

Observations of Ichthyoplankton Community Structure in a New England Estuarine System: An Ongoing Time-Series of Larval Fish Ingress and the Effect of Environmental Drivers

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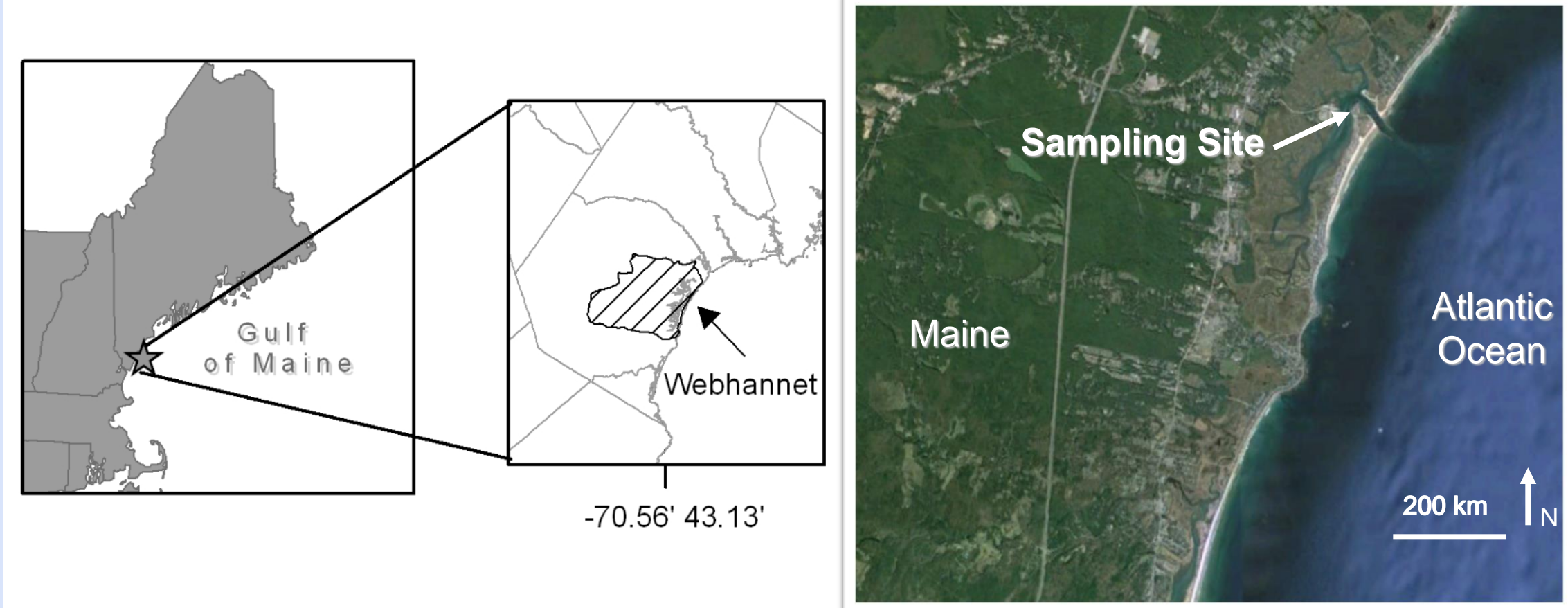
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Background

Understanding larval fish population dynamics is important for determining recruitment availability, dispersal distances, and changes in species distribution and abundance. Most larval fish studies in the Gulf of Maine (GoM) sample sub-tidal and pelagic habitats, with poor temporal replication. This ongoing study examines the community structure, diversity, and abundance of larval fishes in the Webhannet River Estuary in Wells, ME, USA. With samples collected 2-6 times monthly since 2009, this study represents one of the most robust and longest running larval fish sampling efforts in a Gulf of Maine Estuary.

Study Site

Webhannet River Estuary, Wells, ME



Sample Collection

- Sampling occurs at the ingress to the Webhannet River Estuary during incoming high tide for one hour, 2-6 times monthly, at a fixed location and depth of 1 meter. This study has been occurring since 2009.
- Plankton are collected using a 500 μ m mesh General Oceanics (GO) plankton net with a GO mechanical flow meter and depressor anchor.
- Larval fish are measured to standard length and identified to species level.
- Concurrent with this project, NOAA's System Wide Monitoring Program (SWMP) collects 15 minute data on water temperature, salinity, pH, dissolved oxygen, turbidity, Chlorophyll a, and depth using YSI data sondes.



