OCEAN PLANNING IN THE NORTHEAST

Draft summary of marine life data sources and approaches to define ecologically important areas and measure ocean health

Developed in support of the Healthy Ocean and Coastal Ecosystem Goal for Ocean Planning in the Northeast

June 2014

INTRODUCTION

GENERAL INFORMATION

This document provides a summary of the marine life data sources and ecological assessments that will enable the Northeast Regional Planning Body (RPB) to make progress on Actions 1-1 and 1-2 under the Healthy Ocean and Coastal Ecosystems Goal in the Northeast Regional Ocean Planning Framework.

This compilation is not comprehensive of every data source in existence and we have categorized data and assessments for ease of communication. A related visual presentation is currently being developed to summarize information in this document for communication and decision making purposes.

The purpose of this information is first to provide an introduction to RPB members and the public about what types of marine life spatial data exist in our region to inform options for characterizing marine mammal, sea turtle bird, and fish distribution and abundance for use in ocean planning. Secondly, we review existing regional efforts to identify areas of ecological importance and measure the health of the marine system in order to demonstrate how existing data and/or new data products could potentially be used in additional assessments for ocean planning.

RELEVANCE

Although not comprehensive of every data source in the Northeast region, this document provides an overview of most of the major marine life data sources and marine ecosystem assessment approaches—including related agency programs—which could be considered and leveraged for ocean planning in the Northeast U.S. region. Major data sources and approaches include most efforts that are statewide and/or regional in scope. It is current as of June 6, 2014 and will be updated on an as-needed basis.

AUTHORSHIP

This document was researched, prepared and designed by Emily J. Shumchenia under contract to the Northeast Regional Ocean Council (NROC), with substantial assistance and feedback from RPB staff, state and agency staff through the northeast ocean planning Natural Resource Work Group, and other members of the ocean science and policy community. While many marine life experts have reviewed the content in this document, including many involved in the projects that are summarized, not every page has been reviewed by the project lead. We will continue to accept reviews and feedback on this draft and subsequent drafts.

STRUCTURE OF THIS DOCUMENT

Pages

Each page in this document is a summary of a particular data source or approach related to marine life spatial products or assessments.

The data source or approach title appears at the top of the page, along with the name or names of scientists or practitioners who have led the project and/or assisted in the compilation of information on the page. These individuals may have authored text in this document, provided comments, or simply serve as a local contact for inquiries.

Page Sections

After a brief introduction about the approach, the narrative text on each page is divided into five sections.

The “DATA COLLECTION” section addresses the “what and where” about the data.

The “TEMPORAL EXTENT” section holds details about when data were collected, how frequently data were collected, as well as the points in time or time windows that spatial products represent.

The “TREATMENT OF DATA” section describes how data may have been transformed for analysis and spatial product development.

In the "SPATIAL PRODUCTS" section, we describe specifically what types of maps were developed with the data.

Lastly, the "USES" section describes how the spatial data and approaches have been used by management or regulatory entities, and in some cases, reasons why they are not being used.

Key Attributes

Along the right side of every page is a series of icons that reflect key attributes about the data sources and approaches examined. First, if new data collection is part of the particular effort, the appropriate "Data" icons will be shaded – marine mammals, birds, turtles, fish and/or environmental data were examined here. The second group of icons relates to "Spatial Products". Spatial products are essentially maps - Tier I products are maps of species observations alone; Tier II products represent species observations plus habitat information on a map. The next icon, for "Areas" is shaded if an approach identified hot spots, ecologically important areas, or areas designated by policy-driven criteria. The next group of icons relate to the measurement of marine ecosystem "Health". If an approach identifies human impacts to marine ecosystems – either singularly or cumulatively – those respective icons will be darkened.

The "Tradeoffs" icon is darkened on the single summary page that characterizes three different Tradeoffs approaches to assign dollar or other values to ecological processes in order to assess the benefits of different scenarios.

Lastly, under the "Extent" icon, we show the state (ME, NH, MA, RI, CT, NY) or whole region (NE) where the data have been collected or where the approach has been applied. For projects that took place outside the Northeast, we entered "NE+" in this area.

Document Sections

There are five sections (1 – 5) in this document that mirror the key attribute icons along the right side of each page. Every section is preceded by an introduction that explains what the section is and what types of data sources or approaches are categorized in that section.

1. Distribution and Abundance Datasets and Databases
2. Spatial Data Products
3. Ecological Areas
4. Measures of Ocean Health
5. Tradeoffs

OPTIONS FOR MOVING FORWARD

After reviewing all of the data sources and assessments presented in this document, we suggest the following options for developing new marine life spatial data products under Action 1-1 and for considering the potential utility of additional assessments under Action 1-2.

ACTION 1-1: OPTIONS FOR CREATING NEW SPATIAL DATA PRODUCTS

In order to make progress on Action 1-1, we must develop new spatial data products that characterize the distribution and abundance of marine mammals, turtles, birds, and fish. Across these marine life categories, there are many options to consider. The following table presents these options using the same categories that we used to review each of the projects in the document: Data Collection, Temporal Extent, Treatment of Data, Spatial Products and Uses. This presentation of options is meant to organize the discussion about how new spatial data products can be developed.

By being explicit about the options that we choose moving forward, we maximize the chance for usefulness of the resulting spatial data products and better understand the technical expertise and stakeholder input that

CROSSCUTTING ISSUES	OPTIONS
DATA COLLECTION	• Sources • Geographic scope • How to integrate survey methods? • How to integrate expert knowledge?
TEMPORAL EXTENT	• How many decades of data to include? • Monthly, seasonal, annual summaries
TREATMENT OF DATA	• Summarize by species, guilds, functional groups • Incorporate migration routes? • Which environmental covariates?
SPATIAL PRODUCTS	• Tier I spatial products (observations) • Tier II spatial products (observations + habitat)
USES	• As supporting information • For environmental impact assessment and/or permitting decisions by state or federal regulatory agencies • Assessing compatibility with other uses

will be needed to inform various stages of product development.

In addition, due to differences in biology, sampling methodologies, and a variety of other factors, each of these marine life categories has its own, more specific set of considerations for creating new spatial data products.

Marine Mammals and Sea Turtles

Marine mammals and sea turtles are often lumped together because similar methods are used to observe and map these species. Quantitative observation data are collected using structured scientific survey methods (i.e., effort-corrected) as well as opportunistic, unstructured survey methods (i.e., not effort-corrected); the latter often being conducted by whale watch groups, for example. Most efforts to create marine mammal and sea turtle spatial data products rely on effort-corrected data only. For some species, this reduces the number of observations significantly. Examining options for integrating data from these two survey methodologies is an important consideration in the creation of new spatial data products. Another issue for marine mammals and sea turtles is that relatively little quantitative data exist on migration routes. Consideration of expert and traditional knowledge is one option for addressing this issue.

Marine Birds

There are a number of field methodologies used to characterize bird distribution and abundance (e.g., sightings, telemetry, nesting sites), and options for integrating these data are important to consider. Similarly, options for integrating tracking data that highlight marine bird migration routes could improve the spatial characterization of several marine bird species. Lastly, there are several options for modeling bird distribution and abundance using habitat data as environmental covariates that could be examined.

Fish

Fishery-independent data (fish trawls) are collected in offshore and nearshore areas using different protocols and survey equipment. Discussing options for integrating these datasets would ensure that we benefit from all available data and create seamless spatial characterizations of fish distribution and abundance in the region. A range of options also exists for integrating expert knowledge (e.g., fishers' experience) into new spatial data products. The New England Fishery Management Council has developed a number of new spatial data products as part of the

Fisheries Omnibus Essential Fish Habitat Amendment 2 that also present options to consider for developing or using existing spatial data products that meet the needs of the ocean planning community.

ACTION 1-2: OPTIONS FOR ADDITIONAL ASSESSMENTS TO SUPPORT OCEAN PLANNING

In order to consider options for any potential additional assessments to support ocean planning, we summarized regional efforts to identify areas of ecological importance and measure the health of the marine ecosystem. In doing so, we discovered that it is critical to understand the management application of each approach in order to consider its potential for use in regional planning.

Ecological Areas

There are numerous regional methods for identifying important ecological areas; some of which are more technically driven and some of which are more policy driven. Consideration must be given to the approaches used to identify ecological areas through existing programs—such as Essential Fish Habitat or MA Special, Sensitive or Unique (SSU) Areas—and how those approaches and their end-products are potentially utilized in a regional planning effort. When considering any additional assessments, the RPB should recognize that the approaches that are currently used to support decision-making are often the approaches that had a clearly defined management intent and legal application upfront.

Measures of Ocean Health

There are a variety of ways to measure ocean health in support of ocean planning, including estimating the impact of a single human use, the cumulative impact of several uses, and developing indices to track ocean conditions considering human and other factors. Generally, there appear to be more approaches to estimating the impact(s) of a single human use on a single species or marine habitat component. Cumulative impact assessments are still evolving, and while there have been recent developments in the region, these approaches have not yet been used to support ocean planning and management decisions. Lastly, there are numerous indicator programs already in existence that offer opportunities for tracking ecological conditions over periods of time. This document does not compile these individual indicator programs since they are already compiled elsewhere. Instead, we present a few emerging opportunities to characterize ecosystem health at a regional scale in the context of human needs and societal goals.

Tradeoffs

Ecosystem services tradeoff analyses have been piloted in the Northeast region and have advanced our understanding of how such approaches can be used to support ocean planning and management. However, to date, these assessments have not been used in a planning or regulatory context.

Other Considerations

Approaches to identify important ecological areas and measure ecosystem health exist on gradients of complexity and capacity needs. While the conceptual and computational complexity of these approaches generally increases from Ecological Areas to Cumulative Impacts to Tradeoffs, the capacity and resources needed to accomplish these analyses—as well as the capacity to interpret them and keep the results up to date—also tend to increase.

Finally and perhaps most importantly, it is critical that the decision-makers (i.e., agency staff issuing permits or quantifying potential impacts) have a solid level of understanding and comfort with the spatial data product inputs, the treatment of that data and the resulting spatial product or other outputs. This level of understanding most often resulted when both decision-makers and marine life experts contributed to spatial data product development.

TABLE OF CONTENTS

PROJECT NAME

Project Lead or Primary Contact

DATA COLLECTION
A brief description of the methods used to collect data and what variables are collected.

TEMPORAL EXTENT
The dates and times of year that data have been collected or the sampling periods that spatial data products represent.

TREATMENT OF DATA
How the data have been summarized (e.g., by species group or functional group) or if any other data have been used as proxies.

SPATIAL PRODUCTS
A description of the spatial outputs of the project (e.g., maps, models, other results).

USES
How the product has been used in other marine life mapping or research; how the product has been used in ocean planning or coastal management applications.

DATA

MAMMALS

BIRDS

TURTLES

FISH

HABITAT

SPATIAL PRODUCTS

TIER I

TIER II

AREAS

HEALTH

IMPACT

CUMULATIVE

TRADEOFFS

EXTENT

NE & NE+

1. DISTRIBUTION AND ABUNDANCE DATASETS AND DATABASES

Our understanding of the distribution and abundance of marine life depends on our record of observations of marine species at certain locations and times. Scientists use a range of methods to observe marine species — from ship-board visual surveys to deploying tags that beam data to satellites. Even historical records of species observations and new, sophisticated tools that are still being developed — each method ultimately results in a dataset that consists of locations where and times that a species occurred. These sources would typically be available as spreadsheets, database files or geodatabases. Here we compiled some of the major datasets of marine life distribution and abundance in the Northeast U.S. If a particular species group is present in a data source, the marine life icon will be shaded black. We examined data sources that included observation records of marine mammal, marine bird, sea turtle and fish occurrence, as well as physical habitat characteristics.

MAMMALS

BIRDS

TURTLES

FISH

HABITAT

ATLANTIC MAMMAL/TURTLE LITERATURE

Gordon Waring, NOAA NEFSC

This is a reference document that includes the latest and best information on marine mammals and sea turtles in the U.S. Atlantic from Maine to the Florida Keys.

DATA COLLECTION
This document identifies data gaps in the knowledge of marine mammals and sea turtles in the Atlantic, and articulates research priorities recommended by national/regional agencies and groups (e.g., Marine Mammal Commission, NMFS and FWS recovery plans, Sea Turtle Expert Working Group,). This study area corresponds to the Bureau of Ocean Energy Management (BOEM) north-Atlantic, mid-Atlantic, south-Atlantic and Straits of Florida outer continental shelf (OCS) planning areas. Data are derived from primary literature, NMFS stock assessment reports, species recovery plans and websites.

