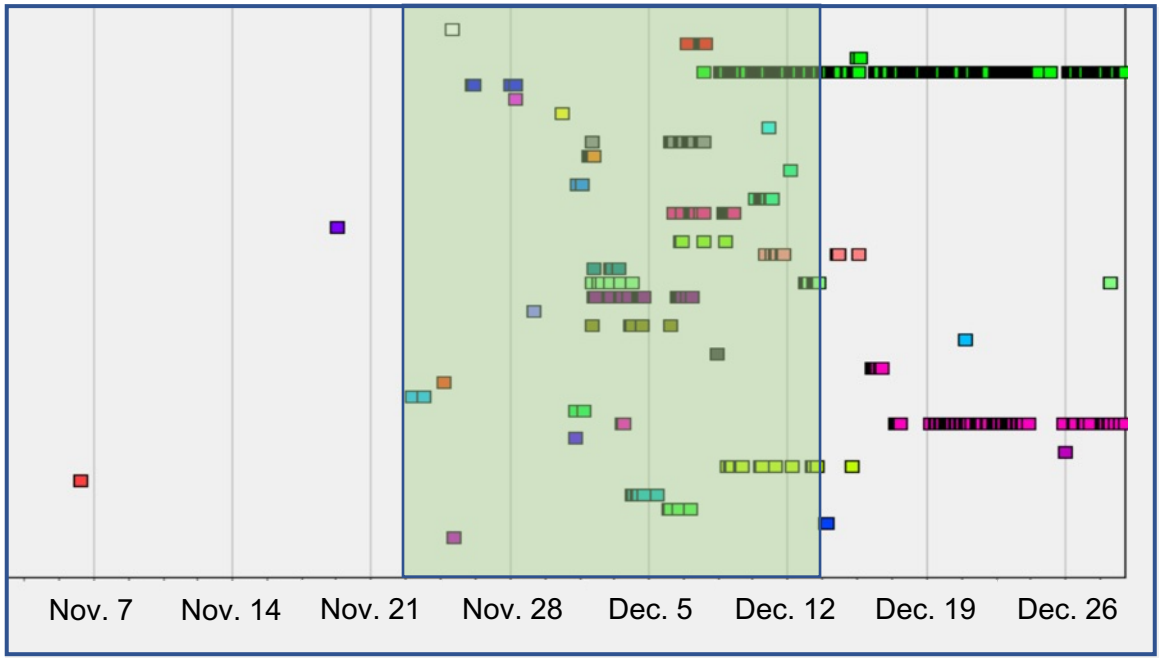


Tagging Highlights

- Flounder exit estuaries via diverse pathways
- Later migration than expected (mid-Nov – mid-Dec)

Abacus Plot for 2020 Tagging Season

Each row shows detection dates for one fish



PRELIMINARY RESULTS

Caitlin McGarigal

Tagging Highlights

- Flounder exit estuaries via diverse pathways
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- Several fish detected in hypothesized offshore spawning area
- More coastal, oceanic habitat use than expected

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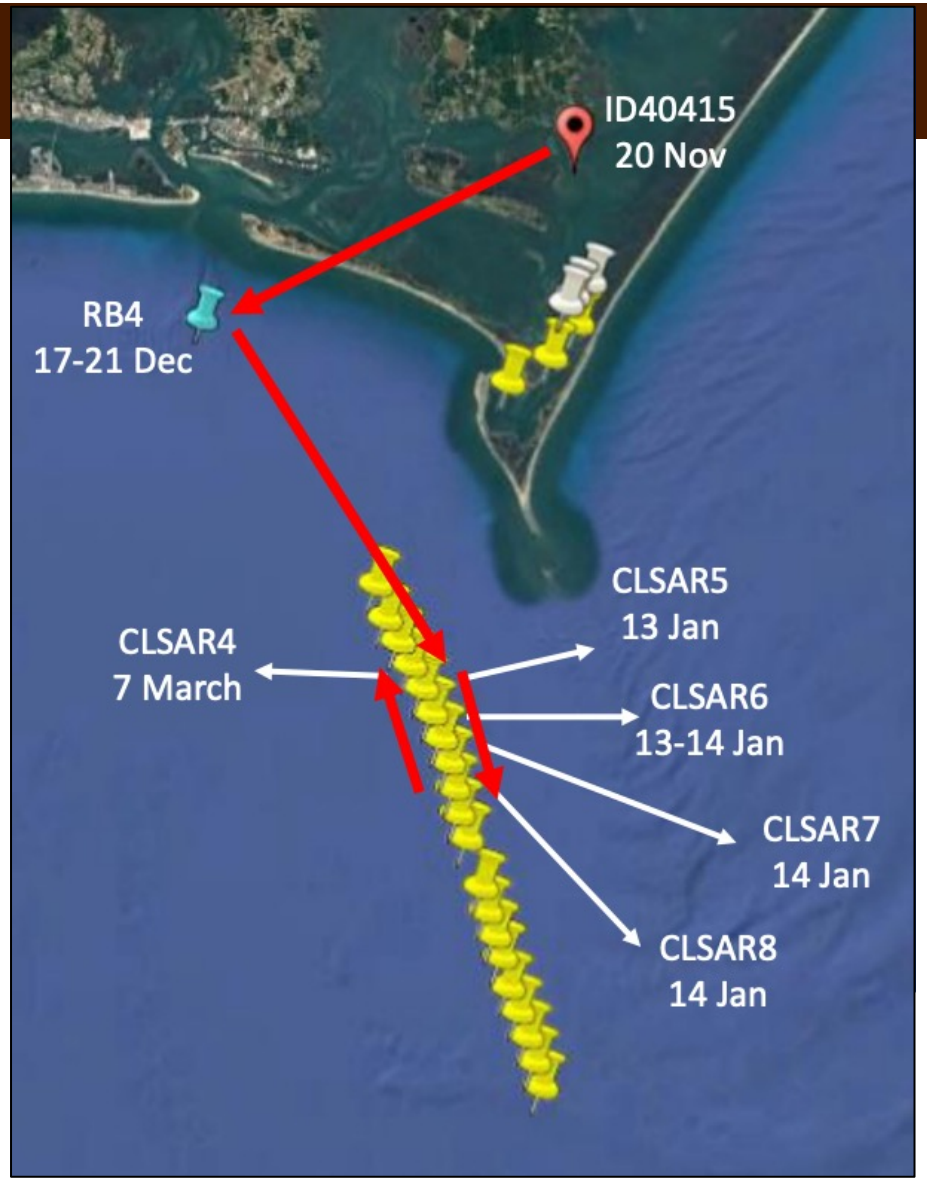