Acknowledgements

A large number of trained, dedicated, and motivated individuals have helped in the collection, processing, and identification of specimens in our collection. This includes staff, student interns, graduate students, and citizen scientists. We are grateful for their help and assistance. This work is supported through operational support to the Wells NERR from the National Oceanic and Atmospheric Administration (NOAA) Office for Coastal Management.

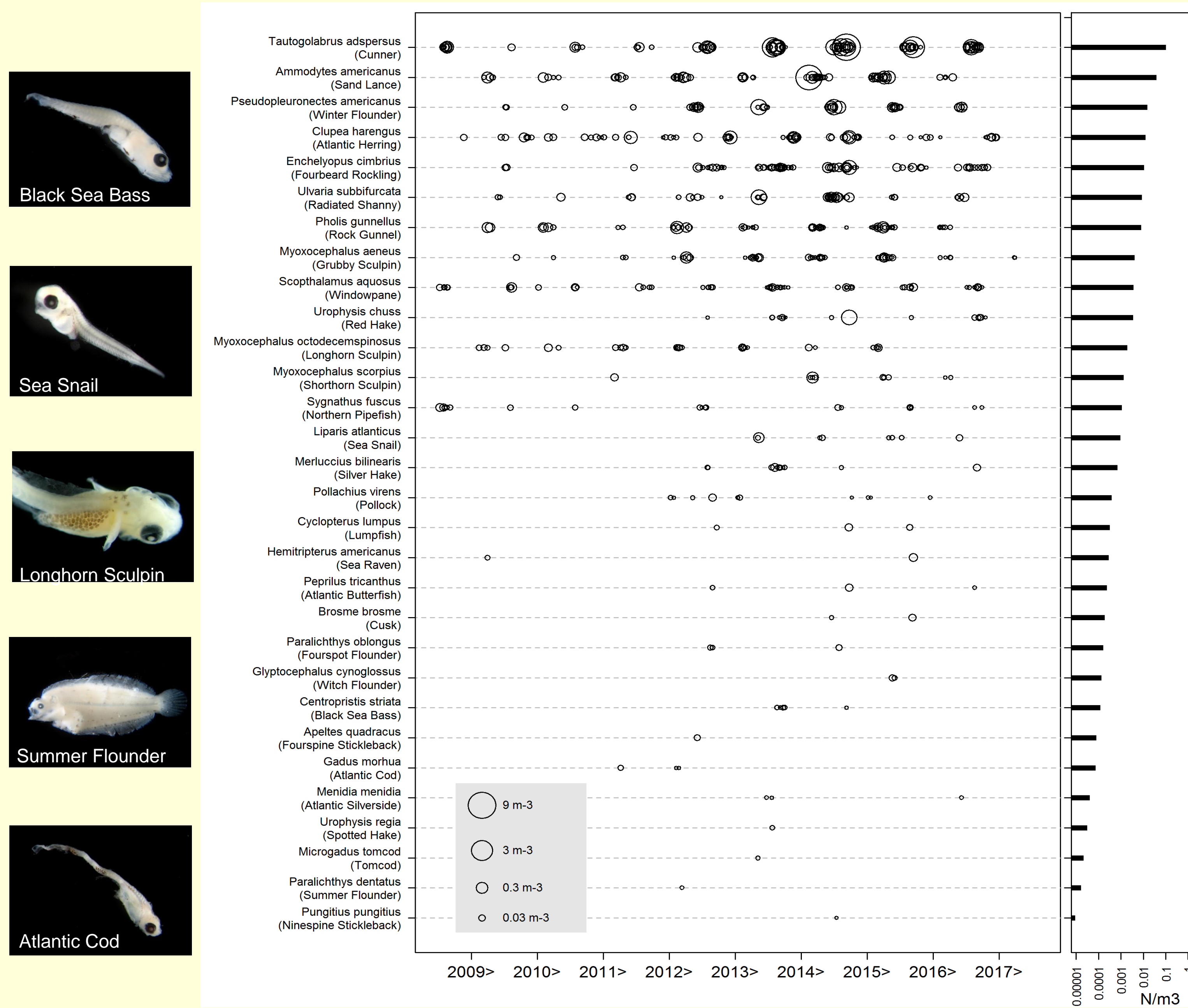


Figure 1. Time series of larval fish captures (by species) at Webhannet River Estuary, Wells, ME. Symbols are centered on sampling date and scale with double-square-root-transformed density. Right: Mean density by species across all samples in time series (log₁₀ scale).