TEMPORAL EXTENT
Synthesis of all existing data from the above sources. Seasonal trends are discussed.

TREATMENT OF DATA
The document provides a basis for analysis of potential impacts of BOEM-regulated activities on protected sea turtles and marine mammals as required by NEPA, for petitioning that might be required by the MMPA, and for Section 7 consultations under the ESA. The document can also serve as a guide to future decisions on planning and funding of needed research on sea turtles and marine mammals in the U.S. Atlantic.

SPATIAL PRODUCTS
The document contains a collection of maps including sightings (not effort-corrected), strandings, tags, and fishery-bycatch locations by species. In addition, there are maps of other relevant supporting information such as management and habitat areas. A list of data sources used to create the maps is included.

USES
To inform BOEM on state of the science.

DATA

SPATIAL PRODUCTS

TIER I

TIER II

AREAS

HEALTH

IMPACT

CUMULATIVE

TRADEOFFS

EXTENT

NE & NE+

STATE FISH TRAWLS

All of the New England states' marine resource management departments conduct inshore fish trawls in state waters. What follows are the individual project descriptions and primary contacts:

New Hampshire/Maine (joint) - Doug Grout, Marine Fisheries Division, NH Fish & Game douglas.grout@wildlife.nh.gov and Sally Sherman, Maine Department of Marine Resources, sally.sherman@maine.gov. Coastal bottom trawl in ME/NH waters since 2000 (spring & fall). 115 tows attempted per survey within 5 areas based on geologic, oceanographic, geographic, biological and depth factors.

Massachusetts - Jeremy King, jeremy.king@state.ma.us
Coastal bottom trawl data in MA waters 1978-present
GIS point data of abundance indices, percent occurrence, date of first occurrence

Rhode Island - GSO fish trawl - Mary Kane mkkane@my.uri.edu
1959-present; weekly, year round, 2 tows in Narragansett Bay
Excel spreadsheet of species counts per tow

Rhode Island – RI Department of Environmental Management - Mark Gibson mark.gibson@dem.ri.gov
1990-present; 12 fixed stations in Narragansett Bay and nearshore RI; Point data http://www.narrbay.org/biological_data.htm

Connecticut – Long Island Sound - Deborah J. Pacileo - Marine fisheries GIS, deb.pacileo@ct.gov
Monthly trawls since 1984; Abundance and biomass; unknown spatial data

USES
These data provide state managers with information towards state stock assessments and may provide regional/federal managers with an inshore/nearshore perspective for stock assessments. Massachusetts trawl data were used in the MA Ocean Management Plan (OMP), the Rhode Island nearshore trawl data were used to inform the RI Ocean Special Area Management Plan (OSAMP), and the Connecticut trawl data have recently been used by The Nature Conservancy for the Long Island Sound Ecoregional Assessment.

DATA

SPATIAL PRODUCTS

TIER I

TIER II

AREAS

HEALTH

IMPACT

CUMULATIVE

TRADEOFFS

EXTENT

NE

AVIAN COMPENDIUM

Allison Sussman, USGS

The Atlantic Seabird Compendium is a BOEM-funded project that combines marine bird datasets from multiple sources into a central repository that is curated by the USGS.

DATA COLLECTION

The majority of the data are strip transects (mostly 300m width) but there are also some “non-scientific” observational records (e.g., Audubon Christmas Bird Counts (CBC)). Data in the compendium are from >65 existing datasets including the Avian Knowledge Network, GeoMarine Inc., CapeWind, Manomet Center for Conservation Science, the Canadian Wildlife Service PIROP dataset, OBIS-SEAMAMP, RI OSAMP, NJ DEP, DOE-BRI, AMAPPS, Acoustic Herring, ECOMON, NMFS seabird bycatch, The Nature Conservancy, Center for Conservation Biology at the College of William and Mary, and USFWS Sea Duck Joint Venture.

TEMPORAL EXTENT

Most data span 1960s-2010 (shorebirds) and 1978-2009 (seabirds). CBC data are 1907-2004. The database is currently being updated to incorporate colony data from 13 New England states from 2013.

TREATMENT OF DATA

Curation “Phase 1” occurred between 2005-2006; Phase 2 between 2011-2013; and Phase 3 is 2013-present. A summary of the data has been released to data.gov and the full dataset is available upon request in geodatabase or Microsoft Access database. It is also (or will be) archived through NOAA NODC. Data are fed to OBIS on an annual basis. The Compendium does contain some mammal, turtle and “other” data.

SPATIAL PRODUCTS

Part of the Phase 1 effort included modeling oceanographic data (SST, chlorophyll, bathymetry and geology) to improve models of bird distribution and abundance. The overarching goal of the Compendium was to improve the availability of spatial data (not necessarily create new spatial products). BOEM released two final reports describing the Compendium for shorebirds and seabirds, respectively.
http://www.data.boem.gov/PI/PDFImages/ESPIS/5/5209.pdf
http://www.data.boem.gov/PI/PDFImages/ESPIS/5/5193.pdf

USES

Data from the Compendium have been used by the NOAA Biogeography Branch to assemble Tier II models of bird distribution and abundance in the New York offshore planning area, along the Mid-Atlantic and are currently being assembled for the entire U.S. Atlantic coast (see page 26 on NOAA NCCOS models for more information). Compendium data are used in the MA OMP to create Tier I seabird products in order to understand which species are to be further studied for consideration as designation as a Special, Sensitive or Unique (SSU) resource.

BOEM incorporated the data and specific information contained in the Compendium to assemble their Statistical Guidelines for Avian Surveys document.

DATA

SPATIAL PRODUCTS

TIER I

TIER II

AREAS

HEALTH

IMPACT

CUMULATIVE

TRADEOFFS

EXTENT

NE & NE+

PASSIVE ACOUSTIC DATA

Passive acoustic data refers to records of “observations” made by listening to the marine environment. Mammals, fish, marine invertebrates, sea birds, bats, physical oceanographic events/processes (e.g., earthquakes, waves, wind, rain) and many human activities (e.g., ships, sonars, dredging, pile-driving) can be detected by passive acoustic monitoring (PAM). Species, populations and individuals (in some cases) can be identified by their acoustic signatures. Depending on the type of PAM system that is operated (e.g., single or array of hydrophones, omnidirectional or “beamed” directional capabilities, bottom-mounted or towed behind ship, embedded in tag, placed on animal, or on an autonomous vehicle like a glider) information can range from presence/absence to precise locational data for sound-producing animals of interest. In addition, PAM can be used to monitor geophysical events (e.g., earthquakes, storms), ocean-basin scale climatic variables (e.g., temperature, pressure, salinity) and local- to global-scale human activities of interest (e.g., presence of vessels in a closure area, defense surveillance, violation of nuclear test ban treaty). Because PAM can be deployed and operated without human involvement for long periods of time and over large areas, these observations are extremely valuable for filling in gaps in visual observer-based sampling methods in order to better understand marine life distribution and abundance. For example, PAM provides information about marine life activity at night and during storms, which are both times when scientists are not able to be out sampling the environment. Additionally, sounds that are low frequency (low “tones”) can be detected over far wider ranges than they would be visible from platforms like ships, planes or shore.

DATA COLLECTION
The distance that receivers can “hear” depends on the type of device and the frequency of the sound (which affects its travel distance). In deep water environments, relatively loud low frequency sounds like fin whale calls can travel hundreds of thousands of miles. However, in shallower coastal waters, these calls travel less far due to strong sound absorption. Regional presence of fin whale callers can thus be monitored by sensors not far off the US east coast. Other animals that produce higher frequency calls (e.g., many toothed whales, like dophins and porpoises) or softer signals (e.g. many fish) will be monitored more locally to sensors.

TEMPORAL EXTENT
PAM has recently grown as a sampling methodology; many existing records are from the last several decades. The temporal frequency of “observations” depends on the deployment and survey goals.

TREATMENT OF DATA
PAM data ranges from presence only to array-based location data to tag-based location data. It is unclear if numbers of individuals can be reliably estimated from PAM records (this is also an active area of research). It is increasingly commonplace to integrate PAM records within comprehensive surveys that use visual, acoustic and other detection methods (methods to do so are not yet standardized and this is also an active area of research). There is no central database for all active PAMs projects/data though OBIS now integrates some passive acoustic data.

SPATIAL PRODUCTS
NMFS is currently engaged in a project to pilot the development of PAM database – Sofie Van Parijs at NEFSC is heavily engaged in this effort.

USES
PAM data have been contributed to NOAA soundscape characterizations (quantifying underwater sound as a human impact on marine life) and the CetMap project. OBIS-SEAMAP contains PAM records.

DATA

SPATIAL PRODUCTS

TIER I

TIER II

AREAS

HEALTH

IMPACT

CUMULATIVE

TRADEOFFS

EXTENT

NE & NE+

NARWC DATABASE

Bob Kenney, University of Rhode Island Emeritus

The North Atlantic Right Whale Consortium database is a collection of marine mammal and turtle observations in the North Atlantic Ocean. The NARWC database was established in 1986 through a partnership between the University of Rhode Island, The New England Aquarium, Provincetown Center for Coastal Studies, Woods Hole Oceanographic Institution, and the other organizations comprising the NARWC.

DATA COLLECTION
While the NARWC does not actively collect data, it curates data from around the North Atlantic that fall into two categories: the "Sightings database" (curated by URI) and the "Identification database" curated by NEAq. Funding for the curation of the Sightings database by Bob Kenney ended in August 2013. These are sightings contributed by NEFSC: http://www.nefsc.noaa.gov/psb/surveys/index.html

TEMPORAL EXTENT
Standardized shipboard and aerial sightings 1978 – 2013.

TREATMENT OF THE DATA
The database maintains minimum standards for acceptable sightings conditions that include visibility of at least two nautical miles, a sea state of Beaufort 4 or lower, and, for aerial surveys, a maximum altitude of no greater than 1,200 feet.

SPATIAL PRODUCTS
Bob Kenney has provided NARWC data in the past as point data summaries of all observations at centroids of each cell in a 5'x5' grid.

USES
The NARWC data sharing policy prohibits third parties from obtaining raw data and presenting them for public use. However, numerous efforts have used NARWC data, at various time steps in the last decade including the Massachusetts Ocean Management Plan, the Rhode Island Special Area Management Plan, the NY Biogeographic Assessment, the Ecological Characterization of Stellwagen Bank, and The Nature Conservancy's Northwest Atlantic Marine Ecoregional Assessment (NAMERA).

DATA

SPATIAL PRODUCTS

TIER I

TIER II

AREAS

HEALTH

IMPACT

CUMULATIVE

TRADEOFFS

EXTENT

NE & NE+

WHALE CENTER OF NEW ENGLAND

The Whale Center of New England is a non-profit organization that maintained a database of mammal observations during whale-watches.

DATA COLLECTION

Data in this database are referred to as “off-effort” or “opportunistic” data because they are not collected using a structured scientific method, with which one can make an unbiased measurement of survey effort. Therefore, the observations cannot be effort-corrected, as can transect-based ship or aerial surveys. This severely limits their utility in traditional Sightings-Per-Unit-Effort (SPUE) databases, maps and other spatial products.

TEMPORAL EXTENT

Unknown

TREATMENT OF DATA

Unknown

SPATIAL PRODUCTS

Unknown

USES

Some of these data are in the NARWC database.

Due to a leave of absence (illness) of their chief scientist, the Whale Center of New England closed/ceased active operation. This may severely limit future data availability.

DATA

SPATIAL PRODUCTS

TIER I

TIER II

AREAS

HEALTH

IMPACT

CUMULATIVE

TRADEOFFS

EXTENT

NE & NE+

FISHERY OBSERVER PROGRAMS

Fishery Observer programs provide data about mammals, birds and sea turtles that are caught as bycatch in commercial fisheries.

DATA COLLECTION
NOAA contracts with a few agencies to put observers on commercial fishing boats and to collect data about bycatch (among other things about the commercial fish species).

TEMPORAL EXTENT
Annual discard reports are available online from 2009-2011; additional documents are available from 2009-2013. The original call for a Fishery Observer Program originated in the 1996 amendment—the “Sustainable Fisheries Act”—to the Magnuson-Stevens Act.

TREATMENT OF DATA
These data must be summarized by 30’ boxes and are subject to confidentiality issues that severely limit their usefulness. Some have found it problematic to be granted access to these data.

