

# Forage Fish Energetics in Coastal Maine Habitats to Support Ecosystem-based Management

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# Part of Broader Foraging Ecology Study



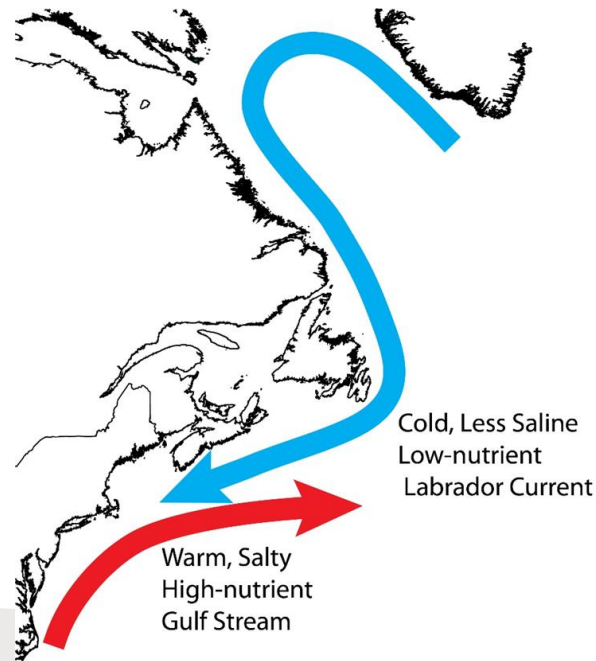
## *“Evaluating the foraging ecology of Striped Bass in Maine waters”*

- Stomach content analysis
  - Cooperative research with local fishermen
- Stable isotope analysis
- **Prey energetic content analyses**



# The Gulf of Maine (GoM)

- Northwest Atlantic Ocean
- Spans from Cape Cod, MA to Nova Scotia, Canada
- Historical intersection between **cold water from the Labrador Current** and **warm water from the Gulf Stream**
- Experiencing some of the most intense warming in the world

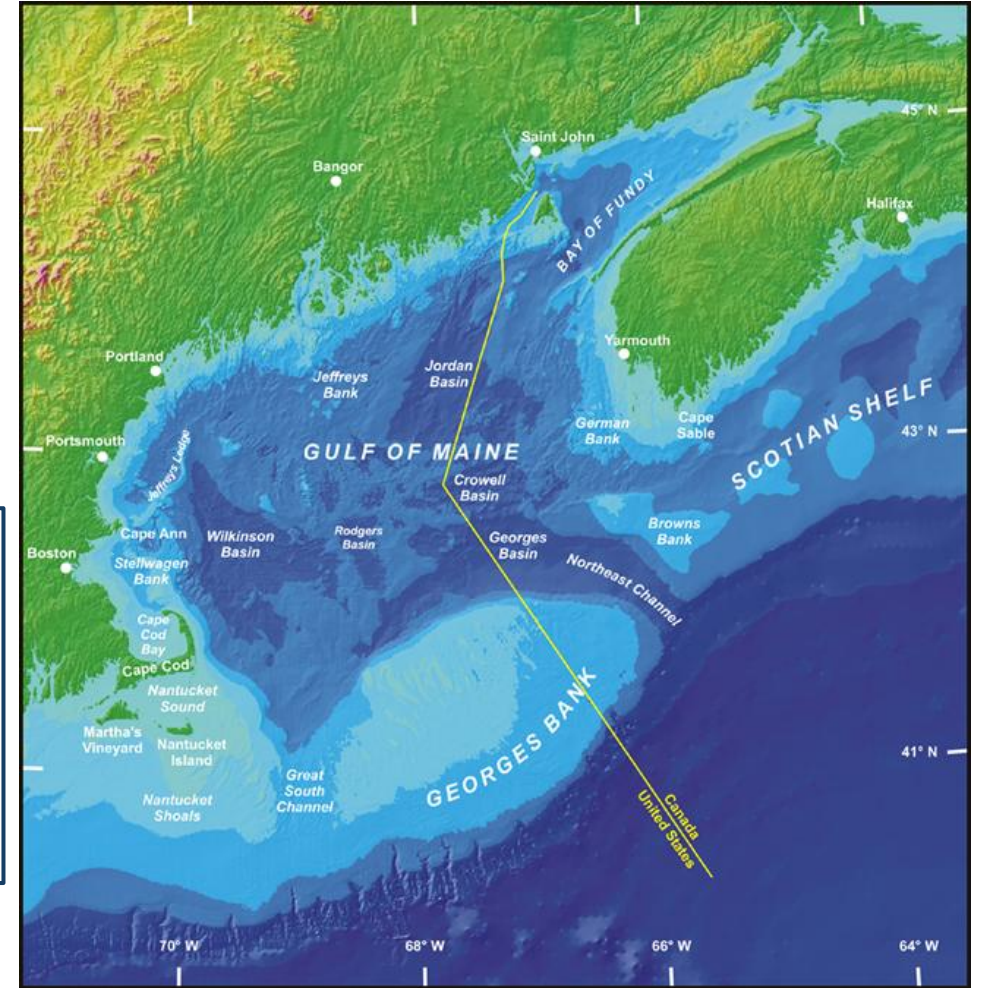


Changes in water mass fluxes

- ❖ Labrador Current = weaker
- ❖ Gulf Stream = northern shift 2011-2024

Bathtub theory

- ❖ Relatively shallow
- ❖ Fed by 60+ rivers
- ❖ Partially enclosed by Georges Bank



Map of the Gulf of Maine. From New England Coastal Wildlife Alliance (NOAA).

# The Gulf of Maine (GoM)

- Currently projecting a **temporary pause in warming over the next decade**
  - **Slight southern shift** of the Gulf Stream (*Koul et al. 2024*)
  - Altering the interactions of...