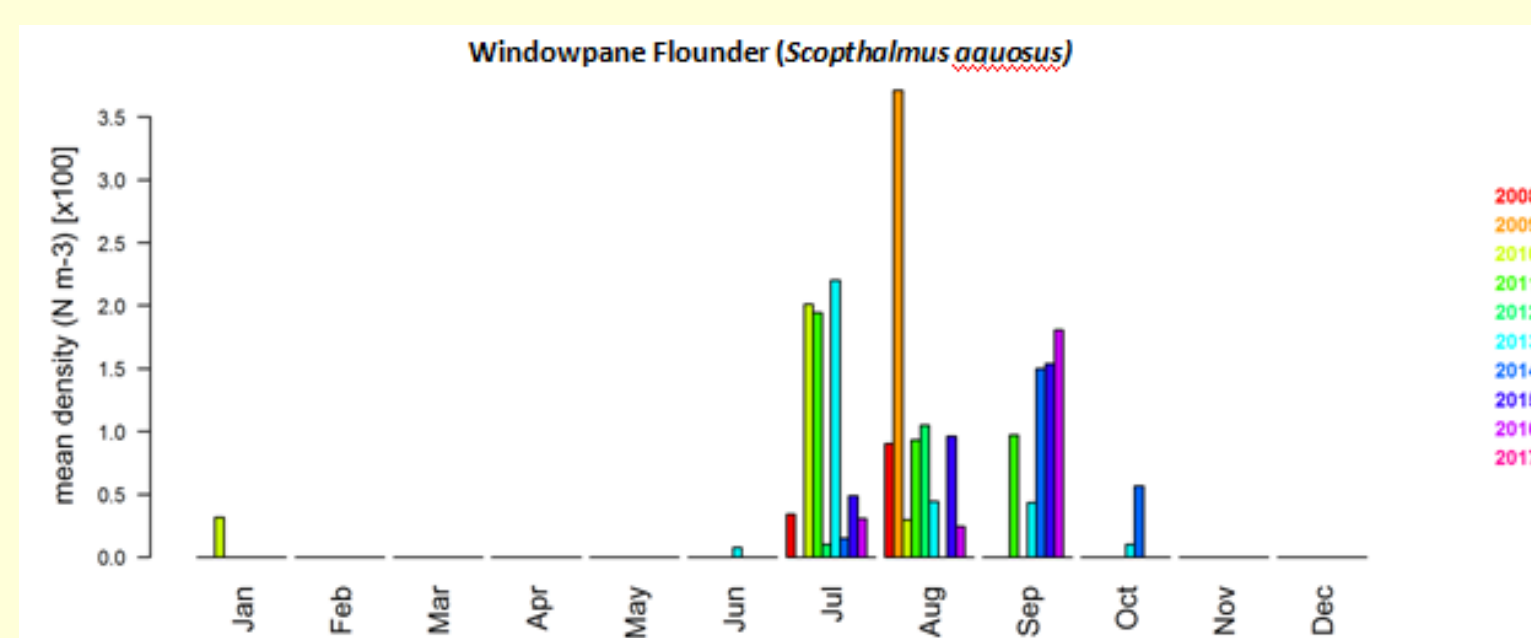


Figure 2. Windowpane flounder (*Scophthalmus aquosus*) seasonal cycle of abundance by year, indexed as mean density across all sampling occasions within a month.