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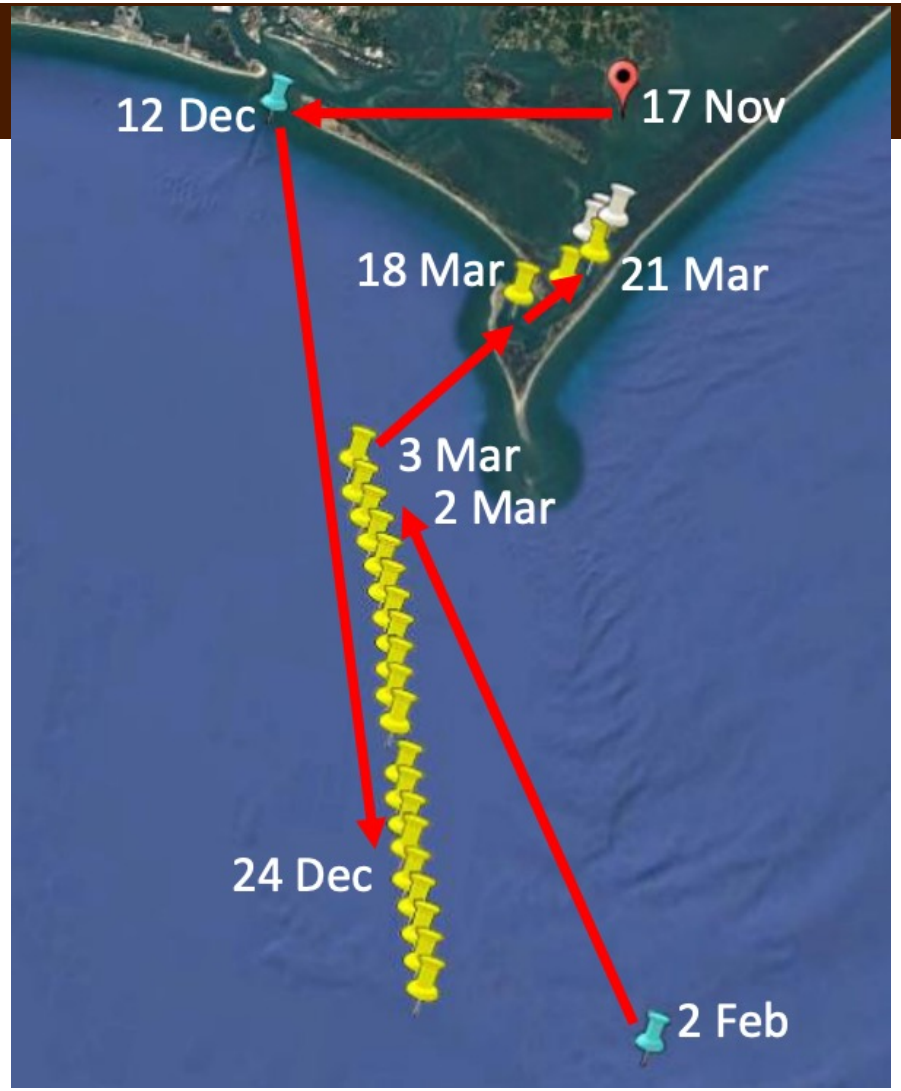
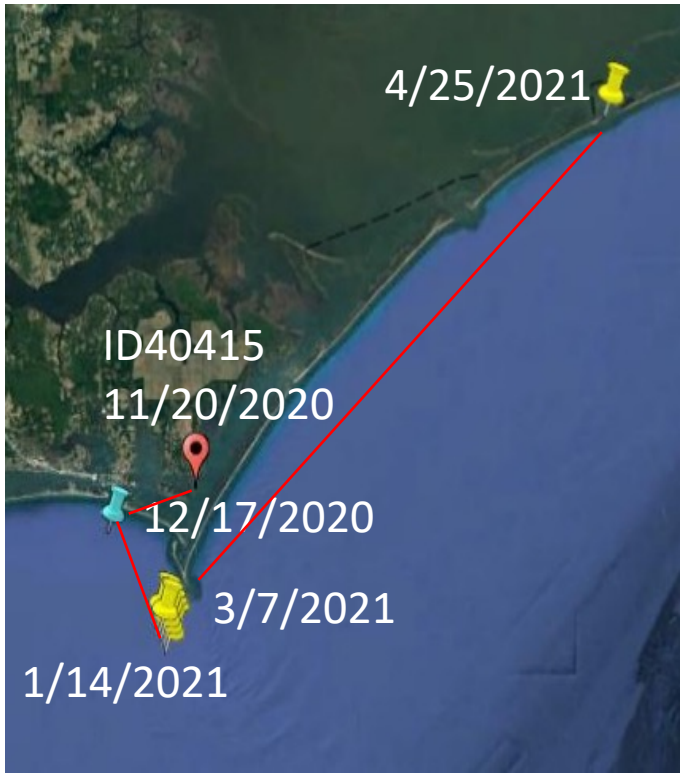
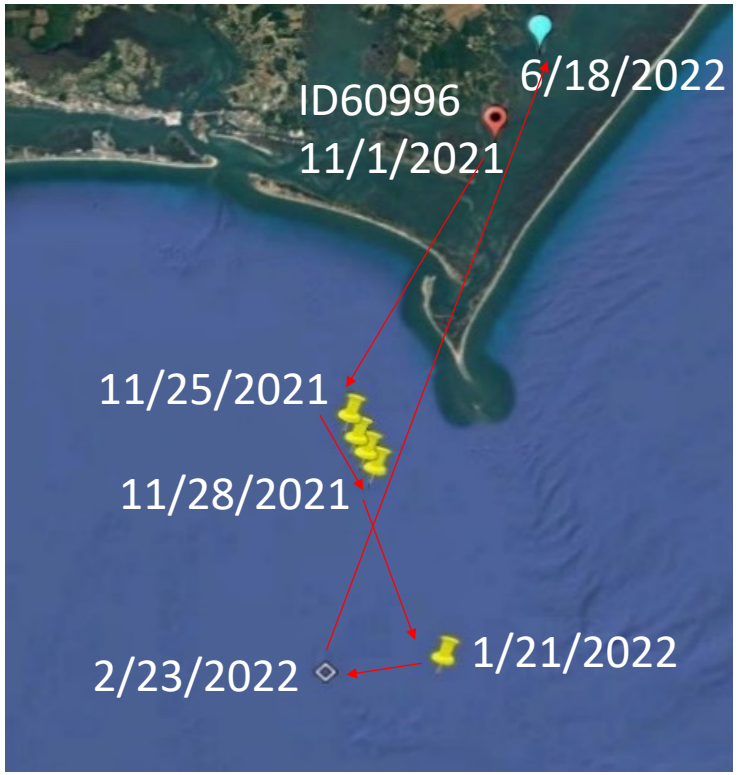


Caitlin McGarigal

Tagging Highlights – Additional Examples of Return Migrations





Caitlin McGarigal

PRELIMINARY RESULTS

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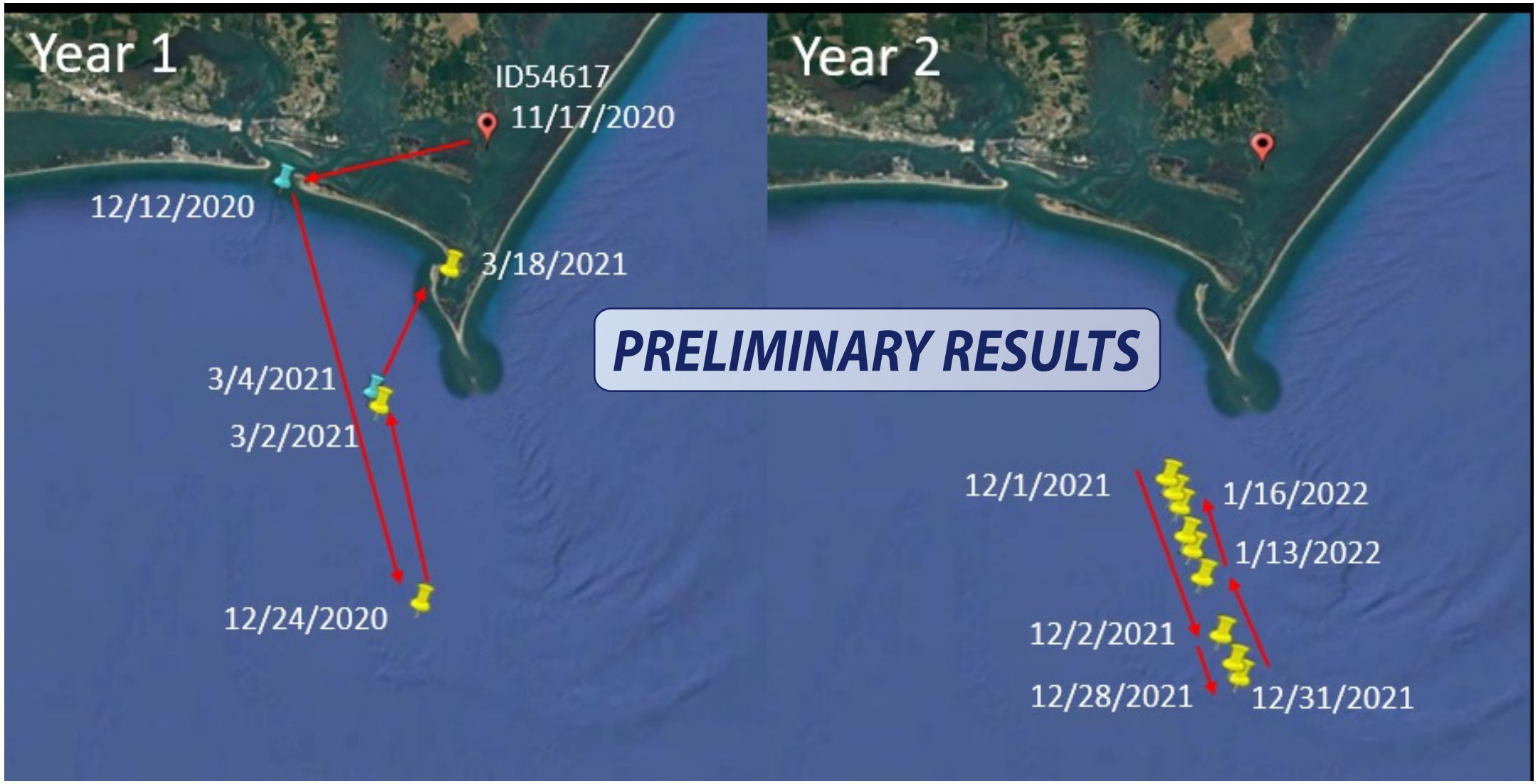

Caitlin McGarigal

Tagging Highlights

- Flounder exit estuaries via diverse pathways
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- Several fish detected in hypothesized offshore spawning area
- More coastal, oceanic habitat use than expected
- Some individuals return to North Carolina inlets
- Some fish overwinter near inlets