The GoM is undergoing

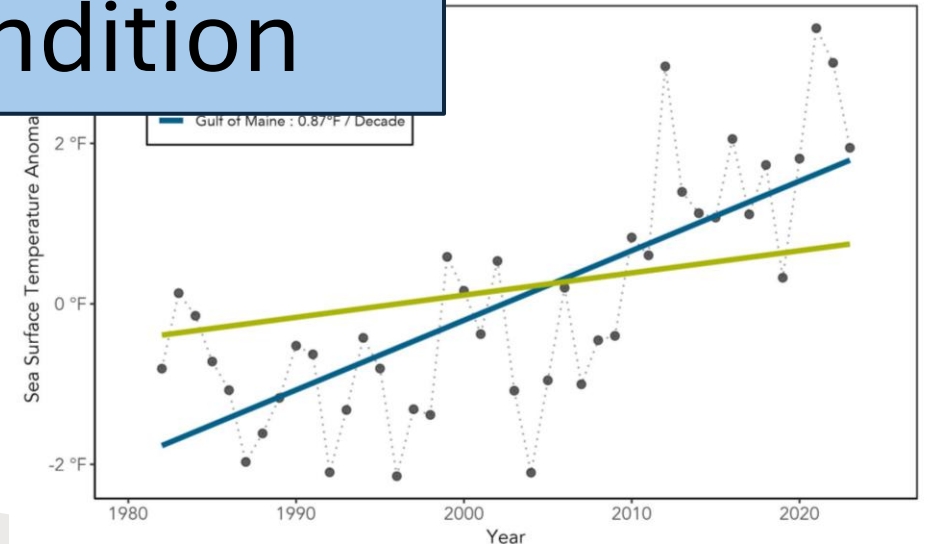
- Climate-induced s
  - ❖ Species distribution
  - ❖ Productivity (phytoplankton blooms, fish productivity)
  - ❖ Spawning timing
  - ❖ Migration timing
  - ❖ **Forage quality and abundance**

The quality of the forage base drives predator species productivity and condition



Credit: K. Cantner, American Geosciences Institute.

itions

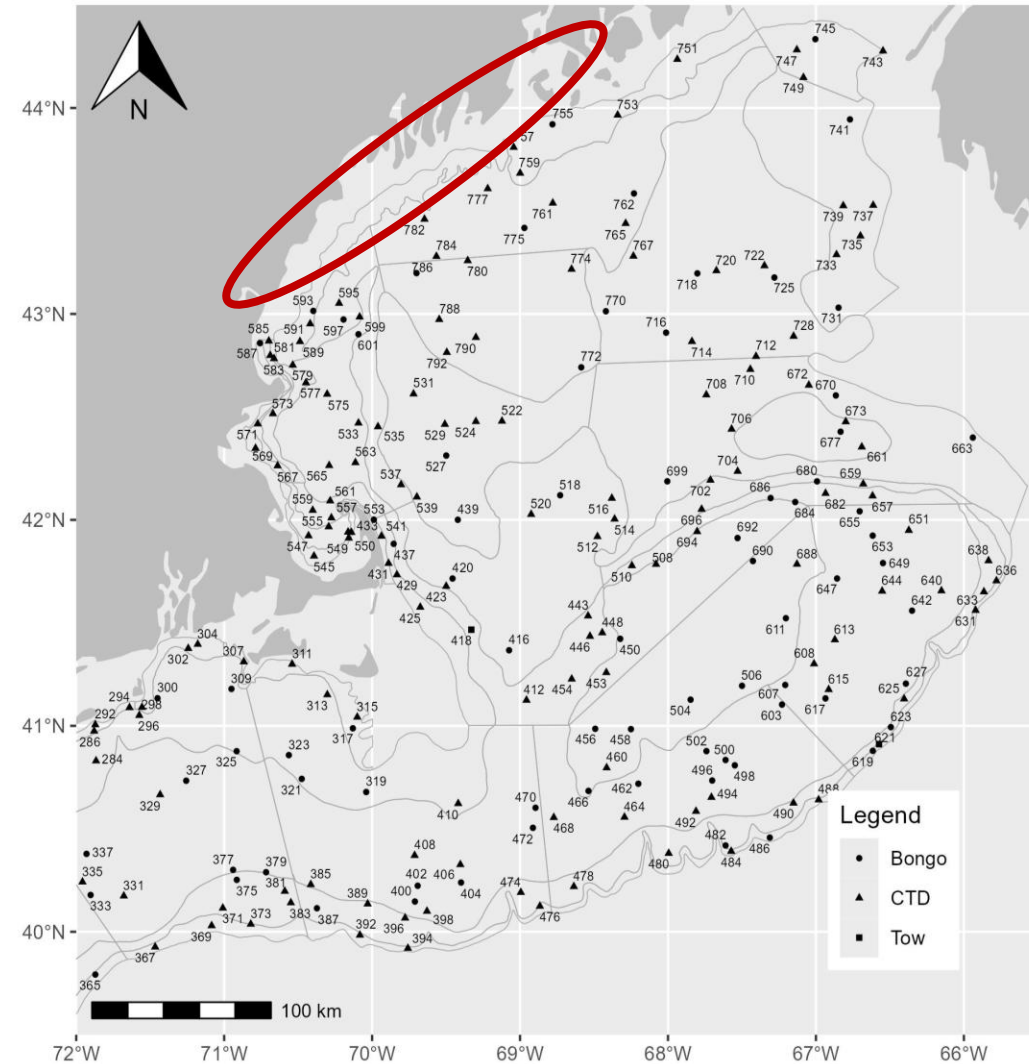


# Long-Term Monitoring: Forage Fish

- Annual State of the Ecosystem Report
  - Northeast US Ecosystem Indicator Catalog
  - Ch. 20: Forage Fish Energy Density
    - 8 forage species kJ/g wet weight
    - Emphasizes that continuous monitoring is necessary
- ✓ Offshore coverage of forage fish ED

