NOAA FISHERIES

NEFSC

Ecosystem Reporting

Communication of ecosystem status and trends through development of web-based products; data sharing and availability to stakeholders.

Kevin Friedland

NEFSC Ecosystem and Climate Science Program Review

Communication Session

June 8, 2016

Northeast Fisheries Science Center

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GO!

Ecology of the Northeast Continental Shelf
Background information on the structure and function of the Northeast Shelf Ecosystem

Climate Change
Effects of Climate Change on the Northeast Continental Shelf

Ecosystem Status
Assessment of Ecosystem Condition, Threats, and Impacts

Current Conditions
Semiannual Review of the Physical and Biological Status of Ecosystem

Spatial Analyses
Species Distribution Patterns in Space and Time

Modeling Approaches
Development and Application of Multispecies and Ecosystem Models

There is now broad agreement that we need to adopt a more holistic approach to marine resource management at both the national and international levels. To accomplish this goal, the foundation of marine Ecosystem-based Management is now being developed and refined. Virtually all specifications of marine EBM share at least three common elements: (1) a commitment to establishing spatial management units based on ecological rather than political boundaries, (2) consideration of the relationships among ecosystem components, the physical environment, and human communities, and (3) the recognition that humans are an integral part of the ecosystem. We need to account for the important goods and services derived from marine ecosystems and the diverse and cumulative impacts of human activities in these systems (Figure 1) to forge a sustainable future.

Figure 1. Examples of some important ecosystem services (blue icons), stressors (red), adverse effects (yellow), and issues of special concern (green) that will be considered in Ecosystem-Based Management on the Northeast U.S. Continental Shelf (adapted from image by Barbara Ambrose, National Coastal Data Development Center).

The importance of implementing marine Ecosystem-based Management in the United States has recently been highlighted with the adoption of a new National Ocean Policy, established under presidential order on July 19, 2010. This policy identifies nine objectives, the first of which establishes Ecosystem-based Management (EBM) as its guiding principle. The second priority highlights the importance of Coastal and Marine Spatial Planning as a tool for EBM. It is clear that the impetus toward adopting the basic tenets of EBM is gaining momentum. We need to establish the scientific architecture in support of EBM in the region to meet these emerging challenges and opportunities. The objective of our Ecosystem Considerations website is to provide a broad overview of the ecology of the Northeast U.S. Continental Shelf to support this overarching need. This region as a whole is recognized as one of more than 60 Large Marine Ecosystems distributed throughout the world ocean.

This site comprises several inter-related components designed to address different issues and needs. We seek to provide basic information on fundamental ecological properties of the system to the broad spectrum of stakeholders who will be engaged in the discussion of policy alternatives to meet the needs for Ecosystem-Based Management in the region. We build on the longstanding commitment of the Northeast Fisheries Science Center to understand and monitor changes in ecosystem structure and function in this region with the objective of informing management decisions.

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http://www.nefsc.noaa.gov/ecosys/

Ecology of the Northeast Continental Shelf

Background information on the structure and function of the Northeast Shelf Ecosystem

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Modeling Approaches

Development and Application of Multispecies and Ecosystem Models

Approximately 25,000 hits per year

Ecosystem Status Report

Started as a biennial report, has evolved into web report updated as required.

Provides a range of information to managers, stakeholders, scientists, and the public.

Informs IEA process.

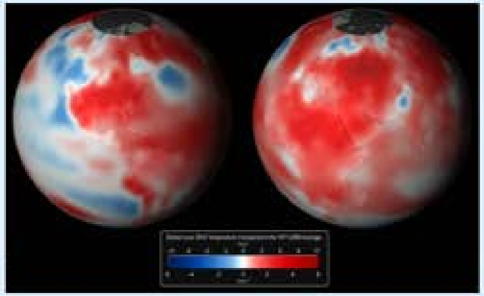
Source of information for research.