PRELIMINARY RESULTS

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Tagging Highlights

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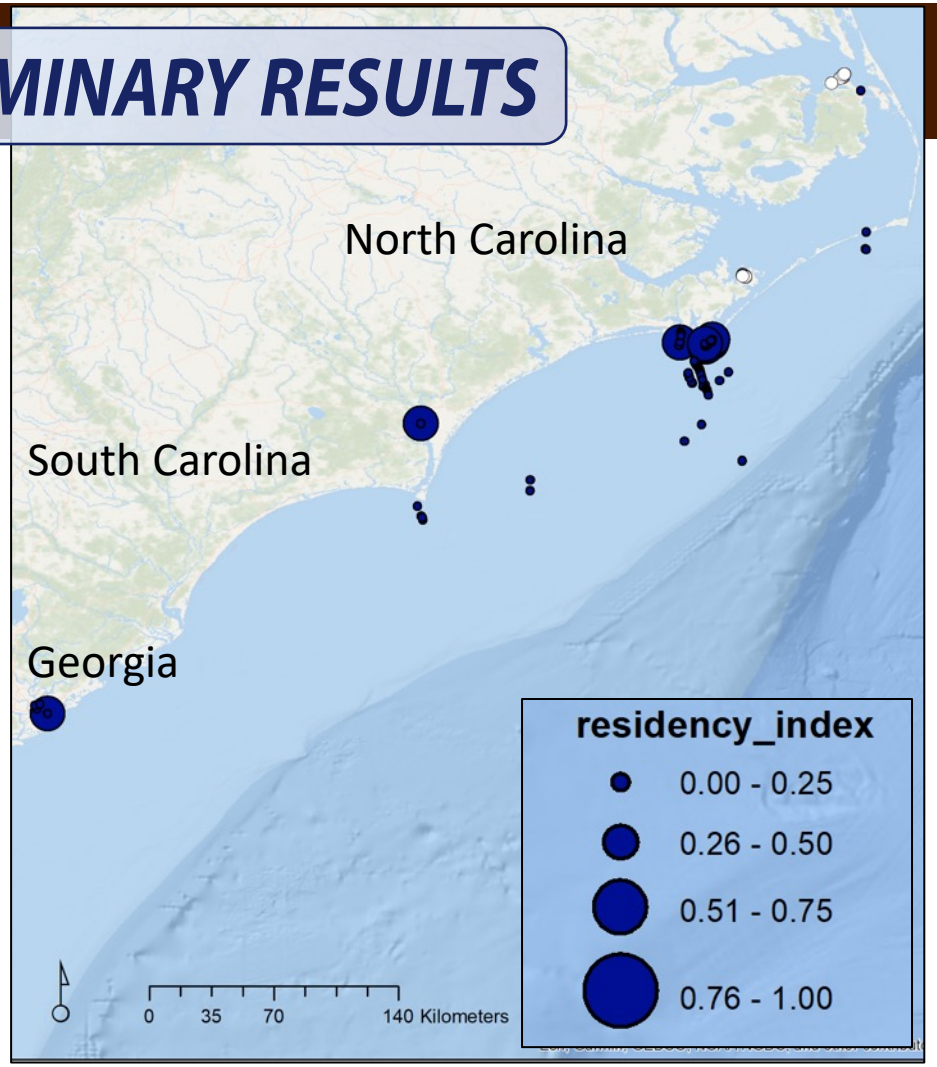
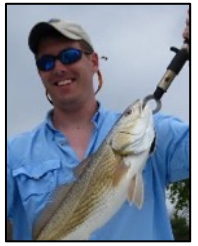
- Flounder exit estuaries via diverse pathways
- Later migration than expected
- Several fish detected in hypothesized offshore spawning area
- More coastal, oceanic habitat use than expected
- Some individuals return to North Carolina estuaries
- Some fish overwinter near inlets
- Others migrated south to Onslow Bay, Winyah Bay & Savannah, GA