## Lacking data on forage fish ED for inshore habitats

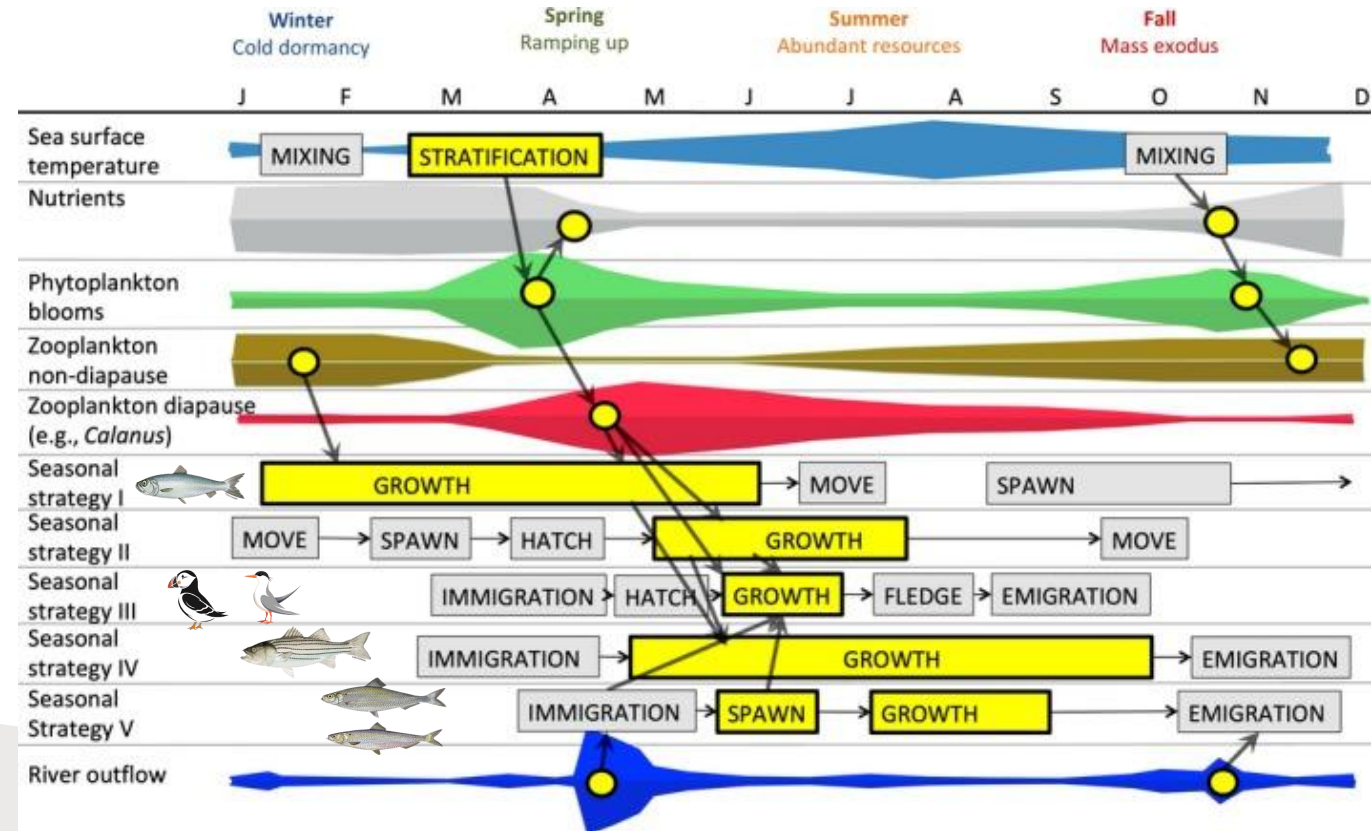
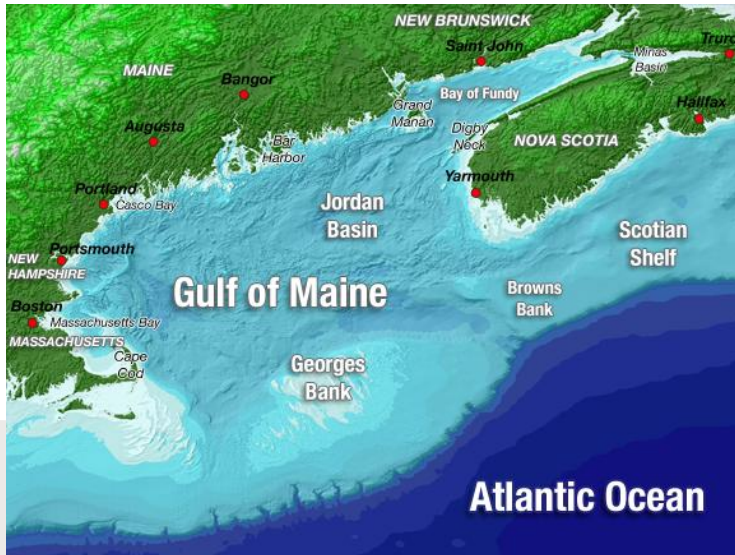
- ❖ **4 of the same species:** Alewife, Atlantic herring, Atlantic mackerel, longfin squid
- ❖ **3 new species:** American sand lance, Atlantic menhaden, Blueback herring



NEFSC Bottom Trawl Survey Stations

# GoM Ecological Importance

- Gulf of Maine is a **seasonal foraging hotspot** for ecologically and economically important species
- Strong seasonality impacts species phenology
- Quantity matters...but also quality!
- Forage fish nutritional quality → predator condition
  - Growth, reproductive success, energy storage, survival