SPATIAL PRODUCTS
For local and regional interests, the 30’ summary grid severely limits the scale of interpretation for these data, and maps may not be useful for local or regional planning.

A paper came out recently that utilized bycatch records at a global scale to estimate global hotspots for mammals, turtles and birds:

Lewison, R.L. et al., 2014. Global patterns of marine mammal, seabird, and sea turtle bycatch reveal taxa-specific and cumulative megafauna hotspots. PNAS 111: 5271-5276.

USES
Data have been used in RI OSAMP marine mammal distribution maps and in at least one book about marine mammal distribution and abundance in the NY region.

DATA

SPATIAL PRODUCTS

TIER I

TIER II

AREAS

HEALTH

IMPACT

CUMULATIVE

TRADEOFFS

EXTENT

NE & NE+

NEFSC MAMMAL SURVEYS

Debi Palka, NOAA

Since 1991, the Protected Species Branch (PSB) has been conducting line-transect shipboard and aerial abundance surveys over waters ranging from North Carolina to the Gulf of St. Lawrence in Nova Scotia, Canada, and from the coastline to slightly beyond the EEZ, which is 200 nautical miles offshore. The goals of these surveys are to estimate the most unbiased and precise abundances as possible for as many cetacean and turtle species as possible, and describe the distribution and habitat preferences of as many cetacean and turtle species as possible.
http://www.nefsc.noaa.gov/psb/surveys/aerialsurveys.htm

DATA COLLECTION
These are visual surveys conducted from ships along line transects of whales, dolphins, porpoises, seals, sea turtles and some large fish species (e.g., sunfish, sharks, and rays). On the same ship, a passive acoustic sensor records animal noise, and a separate team of scientists records the physical characteristics (surface water temp, salinity and depth) of the water as well as distribution/abundance of plankton. Biopsy samples of the megafuna are also occasionally collected. Aerial abundance surveys of the same organisms are conducted on planes equipped with probes to sample the physical characteristics of the water.

TEMPORAL EXTENT

1991 – present

TREATMENT OF DATA
Survey transects are stratified first by depth and then in deeper water by expected mammal density (shallow, high-, med-, and low-density transects).

SPATIAL PRODUCTS
Web map viewer (at link above) shows transect layout for shipboard surveys (1998-2004; 2007, 2011, 2013) and aerial surveys (1995 – 2012).

USES
These data have been used for numerous management applications in the region, including the Massachusetts Ocean Plan and the RI Special Area Management Plan. As contributions to the North Atlantic Right Whale Consortium Database, the NEFSC mammal surveys are widely available and widely used in general.

DATA

SPATIAL PRODUCTS

TIER I

TIER II

AREAS

HEALTH

IMPACT

CUMULATIVE

TRADEOFFS

EXTENT

NE & NE+

NEFSC FISH TRAWLS

The NOAA Northeast Fisheries Science Center has been conducting offshore multispecies bottom trawl surveys for fishery-independent stock assessment in some form since 1963.

DATA COLLECTION
These are bottom trawl data that have been calibrated by vessel and gear type over the course of the survey. In addition to fish abundance and biomass per tow, scientists record surface temperature and conduct temperature-salinity profiles.

TEMPORAL EXTENT

Fall surveys (1963 – 2013); Winter surveys (1991 – 2009); Spring surveys (1968 - 2014); Summer surveys (1963 – 1981).

TREATMENT OF DATA
Stations are stratified by depth and region.

SPATIAL PRODUCTS
See page 18 on NEFSC Spatial Ecology Tools; Web map viewer http://nefsc.noaa.gov/ecosys/spatial_tools/mapping.html

USES
These data are incorporated in the NEFSC Ecosystem Assessment Program's research on fish distribution and abundance shifts due to ocean warming and have been used for numerous fisheries management applications in the region.

DATA

SPATIAL PRODUCTS

TIER I

TIER II

AREAS

HEALTH

IMPACT

CUMULATIVE

TRADEOFFS

EXTENT

NE & NE+

2. SPATIAL DATA PRODUCTS

Spatial data products are often the maps that help visualize distribution and abundance data. There are a number of methods available to map distribution and abundance data. For the purposes of this effort, we have defined two broad Tiers of spatial data products that differ based on how maps are developed.

Tier I products are simple representations of only species distribution and abundance using recent observations of the species. The purpose or goal of a Tier I product is to display the spatial pattern of a species distribution and abundance over a defined time period.

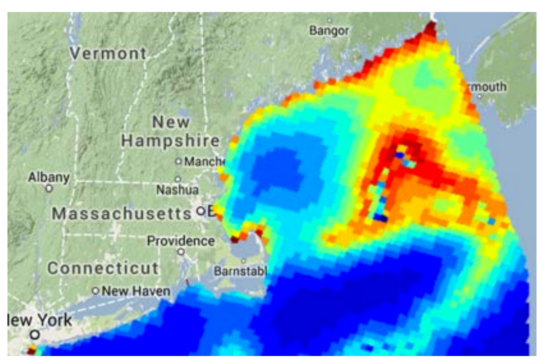
A Tier II product uses information about a species' habitat to develop a model of species abundance and distribution. The purpose of a Tier II model is to link species observations to habitat data or properties of the physical environment. Hopefully these physical properties are at least partially responsible for the species being where it is. Using those relationships, Tier II models estimate species abundance over much wider areas. Importantly, these more "complicated" models project species occurrence or abundance into areas where no observations have been made.

Additional considerations for the use of Tier I and Tier II products include adding historical species ranges and forecasting future species occurrences based on established species-environment relationships and how we think the environment will be changing in the future. These approaches may use animations or movies to help visualize biological and physical change—or even uncertainty—over time.

In this inventory, some efforts both collected new data and developed spatial data products. Data icon will be highlighted black if that is the case.

Why not call this section "Maps"?

We consider "Spatial Data Products" to be a category more broad than "Maps". A map is often thought of as a static, two-dimensional product. This section describes outputs that are more than just static maps — they are models of species distribution, abundance, and species-habitat relationships in space and time. Often, Spatial Data Products cannot be fully understood with a single two-dimensional, static map. Spatial Data Products may be more appropriately visualized by a series of maps or an animation.



This cetacean density model from Duke University is an example of a Tier II model. This model uses relationships between whale abundance, ocean temperature and ocean depth to estimate whale density across the study area – even into areas where we have not surveyed for whales.

NEFSC SPATIAL ECOLOGY

Mike Fogarty, NOAA

The NOAA Northeast Fisheries Science Center Ecosystem Assessment Program and Spatial Ecology Lab produced a number of spatial data products related to trends in fish species abundance and distribution.

DATA COLLECTION

Data are derived from NOAA NEFSC Fish Trawls (see page 16 for more information).

TEMPORAL EXTENT

Total fish biomass is estimated for 2007-2011; species richness is estimated for 2009-2011; spring/fall cod abundance is estimated for 1968-2012 in ~5-year chunks that are spliced together to form a simple animation; Primary productivity is calculated for 1998-2007; Benthic invertebrate data were collected from 1956-1965.

TREATMENT OF DATA

For fish trawl data, total biomass and vertebrate richness were calculated. Interpolation between stations was accomplished with empirical Bayesian kriging. Abundance of several key zooplankton species was interpolated using empirical Bayesian kriging.

SPATIAL PRODUCTS

Static maps include habitat (bathymetry, terrain roughness, sediment from USGS, pelagic temperature and stratification), benthos, lower trophic levels, forage fish, protected species (mammals, turtles), fish communities from fishery-independent surveys, fishery metrics (gear, landings), incidental catch, oil/chemical spills. Data are available as Google Earth KMZ files from http://nefsc.noaa.gov/ecosys/spatial_tools/KMZ_files.zip

USES

Using these data, researchers at NEFSC have done specific studies/analyses on fish-habitat relationships. This is an example of habitat movement patterns due to climate change for butterfish: http://www.fisheries.noaa.gov/podcasts/2014/02/changing_climate.html#.Ux24NuddXkb. These data are also considered in NEFMC habitat amendment (designating closure areas), and stock assessments.

DATA

SPATIAL PRODUCTS

TIER I

TIER II

AREAS

HEALTH

IMPACT

CUMULATIVE

TRADEOFFS

EXTENT

NE & NE+

NEFSC FISH DISTRIBUTION MOVIES

Jon Hare and Dave Richardson, NOAA

The NOAA Northeast Fisheries Science Center created animated maps of fish distribution and abundance, by species and size class, over time in the Northeast region.
http://www.nefsc.noaa.gov/epd/ocean/MainPage/ioos.html

DATA COLLECTION
Data are derived from NOAA NEFSC Fish Trawls (see page 16 for more information). Data exist from the 1960s - ~2009, and this varies by species. There are movies for 38 species (some with more than one size class and/or season) in this analysis.

TEMPORAL EXTENT
Fish distribution animations include NEFSC data from the 1960s – 2009 spring/fall trawl surveys. Each annual map (i.e., a single video frame) is informed by five years of data in order to dampen the effects of a single anomalous year on the animation.

TREATMENT OF DATA
An inverse-distance weighting scheme with a "depth penalty" is used to interpolate between NEFSC trawl sampling locations. This method better represents distributions of species that are linked to changes in depth (Tier II). The abundances represented in the movies also reflects the application of a calibration coefficient to account for differences in catchability of different survey vessels used over the long record of data.

SPATIAL PRODUCTS
Each species has a separate spring and fall movie; some have additional size class-specific movies within each season.

USES
These animations have been used internal to NOAA for furthering our understanding of fish stock changes over time and the implication of climate change. Movies for butterfish have been used as an interface and communication tool between scientists and fisherman who are interested in tracking species movements with ocean warming.

DATA

SPATIAL PRODUCTS

TIER I

TIER II

AREAS

HEALTH

IMPACT

CUMULATIVE

TRADEOFFS

EXTENT

NE & NE+

NEAQ AQUACULTURE

Michael Tlusty, New England Aquarium

This study looked at available space for aquaculture development in the Gulf of Maine by concurrently assessing the distribution and abundance of marine mammals and sea turtles, and the current social and economic efforts of the fishing and shipping industries. Only the marine life components are discussed here.

DATA COLELCTION
New data collection was not a specific goal of this effort.

TEMPORAL EXTENT
Same as the NARWC database – 1978-2009; seasonal and annual analysis.

TREATMENT OF DATA
SPUE was calculated for each 5'x 5' grid cell. Analyses were by the following species groups "all baleen whales" "all sea turtles" "all baleen whales and sea turtles" and by individual species: fin whale, humpback whale, minke whale, North Atlantic right whale, and sei whale. Interpolation was by kriging. Summaries over 10' grids were used to compare with the fishing and shipping distributions. Each layer was converted to a "Z-score" by subtracting the mean and dividing by the standard deviation. This put each layer (marine life, fishing, shipping) on a common relative dimensionless scale. The 3 layers were then summed to show areas of high and low use.

SPATIAL PRODUCTS
Maps of survey effort (each season and annually), SPUE for all species groups and individual species (each season and annually). Maps of cumulative use (marine life + fishing + shipping) for each season and annually in both interpolated (smooth kriging) and 10' summary squares. Images of these maps can be viewed and downloaded at http://www.marinegis.org/aquaculture.html

USES
To assess the available space for aquaculture development in the Gulf of Maine. Used as a case study in two meetings of a workshop (Boston September 2010 and Vancouver January 2011) in which a cross-section of leaders from the seafood industry (including major buyers and producers), academia, and NGOs gathered to discuss open ocean aquaculture.

DATA

SPATIAL PRODUCTS

TIER I

TIER II

AREAS

HEALTH

IMPACT

CUMULATIVE

TRADEOFFS

EXTENT

GoM

SEA DUCK JOINT VENTURE

Chris Dwyer, USFWS

The Atlantic and Great Lakes Sea Duck Migration Study is an ongoing study with multiple partners in the US and Canada – federal, nonprofit, academic, etc. They coordinate with the BOEM-Biodiversity Research Institute (BRI) MidAtlantic marine birds tracking study.

Steering committee: Shannon Badzinski (Environment Canada-CWS), Tim Bowman (USFWS), Sean Boyd (Environment Canada-S&T), Chris Dwyer (USFWS), Grant Gilchrist (Environment Canada-S&T), Scott Gilliland (Environment Canada-CWS), Christine Lepage (Environment Canada-CWS), Dan McAuley (USGS), Jay Osenkowski (Rhode Island DEM), and Emily Silverman (USFWS).