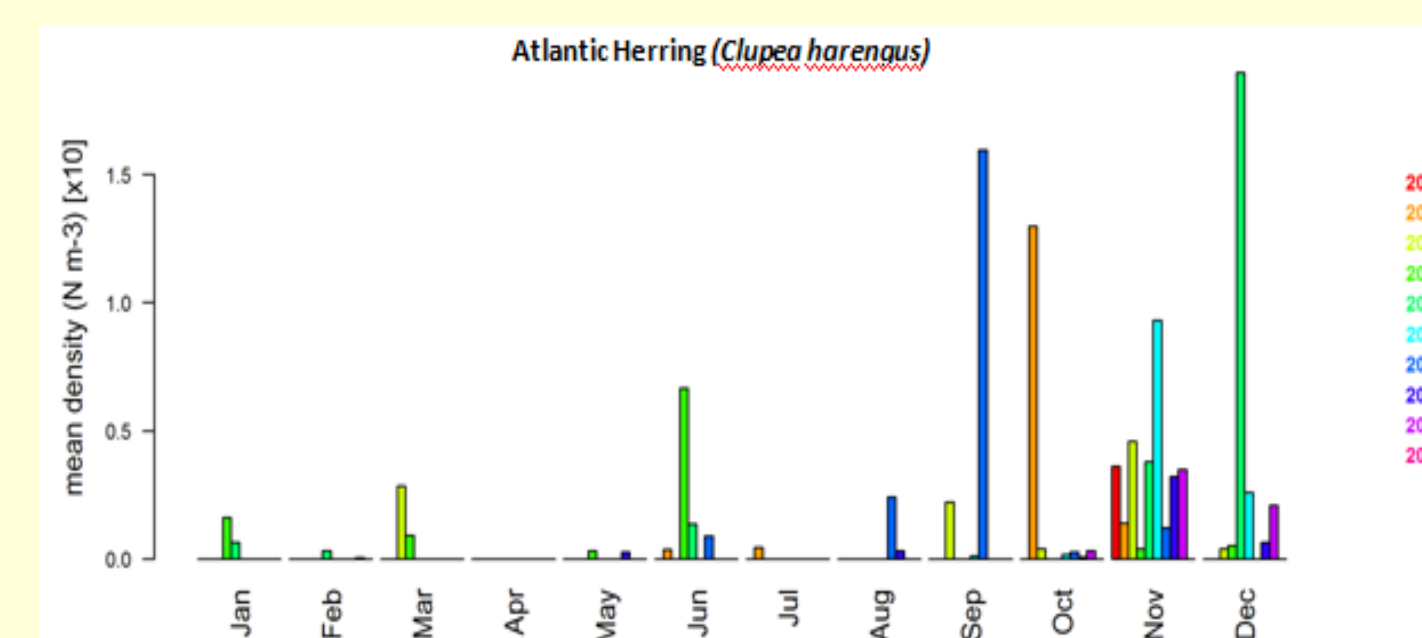


Figure 3. Atlantic herring (*Clupea harengus*) seasonal cycle of abundance by year, indexed as mean density across all sampling occasions within a month.