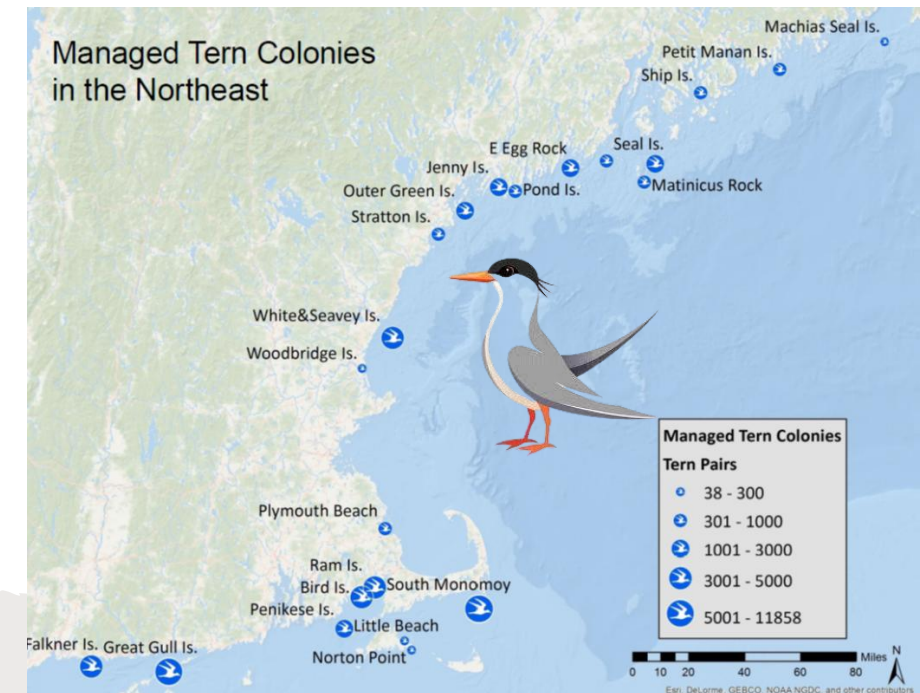
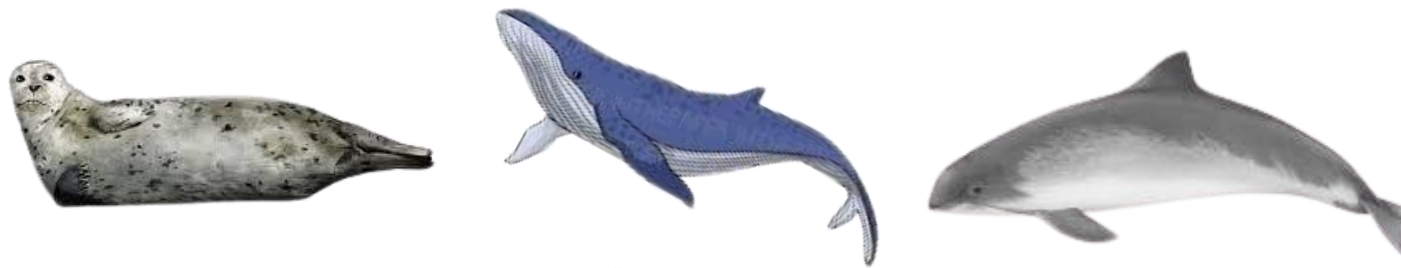
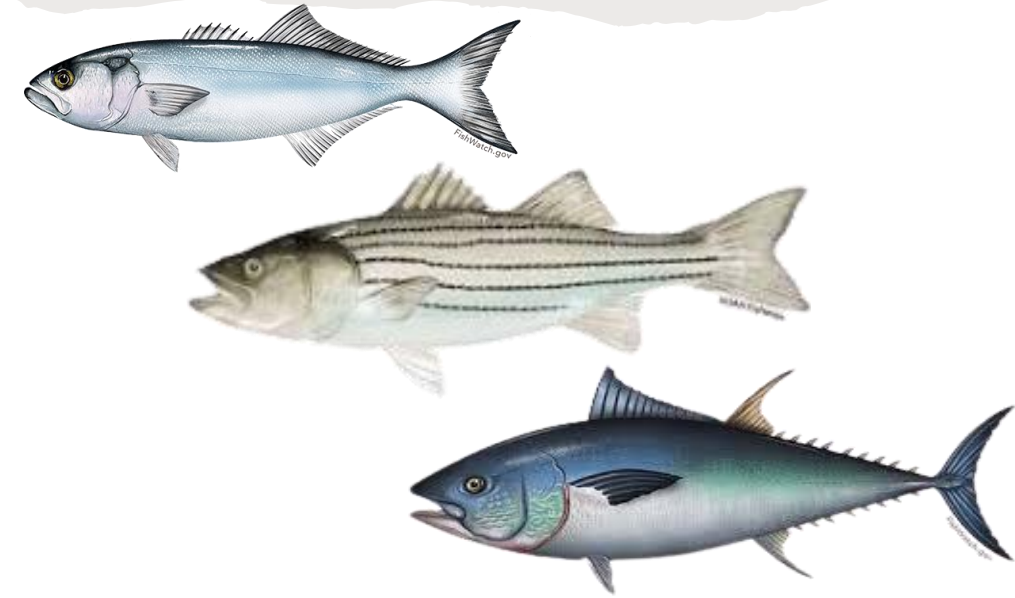


Staudinger et al. (2019). It's about time: A synthesis of changing phenology in the Gulf of Maine ecosystem. *Fisheries Oceanography*, 28(5), 532–566. <https://doi.org/10.1111/fog.12429>.

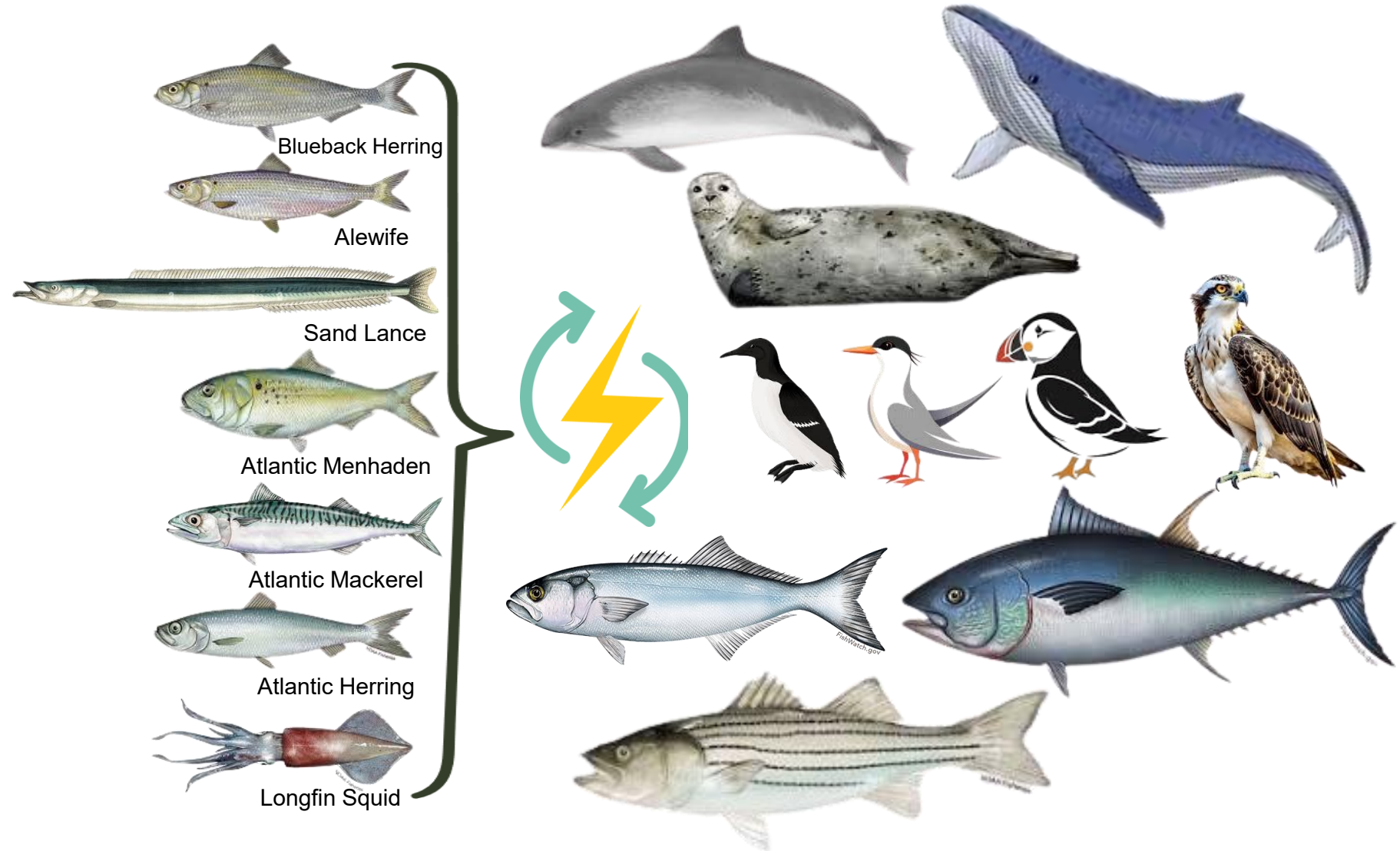
# Predatory Demand

*WHAT PREDATORS RELY ON AVAILABLE FORAGE?*

- **Recreationally and commercially important migratory fishes** (e.g., bluefish, striped bass, Atlantic bluefin tuna)
- **Marine seabirds** to support coastal breeding colonies
- **Large pelagic predators** (sharks, marine mammals) during summer feeding periods