ECOSYSTEM CONSIDERATIONS

Ecosystem Status Report for the Northeast Large Marine Ecosystem

2. Climate Forcing

Climate impacts the marine environment via changes in ocean temperature, biogeochemistry, vertical mixing, and circulation, all of which can affect the dynamics of marine ecosystems. The climate of the U.S. NES LME is influenced by both natural and anthropogenic factors. The continued global increase in long-lived, greenhouse gas emissions combined with the high rate of natural climate variability in the Northwest Atlantic Ocean (Messié and Chavez 2011) renders it a challenge to attribute ecosystem change to either natural or anthropogenic climate forcing. However, the observed century-scale warming of the global ocean is very likely (> 90%) caused by anthropogenic emissions of greenhouse gases (Hegerl et al. 2007). Here, we describe the historical and the most recent state of the climate of the U.S. NES LME along with projections of climate change for this region.



Click image to enlarge

2.1 Natural Climate Variability

- 2.1.1. Atlantic Multidecadal Oscillation
- 2.1.2. North Atlantic Oscillation
- 2.1.3. Gulf Stream Path
- 2.1.4. El Niño Southern Oscillation

2.2 Climate Projections

- 2.2.1. Introduction
- 2.2.2. Ocean Warming
- 2.2.3. Ocean Acidification

ECOSYSTEM CONSIDERATIONS

Ecosystem Status Report for the Northeast Large Marine Ecosystem

3. Physical Pressures

Click image to enlarge

Oceanographically, the NES LME is located on the western boundary of two large oceanic gyres, which span the North Atlantic Basin. The source waters feeding the NES LME include contrasting water masses carried by the converging currents from these two gyres: the Gulf Stream carrying warm and salty water from the south and the Labrador Current carrying cold and fresh water from the north. Climate oscillations (e.g. NAO, AMO) and long-term trends (e.g. warming, acidification) can lead to changes in the intensity of these currents, their position relative to the NES LME, and the water masses that they carry (Curry and McCartney 2001; Häkkinen and Rhines 2004; Joyce et al. 2000; Marsh 2000), ultimately influencing the physical environment of the NES region.

Climate drivers impact the physical environment of the NES LME through a combination of external pressures at its boundaries and direct effects on internal conditions. External influences on the NES include the Gulf Stream at the southern and offshore boundary, the Labrador Current at the northern boundary, river discharges at the coastal boundary and winds and atmospheric fluxes at the sea surface. In addition to these external pressures, climate processes also directly influence the internal physical environment of the NES, altering the horizontal and vertical distribution of temperature and salinity. The combination of these physical pressures can cause significant ecosystem changes, which are discussed in sections 4-6.

3.1. Gulf Stream

3.2. Labrador Current

3.3. River Flow

3.4. Winds

3.5. Temperature

3.6. Salinity

3.7. Stratification

ECOSYSTEM CONSIDERATIONS

Ecosystem Status Report for the Northeast Large Marine Ecosystem

8. Human Dimensions

Central to EBM is an understanding of coupled socio-ecological systems (human and natural environment) which reflects the interface and reciprocal interactions that link human (e.g., economic, social, cultural) and natural (e.g., oceanographic, atmospheric, geological, biological) sub-systems. Coastal communities of the NES LME (and around the U.S.) depend on the ocean for meeting economic, social, and cultural needs. Fishing (commercial, recreational, and subsistence), coastal tourism and recreation, shipping, and spiritual or cultural practices centered on marine locations or species are but a few examples. In turn, human activities shape the marine environment, generating a feedback mechanism between the coupled systems. The following overview highlights some indicators of these dependencies, and new avenues by which our scientific understanding of the underlying processes are being bolstered.

It also provides an initial understanding of the potential tradeoffs that must be made under both EBM and MSP, as we analyze the nation's use of the marine environment and understand: 1) how marine resources are utilized; and 2) potential user conflicts inherent in access to these resources. As technology allows new development in and uses of ocean waters, traditional uses of marine resources (e.g., boating, fishing, shipping, spiritual practices) must be considered in the planning process for evolving new activities such as renewable energy in the form of wind farms or tidal generators. MSP is utilized by ocean resource managers, in conjunction with EBM, to better determine how resources may be sustainably used and/or protected.