Goals: describe annual migration patterns and variability; ID near- and offshore areas of high significance; estimate rates of site fidelity for wintering, breeding, staging, molting; map local movements and estimate length-of-stay during winter, spring and fall migration.

http://seaduckjv.org/atlantic_migration_study.html

DATA COLLECTION

This project is focused on 4 species of sea ducks: surf scoter, black scoter, white-winged scoter and long-tailed duck at the “flyway scale” and population scale to enable inference at the same scale. Birds are tagged with satellite transmitters (PTTs) and transmit telemetry data from Argos satellites.

Progress report Feb 2014; Currently, the plan for 2014 is to 1) mark white-winged scoters at a wintering area in Massachusetts; and 2) evaluate logistics for a future white-winged scoter and long-tailed duck capture events in the Nantucket/Cape Cod area.

TEMPORAL EXTENT

More than 400 transmitters have been deployed since 2009.

TREATMENT OF DATA

BRI handles data mapping and management. Data are filtered to remove “bad data” and errant points. All tag data and animal data are stored in Google spreadsheets.

SPATIAL PRODUCTS

BRI developed a custom ArcGIS script to automate map production. They then produce two basic map types: 1) movement maps showing mean location points for each animal per period (i.e., breeding, molt, and winter) connected by migratory path lines and 2) kernel density maps that show broad-scale utilization distribution for all animals.

USES

These data will eventually be used to address BOEM’s offshore energy siting and environmental assessment questions.

DATA

SPATIAL PRODUCTS

TIER I

TIER II

AREAS

HEALTH

IMPACT

CUMULATIVE

TRADEOFFS

EXTENT

NE & NE+

NEAMAP

The Northeast Area Monitoring and Assessment Program (NEAMAP) is an integrated cooperative fed/state data collection program run by the Virginia Institute of Marine Science (VIMS) at the College of William and Mary. NEAMAP samples inshore from Cape Cod to Cape Hatteras.

DATA COLLECTION
Sampling is coordinated with the NOAA NEFSC (who is doing offshore) fishery-independent sampling. A stratified-random sampling design of major estuarine outflows from Cape Hatteras to US/Canada border is employed.

TEMPORAL EXTENT
Pilot surveys in fall 2006; full spring/fall surveys began in 2008.

TREATMENT OF DATA
VIMS is developing an abundance index (delta lognormal based) for each species, but this is currently dependent on data density.

SPATIAL PRODUCTS
http://www.neamap.net

Static maps of bottom water temperature per survey & departure from average, catch history for non index species of interest or concern (sturgeon, turtle, coastal sharks), spring/fall biomass of each species are currently available on a web map viewer:

http://www.vims.edu/research/departments/fisheries/programs/multispecies_fisheries_research/interaction/index.php

In addition, users can specify a grid based on equal cell sizes and aggregate point data for a particular species to this grid. The units of display are total catch in either biomass or number of individuals.

Abundance indices are downloadable in excel files per species:
http://www.vims.edu/research/departments/fisheries/programs/multispecies_fisheries_research/abundance_indices/NEAMAP/index.php

USES
NEAMAP data have been requested by ASMFC for stock assessment. To date, some data have been used, but some have not due to the length of record for some species.

DATA

SPATIAL PRODUCTS

TIER I

TIER II

AREAS

HEALTH

IMPACT

CUMULATIVE

TRADEOFFS

EXTENT

NE & NE+

MASSACHUSETTS CEC

The Massachusetts Clean Energy Center funded a multiyear field survey effort of whales and sea turtles for offshore wind energy planning in Massachusetts using aerial observers, photography and passive acoustic monitoring.

DATA COLLECTION
The sampling approach for this project is a strip-transect survey method – 7 nm spacing, 37 nm length, with a 2nm detection swath on each transect. In the first field season, 24 aerial surveys and 11 months of continuous acoustic monitoring were conducted.

TEMPORAL EXTENT
The first field season was October 2011 – September 2012. A second year of data collection (field season 2013) has occurred, and a third year of data collection has recently been approved (field season 2014).

TREATMENT OF DATA
Raw sightings data are mapped to show distribution patterns, but the authors have little confidence in these patterns due to the limited (i.e., one year) amount of data. There were an inadequate number of sightings to estimate density (and SPUE) for all species except leatherback and loggerhead turtles, basking, blue and dusky sharks and ocean sunfish. A second year of sightings may provide enough data to calculate SPUE and map densities for other species. The acoustic data do not have a specific location component and thus provide seasonal trends of marine animal and ambient noise over the course of the year.

SPATIAL PRODUCTS
Static maps are bubble plots showing distribution and abundance of animals observed over the course of the entire 2011-2012 field season. Seasonal and annual gridded SPUE maps are provided for right whales, all delphinids, leatherback and loggerhead turtles. This work also resulted in a methodological paper in Marine Technology Society Journal "Automated vertical photography for detecting pelagic species in multitaxon aerial surveys" – which shows that density estimates from photos were higher than aerial observation estimates for some species (but not leatherback turtles or basking sharks).

USES
These data and maps will eventually support environmental assessments in the MA Wind Energy Area for ESA and MMPA compliance.

DATA

SPATIAL PRODUCTS

TIER I

TIER II

AREAS

HEALTH

IMPACT

CUMULATIVE

TRADEOFFS

EXTENT

MA

SHARP

Chris Elphick, University of Connecticut

The Saltmarsh Habitat and Avian Research Program (SHARP) was founded by academic, governmental and non-profit collaborators to provide critical information for the conservation of tidal marsh birds. The program provides a consistent platform for monitoring the health of tidal marsh bird communities and the marshes they inhabit.

DATA COLLECTION
SHARP collects data on tidal marsh birds and six focal species: American black duck, Clapper rail, Willet, Saltmarsh sparrow, Nelson's sparrow and Seaside sparrow. Their specific objectives are to provide population estimates for tidal marsh species, estimate population change over the last two decades for tidal marsh species, model spatial variation in the reproduction and survival of the six focal species, identify the most critical areas for the long-term preservation of tidal marsh species, and explore tidal marsh bird community resistance to extreme storm events and climate change. SHARP collects bird counts passively and by broadcasting calls.

TEMPORAL EXTENT
To date SHARP has completed 3 field seasons of data collection from Maine to Virginia, and plan to continue data collection in the 2014 field season. Each sample location is visited at least twice throughout the survey period

TREATMENT OF DATA
Raw occurrence data (Tier I) are integrated with three different remote-sensing vegetation indices in order to build models that predict tidal marsh bird occurrence throughout the study area (Tier II). These models are in-progress.

SPATIAL PRODUCTS
Spatial products are currently in development. Available maps include historical survey points, current survey locations and currently monitored demographic plots.
http://www.tidalmarshbirds.net/?page_id=76

USES
To provide the ten states in the SHARP study area with a detailed description of their responsibility for conservation. To provide managers with the information necessary to preserve tidal marsh species and habitats in the face of climate change and sea level rise. SHARP intends to build on an existing working group of local, state and NGO stakeholders to implement the findings of this work.

DATA

SPATIAL PRODUCTS

TIER I

TIER II

AREAS

HEALTH

IMPACT

CUMULATIVE

TRADEOFFS

EXTENT

NE & NE+

AMAPPS

Debi Palka, NOAA and Jeff Leirness, USFWS

The Atlantic Marine Assessment Program for Protected Species (AMAPPS) is a multi-agency monitoring effort funded by BOEM, Navy, NOAA and USFWS. One of the goals is to document distribution changes and abundance trends. NOAA coordinates surveys for marine mammals, sea turtles and seabirds from Nova Scotia to Miami FL using aerial and shipboard platforms. The USFWS coordinates aerial surveys focusing on seabirds from the US/Canadian border to Cape Canaveral FL: ¼ nm offshore to 30m depth; transects are run every 5' latitude.

DATA COLLECTION
Most recently NOAA shipboard surveys occurred from Mar-April 2014 in waters from North Carolina to Massachusetts, focusing on wind energy planning areas and the shelfbreak targeting marine mammals, seabirds, turtles and large fish and sharks. These surveys included passive and active acoustic monitoring, collection of hydrographic and plankton information, as well as collection of cetacean sightings and photographs. Previous similar shipboard surveys were conducted during the summers of 2011 and 2013. USFWS and NOAA aerial abundance surveys started in summer 2010, where the most recent was during spring 2014, and near future surveys are proposed for winter 2015, and fall 2015. Teams have also deployed satellite telemetry packages on loggerhead turtles, harbor seals, and gray seals. In addition razorbills across all four known breeding colonies in the Northeastern U.S are proposed to be deployed in the near future.

TEMPORAL EXTENT
First aerial line transect and turtle telemetry sampling and first shipboard and aerial surveys began in 2010 (to present).

TREATMENT OF DATA
The NOAA team are creating spatially-temporally explicit density model using data from ~2010-present using environmental/habitat covariates (Tier II). These models and associated reports are scheduled to be released in July 2015. Seabird products will be raw density maps (Tier I). Preliminary raw density maps have been created but not yet released. There are ongoing NOAA and USFWS efforts to account for perception bias for all of the target species. A species database is held at NEFSC, which includes environmental variables and ocean model data (e.g., mixed layer depth, sea surface height); species data are also held in the USFWS/USGS Seabird Compendium database; acoustic data are held in the DOE TETHYS database. Many datasets are available through OBIS-SEAMAP or will be available there soon.

SPATIAL PRODUCTS
Not yet available; see above.

USES
AMAPPS will provide data to BOEM/Navy to support environmental assessments; NOAA will use these data for stock assessments required under MMPA, and to support programs that monitor risk of extinction and recovery of species detected.

DATA

SPATIAL PRODUCTS

TIER I

TIER II

AREAS

HEALTH

IMPACT

CUMULATIVE

TRADEOFFS

EXTENT

NE & NE+

OBIS-SEAMAP
DUKE UNIVERSITY

Patrick Halpin, Duke Marine Geospatial Ecology Lab

This database and online mapping tool (http://seamap.env.duke.edu) collects and contains marine mammal, seabird and sea turtle observation data from around the world.

DATA COLLECTION
Data types include individual occurrences and tracks (labeled by platform – plane, shore, tag, boat) from over 600 individual datasets. Data are derived from visual sightings and telemetry (e.g., satellite tags, acoustic monitoring, or photos). Cetacean records come from NEFSC, SEFSC, UNCW aerial surveys, YoNAH project (photo ID + molecular genetics) 1992-1993; Passive Acoustic Monitoring data are not in the habitat models.

TEMPORAL EXTENT
In the U.S. Northeast, occurrence data range from 1926-present. Environmental data are also available including sea surface temperature, sea surface height, chlorophyll-a and bathymetry that can be time-synched to the observations data (from 1987-present).

TREATMENT OF DATA
Animal observations and survey effort data are collected from different sources and are normalized and presented in a single viewer for review and query (space, time, taxon, jurisdictional geography). Original data providers maintain access control over datasets.

SPATIAL PRODUCTS
Web map viewer that displays raw observations and access to a variety of focused data portals (photo ID, sea turtle nesting, marine mammal models). In the Northeast, Duke has developed models of marine mammal distribution & abundance, under the Navy SERDP program and NASA funding. The Duke Habitat models take species occurrences and correlate them to environmental covariates to derive a (survey-effort corrected) habitat suitability index. A web map viewer displays raw observations and each model output (i.e., individual species, guild, season) on a map. For each model output, contributing datasets are listed along with quantification of model fit. For each species and season, contributing datasets and environmental covariates are different. A new round of mammal density models is now under review and will be hosted at OBIS-SEAMAP and served to other marine data portals (Marine Cadastre and others).

USES
The database has been used within the scientific community and by NOAA's CetMap program for mapping biologically important areas for cetaceans. The U.S. Navy uses the spatial data products for NEPA, MMPA, and ESA compliance in their Operating Areas.

DATA

SPATIAL PRODUCTS

TIER I

TIER II

AREAS

HEALTH

IMPACT

CUMULATIVE

TRADEOFFS

EXTENT

NE & NE+

NCCOS AVIAN MODELING

Brian Kinlan, NOAA

The NOAA Biogeography Branch of the National Centers for Coastal Ocean Science (NCCOS) has developed a methodology to map and assess the marine environment and marine life in several sub-regions. This methodology was first applied in Stellwagen Bank National Marine Sanctuary (see page 28 for more information), but discussed here are the marine bird spatial products that have been developed over the past ~5 years.

DATA COLLECTION

New data collection is not a primary goal of this work. Data are derived from the Avian Compendium.