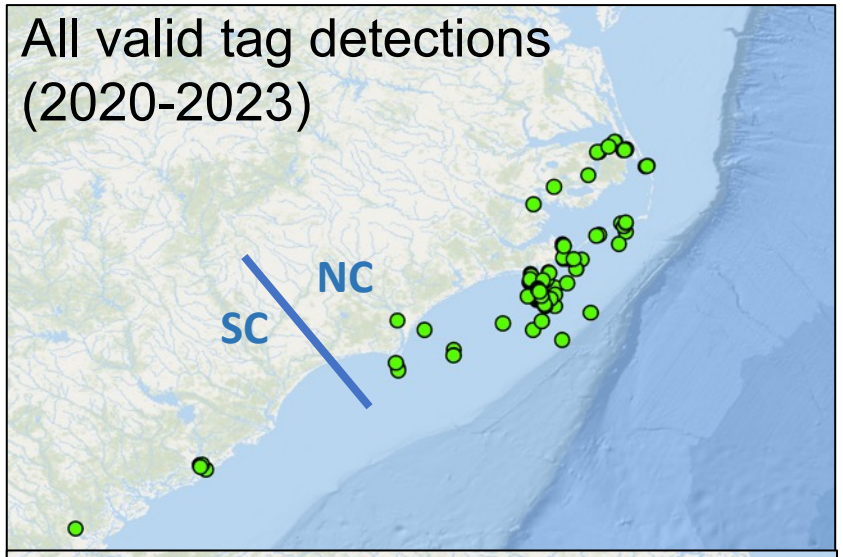


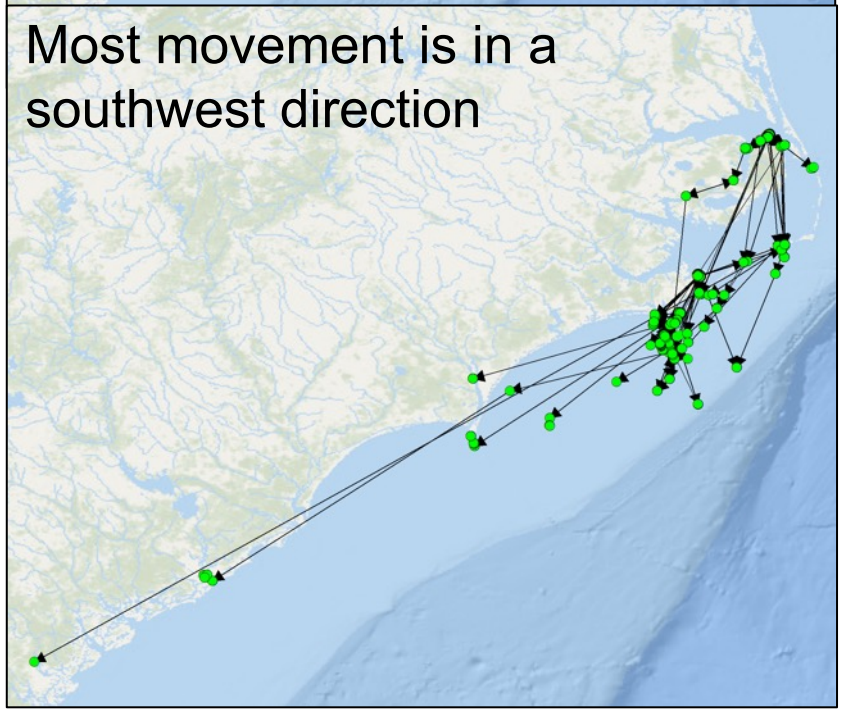
Joe Luczkovich

Tyler Peacock

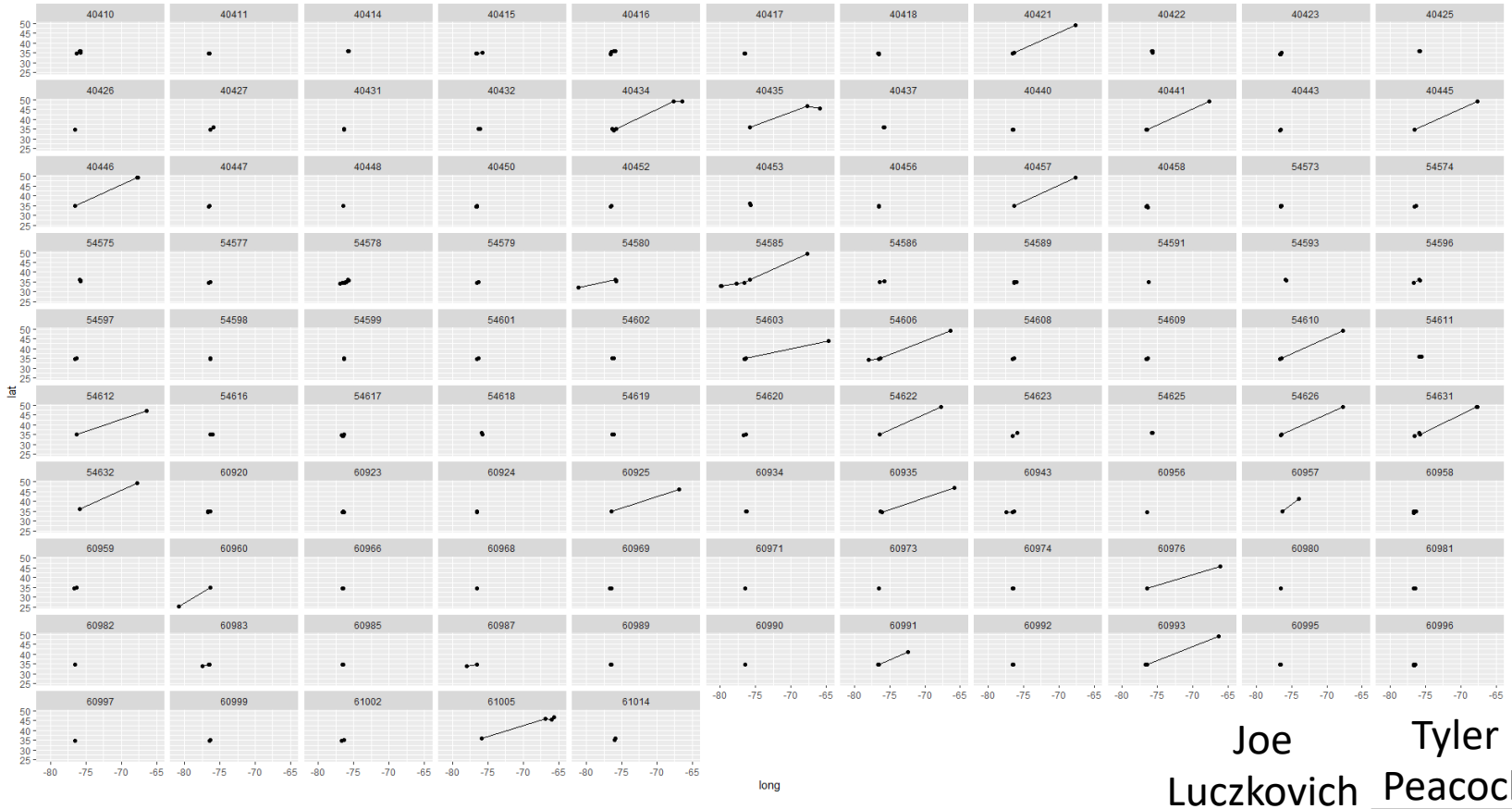


Tagging Highlights – Ongoing Synthesis of Patterns





But the collective movement patterns among fish indicate the majority of fish move very little



PRELIMINARY RESULTS

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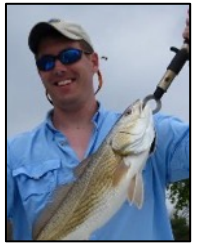
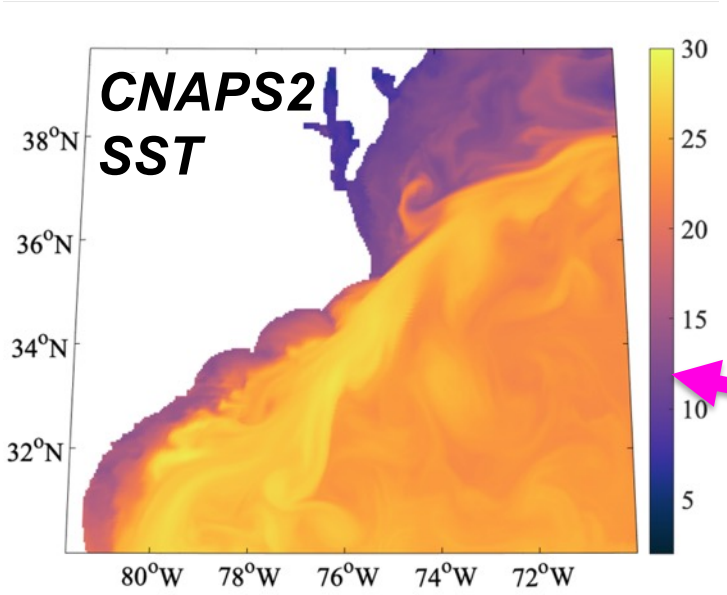


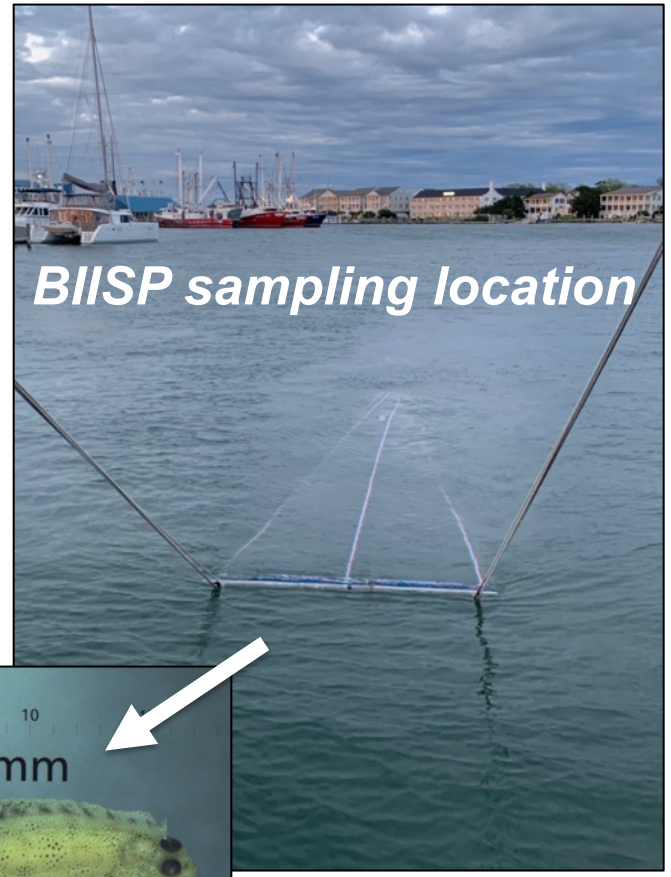
Larval Dispersal Modeling

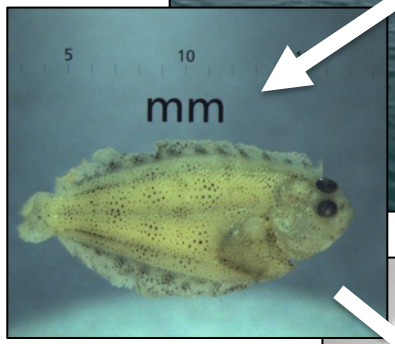
Methods

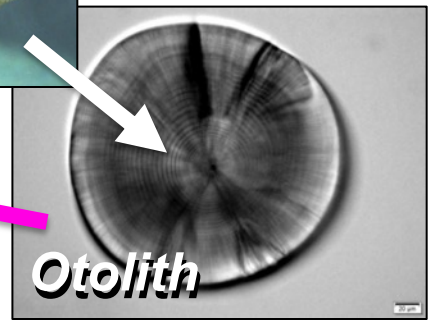
- Estimate larval flounder ages from Beaufort Inlet Ichthyoplankton Sampling Program (BIISP)
- Backward tracking of larvae with Connectivity Modeling System (CMS)
- Coupled Northwest Atlantic Prediction System 2 (CNAPS2) – daily data at 4-km resolution
- Runs for 2005-2006 & 2018-2020 during days when flounder were sampled

