NES-LTER: A New Long Term Ecological Research Site on the Northeast US Shelf

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Introduction

The northwest Atlantic, renowned for its fisheries, is experiencing faster-than-average warming and other climate-related impacts. To date, lack of systematic and detailed measurements over a sufficient length of time has hampered our ability to observe the responses of pelagic food webs to environmental perturbations and uncover the underlying causes and implications. To address this challenge, a new NSF-supported Long-Term Ecological Research site on the Northeast US Shelf (NES-LTER) will be established later this year. NES-LTER goals are to understand and predict how planktonic food webs change through space and time, and how those changes impact the productivity of higher trophic levels. While patterns of ecosystem change over seasons to decades have already been documented in this region, the key mechanisms linking changes in the physical environment, planktonic food webs, and higher trophic levels remain poorly understood. For this reason, predictive capability is limited and management strategies are largely reactive.

Overarching questions

The NES-LTER long-term research plan is guided by an overarching science question:

- **How is climate change impacting the pelagic NES ecosystem and, in particular, affecting the relationship between compositional (e.g., species diversity and size structure) and aggregate (e.g., rates of primary production, and transfer of energy to important forage fish species) variability?**

The answer to this motivating question depends (at least) on the answers to three more specific questions that will be targeted during Phase 1:

- What are the main factors controlling spatial and temporal patterns of plankton species composition and biological production?
- How is variability in the feeding, condition, and distribution of pelagic forage fish linked to interannual variability and multi-year trends in plankton size structure and species composition and the ratio of export to total primary production?
- Is the NES ecosystem (and the services it provides) vulnerable to dramatic transformation in the face of rapid climate-induced environmental changes? Or does the diversity of species confer resilience, providing a buffer against dramatic changes in overall productivity via shifts in species composition?