TEMPORAL EXTENT

Data from the Avian Compendium are from 1978-2012.

TREATMENT OF DATA

The NCCOS methodology applies the concept of a seasonal climatology to marine bird data. Environmental covariates such as sea surface temperature and water depth (among many others) are mapped (Tier I) and then used to estimate marine bird abundance and probability of occurrence and detection (Tier II). A seasonal climatology for each bird species and ecological group is calculated (i.e., a spring climatology is average bird abundance for every March-May between 1978 and 2012).

SPATIAL PRODUCTS

Grid size is 2 km. Products are static raster grids (maps) of predicted bird abundance and probability of occurrence (Tier II). NCCOS Phase 1 products cover NY bight (complete and report available); Phase 2 products cover the Mid Atlantic (complete; includes southeastern NE - tech review of report expected out this spring); Phase 3 products will cover the entire US Atlantic (2013-16).

Future work may also incorporate weightings by vulnerability (using BOEM-Normandeau vulnerability study, potentially).

USES

No documented uses yet, but has the general intent identify important seabird areas and to inform wind energy planning (see page 31 on NY Biogeographic Assessment for their plans).

DATA

SPATIAL PRODUCTS

TIER I

TIER II

AREAS

HEALTH

IMPACT

CUMULATIVE

TRADEOFFS

EXTENT

NE & NE+

NCSU AVIAN MODELING

Earvin Balderama and Beth Gardner, North Carolina State University

North Carolina State University has been developing spatial products related to the distribution and abundance of marine birds and assessing risk using statistical methods that are specifically designed for datasets that have many "zero observations" and are over-dispersed (few very high observation counts).

DATA COLLECTION
No new data are being collected as part of this effort. This team is using data from NOAA Fisheries Science Centers (including NEFSC) from shipboard and aerial surveys from the Gulf of Maine to North Carolina.

TEMPORAL EXTENT
Data in the models range from 1992-2010. Models can output monthly, seasonal or annual products.

TREATMENT OF DATA
Similar to the NCCOS models, this team is using environmental and biophysical covariates to estimate marine bird abundance and probability of observation (Tier II). Example mapped covariates (Tier I) are bathymetry, sea surface temperature, chlorophyll a concentration, distance to shore, and a time variable.

SPATIAL PRODUCTS
Maps have 4 km grid cells and are static, continuous raster layers. Maps can be made to represent monthly, seasonal or annual summaries of marine bird distribution, abundance and probability of observation. Probability of observation is meant to map a species' or guild's risk of impact from human activities.

USES
No documented uses; models are still in development.

Statistically, this methodology is similar but distinct from the NCCOS approach, and so comparing the outputs from each of these models (using the same species and temporal range of data) would provide a cross-validation of each approach.

DATA

SPATIAL PRODUCTS

TIER I

TIER II

AREAS

HEALTH

IMPACT

CUMULATIVE

TRADEOFFS

EXTENT

NE & NE+

STELLWAGEN BANK ECOLOGICAL CHARACTERIZATION

An Ecological Characterization of the Stellwagen Bank National Marine Sanctuary Region is an application of the biogeographic assessment approach by the NOAA NCCOS team. The objectives were to conduct geospatial analyses of fish, seabird, marine mammal and contaminants (sediment and tissue-mussels & fish) in the region; identify additional biological and physical spatial datasets in the SBNMS region; identify ecologically important areas; and model bio-physical dependencies that may explain ecosystem dynamics.

DATA COLLECTION
New data collection was not a specific goal of this effort.

TEMPORAL EXTENT
Varied depending on data source – uses data from last several decades. Distribution and abundance estimates are made seasonally and annually.

TREATMENT OF DATA
After developing Tier I spatial products of biological and physical properties, this effort explored species-environment relationships. For example, authors linked fish larval diversity/abundance with oceanographic conditions and productivity. Summer/winter seabird distribution was estimated from regression trees using bathymetry and sea surface conditions (Tier II). Cetacean-environment modeling (Tier II) found that static features such as the location of 100m isobaths were better predictors than dynamic features. Sand lance spawning ground was found to be important.

SPATIAL PRODUCTS
Maps of bathymetry, substrate, sea surface temperature, circulation and currents, phytoplankton, zooplankton, chemical contaminants, fish diversity, fish species distribution and abundance, seabird distribution, abundance and diversity, and marine mammal distribution, abundance and diversity.

USES
Outputs could be used to develop a hotspot analysis. Unknown degree of regulatory use/adoption.

DATA

SPATIAL PRODUCTS

TIER I

TIER II

AREAS

HEALTH

IMPACT

CUMULATIVE

TRADEOFFS

EXTENT

MA+

NEAQ SCIENTIFIC + OPPORTUNISTIC METHOD

Brooke Wikgren and Scott Kraus, New England Aquarium

The purpose of this effort was to improve distribution and abundance estimates for marine mammals by incorporating "opportunistic" mammal observations that cannot be effort-corrected and are therefore not usually included in traditional spatial data products (SPUE maps). This is important because, for example, there are 3100 additional opportunistic records of right whales that could be added to the existing 3700 "scientific" records.

DATA COLLECTION
New data collection was not a specific goal of this effort.

TEMPORAL EXTENT
Observations were aggregated by 2-month intervals, starting with Feb/March.

TREATMENT OF DATA
Data were derived from the NARWC database. Structured scientific observations data were converted to SPUE and mapped in the traditional way – observations were summarized per 5' x 5' grid cell (Tier I). Opportunistic data included observations from the NARWC database, whale-watch data and satellite tag data. Data were treated as "presence only" and the probability of whale presence was modeled with the Maxent program using environmental covariates (sea surface temperature, depth, distance to land, distance to physiographic areas in the Gulf of Maine-banks, shelves, etc., seafloor slope, latitude and longitude) (Tier II). The SPUE dataset (scientific) was used as a primary co-kriging variable and the probability of presence (opportunistic) was used as the secondary variable in areal co-kriging, which then predicted whale abundance (per 1km trackline of survey effort) to a number of polygons (in this case study, related to lobster fishing areas).

SPATIAL PRODUCTS
Maps of whale abundance per 1km trackline of survey effort for each 2-month interval of the year.

USES
New published scientific literature:
Wikgren, B., Kite-Powell, H., and Kraus, S. 2014. Modeling the distribution of the North Atlantic right whale *Eubalaena glacialis* off coastal Maine by areal co-kriging. Endangered Species Research 24: 21-31.

No management/regulatory uses yet.

DATA

SPATIAL PRODUCTS

TIER I

TIER II

AREAS

HEALTH

IMPACT

CUMULATIVE

TRADEOFFS

EXTENT

GoM

3. ECOLOGICAL AREAS

Important Ecological Areas are places in the marine environment that are particularly important to the structure and function of the ecosystem. The premise underlying Ecological Areas is that because of their particularly high significance within the ecosystem, managers and regulators should be made aware of their location and value when managing activities in neighboring environments.

Ecological Areas can be delineated with a range of methods depending on whether the goal of the approach is more scientific (i.e., ecological) or policy-driven (i.e., for conservation or protection). The first type of method is predominately quantitative and uses Tier I and Tier II spatial data products and overlays, sums, or averages them in order to define species “hotspots”. This method does not pre-define what areas are important; rather, it highlights areas of biological aggregations and infers that these are areas of ecological importance. An example of this type of Area is the marine bird abundance hotspot analysis in “A Biogeographic Assessment of Seabirds, Deep Sea Corals and Ocean Habitats of the New York Bight”.

The second approach uses Tier I and/or Tier II spatial data products from multiple marine life components along with research about known important habitat types in order to clip or set criteria for the Ecological Area. For example, observations and research may show that fish prefer to lay eggs on cobble substrates. We may then decide that all cobble substrates with high fish abundance should then be considered ecologically important Areas. Examples of this type of integrated ecologically important Area are The Nature Conservancy’s Northwest Atlantic Marine Ecoregional Assessment designation of Ecologically Important Areas.

The third type of Ecological Area is defined mostly by a policy or management need. These areas are often composed of Tier I and/or Tier II spatial data products that are interpreted or clipped using policy or management criteria or definitions. An example of a policy-driven ecological Area is the Sensitive, Special or Unique Habitats defined by the Massachusetts Ocean Management Plan.

Efforts that have developed methods to define Areas using any of these approaches with have the Areas icon shaded black. Many of these efforts have also developed their own spatial data products (Tier I and/or Tier II) and collected additional new data.

NY OFFSHORE ASSESSMENT

Brian Kinlan, NOAA and Jeff Herter, New York DOS

The New York Bight Biogeographic Assessment was conducted by the NOAA Biogeography Branch and the NY Department of State.

DATA COLLECTION

No new data were collected. Deep sea coral and sponge data were from the NOAA Deep Sea Coral Research geodatabase (USGS Cold-Water Coral Geographic Database, Watling et al. database (2003), the Theroux and Wigley database (1998), Smithsonian Institution’s National Museum of Natural History and NMFS NEFSC’s National Systematics Lab, archives of the former National Undersea Research Center, surveys by Dr. Barbara Hecker and her colleagues (e.g., Hecker et al., 1980, 1983), Peter Auster of the University of Connecticut, and NOAA NEFSC). Bathymetry data were derived from USGS, NOAA, and Woods Hole MBES sources. Sediment data came from John Goff's usSEABED data; hard bottom information was from NOS, USGS, and TNC interpreted point data from usSEABED & NMFS.

TEMPORAL EXTENT

1980s - ~2007 depending on the data source.

TREATMENT OF DATA

Ocean habitats were 30-arc second seasonal climatologies of SST, surface chlorophyll, surface turbidity, and nearshore zooplankton biomass.

Seasonal and annual models of seabirds were generated using long-term satellite, oceanographic, hydrographic and biological datasets as spatial predictors of the bird data (Manomet Bird Observatory (MBO) Seabird and Cetacean Assessment Program (CSAP) database - visual shipboard observational data 1980-1988).

SPATIAL PRODUCTS

Static maps of bathymetry (Tier I), mean grain size (Tier I), sediment composition plus certainty (Tier I), hard bottom occurrence (Tier II) ocean habitats (Tier I), seasonal and annual maps of seabird species and seabird ecological groups (all Tier II), relative indices of seabird abundance and occurrence (Tier II). Deep sea coral and sponge occurrence were mapped at point locations (Tier I). Additionally, annual predicted hotspots of seabird abundance, richness and diversity were mapped.

USES

NY plans to integrate this information with other ecological, geophysical and human use data to obtain a broad perspective on the ocean environment, human uses and their interactions. NY will then use this information in an ecosystem-based framework to coordinate and support decisions balancing competing demands in their offshore environment, and ultimately develop a series of amendments to NY’s federally approved Coastal Management Program.

DATA

SPATIAL PRODUCTS

TIER I

TIER II

AREAS

HEALTH

IMPACT

CUMULATIVE

TRADEOFFS

EXTENT

NY

NEFMC GROUNDFISH HOTSPOT ANALYSIS

Michelle Bachman, NEFMC

The groundfish hotspot analysis was developed by the New England Fishery Management Council for Omnibus Essential Fish Habitat Amendment 2 to identify locations where age-0 and age-1 groundfish occurred in clusters of unusually high abundance.

DATA COLLECTION
New data collection was not a specific goal of this effort.

TEMPORAL EXTENT
2002-2012 data from NEFSC trawl and dredge surveys and industry-based trawl surveys; MA and ME-NH trawl surveys.

TREATMENT OF DATA
Survey catch data (number of juvenile fish per tow) were adjusted in a two-step procedure to down weight catches on tows that occur in strata having higher numbers of zero catch tows. Juveniles were identified by length, with the maximum size by species selected to capture all age-0 and most of the age-1 fish. A zone of spatial autocorrelation was identified for each species to use as the zone of indifference when calculating the Getis-Ords G* spatial statistic. Tows that were significant at the 0.05 level and had higher than average catches were identified as hotpots.

SPATIAL PRODUCTS
Species- and survey-specific layers identifying individual hotspot tows by their original starting latitude/longitude. Hotspots were also summed by season and binned to a grid size of 100 km^2. These gridded layers were weighted according to stock vulnerability, sub-population characteristics, residency characteristics, and substrate affinity, and could be combined across multiple species of interest.

USES
In combination with SASI model outputs (see page 49), the hotspot grids were used to identify candidate management areas, i.e. habitats that have high abundance of juvenile groundfish in one or more seasons and are vulnerable to the impacts of fishing. A similar analysis was conducted on weight per tow data for large fish to identify potential spawning management areas.