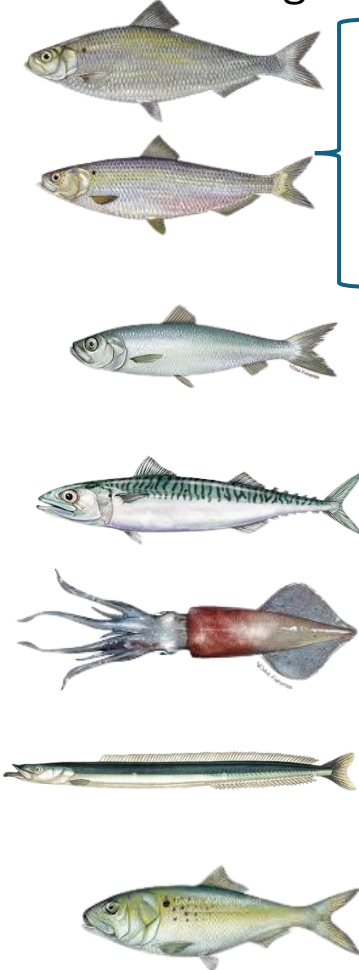


# Research Objective: Quantify temporal and size-based variation of inshore GoM forage fish energy density



# Species Introduction

River herring



Species	Population Status	Spawning Season	Fishery	Notes
Alewife	Depleted	Spring	<b>Commercial / Recreational</b>	Anadromous
Blueback Herring	Depleted	Spring	<b>Commercial / Recreational</b>	Anadromous
Atlantic Herring	Overfished	Spring / Fall Contingents	<b>Commercial</b>	Recent declines in condition (size)
Atlantic Mackerel	Healthy	Spring/Summer	<b>Commercial / Recreational</b>	Move inshore in summer
Longfin	Healthy	Spring	<b>Commercial / Recreational</b>	Move inshore in summer
American eel	Healthy	Spring	<b>Commercial / Recreational</b>	Strictly marshore or estuarine
Atlantic Menhaden	<i>Healthy</i>	Fall	<b>Commercial / Recreational</b>	Managed with EBFM

Managed with ecological reference points (ERPs) to **account for their role in the ecosystem**



# Methods: *Field*

## Prey sample collection:

- Biweekly beach seining
- ME-NH seasonal trawl survey
- Stomach contents
- Dropped seabird prey
- Hook and line (e.g. sabiki)