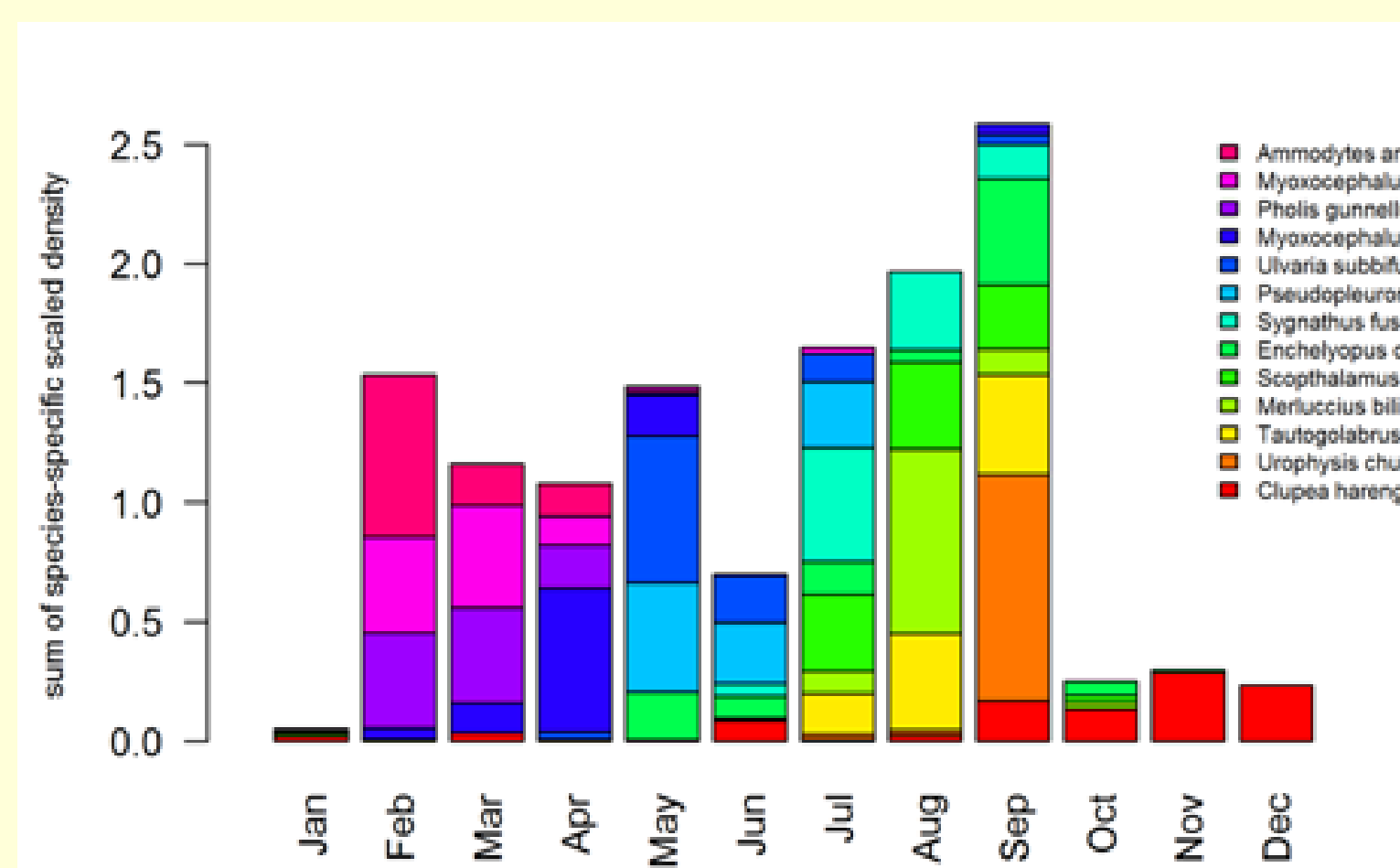


Figure 4. Comparative phenology of common species of larval fish captured on flood tide at Webhannet River Estuary, Wells, ME.