8.1. Coastal Population Densities and Per Capita Income Trends

8.2. Revenue & Employment

8.3. Community Vulnerability

8.4. Communities-at-Sea

8.5. New Avenues: Local Ecological Knowledge (LEK)

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ECOSYSTEM CONSIDERATIONS

nefsc > ecosys > ecosystem status report > ecosystem services

Ecosystem Status Report for the Northeast Large Marine Ecosystem

9. Ecosystem Services

Ecosystem services are the benefits humans derive from different aspects of ecosystem structure and function. These can be partitioned into (1) Provisioning Services, (2) Supporting Services, (3) Regulating Services and (4) Cultural Services. Ecosystem-based management is intended to ensure the sustainable flow of these services that are so vital to human well-being.

Ocean-related industries provide over $50 billion to the GDP in the Northeast (National Ocean Economics Program [NOEP] data available at http://www.oceaneconomics.org/Market). and are therefore important elements of the fabric of coastal economies in the region.

In the following, we provide an overview to some of the critically important ecosystem services now being tracked in the Northeast. In subsequent sections, we describe the threats and impacts to the sustainable delivery of these services and some of the resulting impacts on human communities of impaired ecosystem structure and function.

9.1 Provisioning Services

Provisioning services of current or potential importance for the Northeast Continental Shelf include production of seafood from capture fisheries and aquaculture, energy from renewable (wind and tides) and non-renewable (oil, gas) sources, natural products such as seaweeds used in pharmaceuticals, cosmetics and food products

9.1.1. Capture Fisheries

9.1.2. Recreational Fisheries

9.1.3. Mariculture

9.1.4. Natural Products

9.1.5. Renewable Energy

Current Conditions

Produced as a biannual report.

Inform community on changes in conditions on a time scale that reflects production cycle and survey activities.

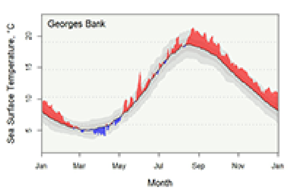
Source of information for research.

ECOSYSTEM CONSIDERATIONS

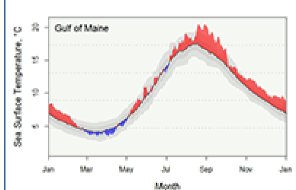
Current Conditions of the Northeast Shelf Ecosystem -- Spring 2016 Update

Fall Sea Surface Temperature - Northeast Shelf Ecosystem

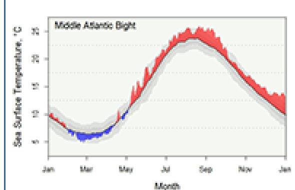
The Northeast Shelf Large Marine Ecosystem experienced above-average sea surface temperatures (SSTs) during the fall of 2015, after a period of below-average temperature during spring. In each graph the long-term mean SST is shown as a dark gray line, with areas representing plus and minus 1 and 2 standard deviations of the mean as progressive shades of gray, respectively. SSTs for 2015 above the mean are shown in red and below the mean in blue. Though all areas show above-average summer-into-fall temperatures, SSTs were well above the mean in the northern end of the ecosystem, as seen in the Gulf of Maine, Georges Bank, and Scotian Shelf subareas (see figures). Many days were above the mean by more than 2 standard deviations in these areas. SSTs were at or just above the long-term means during October of last year in the Middle Atlantic Bight and Gulf of Maine, representing the only temperature moderation during the fall season.