Beach seine



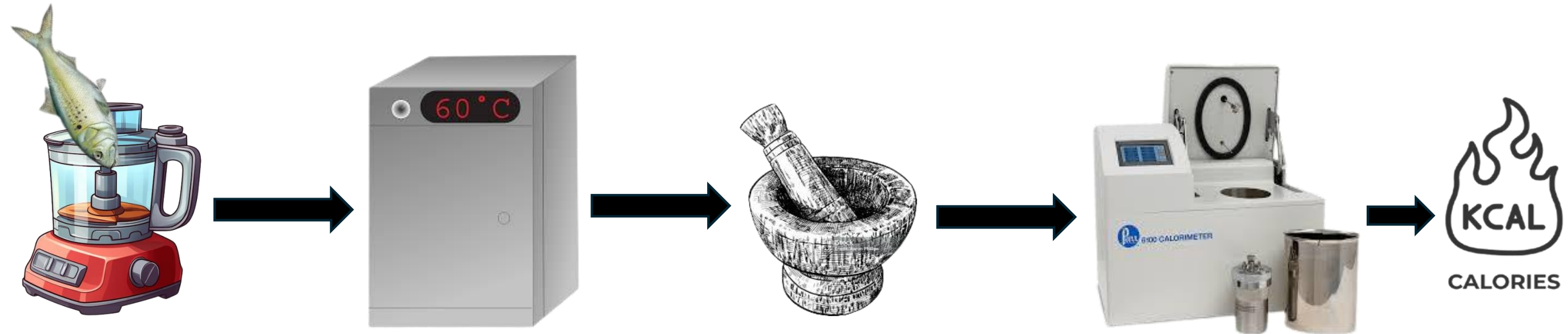
Dropped seabird Prey: Atlantic herring



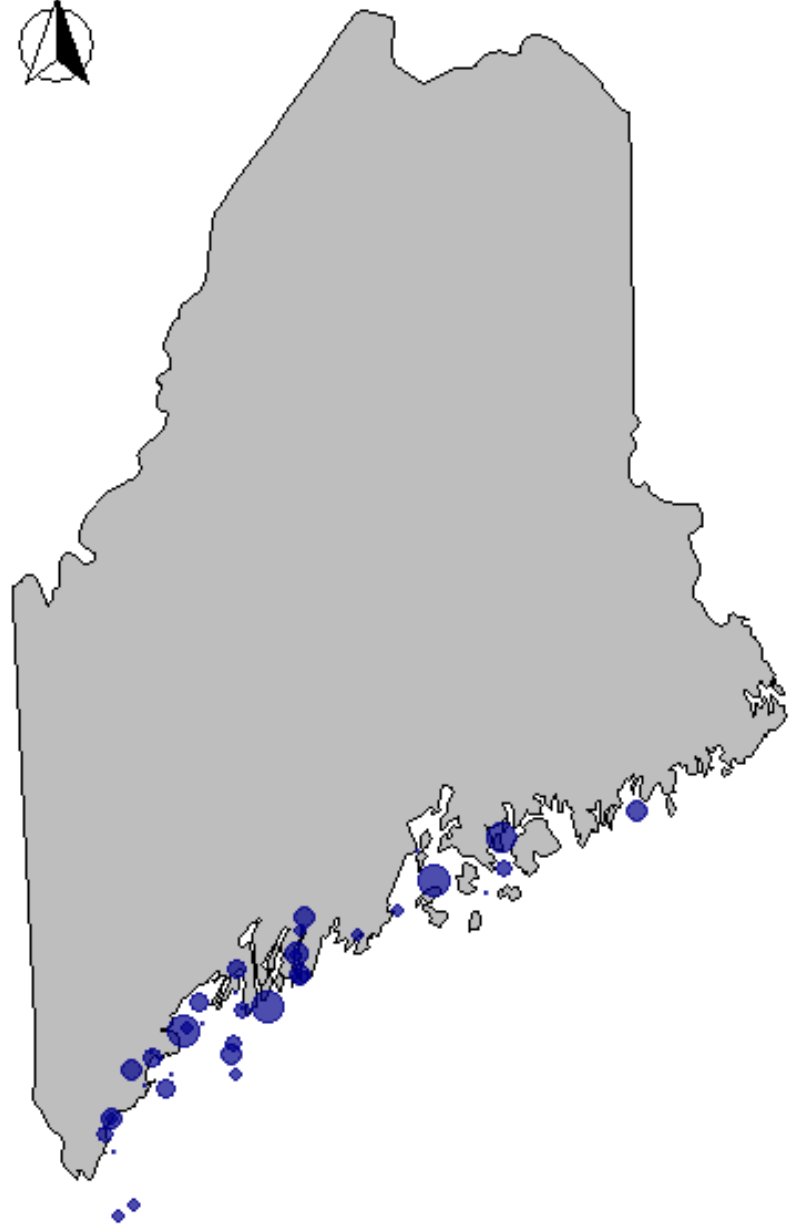
Stomach contents

# Methods: *Laboratory*

- Record full length (mm) and wet weight (g)
- Fully homogenize whole prey
- Dry subsample to constant weight (60°C)
- Grind to fine powder
- Run on bomb calorimeter to determine kJ/g dry weight
  - Back calculate to wet weight (using %moisture)