Brian Bartlett



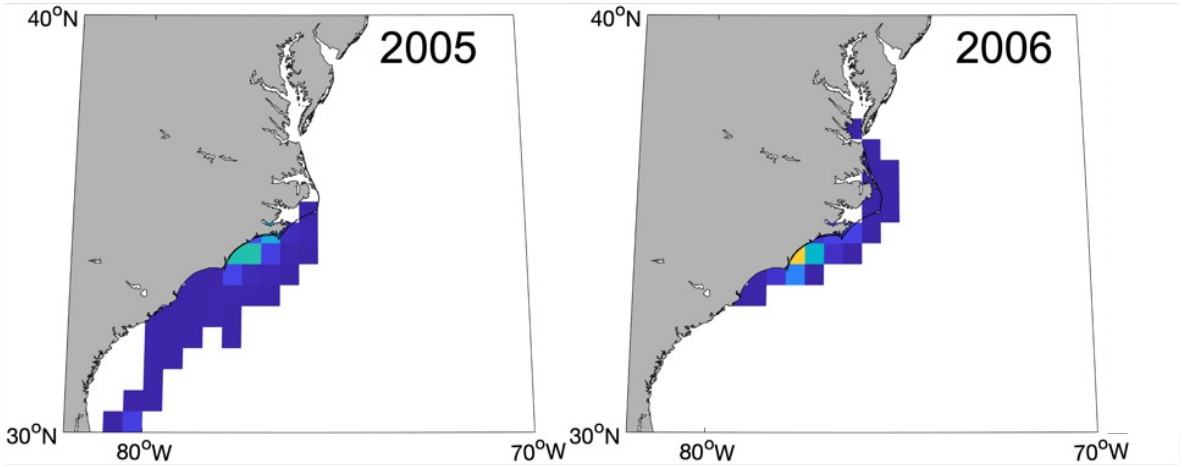


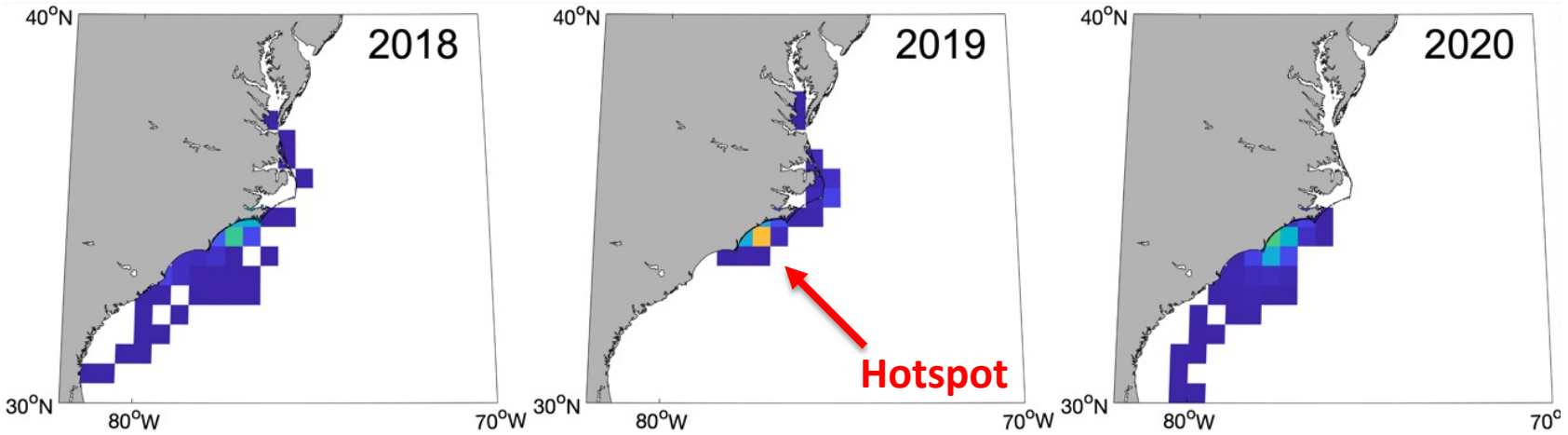


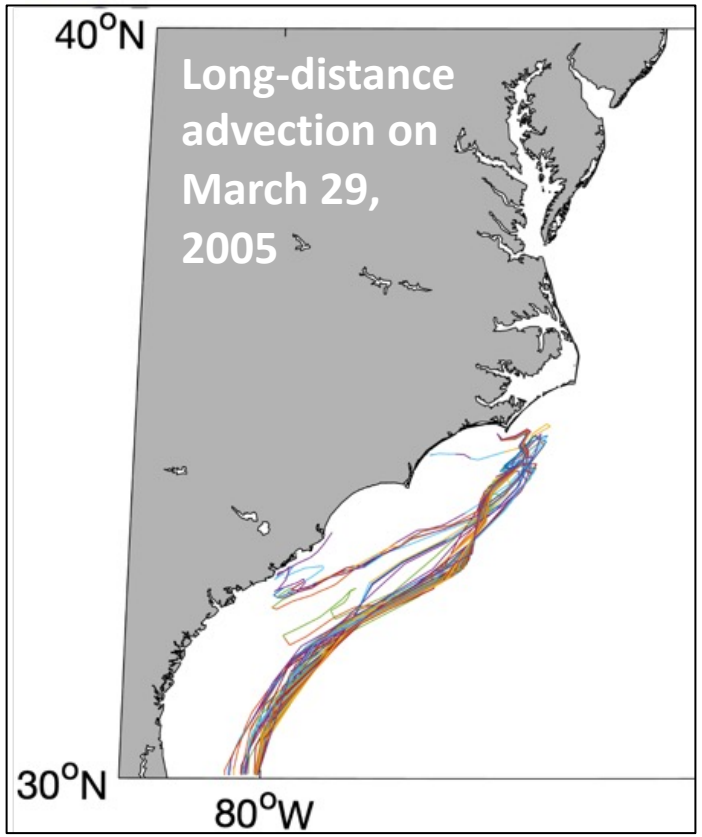


Probability of Larval Origin Based on Dispersal Model

Brian Bartlett







Where do larvae come from?

PRELIMINARY RESULTS

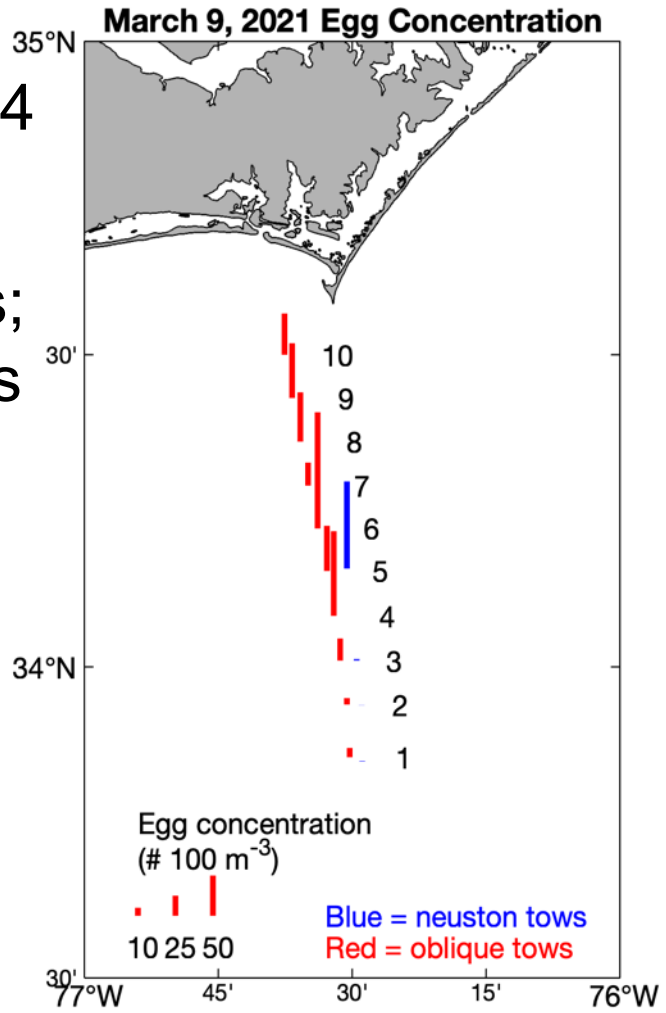
- Interannually consistent hotspot in south Onslow Bay near the coast
- Episodic connectivity across longer distances

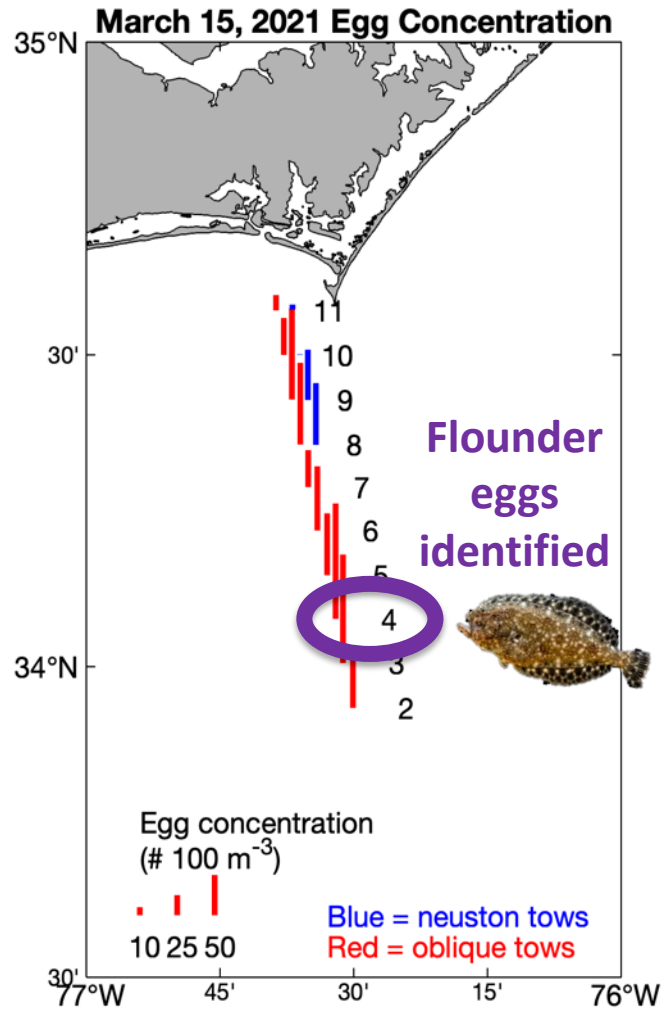
Offshore Egg Surveys to Identify Spawning Grounds

