Ecological and Management Implications of Climate Change Induced Shifts in Phenology of Coastal Fish and Wildlife Species in the Northeast

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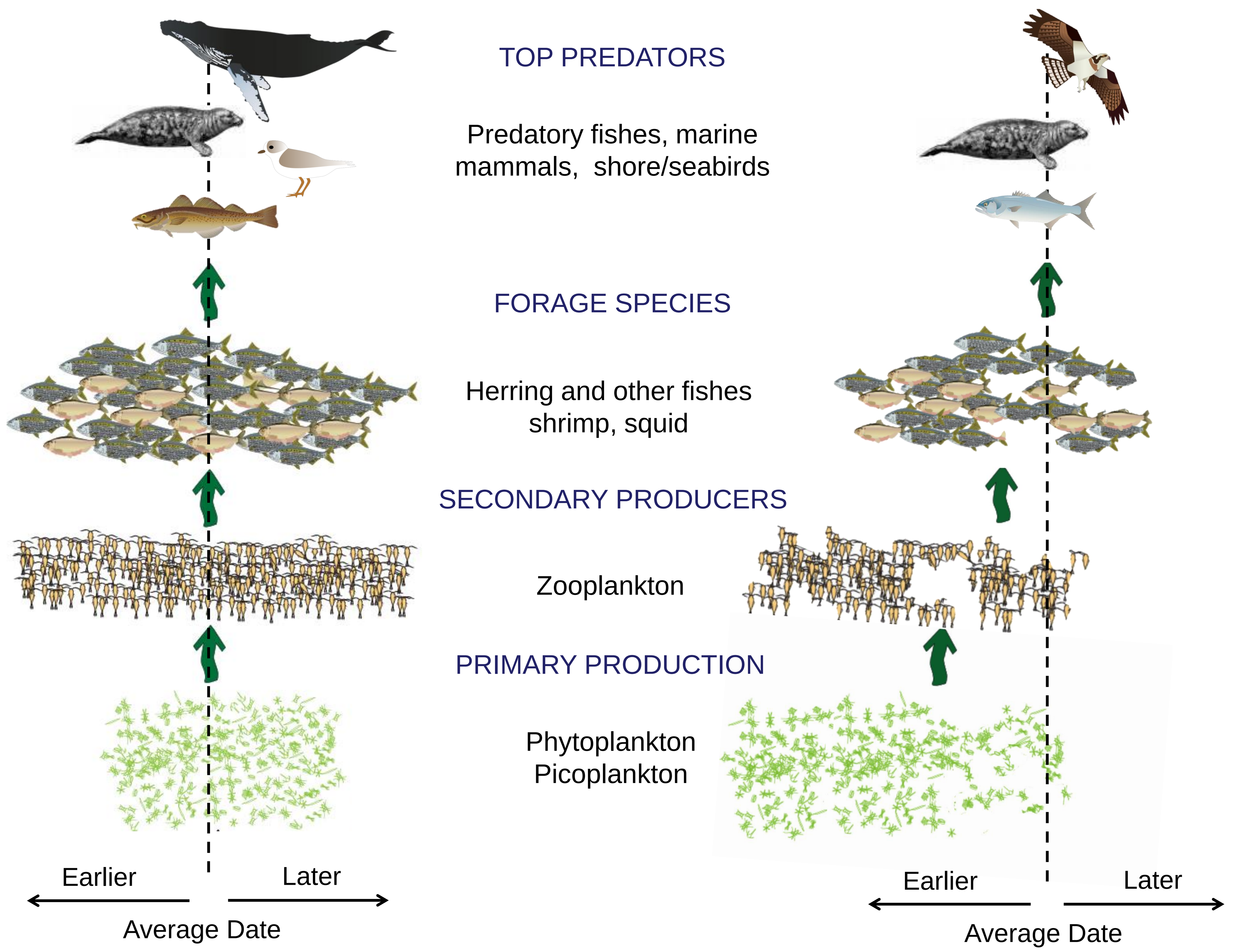
Overview