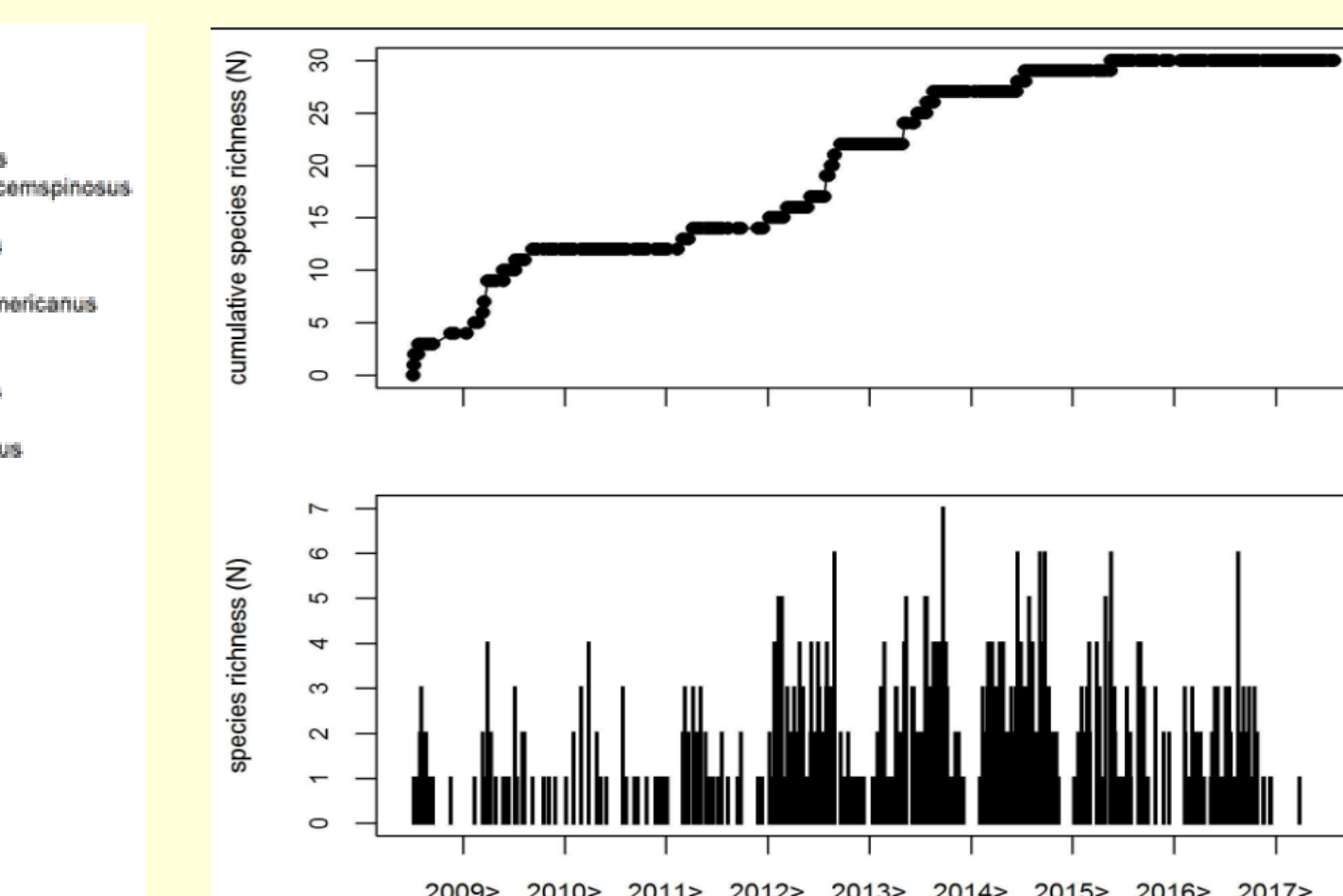


Figure 5. Top panel: Cumulative species curve as a function of sampling date. Bottom panel: sample-specific species diversity (N). Note that neither value has been scaled for variability in effort among sampling dates.