Paul Salib

PRELIMINARY RESULTS

- Two cruises in Mar 2021;
  Four cruises in Feb/Mar 2022
- 58 samples collected in Year 1; 54 samples in Year 2
- >4,000 fish eggs in 2021 samples;
  Projected >6,000 in 2022 samples
- DNA barcoding of CO1 gene





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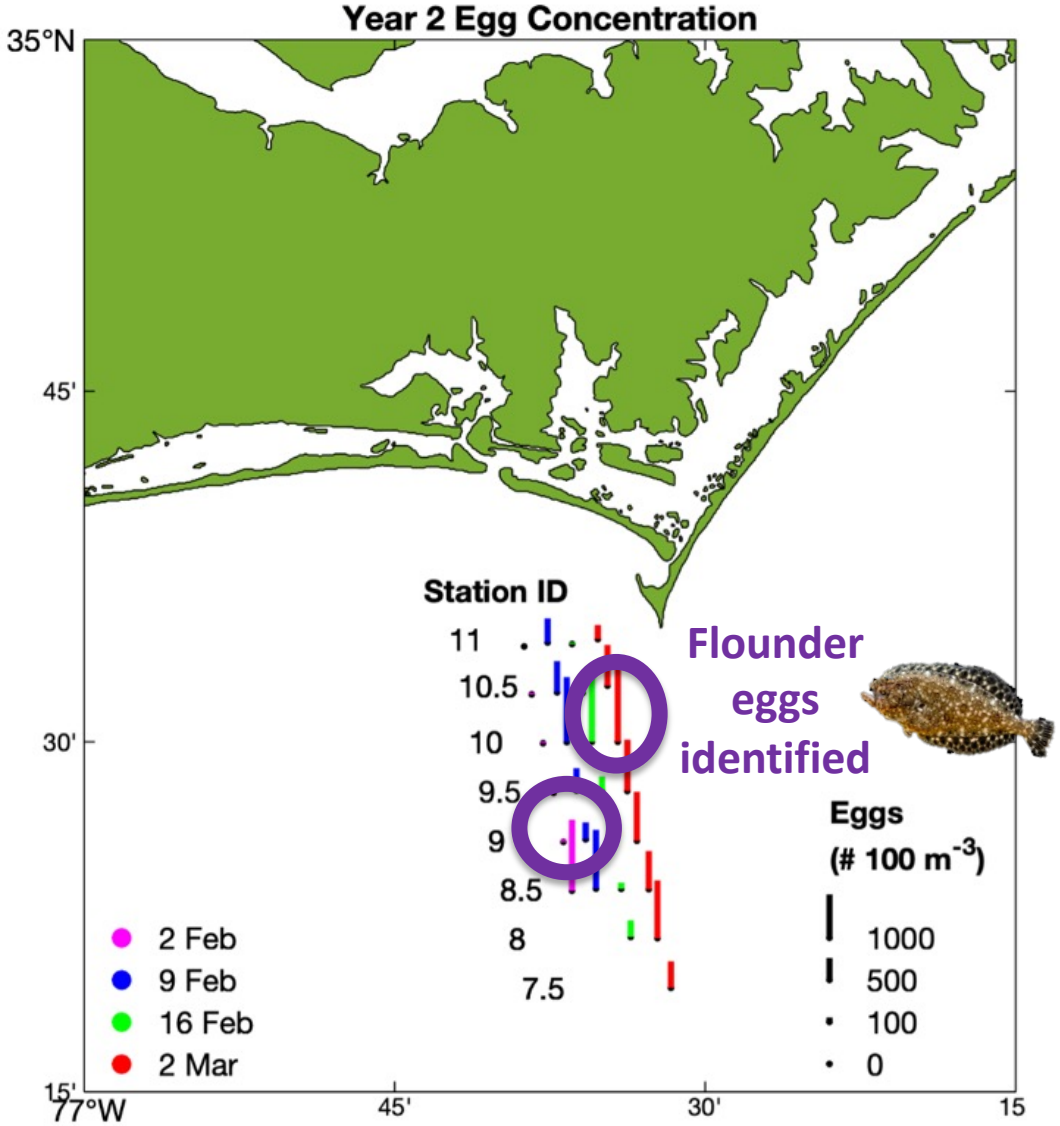
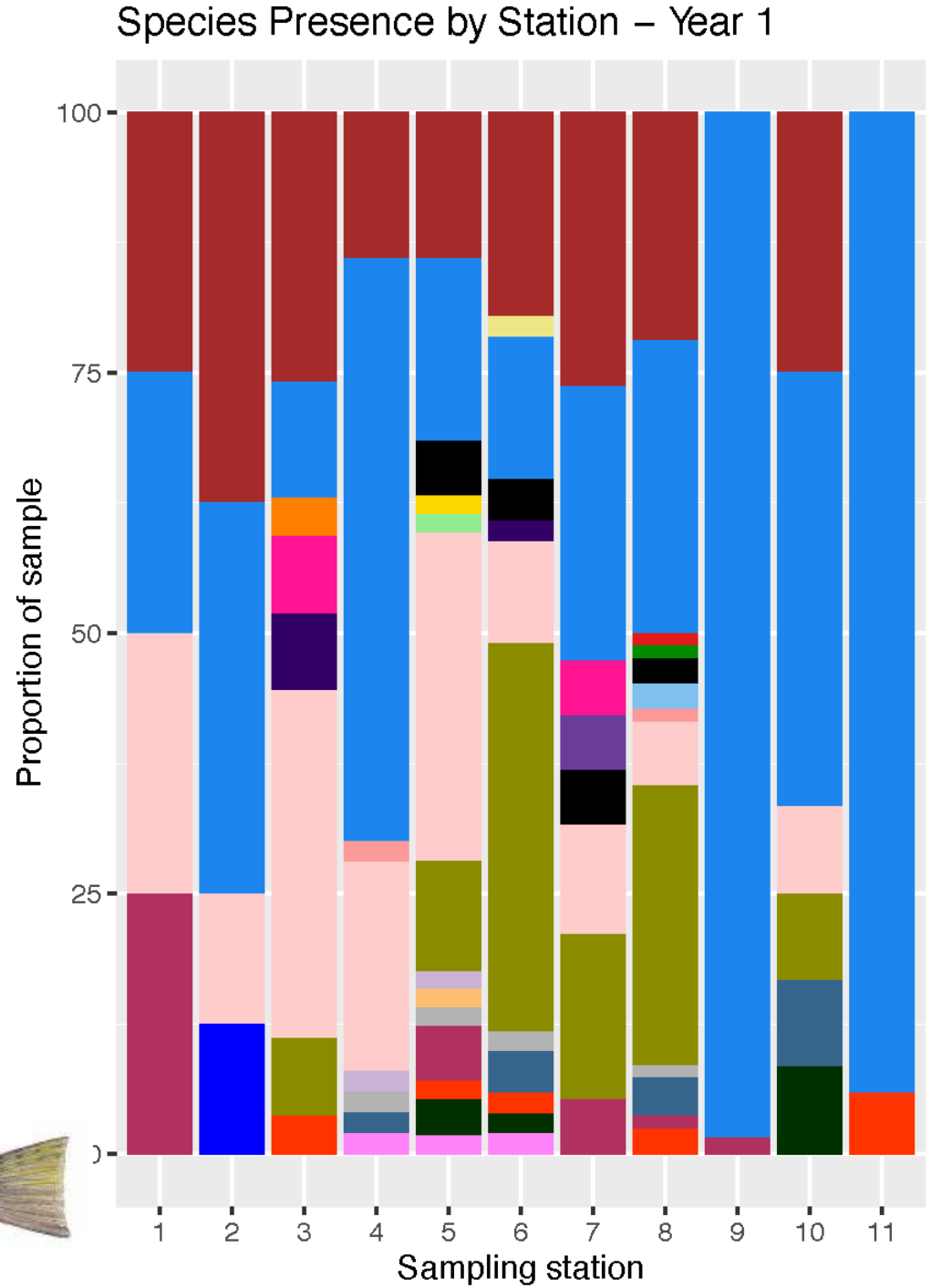