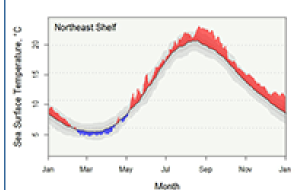
Georges Bank



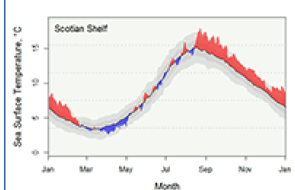
Gulf of Maine



Middle Atlantic Bight



Northeast Shelf



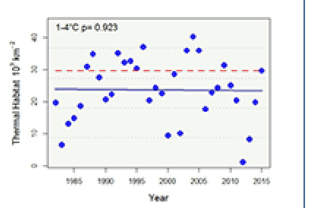
Scotian Shelf

ECOSYSTEM CONSIDERATIONS

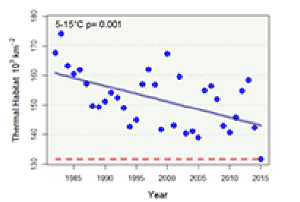
Current Conditions of the Northeast Shelf Ecosystem -- Spring 2016 Update

Ecosystem Shift in Thermal Habitat

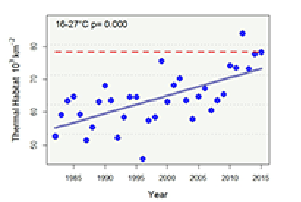
Temperature affects the behavior and physiology of marine organisms; thus it is a key determinant of habitat within the ecosystem. The area of cold water habitats (1-4°C) shows no time series trend despite extremely low values in recent years. Cold water habitats in 2015 were approximately 30,000 km^2. (2015 value marked over the time series with dashed red line, linear trend shown with blue line, regression model significance shown in upper left.) Cool water habitats (5-15°C) show a negative trend over time, declining on the order of 531 $km^2\ yr^{-1}$, which is matched by a corresponding increase in warm water habitats (16-27°C) at a rate of 545 $km^2\ yr^{-1}$. The cool water habitats were the lowest of the time series at 132,000 km^2.



NES cold water habitats



NES cool water habitats



NES warm water habitats

CURRENT UPDATE
Sea Surface Temp
Bloom Development
Bloom Start/Magnitude
SST Distribution
Chlorophyll
Thermal Habitat Shift
Long-term Temp
Satellite SST
Survey Temp
Thermal Transition
SST Forecast
Species Distribution
Kernel Density
Wind Speed
Frontal Strength
PREVIOUS UPDATE

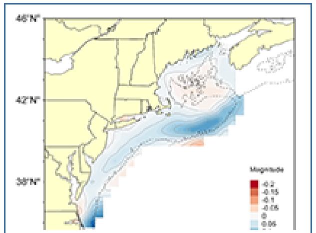
ECOSYSTEM CONSIDERATIONS

nefsc > ecosys > current conditions > frontal strength

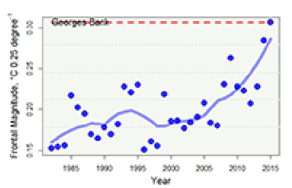
Current Conditions of the Northeast Shelf Ecosystem -- Spring 2016 Update

Change in Frontal Strength

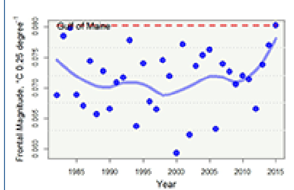
Temperature fronts form at the interface between differing water masses, often marking the boundary of an ocean current within the ecosystem. Fronts are of biological significance because they tend to concentrate organisms at both lower and upper trophic levels. A measure of fronts is the gradient magnitude, which relates the change in SST per unit distance across a frontal feature. The map shows the linear trend in gradient magnitude over the time period 1982-2015. Frontal gradient magnitude has increased on Georges Bank and in much of the Middle Atlantic Bight, suggesting that stronger frontal features can be found in these areas over time. Frontal magnitude has decreased in much of the Gulf of Maine, suggesting an opposite trend of less well developed fronts. Time series of frontal magnitude is summarized for the four Northeast Shelf ecoregions. Magnitude has increased dramatically during the most recent decade of the time series in the Middle Atlantic Bight, Georges Bank and Scotian Shelf areas (blue line is time series smoother, dashed red line marks 2015 data). Magnitude in the Gulf of Maine does not have a well-developed trend. In all areas, frontal magnitude in 2015 was the highest in the time series.



