Advancing near-term ecological forecasting in the Northeast U.S. Large Marine Ecosystem: Synthesizing the state of the science, current challenges, and future opportunities

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Marine ecosystems around the world are changing rapidly, igniting numerous complex socio-ecological challenges and creating an urgent need for near-term forecasts to give stakeholders time to anticipate and plan for expected changes. Nowhere is the need for these predictions greater than in the Northeast U.S. Large Marine Ecosystem (NES LME), which is warming faster than most of the world's oceans. Despite the important need for ocean predictions in this region, generating this information has proven exceptionally difficult. Part of this difficulty stems from lower physical oceanographic prediction skill in the NES LME than in other LMEs with well-identified system drivers, such as the California Current and Bering Sea. With limited forecasting skill, development of ecological forecasts for resource management-relevant outcomes has been slow.

The Gulf of Maine Research Institute hosted a two-day hybrid workshop in Woods Hole, MA on February 25–26, 2025, to face this challenge and advance near-term ecological forecasting in the NES LME. Over 25 participants gathered to synthesize the state of the science, current challenges, and future opportunities for near-term ecological forecasting in the region, while also fostering a regional community of ecological forecasters and forecast users. The objectives were to:

1. Bring together relevant researchers to share information on the current state of ecological forecasting in the NES LME, and more broadly across terrestrial systems in the region, and other large marine ecosystems

2. Synthesize the state of the science and current challenges to identify future research opportunities with greatest potential impact to support the development of ecological forecasting systems and products

3. Establish and develop a plan for continued support of a collaborative community of regional ecological forecasters

Current State

Modeling and predicting physical ocean dynamics across the range of scales relevant to ecological processes and stakeholder decisions has proven difficult in the NES LME. Early, coarse-resolution models struggled to simulate the Gulf Stream's path and its separation from the continental shelf and could not resolve water mass transport through the region's fine-scale bathymetry. More recent high-resolution empirical and dynamical models have since demonstrated real skill, from seasonal-to-interannual prediction of ecologically important environmental variables to hourly-to-daily forecasts of shelf conditions. Building on this progress, NOAA recently invested in a high-resolution, coupled physical-biogeochemical model, MOM6-NWA12-COBALT, that has markedly improved predictive capability for the region. Importantly, the system is now planned to run operationally, producing new seasonal forecasts every three months and new decadal predictions annually. Retrospective evaluations show substantial skill for ecologically critical drivers such as bottom temperature, dissolved oxygen, and aragonite saturation, and a separate high-resolution regional modeling effort has demonstrated similar gains in multi-year temperature and salinity prediction.

With these products only recently becoming available, the physical and biogeochemical advances are just beginning to support near-term ecological forecasts. Existing biological and fisheries forecasting products in the region tend to cluster at either end of the time-scale spectrum: near-term nowcasts, such as current shellfish toxicity risk or zooplankton distributions, or longer-term projections of species distribution shifts and stock trajectories under climate change. Comparatively little exists at the seasonal-to-multiannual scale most relevant to many resource management decisions, a gap workshop participants identified as a key opportunity for the field going forward.

Challenges

Beyond establishing the current state of forecasting in the NES LME, lightning talks and subsequent discussions surfaced four cross-cutting challenges. Participants noted these challenges are interconnected, such that progress in one area depends on advances in the others. The four challenges were:

- **Spatial and Temporal Scale** — aligning the scales at which forecasts are produced with the scales relevant to ecological processes and management decisions.
- **Interpretability vs. Predictability** — balancing mechanistic understanding, which builds trust and explains forecast error, against the flexibility of statistical and machine learning approaches.
- **Evaluating and Communicating Forecast Performance** — establishing consistent, retrospective skill assessment and translating uncertainty into decision-relevant terms.
- **Connecting Science, Decision-Making, and Community Capacity** — sustaining the relationships, funding, and infrastructure needed to keep forecasts useful to the people who rely on them.

Pathways Forward

Progress in near-term ecological forecasting across the NES LME has never been better positioned to accelerate. Data availability has expanded, regionally downscaled physical models now better resolve the dynamics most consequential for biological processes, and a growing suite of statistical and machine learning tools offers new ways to connect physical drivers to ecological responses. At the same time, the communities and decision-makers most affected by a rapidly changing ecosystem have clear and pressing information needs. This workshop reflected both the urgency of that moment and a shared commitment to meeting it, with five pathways emerging from discussions as particularly important for translating that commitment into progress:

- **Forecasting Competitions** — structured challenges that benchmark different modeling approaches against shared data and evaluation criteria.
- **Transdisciplinary Teams** — teams that pair forecast developers with decision-makers and social scientists from the outset of a project.
- **Working Groups** — focused, time-limited groups tackling a specific forecasting problem or application.
- **Regional Convenings** — recurring meetings, like this workshop, that sustain community connections and identify new priorities.

- **Co-production Networks** — ongoing partnerships between forecasters and end-users to jointly define and refine forecast products.

Next Steps

Workshop participants are preparing a peer-reviewed manuscript synthesizing these discussions, with submission planned for fall/winter 2026. This page will be updated with a link to the manuscript upon publication.