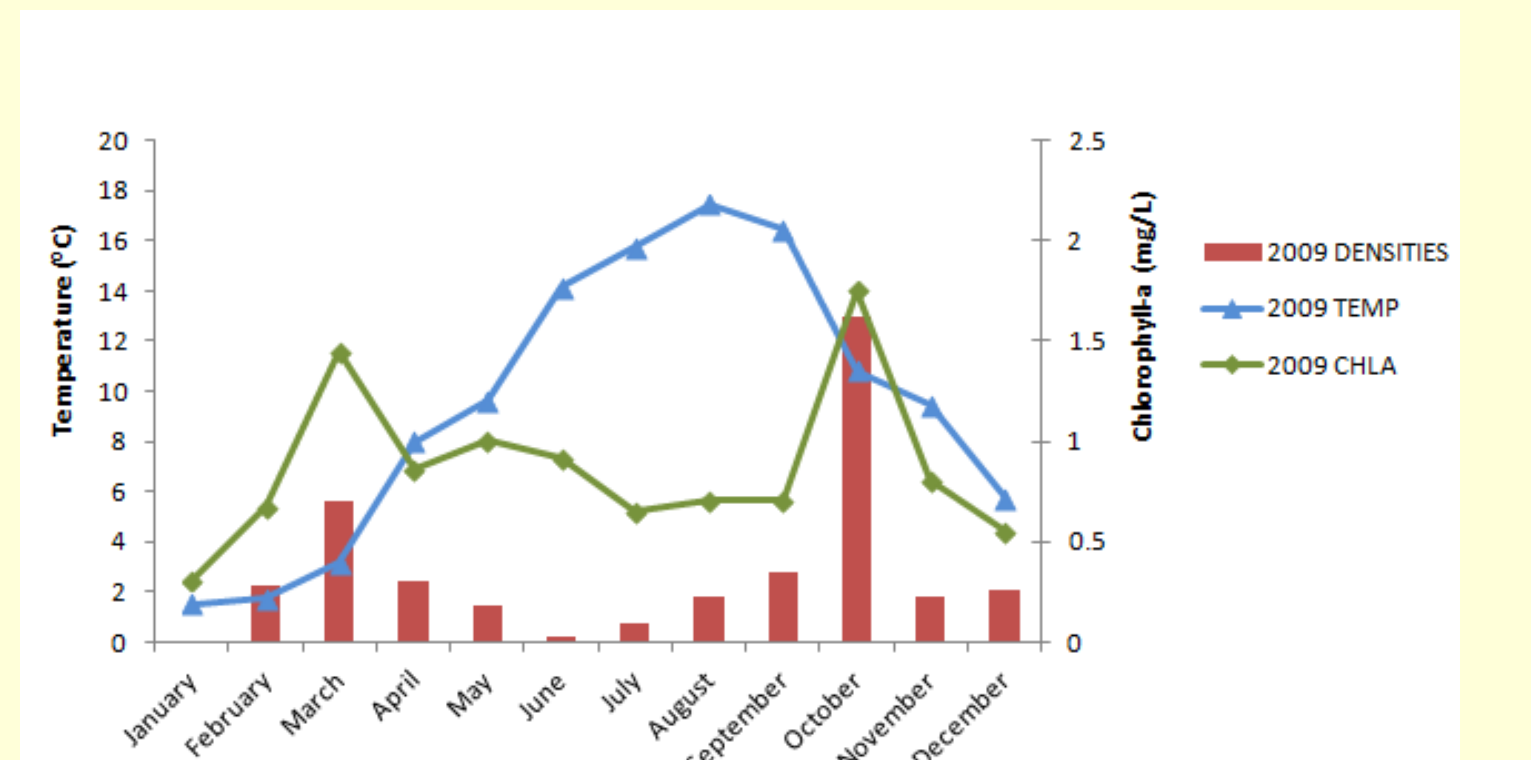


Figure 6a. Monthly larval fish densities (fish/100m³) in 2009 with monthly temperature and chlorophyll-a value (mg/L) plots.