Northeast US Shelf Study Site

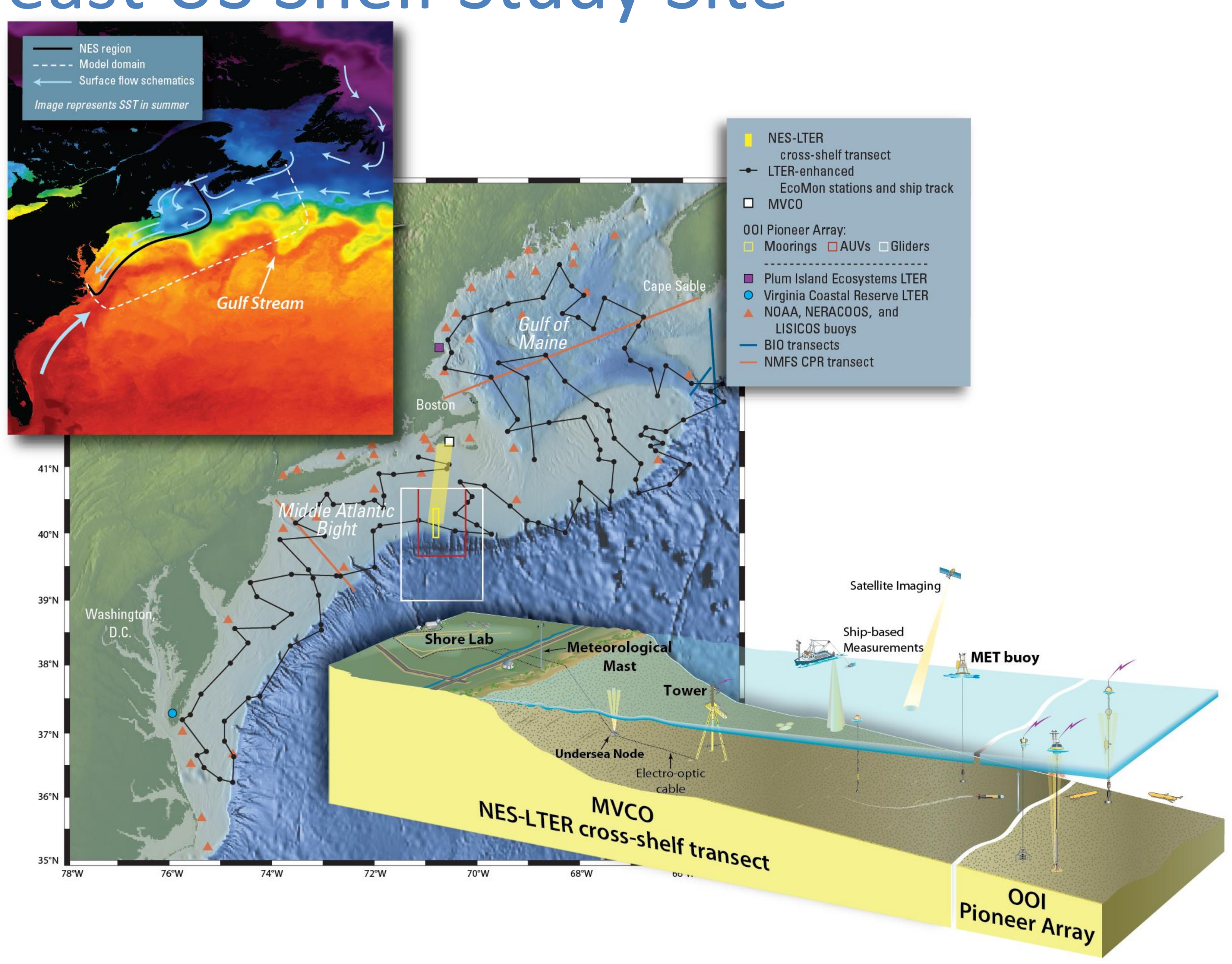


Fig. 1. The greatest focus of the proposed NES-LTER is on a cross-shelf transect from the Martha's Vineyard Coastal Observatory (MVCO) to the Ocean Observatories Initiative (OOI) Pioneer Array (foreground). However, quarterly EcoMon surveys (central map shows example cruise track) and biannual trawl surveys supported by NOAA, along with LTER-specific enhancements to these cruises, will provide select information at broad spatial scales and a greater contextual understanding of changes occurring in the NES ecosystem. Additional observations will come from regional observing system components (e.g., NOAA buoys). The proposed multi-scale modeling effort will address the impacts of high latitude processes and basin-scale forcing in this highly advective system by encompassing a domain that extends beyond NES boundaries (top left, with characteristic SST distribution). Slopeward extent of the OOI infrastructure is not depicted in the transect.

Conceptual Framework

The NES-LTER project will explore two types of variability that ecological communities exhibit in response to environmental variation: compositional and aggregate. Compositional variability reflects change in the relative abundance of component species; aggregate variability reflects changes in summary properties such as total abundance, biomass, or production. Understanding both of these aspects of community variability is critical for predicting the responses of community structure and function to physical and/or biological perturbations (Fig. 2). In Phase I, the NES-LTER project will be focused on understanding the relationship between variability in species composition and variability in aggregate properties such as production and export across a range of space and time scales in the NES ecosystem, as well as how this relationship may be influenced by climate change (Fig. 3).

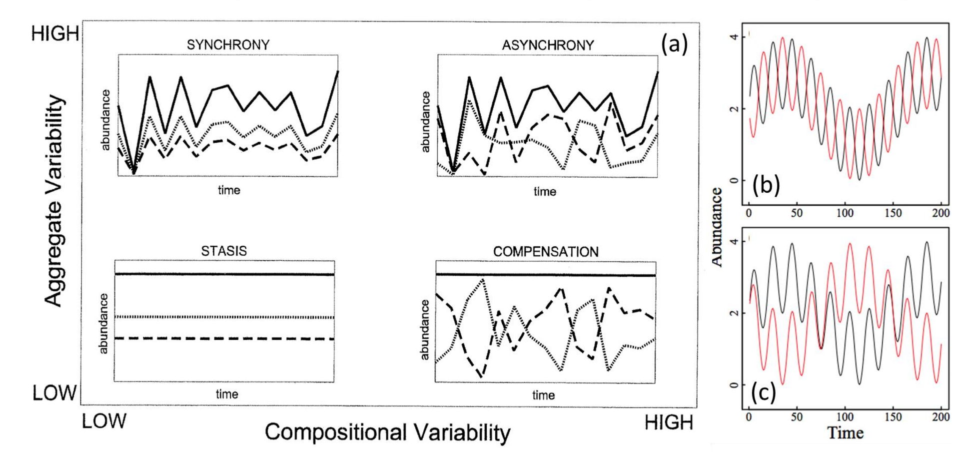


Fig. 2. (a) Communities display at least two types of variability over time: compositional variability, which results from changes in the relative representation of taxa within the community (broken lines), and aggregate variability, which results from changes in an integrated property of the community (e.g., production or standing biomass, solid lines) to which all taxa contribute. Community dynamics may appear synchronous on long timescales but compensatory on short timescales (b) or vice-versa (c). From (a) Micheli et al. (1999); (b,c) Defriez et al. (2016).