# Small Pelagic Fish Collections







## *2024-2025 Prey Collections*

Number of Fish Sampled

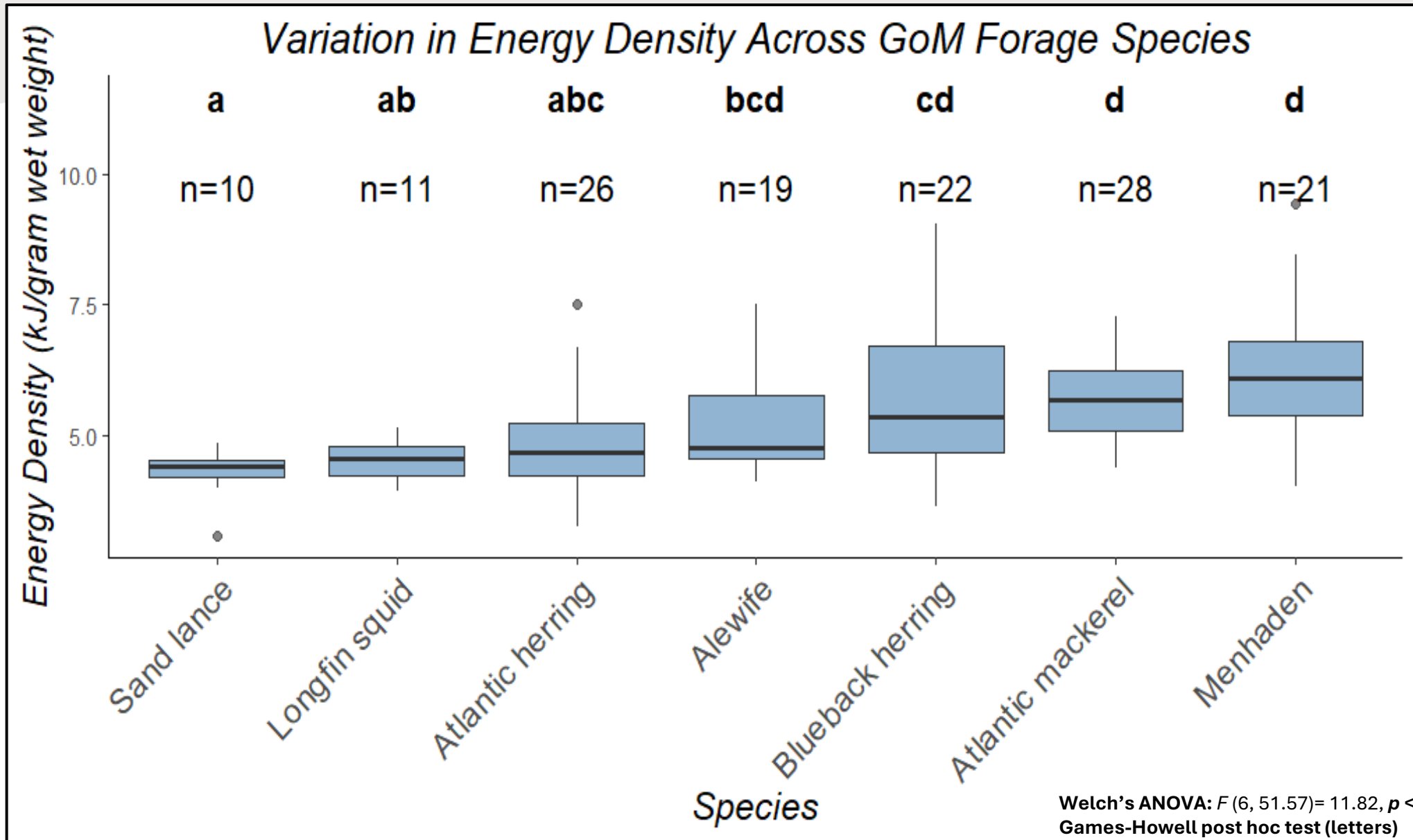
- 2
- 5
- 7
- 10

100 km 

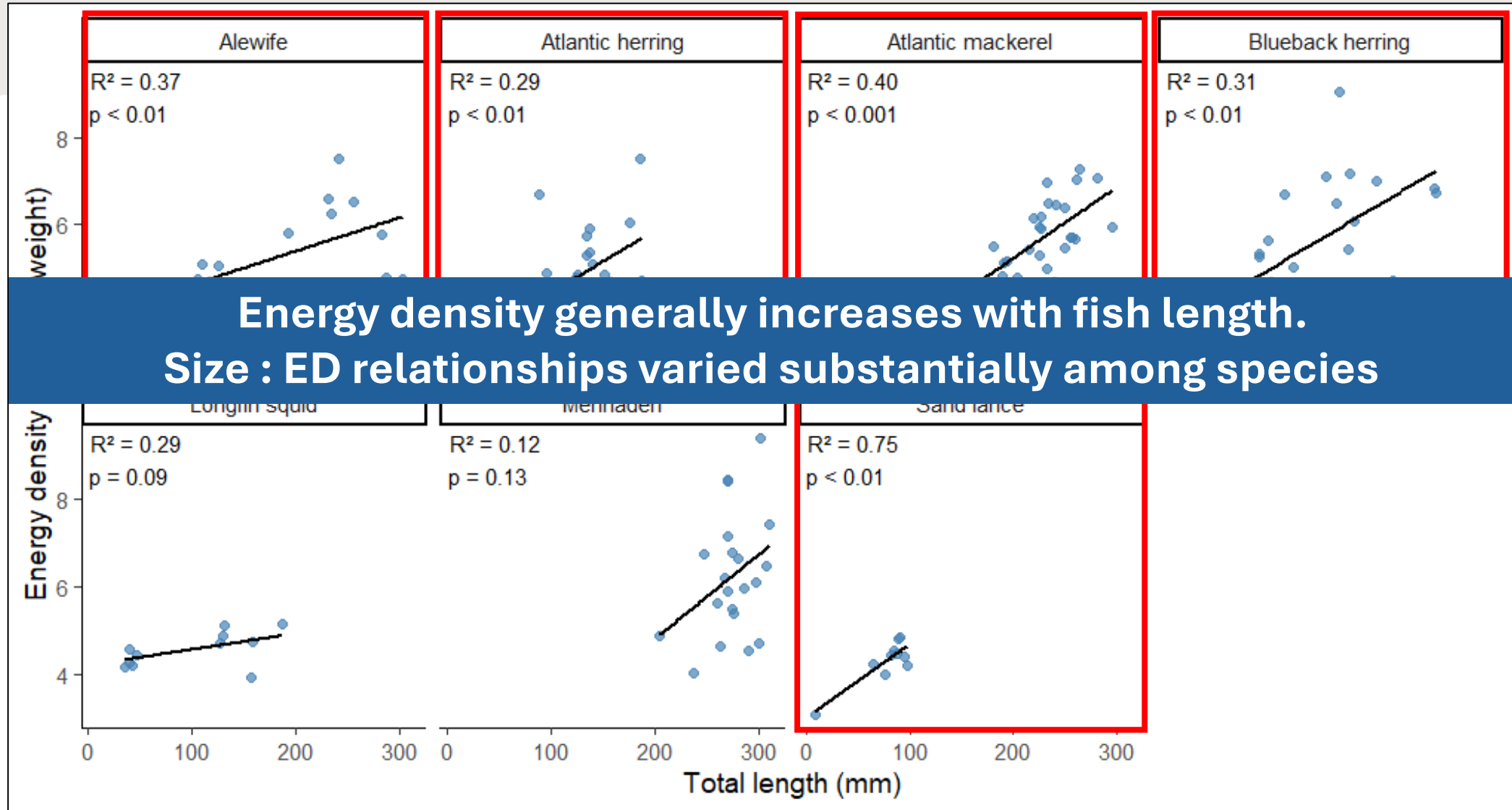
# Inter- and Intra- Species Differences

- Differences **among** species  vs 
- Differences **within** species → size and season  
 vs 

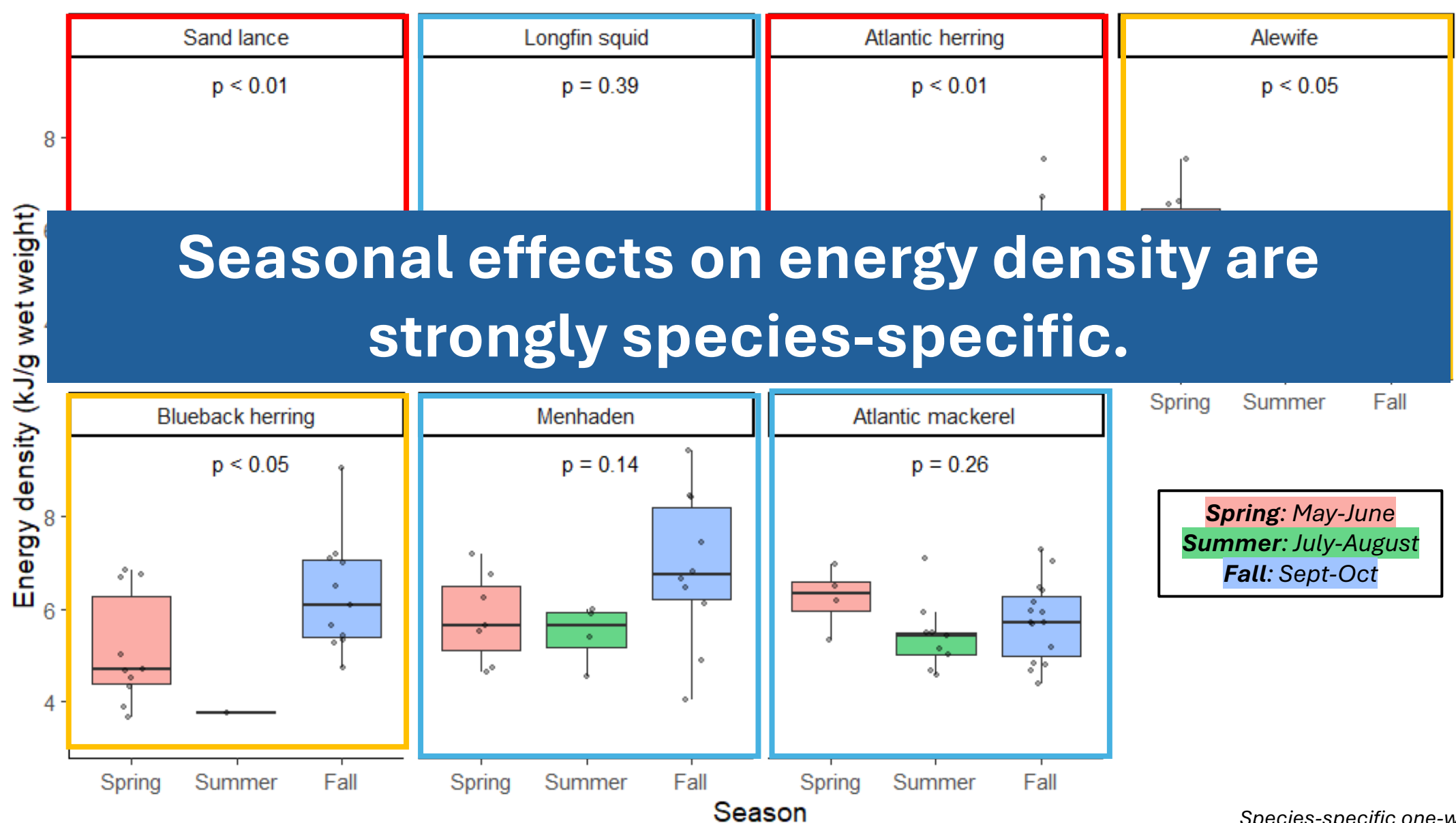
# Preliminary Energetics Results: Interspecies Differences