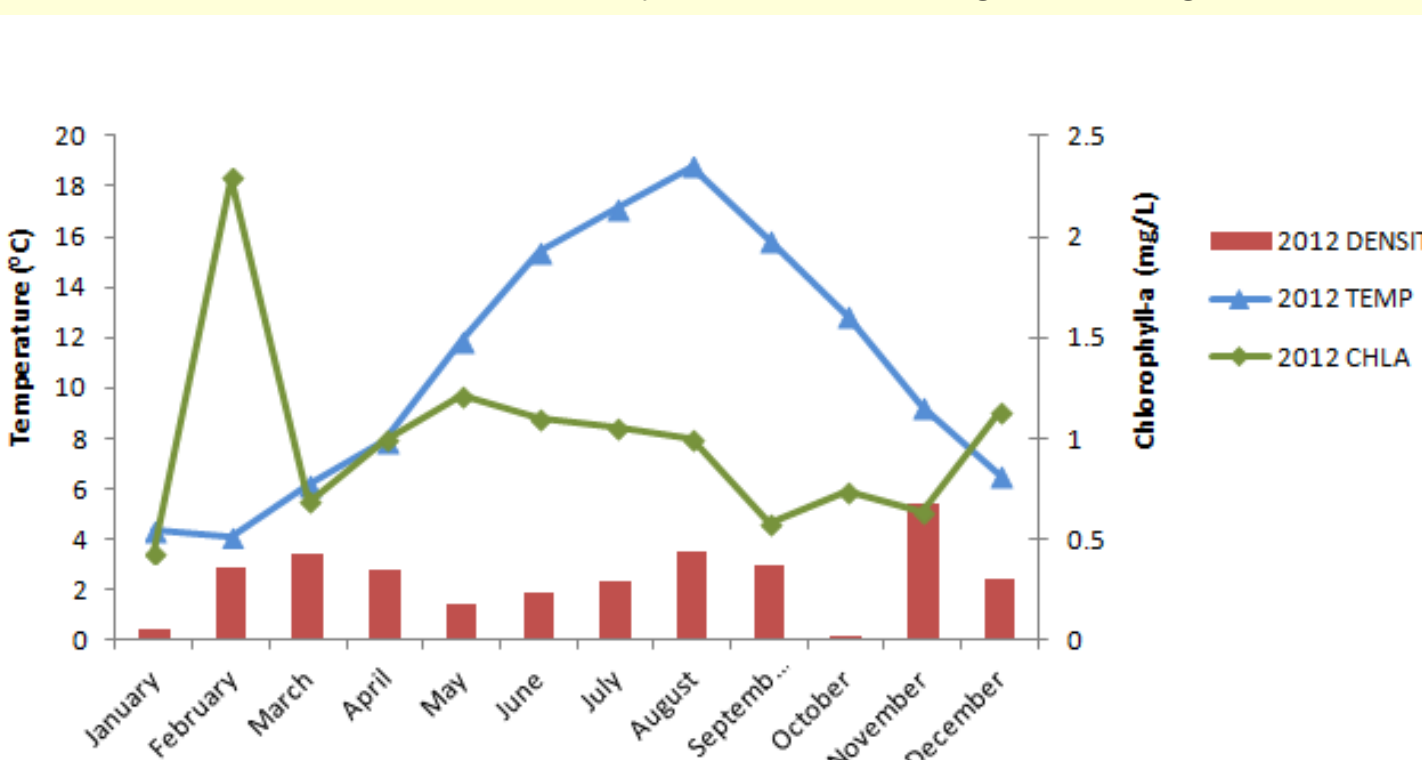


Figure 6b. Monthly larval fish densities (fish/100m³) in 2012 with monthly temperature and chlorophyll-a value (mg/L) plots.

Results

- A total of **7,570 individuals** have been collected
- 35 species** of fish documented to-date
- Overall, the three most dominant species (by number):
 - Tautoglabrus adspersus* (cunner)
 - Ammodytes americanus* (sand lance)
 - Clupea harengus* (Atlantic herring)
- Substantial seasonal and year-to-year variability (Figs. 3-4)
- Seasonal Patterns:
 - Abundances typically peak in the fall (corresponds with major plankton blooms)
 - Diversity (Shannon-Wiener, *H*) highest in the spring
 - Several distinctly "spring" or "fall" species (Fig. 4)
 - Seasonal patterns for individual species (e.g., windowpane flounder) shift over time (Fig. 2)
 - Reproductive phenology of such species may be changing in response to changes in the GoM (e.g., temperature, current structure, primary production)
- Anomalies in 2013 and 2014 (following an anomalous warming period in the GoM in 2012):
 - Occurrence of *Centropomus striata* (black sea bass) and *Urophycis chuss* (red hake) larvae
 - May be a sign of range expansions of more southerly species
 - Peaks in the number of larval fish caught for several other species, including *Tautoglabrus adspersus* (cunner)
- Catch densities follow peaks in chl-a concentrations (Fig. 6a)
 - However, concurrent declines in primary production and larval fish densities in 2012 suggests a potential breakdown in any links between bloom dynamics and the production or survival of larval fish in the area (Fig. 6b)

Summary

- This 10-year time series yields a panoptic picture of seasonal and interannual variability in the larval fish assemblage in the Webhannet River Estuary
- Commercially and ecologically important oceanic species depend on estuarine nursery habitats to maintain their stocks
 - Majority of fish caught are marine migrant species
 - e.g., Atlantic herring, Atlantic cod, pollock, flatfishes
- Oceanographic dynamics affect the coastal distribution of larvae
 - Observations of rarer species (e.g., black sea bass)
- Demonstrates the potential for a high-frequency, relatively inexpensive coastal monitoring campaign to quantify trends in ecologically and economically important species

Implications

- Rapid changes in the GoM may drive shifts in the reproductive timing of marine fishes, and the production and survival of their larvae.
- The 2012 temperature anomaly appears to have muted the typical fall bloom and reduced the production or survival of larval fishes in our area (Fig. 6b).
- Changes in temperature appear to have affected the diversity of species entering the estuary (e.g., black sea bass in 2013-2014).
- Increasing temperatures contributing to range expansions of more southerly species into the GoM.

Future Work

We will continue to collect year-round time-series data on species diversity in the Webhannet River Estuary. We are collaborating with researchers from the NOAA Southwest Fisheries Science Center (SWFSC) and Rutgers Marine Field Station to compare similar time series from a Mid-Atlantic estuary, and offshore trawls conducted as part of the Shelf-Wide Plankton Surveys conducted by the NEFSC. This work will allow us to assess potential shifts in phenology, correlations between species occurrence, abundance, and density in relation to environmental drivers, and the ongoing dynamics of potential range expansions of more southerly species into the GoM.