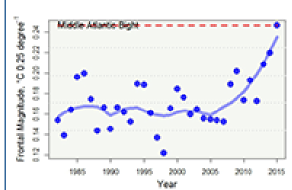
Frontal magnitude map



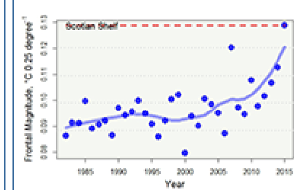
Georges Bank



Gulf of Maine



Middle Atlantic Bight



Scotian Shelf

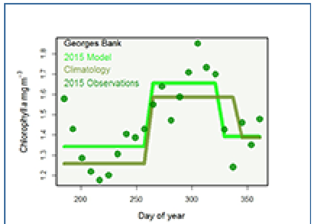
ECOSYSTEM CONSIDERATIONS

nefsc > ecosys > current conditions > bloom

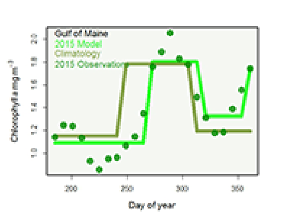
Current Conditions of the Northeast Shelf Ecosystem -- Spring 2016 Update

Fall Bloom Development on the Northeast Shelf

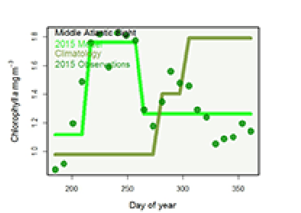
There were well-developed fall blooms detected in the Gulf of Maine and Georges Bank areas, though the bloom in the Gulf of Maine started later in the year than typical (see figures). The blooms were of shorter duration than the climatological pattern and had average bloom chlorophyll levels that matched climatological levels of 1.7 - 1.8 mg m^{-3} during the peak of the bloom. The Scotian Shelf subregion, which typically has a fall bloom, had a highly variable pattern of chlorophyll concentrations. A distinct fall bloom is not typical of the Middle Atlantic Bight area, but a bloom developed this year during July, with bloom chlorophyll levels peaking at 1.8 mg m^{-3}. The composite depiction of the bloom pattern for the Northeast Shelf reflects the fall blooms in the Gulf of Maine and Georges Bank, but can also be seen to affect the Middle Atlantic Bight.



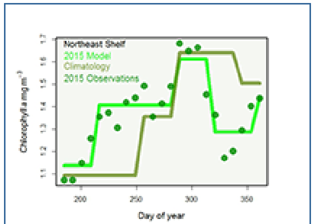
Georges Bank



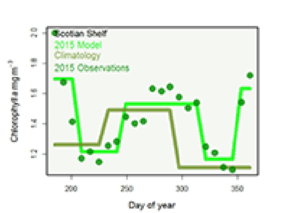
Gulf of Maine



Middle Atlantic Bight



Northeast Shelf



Scotian Shelf

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State of the Ecosystem

Briefing Document for Councils

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- 9. Ecosystem Services
- 10. Stressors and Impacts
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ECOSYSTEM CONSIDERATIONS

nefsc > ecosys > ecosystem status report > executive summary

Ecosystem Status Report for the Northeast Large Marine Ecosystem

Executive Summary

National and international efforts are now underway to establish an integrated framework for fisheries management accounting for ecosystem factors. A critical element of this overall approach involves an assessment of ecosystem status and trends. The NEFSC Ecosystem Status Report is intended to meet this need for the Northeast Continental Shelf Ecosystem Large Marine Ecosystem (NES LME). Here, we provide a synopsis of selected sections of the overall report.

We first provide observations on climate forcing and hydrographic conditions. We next document changes at the base of the food web (including the production of the phytoplankton that fuel the system and the small planktonic animals that graze on these microscopic plants and serve as prey for fish and other species). We further report on the status of fish and shellfish of commercial and recreational importance that provide high quality food resources. Humans are an integral part of marine ecosystems; accordingly we provide metrics related to human well-being and the status of certain uses of the ocean in addition to fishing. Finally, we describe several pressures and stressors affecting the status of the system. The highlights of this report are summarized here.