Egg survey also revealed patterns of hidden biodiversity

Spottail pinfish

Searobins



Paul Salib

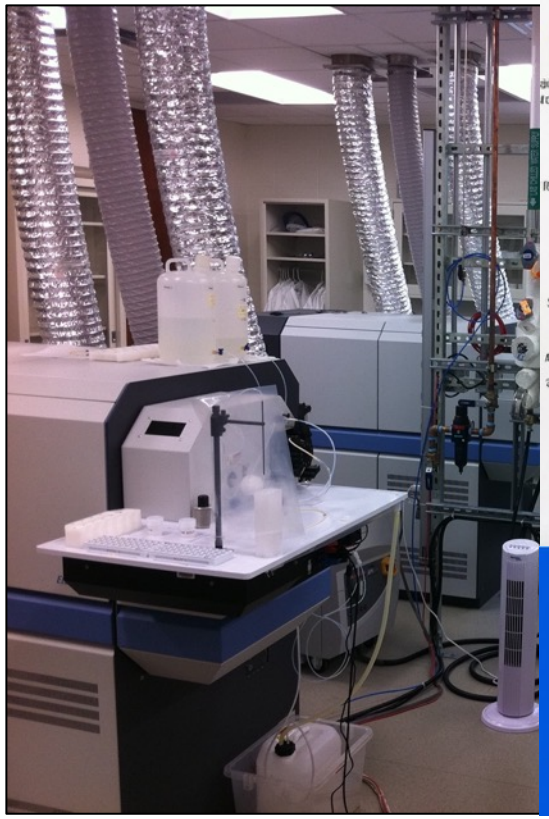
Species

- Actinopterygii
- Calamus leucosteus
- Diplodus holbrookii
- Diretmichthys parini
- Echiophis punctifer
- Epinephelus morio
- Gymnachirus nudus
- Kathetostoma albigutta
- Ophichthidae
- Pagrus pagrus
- Paralichthys albigutta
- Paralichthys dentatus
- Paralichthys lethostigma
- Pareques umbrosus
- Prionotus carolinus
- Prionotus evolans
- Prionotus martis
- Prionotus ophryas
- Prionotus roseus
- Prionotus rubio
- Prionotus scitulus
- Stenotomus chrysops
- Synodus foetens
- Synodus intermedius
- Trachinocephalus myops

PRELIMINARY RESULTS

Using Chemistry to Reveal Past Migration Histories

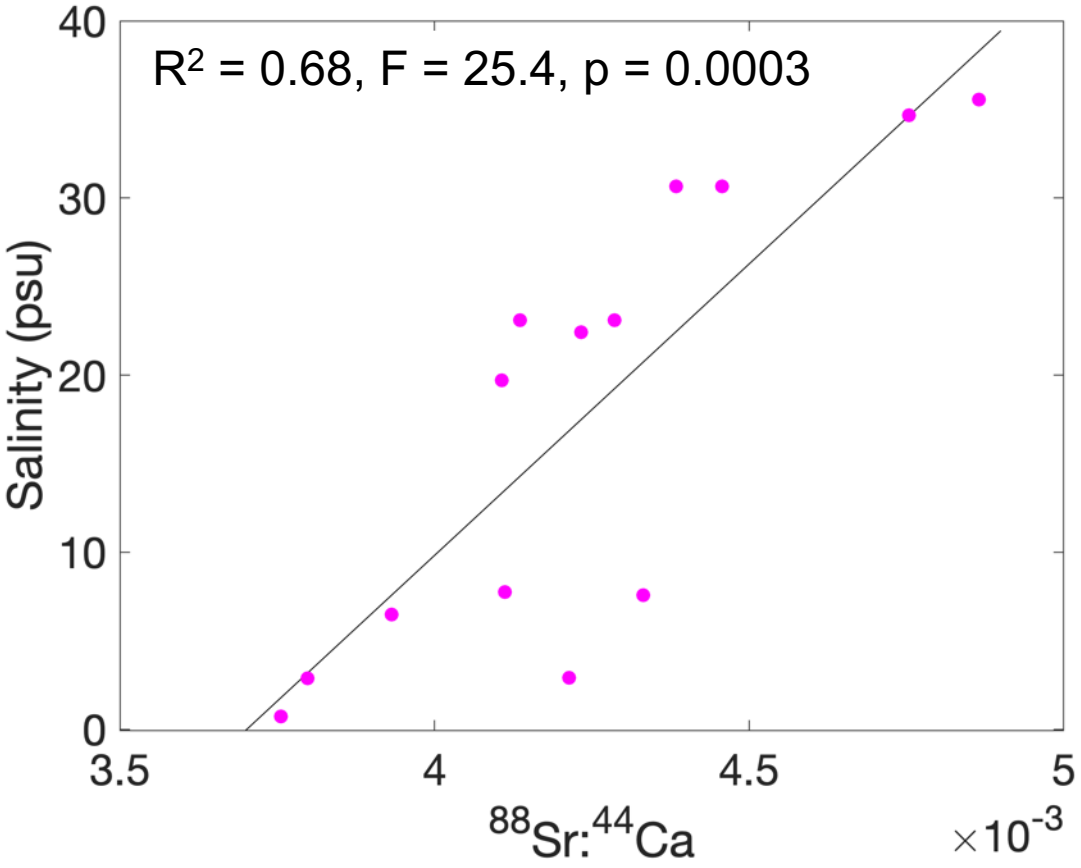
- Otoliths (fish ear bones) form ***daily growth rings***
- Otoliths are mainly made of calcium carbonate, but they incorporate small amounts of ***other chemicals***
- This reflects characteristics of the waters ***where fish reside***
- Examined otoliths from ***298 fish*** for ^{24}Mg, ^{25}Mg, ^{43}Ca, ^{44}Ca, ^{55}Mn, ^{88}Sr, ^{137}Ba, and ^{138}Ba
- Chemical analyses performed by Nathaniel Miller from ***University of Texas – Austin***



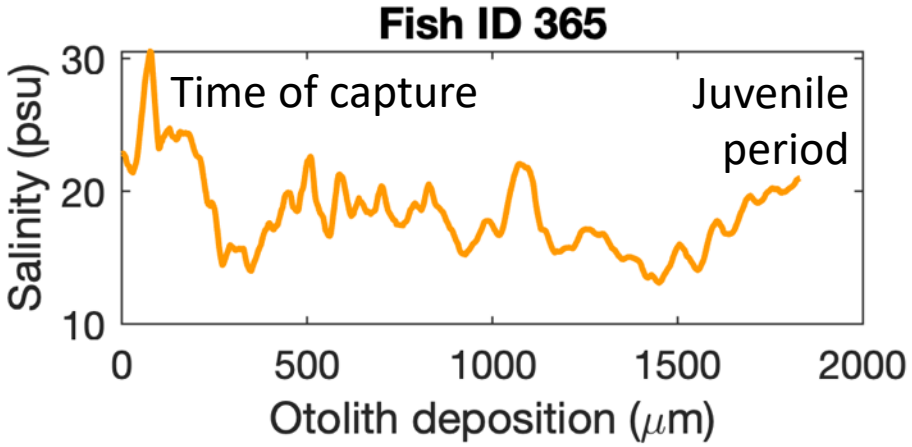
Instrumentation used for Laser Ablation – Inductively Coupled Plasma - Mass Spectrometry (LA-ICP-MS) at UT Jackson School of Geosciences

- ***Alternative title:*** Shooting lasers at fish to know their darkest secrets. ***Science is magic!***

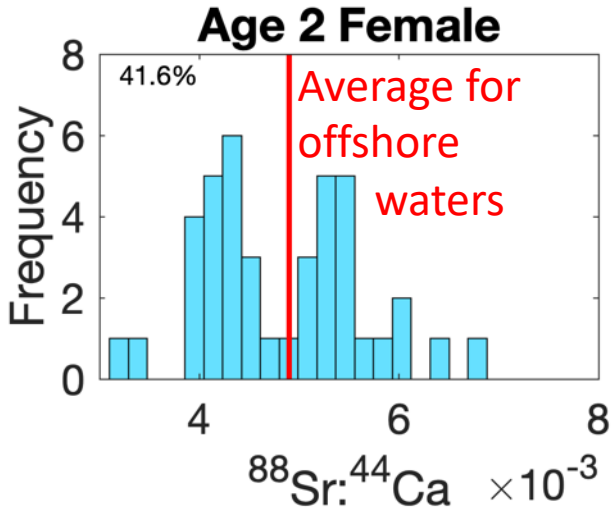
Using Chemistry to Reveal Past Migration Histories