DATA

SPATIAL PRODUCTS

TIER I

TIER II

AREAS

HEALTH

IMPACT

CUMULATIVE

TRADEOFFS

EXTENT

NE

GoM MARINE ECOSYSTEM

Andrew Allen, UMass Amherst and Linda Welch, USFWS

This is a new project aimed at identifying important ecological areas in the Gulf of Maine – partners at UMass Amherst, USFWS, Biodiversity Research Institute, Maine Department of Inland Fisheries and Wildlife, USGS Maine Cooperative Fish and Wildlife Research Institute, UMaine, Gulf of Maine Research Institute, Mass Division of Fish & Wildlife, New Hampshire Fish & Game.

DATA COLLECTION
At-sea surveys (14 days) will occur biannually at 10-12 transects. Marine mammals and marine birds observations will be collected along 300m strip transects. Single-beam hydroacoustics will be groundtruthed with midwater trawl to characterize fish, nekton and euphasiids. Ichthyoplankton and zooplankton samples will be taken at transects and fixed sites. Temperature, salinity, photosynthetic active radiation, and turbidity will be measured at each site. Single beam acoustics will be classified with an automated algorithm and groundtruthed with diver observations (benthic habitat mapping).

TEMPORAL EXTENT
At-sea surveys are scheduled for July 2014, Feb 2015, July 2015, Feb 2016.

TREATMENT OF DATA
Spatial hierarchical modeling of density for Species of Greatest Conservation Need (SGCN) as a function of biological and physical environmental parameters (Tier II). Candidate upper-trophic level taxa will include whales, Atlantic puffins, Razorbills, terns, and Common eiders; Mid-trophic level focal taxa include Atlantic herring and sand lance (*Ammodyte* spp.); euphausiid spp., total zooplankton biomass, *Calanus finmarchicus* to represent secondary production at the lower-trophic level. These spatial products will then be used to calculate and map a biological hotspot index based on a “representative suite” of focal species (not yet determined). Data will be used to investigate relationships among seabird habitat use, foraging behavior and reproduction.

SPATIAL PRODUCTS
Distribution and abundance maps (Tiers I and II) for 27 SGCN in the GoM coastal zone. Maps of habitat use. Biological hot spot maps. In progress.

USES
Data will be used to validate other models (e.g., NCCOS marine bird models); coordinate with other efforts to expand knowledge of seabird habitat (e.g., Sea Duck Joint Venture, DOE-BRI).

DATA

SPATIAL PRODUCTS

TIER I

TIER II

AREAS

HEALTH

IMPACT

CUMULATIVE

TRADEOFFS

EXTENT

GoM

OTHER HOTSPOT METHODS

1. White, Lawson, Veit: Collaborative project between WHOI (Lawson Lab) and CUNY (Veit Lab) to create maps and models of biological resource aggregation (hotspots) offshore and in canyon areas. Overlays oceanographic features (location of fronts) with prey density (phyto/zooplankton abundance, fish aggregations) and predators (seabirds, whales).

2. Santora & Veit, 2013: This is a paper in Marine Ecology Progress Series that describes a methodology to model persistent multispecies hotspots from highly replicated shipboard surveys (in the Southern Ocean). “Hotspot” was defined as a location with anomalies that exceed the grand survey mean by > 1 standard deviation. A hotspot was classified as “persistent” if present >45% times surveyed. The authors then did hierarchical cluster analysis and PCA on the hotspots to see if groups of species had similar spatial persistence. They found that separate hotspots were in proximity to an ocean current, major bird breeding colonies, and 2 submarine canyon systems. Output maps show locations of persistent hotspots.

3. Corkeron et al., 2011: This paper provides a methodology to create spatial models of very sparse marine mammal data (using a case study in Oman). Authors analyzed cetacean sightings data collected from small boat surveys between 2000 and 2003. Data were collected either in areas where humpback whales were thought to be relatively abundant, or in areas that were logistically easy to survey (leading to spatially autocorrelated data that were not suitable for standard analyses). Authors used quasi-Poisson generalized linear models and semi-parametric spatial filtering (which accounted for the autocorrelation) to assess the distribution of whales relative to depth, slope, and distance from shore, in a regular survey grid. This method allowed inferences to be made about the relative “importance” of particular areas for whales. The outputs were maps that showed which areas were most important to each species. They did not extend model predictions into areas not covered by surveys.

USES
Using methods similar to White, Lawson and Veit - maps off Nantucket shoals influenced the extent of BOEM lease blocks in the RI/MA Wind Energy Areas.

NEFMC EFH DESIGNATIONS

Michelle Bachman, NEFMC

The New England Fishery Management Council is currently revisiting the spatial designations of Essential Fish Habitat (EFH) for all 28 managed species.

DATA COLLECTION
New data collection is not a specific goal of this effort.

TEMPORAL EXTENT
NEFMC is using fall and spring fish abundance data from 1968 to 2005 in this mapping effort.

TREATMENT OF DATA
Abundance only method: Generally four map alternatives per species and life stage. On all four maps, inshore areas mapped based on occurrence of the species is at least 10% of tows in a given ten-minute square, plus designation of estuarine areas where the species and life stage was noted as being common or abundant. Continental shelf areas mapped based on four percentages of catch distribution in the 1968-2005 NEFSC spring and fall bottom trawl surveys (25%, 50%, 75%, 90%); data gridded by ten-minute squares. Continental slope designations include all areas between identified depth contours.

Abundance plus habitat considerations method: Similar to the abundance only method, except in treatment of the continental shelf trawl survey data. 25%, 50%, 75%, and 90% data layers were limited to those ten-minute squares overlapping a species-specific temperature range, and then the temperature-limited data layers were clipped by species-specific depth contours. Unsurveyed ten-minute squares were filled in prior to clipping as appropriate. In some instances the Council identified additional discretionary fill areas.

Species range method: Inshore designations as above, but continental shelf designations by whole ten-minute square covering 100% of the area where the species and life stage had been observed in the 1968-2005 NEFSC spring and fall bottom trawl surveys.

SPATIAL PRODUCTS
Up to nine different designation layer options for each species combining inshore, shelf, and slope coverages.

USES
In the NEFMC Omnibus Essential Fish Habitat Amendment 2. NEFMC has used EFH designations as general and inclusive areas of importance to fish. Importantly, this information is used by state and federal regulatory agencies during environmental impact assessment and permitting consultations for proposed projects and agency actions.

DATA

SPATIAL PRODUCTS

TIER I

TIER II

AREAS

HEALTH

IMPACT

CUMULATIVE

TRADEOFFS

EXTENT

NE & NE+

CETMAP

Jolie Harrison, Sofie Van Parijs, Megan Ferguson and Leila Hatch, NOAA

A cetacean (whale, dolphin and porpoise) distribution and density database, modeling assessment and web delivery effort coordinated by NOAA in partnership with efforts to map underwater sound fields in the U.S. EEZ (see page 48 on SoundMap - together these efforts constitute CetSound, http://cetsound.noaa.gov/sound.html). Significant data management and new modeling effort contracted out to the Duke Marine Geospatial Ecology Lab with additional web portal development, new modeling effort and biologically important area assessment effort provided by NOAA and non NOAA CetMap participants (http://cetsound.noaa.gov/participants.html).

DATA COLLECTION
Data underlying the models are derived from OBIS inclusive of surveying effort by the NOAA Fisheries Science Centers in addition to other sources. Data sources are fully described in metadata associated with all products available on the web.

TEMPORAL EXTENT
Monthly summary records; depends on expert-based designation.

TREATMENT OF DATA
Modeling tiers for distribution and density information and criteria for "biologically important areas" (BIAs) were established by the CetMap working group (http://cetsound.noaa.gov/participants.html) to assess the "state of the science" on cetacean habitat modeling. A series of BIAs papers is currently in peer review – due out soon.

Models of various "rigor" or quality
http://cetsound.noaa.gov/cetacean_data_hierarchy.html

Tier 1: Habitat-based density models (highest quality);
Tier 2: Stratified density models;
Tier 3: Probability of occurrence;
Tier 4: Records exist;
Tier 5: Expert knowledge (lowest quality) - BIAs

SPATIAL PRODUCTS
Spatially explicit models of cetacean distribution and density for 20 East coast species, populations or guilds. Current East Coast models are probability of occurrence models from Duke University and will soon be replaced by new habitat-based density models also from Duke (see page 25). Maps are regional and U.S. EEZ-scale. Data and modeling products can be accessed by region, species and month at http://cetsound.noaa.gov/cda.html. Areas, time periods and species of interest are color-coded in the web browser.

USES
NOAA sought to develop regional cetacean distribution and abundance maps at ecological scales relevant to ocean noise and often wide-ranging cetacean species. These maps could be used in assessing cumulative impacts to cetaceans from multiple human uses of the marine environment.

DATA

SPATIAL PRODUCTS

TIER I

TIER II

AREAS

HEALTH

IMPACT

CUMULATIVE

TRADEOFFS

EXTENT

NE & NE+

MA OCEAN PLAN

Todd Callaghan, Emily Huntley and Dan Sampson, MA CZM

Here we consider the designation and mapping of Special, Sensitive, or Unique (SSU) sites by Massachusetts CZM to support the MA Ocean Plan (for information on the ecological valuation exercise previously undertaken by MA Ocean Plan working groups see page 42). All SSUs are mapped using Tier I techniques.

DATA COLLECTION
New data collection is not a direct goal of the specific effort to define SSUs.

TEMPORAL EXTENT
SSUs were designated in the 2009 version of the MA Ocean Management Plan and are reviewed every 5 years. New data will be incorporated, if possible, during revisions (several of the revised 2014 SSUs include new data from 2008-present).

TREATMENT OF DATA
As directed by the MA Oceans Act, CZM has identified 12 species- or habitat-based SSUs: North Atlantic right whale core habitat; Humpback whale core habitat; Fin whale core habitat; Roseate Tern core habitat; Special concern (Arctic, Least, and Common) tern core habitat; Long-tailed Duck core habitat; Leach's Storm-Petrel important nesting habitat; Colonial water birds important nesting habitat; Hard/complex seafloor; Eelgrass; Intertidal flats; Important fish resource areas.

SPATIAL PRODUCTS
Varies depending on marine life/SSU. Whale habitat is modeled with 5'x5' grid cells using the last ~decade of data (to best represent current trends) and a simple natural neighbors interpolation classified into quartiles (+ a zero class) (Tier I). Avian Compendium data were mapped and classified at a regional scale in order to demonstrate the importance of MA state waters to 4 sea duck species. However, Compendium data were too coarse and so sea duck habitat was mapped from USFWS directed survey data by calculating the density of sightings using a 7km moving window interpolation at 250m grid cells effort-corrected by a calculation of the density of transects in the same 7km moving window interpolation (Tier I).

USES
SSUs are a part of the MA Ocean Management Plan and are used directly by project-review teams at CZM in decision-making.

DATA

SPATIAL PRODUCTS

TIER I

TIER II

AREAS

HEALTH

IMPACT

CUMULATIVE

TRADEOFFS

EXTENT

MA

RI OCEAN SAMP

Grover Fugate, RI CRMC

As part of the RI Ocean Special Area Management Plan, the RI Coastal Resources Management Council designation of Areas of Particular Concern (APCs) and Areas Designated for Preservation (ADPs) through the OSAMP domain (efforts to model ecological value through OSAMP-affiliated research are discussed on their own pages).

DATA COLLECTION
New data collection is not a direct goal of the specific effort to define APCs and ADPs.

TEMPORAL EXTENT
APCs and ADPs were designated in the 2010 OSAMP and will be revised every 5 years.

TREATMENT OF DATA
Currently, APCs have either/both ecological and cultural criteria; the ecological criteria are largely habitat- or ecosystem-based and do not refer to individual species at this time (i.e., they refer to moraine habitat for multiple species). Cultural criteria include modern human uses. The sole RI ADP is for sea duck foraging habitat (in waters <20 m deep). The criteria for the sea duck ADP were established based on the first draft of a habitat suitability model for sea ducks after several surveys in the OSAMP area. The 20 m depth threshold was established from existing literature on bird foraging preference and ability.

SPATIAL PRODUCTS
Spatial density models of sea birds were created using detection functions and density surface modeling. Depth and distance to land were environmental covariates (Tier I) used in the Generalized Additive Models (GAMs) with 4km^2 cells (Tier II). The resulting maps estimate sea bird density based on known observations and species-environment relationships.