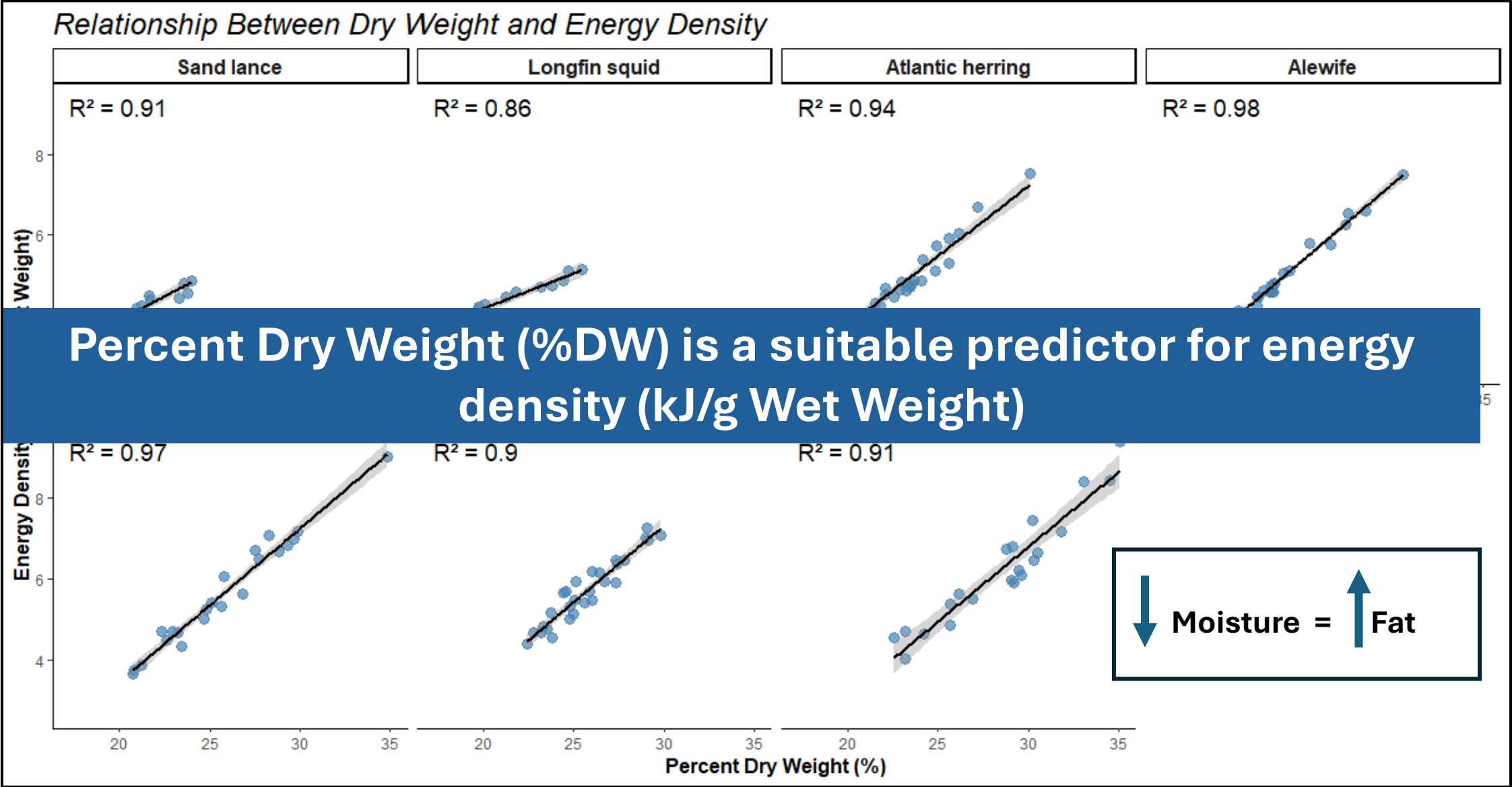
# Preliminary Energetics Results: Size-Based Differences



# Preliminary Energetics Results: Seasonal Differences



# % Dry Weight as Proxy for Energy Density



# Takeaways and Broader Impacts

## Multiple drivers of energy density

- **Season, size, diet, seasonal energy cycle, environmental conditions**

## Suitable predictors for energy density exist

- Less time and money

## Filling regional data gaps for inshore marine ecosystems

- Expanding the spatial continuity of longer-term dataset

## Contribute to open-access energetics database

- *Hermann et al. 2025*

## Ecosystem-based management applications

- Justification for other regional forage taxa to adopt EBM frameworks



*Marine and Freshwater Energy Density Data  
Integrated and Organized by Taxonomy from  
Previous Research Sources (1961 through June  
2024) Discovered by a Literature Review*

# Acknowledgements

## *Project Funding*

- Maine Outdoor Heritage Fund
- Maine Sea Grant
- USFW service

## *Travel Funding*

- NSF-Woods Hole Oceanographic Institution
- National Association of Marine Laboratories
- University of Maine Graduate Student Government

## *Special Thanks To*

- Student Interns: Gaddum Reddy, Grace Leschey, Aiden Wee
- Maine Seabird Colony Interns
- Pelagic Fisheries Lab
- Maine Recreational Fishing Community
- Graduate Thesis Committee
- Maine Department of Marine Resources



WOODS HOLE  
**OCEANOGRAPHIC**  
INSTITUTION



A large school of fish, possibly tilapia, swimming in clear water. The fish are densely packed and moving in various directions. The water is a light greenish-brown color. In the center of the image, there is a semi-transparent blue rectangular box containing the word "QUESTIONS?" in white, serif, all-caps font.

QUESTIONS?