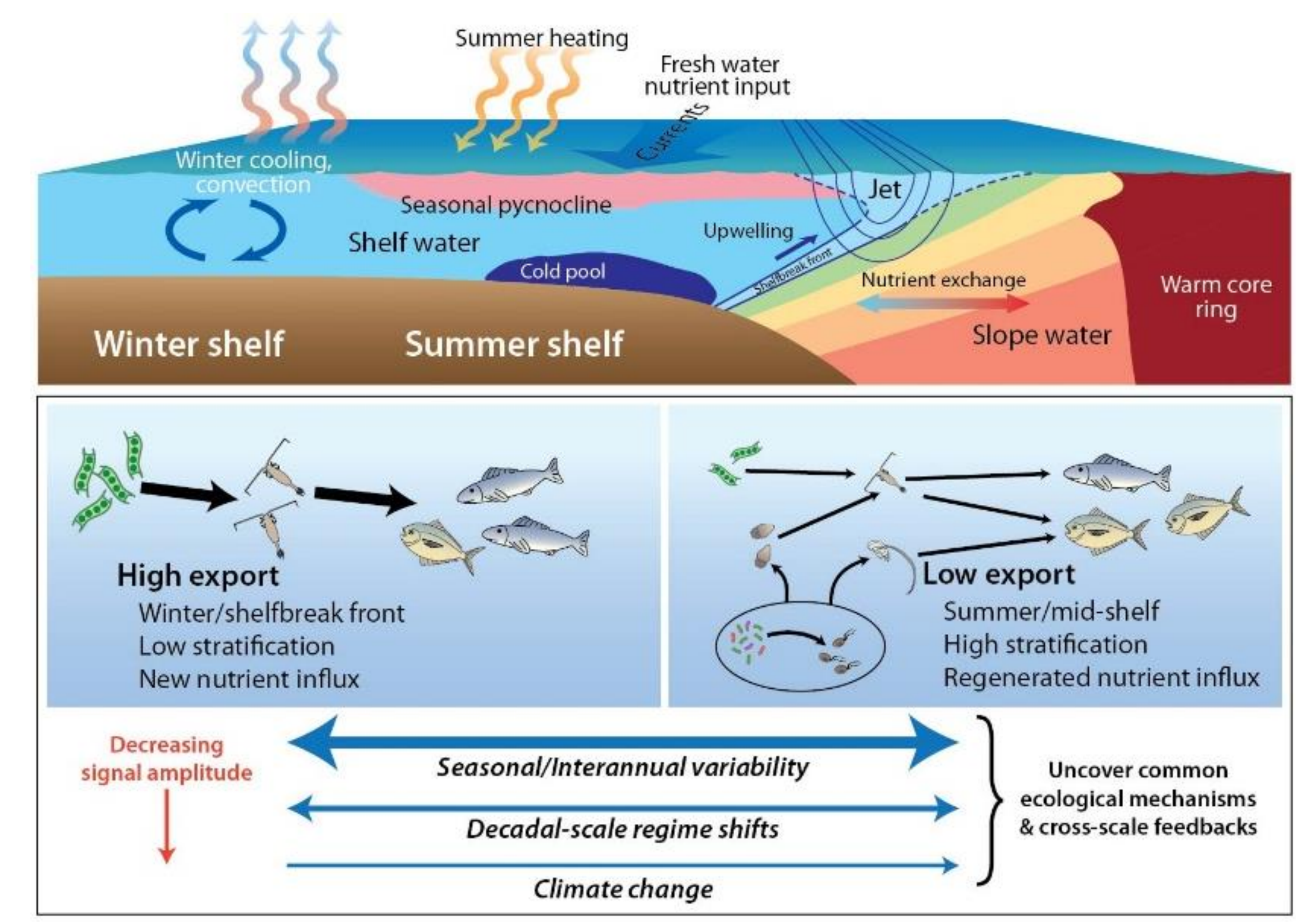


Fig. 3 Top: Conceptual diagram of physical processes across the shelf in winter and summer. Southward advection and various processes at the shelf break lead to nutrient inputs, and processes controlling stratification affect their vertical distribution. Bottom: Representative, simplified food webs of high- and low-export conditions, contrasting the relatively simple food chain of high-export with the more complex microbial loop-dominated food web of low-export conditions. Arrows at bottom indicate the range of time scales for hypothesized shifts between these food webs (and their resulting energy flow and export predictions), extending to predictions for on-going climate change.