USES
The spatial data associated with APCs and ADPs is used directly by project review teams at the RI Coastal Resources Management Council.

DATA

SPATIAL PRODUCTS

TIER I

TIER II

AREAS

HEALTH

IMPACT

CUMULATIVE

TRADEOFFS

EXTENT

RI

TNC NAMERA

Jenn Greene, Sally McGee and Katherine Weaver, TNC

The Nature Conservancy's Northwest Atlantic Marine Ecoregional Assessment, Phase I, represents a "state of the ecosystem" for the entire Northeast U.S. region (and the Mid-Atlantic) including benthic habitats, coastal habitats, marine mammals, marine birds, and fish. Phase II identified portfolios of "critical areas for conservation of ecosystems, habitats, species and ecological processes" by focusing on ecological coherence through spatially explicit correlation analyses (Tier I). Portfolios were developed for coastal, seafloor, and migratory themes (only seafloor and migratory detailed here).

DATA COLLECTION
New data collection was not a specific goal of this effort.

TEMPORAL EXTENT
NAMERA uses datasets from the late 1960s to ~2007.

TREATMENT OF DATA
Data from the Phase I database were used to identify "portfolios" of priority conservation areas. Analysis units for the portfolios were ten-minute-squares (TMS). Below are the summarized criteria for each TMS added to the portfolio by marine life type. The Phase II report contains more detail. TMS with:

- Demersal fish (32 species, data 1968-2006) decadal persistence scores 1 or 2 standard deviations above the regional mean.
- > 4 fish communities (up to 250 species, data 1968-2006) identified by hierarchical cluster analysis.
- > 3 cold water coral presence points.
- > 40 or 50% hard bottom habitat and 3 hard bottom presence points
- Sea grass mean abundances 1-3 standard deviations above the mean.
- 10% of each benthic habitat type. Identified all habitats in previous TMS categories then overlaid with TMS for migratory spp. Those that overlapped were added to the portfolio.
- Cetacean SPUE (Navy spring/summer data 1979-200) 2 standard deviations above mean for at least 3 species of baleen whales or 2 of 3 species of toothed whales and dolphins
- Turtles sightings at highest concentrations for 2/3 species.
- Large pelagic fish (NOAA data, 1965-2004) with decadal persistence scores > 3.

SPATIAL PRODUCTS
Phase I products are Tier I maps of regional scale patterns for each marine life component, Ecological Marine Units, Seabed Forms and Benthic Habitats. Phase II products are maps of the highest-ranking areas for each marine life component and maps of full portfolios for priority areas.

USES
Phase I products have been used extensively to provide context and supporting information in understanding habitat extent and species abundance in the Northeast. State/regional/fed regulators have used NAMERA maps for project-review situations (e.g., scallop grounds in BOEM lease blocks).

DATA

SPATIAL PRODUCTS

TIER I

TIER II

AREAS

HEALTH

IMPACT

CUMULATIVE

TRADEOFFS

EXTENT

NE & NE+

TNC LISEA

Nathan Frohling, TNC

The Nature Conservancy began the Long Island Sound Ecoregional Assessment 2-3 years ago recognizing the need to identify "ecologically notable" places (ENPs) in LIS. Efforts began by applying the Ecological Marine Unit (EMU) concept from NAMERA to LIS (at a finer scale, as recommended in NAMERA documentation), because physical data are of high quality.

DATA COLLECTION
New data collection was not a specific goal of this effort.

TEMPORAL EXTENT
LISEA uses fish community data from the late 1970s – present from the Connecticut Department of Energy and Environmental Protection. A future goal is to incorporate habitat data from recent mapping efforts in addition to the existing NOAA bathymetry and USGS seabed information currently being used.

TREATMENT OF DATA
Seafloor habitats (EMUs) were found with depth, sediment and bathymetric data. Changes in biological communities linked to depth and sediment thresholds informed the descriptions of the EMUs. ENPs were identified considering both biotic and abiotic factors in 1' x 2' grid cells throughout LIS. Biological criteria were based on fish trawl data that included invertebrates. From this data, degrees of persistence for each species were assessed at each grid cell. For example, throughout the 3 decades and accounting for survey effort/catchability, the question was asked "how often was a given species observed relative to what you would expect in a given grid cell?" Places that had high numbers of species (≥ 1 SD,) each species with high persistence over time (found there throughout all three decades), and each species with high relative occurrence (found more often than expected, > 0.5) were considered Ecologically Notable. Abiotically, areas of complex seafloor (metrics include hard bottom areas, derivatives of bathymetry, EMU richness) are also defined as "ENP".

SPATIAL PRODUCTS
Maps of seafloor habitats (EMUs), fish/invertebrates species persistence, and an integrated summary of Ecologically Notable Places. A final report is in progress. Next steps include describing each ENP cell by species, physical features, etc. (as is done in the NAMERA).

USES
Final report in progress, no uses yet. Potential to inform LIS Cable Mitigation Fund LIS Seafloor Mapping Project and MSP efforts whether regional or for LIS.

DATA

SPATIAL PRODUCTS

TIER I

TIER II

AREAS

HEALTH

IMPACT

CUMULATIVE

TRADEOFFS

EXTENT

LIS

RPS-ASA ECOLOGICAL VALUE MAPS

Deborah French-McCay and Danielle Reich, RPS-ASA

This approach was developed by Applied Sciences Associates to model the (non-monetary) ecological value of marine biological resources in the Rhode Island OSAMP area. The premise of this approach is identical to that applied in the Massachusetts Ecological Valuation exercise. It is a dimensionless weighting or ranking of ecological importance.

DATA COLLECTION
New data collection was not a specific goal of this effort.

TEMPORAL EXTENT
Varies by dataset – typically spans the last several decades. Distribution and abundance maps that feed into the weighting schemes can be made for any temporal window – seasonal, annual, decadal – depending on the management question and study goals.

TREATMENT OF DATA
Tier I distribution and abundance maps were developed for each ecosystem component. The definition of ecological value is based on work in Belgium, and at the species level includes measures of aggregation: density, contribution to fitness, productivity, rarity or uniqueness. Weighting schemes were applied to each marine life map to reflect value based on stakeholder input, data quality, or local species/group importance. Weaknesses in value maps tended to propagate. For example, benthic productivity across the OSAMP area was not well-known and affected the resolution or quality of other data layers. The EVM approach fits within a larger Siting Evaluation Model framework developed by ASA that includes models of Cumulative Impacts and Human Uses.

SPATIAL PRODUCTS
Ecological Value Maps (EVMs) can be developed at various levels of organization: individual species, groups (e.g., mammals, birds, turtles, fish, benthic), and ecosystem (adding all the groups into a composite EVM).

USES
Developed under a National Oceanographic Partnership Program (NOPP) award to URI for developing environmental monitoring protocols for renewable energy development. This product was delivered to BOEM as a deliverable for that project. Not currently used for management purposes under the RI OSAMP or for wind energy siting.

DATA

SPATIAL PRODUCTS

TIER I

TIER II

AREAS

HEALTH

IMPACT

CUMULATIVE

TRADEOFFS

EXTENT

NE & NE+

MASSACHUSETTS EVI

Prassede Vella and Todd Callaghan, MA CZM

A working group associated with the MA Ocean Plan explored and tested methods to determine areas with high ecological value by using an approach modeled after Derous et al.'s Belgian part of the North Sea ecosystem valuation. The concept behind this ecological valuation involved weighting marine life components based on 4 criteria: major contribution to fitness, spatial rarity, population of global importance and population of regional importance.

DATA COLLECTION
New data collection was not a specific goal of this effort.

TEMPORAL EXTENT
Varies by dataset, but generally data from the last several decades.

TREATMENT OF DATA
Each species was given an ecological value index score by summing the binary sub-score from each of the 4 criteria. Then the overall EVI value for each grid cell was determined (it ranged from 0 to 22). This effort was eventually abandoned because participants felt that the results were not indicative of true ecological value but more of data availability, species catchability and expert opinion. Problems resulted for example, when, in adding up weights by species group, the fish group had the highest calculated ecological value (because there were >20 species) versus the mammal group (which only had 3-5 species). In general the group felt that this exercise did not add much information to our understanding of the ecological value/importance of species.

SPATIAL PRODUCTS
Spatial products were not produced as a result of this effort. If they had been, individual EVI maps could be generated for each species group and for a composite EVI. The analysis grid was 250 m.

USES
Massachusetts opted to use Tier I-derived SSUs instead of the EVI approach (see page 37). However, this project provided a number of recommendations and lessons-learned for future EVI-type efforts.

DATA

SPATIAL PRODUCTS

TIER I

TIER II

AREAS

HEALTH

IMPACT

CUMULATIVE

TRADEOFFS

EXTENT

MA

AUSTRALIA RAP

Leanne Fernandes/GBRMPA and Peter Corkeron, NOAA

The Australia Representative Areas Program (RAP) is the marine spatial planning framework for the Great Barrier Reef (GBR) and ensures that at least 20% of every bioregion is within a highly protected zone type.

DATA COLLECTION
New data collection was not a specific goal of these efforts.

TEMPORAL EXTENT
Variable depending on dataset.

TREATMENT OF DATA
Biophysical Operational Principles (10 total) were developed by an independent Scientific Steering Committee and include specific criteria for designating areas: Ensure local integrity; Maximize amount of protection; Replicate; Avoid fragmentation; Represent a minimum amount of each non-reef bioregion in no-take-areas; Maintain geographic diversity; Represent all habitats; Apply all available info on processes; Protect uniqueness; Maximize natural integrity. Each of these has specific criteria associated with it for individual habitats or species.

Biophysical spatial data (Tier I) for the GBR planning effort were extremely variable in terms of spatial and temporal coverage, quality, and quantity. In the absence of complete knowledge of a species, environmental or species surrogates were used. Because of the uncertainty associated with surrogacy, the program emphasized replication of protected area types to ensure that the maximum amount of biodiversity was protected. Species-environment relationships were examined with classification and regression trees and multivariate regression trees resulting in Tier II maps. These were reviewed in scientific expert workshops and then presented to the public.

SPATIAL PRODUCTS
Maps of 70 different bioregions, biodiversity, and important habitat areas for marine life components. Example maps:
http://www.gbrmpa.gov.au/zoning-permits-and-plans/rap/docs/maps/technical-information-sheets

USES
These products were used in expert workshops to help classify the biological and physical diversity of the GBR. The RAP provided the basis for developing a new zoning plan for the GBR Marine Park, which took effect in July 2004. Operating principles similar to the Biophysical discussed above were developed for social, economic and cultural aspects of the plan. A schematic of the process is at http://www.gbrmpa.gov.au/zoning-permits-and-plans/rap/representative-areas-program-key-phases-diagram.

DATA

SPATIAL PRODUCTS

TIER I

TIER II

AREAS

HEALTH

IMPACT

CUMULATIVE

TRADEOFFS

EXTENT

NE+

RI ECOLOGICAL VALUATION

Annette Grilli and Emily Shumchenia, University of Rhode Island

The purposes of this effort were to 1) expand the characterization of the benthic landscape ("habitats") beyond the surveyed patches and across the entire Rhode Island Ocean SAMP study area, and 2) determine which environmental features contribute most to high biodiversity in the RI OSAMP area.

DATA COLLECTION
New data collection was not a specific goal of this effort.

TEMPORAL EXTENT
Varied depending on the dataset. The analyses were intended to integrate ecological information over several decades.

TREATMENT OF DATA
Two methodologies were tested with the same input data (tidal velocity, wave height, depth, distance to shore, slope, roughness, grain size (median phi), sediment clay fraction, spring & fall sea surface temp, spring & fall stratification, seafloor aspect ratio, benthic position indices, bottom slop eastness and northness). The habitat typology method allowed the data to "speak for itself" by using cluster and principal components analyses on the input data. The habitat template method used additive equations to estimate energy available to organisms and physical disturbance from the input data in order to find optimal areas for supporting certain species functional groups and high biodiversity. The two different methods found that geomorphology and "coastalness" were important factors in influencing biodiversity in the RI OSAMP area.

SPATIAL PRODUCTS
Maps of each input variable and maps of: marine landscapes (from the habitat typology method), energy available to organisms (habitat template method), natural disturbance (habitat template method), predictive species type (predators, sessile filter feeders, tolerant species, mobile generalists- habitat template method), biodiversity hotspots (habitat template).

USES
Report chapter in RI OSAMP supporting documentation; not being used in a management/regulatory context.