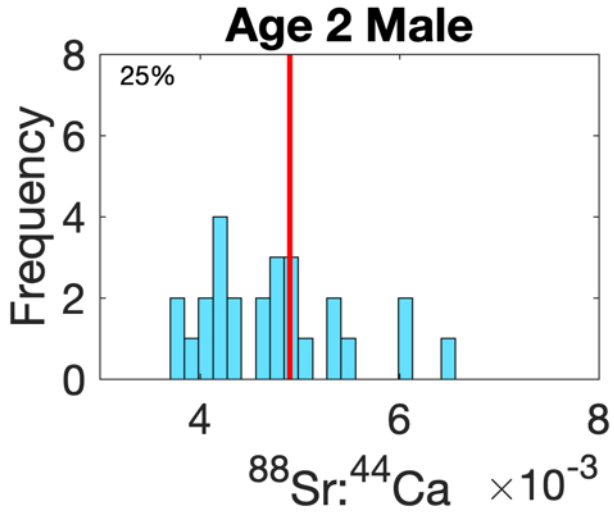


$^{88}Sr:^{44}Ca$ ratios reflect salinities used by fish



First time arriving at an inlet



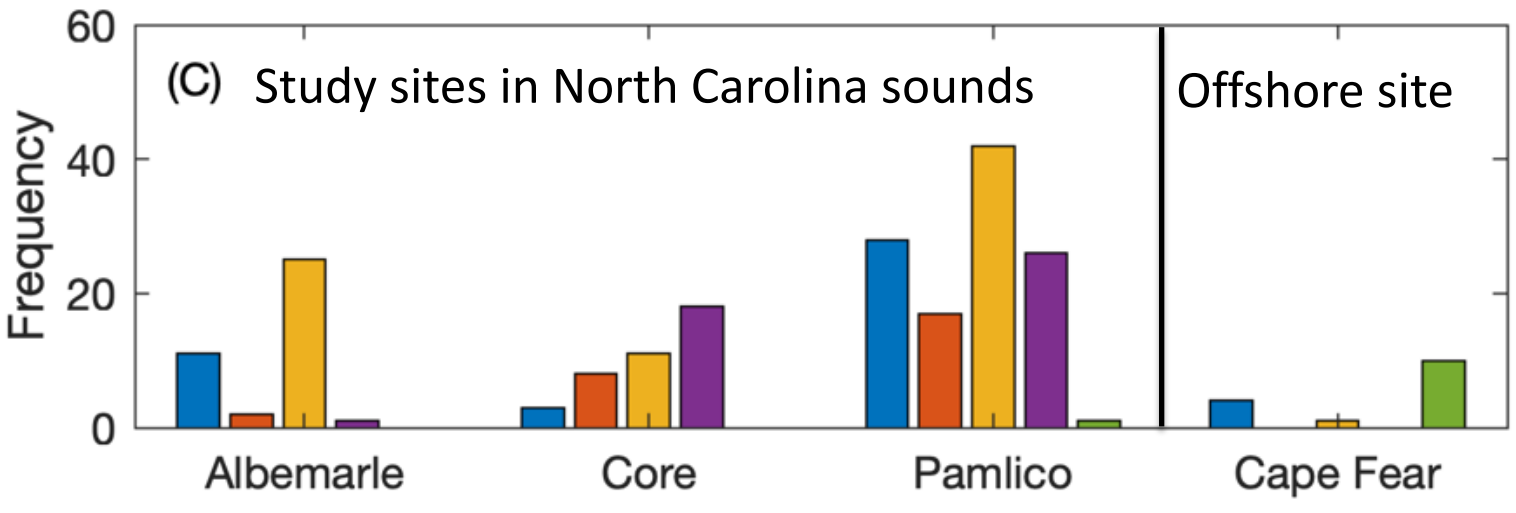


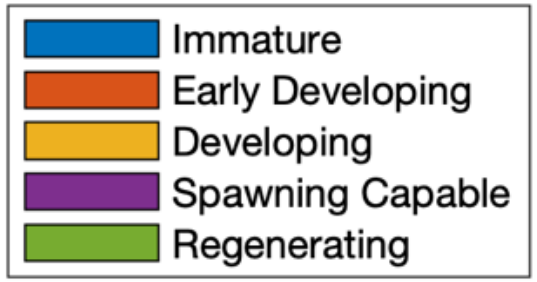
Justin Mitchell

PRELIMINARY RESULTS

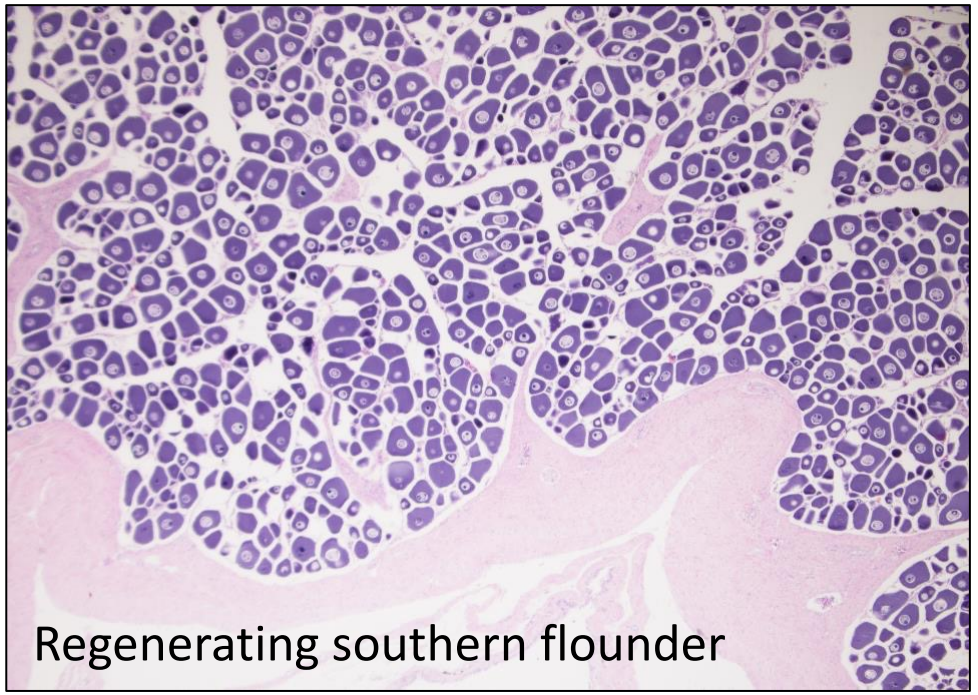
Fish with Regenerating Ovaries Found Primarily Offshore

Jevon Smalls



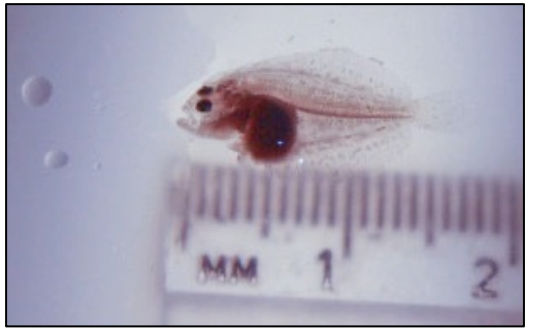


PRELIMINARY RESULTS

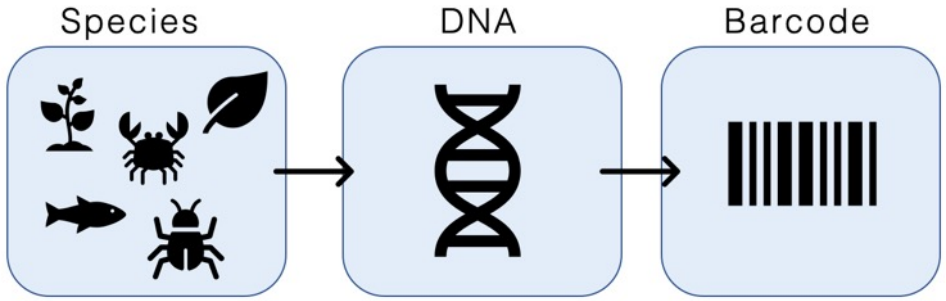


Please Check Out Our Posters to Learn More!

Poster presenter: Brian Bartlett
Title: Potential southern flounder spawning locations identified with particle dispersal modeling



Poster presenter: Paul Salib (presented by me)
Title: Identification of the spawning grounds of the North Carolina stock of southern flounder using the barcode of life



Poster presenter: Tyler Peacock
Title: Migratory behavior patterns of southern flounder in North Carolina

Conclusions

PRELIMINARY RESULTS

- Flounder exit estuaries through ***diverse pathways***
- Fish have been detected around a hypothesized spawning area at the edge of the ***continental shelf,*** but spend substantial time in ***coastal, oceanic waters***
- Diverse offshore spawning areas also indicated by ***DNA barcoding***
- Some adults ***overwinter near inlets,*** while others have been detected to ***migrate southward or return to North Carolina inlets*** shortly after migrating offshore
- Otolith microchemistry and microscopic examination of ovaries both suggest ***many, but not all fish, stay offshore after spawning***
- ***Larval dispersal modeling*** detected a potential spawning ***hotspot*** in southern Onslow Bay, with periodic connectivity across greater spatial scales