Observations and Modeling

By capitalizing on high levels of seasonal and interannual variability in the NES, we will study short-term responses to climate-related variables to a) characterize low and high export food webs, b) understand the linkages and transfer of energy from the phytoplankton to pelagic fish, and c) identify the mechanisms that underlie shifts between high and low export communities. Ultimately, mechanistic knowledge will be scaled up to understand and predict the impacts and feedbacks associated with decadal- to climate-scale forcing in the ecosystem. To accomplish these goals, we have designed a nested sampling strategy that spans orders of magnitude in spatial and temporal scales (Fig. 1), encompasses the five LTER core areas, and includes an interdisciplinary suite of measurement types:

LTER Core Areas

- Patterns and controls of primary production
- Spatial and temporal population dynamics and food web interactions
- Patterns and controls of organic matter accumulation and decomposition
- Patterns of inorganic inputs and movements of nutrients
- Patterns and frequency of disturbance

Measurement types

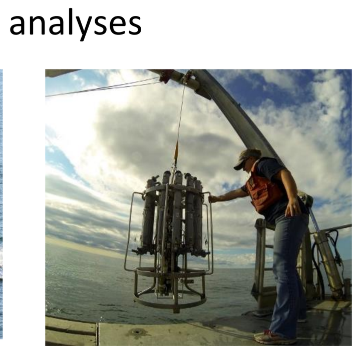
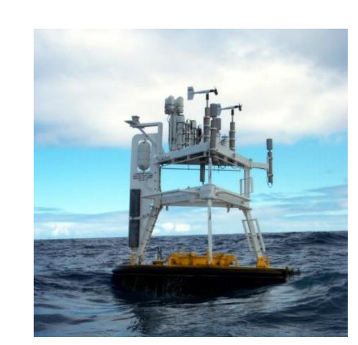
- Physical oceanographic, meteorological, optical, chemical
- Abundance, biomass, and community composition by trophic level
- Rate processes and trophic analyses

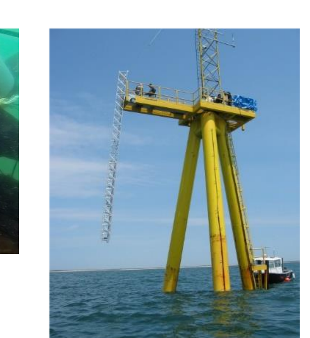
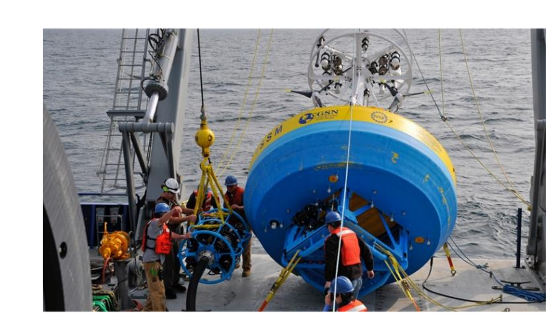
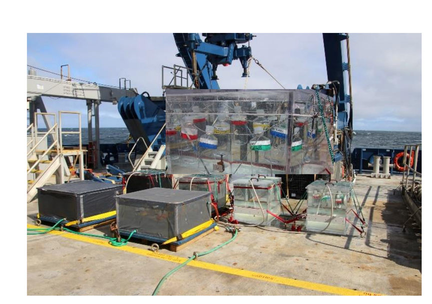
Sampling plan

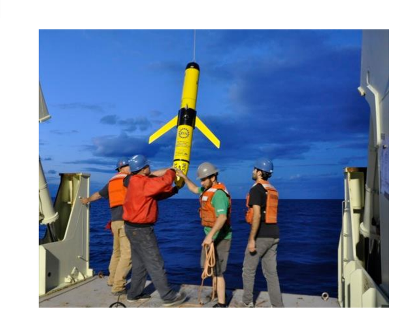
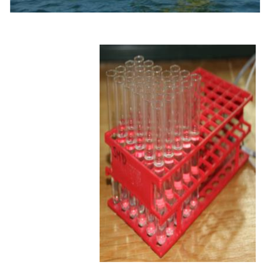
- MVCO, continuous and ~monthly discrete
- OOI Pioneer Array, continuous and quarterly discrete
- Cross-shelf transect, quarterly
- NES-wide surveys (EcoMon), quarterly

Modeling

- FVCOM with regionally tailored COBALT ecosystem model
- Theoretical ecology and population dynamics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