Climate change is causing species to shift their phenology, or the timing of recurring life events, in variable and complex ways. This can potentially result in mismatches or asynchronies in food and habitat resources that impact individual fitness, population dynamics, and ecosystem function. This project seeks to improve our understanding of climate-induced shifts in the seasonal timing of migration, spawning or breeding, and rates of biological development in coastal fishes, marine mammals, and migratory shore and seabirds along the U.S Atlantic coast. Long-term biological observations and environmental monitoring data are being assembled to evaluate the spatial and temporal scales at which phenological shifts are occurring, the primary environmental variables driving them, and to identify shared traits or behavioral changes that are common among different species. Comparisons of phenological shifts among higher trophic level predators and marine forage species will help characterize the adaptive capacity and vulnerability of individual species and regional sub-populations to changing environmental conditions. It will also identify where potential trophic mismatches may occur due to rapid climate change, and reveal gaps in monitoring networks intended to detect such responses among species of commercial, ecological, and conservation importance.

Timing of migration and feeding



In the above figure, dotted lines represent the average historical date of seasonal feeding behaviors. Green arrows depict trophic transfer of energy up the food web. Synchronous food web interactions are depicted in the left panel, while the right shows shifts in timing potentially leading to trophic mismatches and changes in food web structure.

Climate change causes spatial and temporal shifts that may lead to:

- **Shifts and increased variability of migration and breeding timing**
- **Changes in foraging habitats**
- **Reductions in individual size and fitness**
- **Patchiness, decreased abundance, diversity, and resilience**

Photo by M. Staudinger

Photo by F. Staudinger

Project Objectives

1. Synthesize phenological information and datasets on marine species of ecological, commercial and conservation importance including:

Coastal predators:
Marine mammals - seals, whales
Predatory fishes - striped bass, bluefish, cod, flounder
Shore and seabirds – puffins, terns

Forage species:
Forage fishes – alewives, shad, herring, menhaden
Invertebrates - shrimp, squid

Primary and secondary producers:
Phytoplankton, zooplankton

2. Evaluate integrated datasets to identify if and how species are shifting or increasing the variability of phenology:

- Can phenological shifts be detected?
- At what spatial and temporal scales?
- What environmental variables are correlated with shifts?
- What characteristics exacerbate or protect species responses?

3. Explore potential for mismatches among species and trophic levels at different spatial and temporal scales:

- Are predators and prey shifting at different rates?
- What species or populations are most vulnerable to declines?
- Which species may benefit?

Photo by W. Leavenworth

Methods

- Conduct literature review
- Assemble biological and climate datasets, and digitize long-term data pertaining to phenology
- Model species' phenological responses and potential ecological effects
- Develop conceptual model as a decision support tool for evaluating adaptation and management decisions

Phenology-relevant datasets

Migration
- Dates of first arrival, numbers of individuals, colony size, biomass, last departure

Breeding
- Timing and occurrence of breeding / courtship displays

Early life history
- Egg, larval, pup, chick development; life stages present; age / size composition

Food habits
- Diet studies, predator-prey body sizes, dependent relationships

Data sources

Local, state, and federal monitoring programs; trawl, seine, weir, aerial, bird count surveys; fish ladder passage; fishing logbooks; haul out sites; whale watching vessels; fisheries observers; citizen science; historical records

Years.	Herring (*Pomolobus pseudoharengus*).	Shad (*Alosa sapidissima*).	Bass (*Roccus lineatus*).	Tautog (*Tautoga onitis*).
1871	March 7	March 14	March 19	April 27.
1872	March 21	March 27	March 31	May 8.
1873	March 27	March 31	April 2	May 13.
1874	March 19	March 23	March 21	May 8.
1875	March 28	March 30	April 4	May 16.
1876	March 19	March 31	March 30	May 4.
1877	March 15	March 30	March 28	May 1.
1878	March 5	March 26	March 17	April 25.
1879	March 17	March 24	March 21	May 9.
1880	February 28	March 10	March 15	April 20.
1881	March 14	March 21	March 24	April 29.
1882	March 5	April 3	April 1	May 7.
1883	March 22	April 5	April 6	May 2.

Above example shows a historical record of the first appearance of fish, seabirds, and seals in the Taunton River, 1871 to 1883, by Elisha Slade in a letter written to Spencer Baird, published in the *Bulletin of the US Fish Commission.*

Acknowledgements

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