Many figures in this report describe recent and long-term trends and follow a common format for indicating status and trend. The data in the most recent five years (the green shaded area) may have a status above (+), below (-), or within (·) the long term variability, and may show an increasing (↗), decreasing (↘), or no (↔) trend. Inadequate recent data to determine status or trend is indicated by (x).

- Basin-Scale Climate Drivers
- Regional Climate Indicators
- The Base of the Food Web
- Fish and Shellfish
- Ecosystem Services
- Status Determinations and Species of Special Concern
- Other Human Activities and Stressors
- Pulling the Pieces Together

State of the Ecosystem

Climate Subpage

- 11. Status Determinations
- 12. Synthesis
- Contact/Contributers
- Literature Cited
- Glossary
- Site Map

green shaded area) may have a status above (+), below (-), or within (·) the long term variability, and may show an increasing (↗), decreasing (↘), or no (↔) trend. Inadequate recent data to determine status or trend is indicated by (x).

Basin-Scale Climate Drivers

Weather and climate patterns off the Northeastern United States are strongly influenced by processes operating over the entire North Atlantic Basin. Large-scale atmospheric pressure cells play a dominant role in these processes.

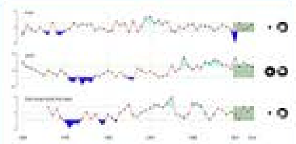

Figure 2.1

The North Atlantic Oscillation (NAO) has been associated with changes in physical and biological components of the North Atlantic, including the U.S. Northeast Continental Shelf. The NAO index is based on the difference in the strength of the Icelandic low pressure atmospheric system and the Bermuda-Azores high pressure system. The NAO has largely been in a positive phase (indicating a dominance of the high pressure system) over the last several decades. However, negative NAO indices have been observed in 3 of the last 5 years (Figure 2.1) with a very low observed NAO value in 2010. During negative NAO conditions, the probability of incursions of the Labrador Current onto the NES increases, bringing fresher, less productive waters into our region. The NAO has been correlated with changes in recruitment of a number of fish species on the NES.

The Atlantic Multidecadal Oscillation (AMO) is a second major basin-scale indicator of climatic conditions in the region, reflecting patterns of sea surface temperature (SST). The warm and cool phases of the AMO have been associated with Atlantic hurricane activity, North American and European summer climate, and changes in the abundance and distribution of North Atlantic biota ranging from phytoplankton to fish. The AMO is currently in a positive (warm) phase, persisting since the shift from a negative (cool) phase in the late 1990s (Figure 2.1). While the mean annual SST for the year 2012 in the U.S. NES LME was the warmest on record (see Section 3), the 2012 mean AMO index did not reflect this event.The NES has historically warmed more quickly than the rest of the North Atlantic during positive phasse of the AMO.

Interannual shifts in the position of the Gulf Stream are correlated with atmospheric fluctuations over the North Atlantic, including the NAO. An index of the position of the North Wall of the Gulf Stream, available since 1966, reveals a shift in the early 1980s from low to high index values (Figure 2.1), reaching a peak in the early-1990s, and characterized by subsequent multiyear reversals related to changes in the NAO index. The Gulf Stream North Wall index has been related to changes in zooplankton communities in the Northeast Atlantic, but the connection in the Northwest Atlantic appears to be weaker. Interestingly, the relationship between NAO and Gulf Stream position is not as clear after year 2000. Around this time, the character of the NAO changes, shifting away from prolonged periods of high or low toward a weaker higher-frequency oscillation.

Regional Climate Indicators

The Base of the Food Web

Environmental Data Center

Develop environmental datasets to support ecosystem based approaches to management.

Data products for work on single species, multispecies, and ecosystem assessments.

Data products/metadata/links and tools available via the intranet.

Serve the data products/metadata/links to the public.

Navigation:

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http://www.nefsc.noaa.gov/ecosys/

State of the Ecosystem subpage:
http://www.nefsc.noaa.gov/ecosys/ecosystem-status-report/executive-summary.html

Questions?