DATA

SPATIAL PRODUCTS

TIER I

TIER II

AREAS

HEALTH

IMPACT

CUMULATIVE

TRADEOFFS

EXTENT

RI

4. MEASURES OF OCEAN HEALTH

There have been numerous approaches used to summarize the status of the structure and functioning of marine ecosystems by creating measures of ocean "health". These measures recognize that the structure and function of marine ecosystems has been altered by human activities through time. The purpose of these approaches is to holistically assess marine ecosystem status in space and time in order to highlight places that require special attention (i.e., they are particularly "unhealthy") or to identify trends in ecological status (i.e., the health of an area is improving).

The measurement of ocean health goes beyond mapping the distribution and abundance of marine life, hot spots and ecologically important areas by describing the vulnerability of marine life due to human activities.

These measures usually require spatial information about human uses of the environment. In addition, they often require that we make a judgment call about the importance of the human use or the marine life involved.

Measures of ocean health can be estimated for a single type of marine life and a single human use (e.g., the impact of wind farm facilities on marine birds) or multiple types of marine life and multiple human uses (cumulative impacts).

Some efforts calculate indices of ocean health by combining estimates of marine life distribution and abundance with ecological values and social values. While there are many efforts developing and utilizing indicators for a particular marine management purpose, here we report on a few projects with recent advances that provide a potential opportunity for regional ocean planning without duplicating existing indicator programs in the northeast.

IMPACTS

CUMULATIVE IMPACTS

IMPACTS

There are numerous reports and papers that examine the impacts of a particular human use of the marine environment on a single marine life component. These types of studies can be useful for making compatibility determinations (examples follow this page). This is a non-exhaustive list of these types of assessments.

Acoustic Monitoring of Temporal and Spatial Abundance of Birds Near Outer Continental Structures (Normandeau Associates, Inc. to BOEM)

Cury, P. M., Boyd, I. L., Bonhommeau, S., Anker-Nilssen, T., Crawford, R.J., Furness, R. W., … Sydeman, W. J. (2011). Global seabird response to forage fish depletion - one-third for the birds. Science, 334, 1703–1706.

HMMH (2012). Environmental Effects of Sediment Transport Alteration and Impacts on Protected Species : Edgartown Tidal Energy Project, submitted to U.S. DOE (303910).

Information Synthesis on the Potential for Bat Interactions with Offshore Wind Facilities (Stantec Consulting Services Inc. to BOEM)

LGL Ltd. (2005). Assessment of the effects of underwater noise from the proposed Neptune LNG project, 235pp.

New Insights and New Tools Regarding Risk to Roseate Terns, Piping Plovers, and Red Knots from Wind Facility Operations on the Atlantic Outer Continental Shelf (Normandeau Associates, Inc. to BOEM)

Normandeau Associates, Inc. 2012. Effects of Noise on Fish, Fisheries, and Invertebrates in the U.S. Atlantic and Arctic from Energy Industry Sound-Generating Activities. A Workshop Report for the U.S. Dept. of the Interior, Bureau of Ocean Energy Management. Contract # M11PC00031. 72 pp. plus Appendices.

Reubens, J. T., Braeckman, U., Vanaverbeke, J., Van Colen, C., Degraer, S., & Vincx, M. (2013). Aggregation at windmill artificial reefs: CPUE of Atlantic cod (*Gadus morhua*) and pouting (*Trisopterus luscus*) at different habitats in the Belgian part of the North Sea. Fisheries Research, 139, 28–34. doi:10.1016/j.fishres.2012.10.011

Review of Biological and Biophysical Impacts from Dredging and Handling of Offshore Sand (Research Planning, Inc. to BOEM)

Robinson Willmott, J. C., G. Forcey, and A. Kent. 2013. The Relative Vulnerability of Migratory Bird Species to Offshore Wind Energy Projects on the Atlantic Outer Continental Shelf: An Assessment Method and Database. Final Report to the U.S. Department of the Interior, Bureau of Ocean Energy Management, Office of Renewable Energy Programs. OCS Study BOEM 2013-207. 275 pp.

TetraTech, Inc. (2000). Stellwagen Bank National Marine Sanctuary submarine cable final environmental assessment, 184pp.

The National Renewable Energy Laboratory (NREL) Wind-Wildlife Impacts Literature Database (WILD) https://wild.nrel.gov

Underwater hearing sensitivity in the leatherback sea turtle (*Dermochelys coriacea*): Assessing the potential effect of anthropogenic noise (Duke University and Wider Caribbean Sea Turtle Conservation Network to BOEM)

DATA
SPATIAL PRODUCTS
TIER I
TIER II
AREAS
HEALTH
IMPACT
CUMULATIVE
TRADEOFFS
EXTENT
NE & NE+

ALWTRT

Bob Kenney, University of Rhode Island Emeritus

The Atlantic Large Whale Take Reduction Team (ALWTRT) advised NOAA NMFS in 2012 regarding the vulnerability of large whales to vertical line fixed gear along the U.S. Atlantic coast. Here we discuss the marine life data and spatial data products—not the fishing/gear portion of the study.

DATA COLLECTION
No new data were collected for this project. Whale data were derived from the NARWC database.

TEMPORAL EXTENT
Data from 1978 – 2010 were used to create spatial data products.

TREATMENT OF DATA
Industrial Economics, a contractor to NOAA, created a co-occurrence model of the density of vertical line fixed gear and large whales in order to assess risk of entanglement. This effort uncovered a universal challenge with modeling large pelagic species occurrence offshore – areas that had no recorded sightings of large whales were modeled as "zero risk" in the original Industrial Economics draft. Seeing that this was an inaccurate and unacceptable result, Industrial Economics hired Bob Kenney to outline a method for deriving minimum values for SPUE cells where values were estimated at 0 based on limited survey effort that 1) are based on the available data; 2) are not purely arbitrary; 3) provide a better reflection of entanglement risk and the conservation benefits of management actions.

SPATIAL PRODUCTS
U.S. Atlantic coast-wide distribution and abundance (SPUE) models for Right, Humpback and Fin whales.

Technical report of the model can be found here:
http://www.nero.noaa.gov/protected/whaletrp/eis2013/june_2013_draft_vl_model_documentation.pdf

USES
Whale abundance/distribution models used in EIS on vertical line entanglement risk. The NOAA Vertical Line Action EIS can be found here:
http://www.nero.noaa.gov/protected/whaletrp/eis2013/index.html

DATA

SPATIAL PRODUCTS

TIER I

TIER II

AREAS

HEALTH

IMPACT

CUMULATIVE

TRADEOFFS

EXTENT

NE & NE+

SOUNDMAP

Leila Hatch, NOAA

An effort coordinated by NOAA to apply sound field modeling and mapping methods to depict temporal, spatial, and spectral characteristics of underwater noise throughout the U.S. EEZ in partnership with efforts to map cetacean distribution and abundance (see page 36). Together, these two efforts constitute "CetSound". http://cetsound.noaa.gov/sound.html

DATA COLLECTION
Uses distribution, density and acoustic characteristics of human activities (e.g., commercial shipping, offshore energy exploration and construction activities) to develop first-order estimates of anthropogenic noise levels for a number of discrete depths and sound frequency bands. Sound frequencies examined are generally low (50 – 1000 Hz) and are captured in seasonal to annual terms.

TEMPORAL EXTENT
"Chronic" and "Event" noise descriptors. Annual averages, snapshot one-second average sound field maps for different frequencies and depths, or for particular periods of operations.

TREATMENT OF DATA
Focused on lower frequencies because higher frequencies are subject to strong absorption effects and are more local in effect. Sound sources include vessels (merchant shipping, ocean-going passenger vessels and mid-sized service, fishing and passenger vessels in regions where data were available) and sustained areas of offshore energy exploration (seismic surveys). Predicted received levels are expressed as equivalent, unweighted sound pressure levels that are averages of aggregated sound levels. Localized or transient events examined include a military active sonar training exercise in Hawaii; a period of seismic exploration in the Beaufort Sea; the installation of an alternative energy platform off New England; and the decommissioning of an oil platform in the Gulf of Mexico. Analytical grid size is 0.1° x 0.1°. Modeling was conducted at discrete depths between 5m and up to 1000m in order to capture how differences in sound propagation can influence marine life that spends time at difference depths.

SPATIAL PRODUCTS
Maps of annual average ambient noise for the US EEZ for global shipping and passenger vessels; maps of the event-scenario of seismic testing in the Beaufort Sea; maps of annual average chronic noise (global shipping, passenger vessels, wind noise and summed outputs) for the North Atlantic Basin, the Northeast, Cape Cod, the Mid-Atlantic and the South Atlantic. Map of the sound fields generated by the installation of an offshore wind facility in Nantucket Sound.

USES
Contributes to NOAA's Ocean Noise Strategy (ONS) and draft framework. A component of this framework is Acoustic Habitat Management in NOAA Sanctuaries and other Marine Protected Areas.

DATA

SPATIAL PRODUCTS

TIER I

TIER II

AREAS

HEALTH

IMPACT

CUMULATIVE

TRADEOFFS

EXTENT

NE & NE+

NEFMC SASI MODEL

Michelle Bachman, NEFMC

The Swept-Area-Seabed-Impact (SASI) model was developed by the New England Fishery Management Council to provide an objective and data-driven framework for evaluating fishery management decisions designed to minimize the adverse effects of fishing on fish habitat, partially fulfilling requirements of the Magnuson-Stevens Fishery Conservation and Management Act. The spatial domain of the SASI model is US Federal waters (between 3-200 nm offshore) from Cape Hatteras to the US-Canada border.

DATA COLLECTION
New data collection was not a specific goal of this effort.

TEMPORAL EXTENT
Dependent on data source: SMAST video surveys – 11 years of substrate data; usSEABED extracted and parsed substrate data - > 50 years of data; flow from FVCOM-Gulf of Maine model – 10 years of data; depth from NOAA – 129 years of data. The estimates for fishing gear characteristics and vulnerability of habitats were obtained by literature searches spanning several decades. Model outputs possible for any time slice of fishing activity.

TREATMENT OF DATA
Fishing gear contact and vulnerability-adjusted area swept, a proxy for the degree of adverse effect, is calculated by weighting an area swept value (i.e., fishing effort value), indexed across units of fishing effort and primary gear types, by the degree of the fishing gear impact, the susceptibility of benthic habitats likely to be impacted, and the time required for those habitats to return to their pre-impact functional value.

SPATIAL PRODUCTS
Spatial grid size of 100 km^2. Maps of "realized adverse effect" for any particular gear type (or combination of gear types) per calendar year (or any time slice). Simulated fishing effort is also mapped, in which area swept for each gear type is applied evenly across grid cells.

USES
SASI model estimates of habitat vulnerability and adverse effects can be used by NEFMC to (1) identify candidate habitat management areas and (2) evaluate the impacts of shifts in the magnitude and/or location of fishing effort on seabed habitats. The SASI document (Appendix D of the Omnibus Essential Fish Habitat Amendment 2) includes a section on applications to fishery management decision-making.

DATA

SPATIAL PRODUCTS

TIER I

TIER II

AREAS

HEALTH

IMPACT

CUMULATIVE

TRADEOFFS

EXTENT

NE & NE+

MA CUMULATIVE IMPACTS

Ben Halpern and Carrie Kappel, NCEAS; Nick Napoli, SeaPlan

The MA Ocean Partnership/SeaPlan funded Ben Halpern and Carrie Kappel at the National Center for Ecological Analysis and Synthesis to apply their global cumulative impacts model to MA – Carrie Kappel lead this effort. The survey area was MA state waters and contiguous fed waters (out to 200 miles).

DATA COLLECTION
New data collection was not a direct goal of the specific effort to define cumulative impacts.

TEMPORAL EXTENT
Varied by existing data source; generally utilized datasets relevant to the last two decades.

TREATMENT OF DATA
A simple habitat map contained classes for hard/soft habitats split again by various depths, including nearshore habitat, and some water column habitat. 20-30 experts in each habitat were given a survey to evaluate 5 components of vulnerability to a list of 58 human stressors. Each habitat had a vulnerability score to each stressor. Scores for each habitat were summed and potential cumulative impact was calculated across the study area.

SPATIAL PRODUCTS
Spatial data were developed for 21 of the 58 stressors (mapped into Tier I models on a 250 m grid). The final map of cumulative impacts was not used in the MA Ocean Plan, but intermediate products resulted from the exercise (e.g., map of cumulative human uses was used by CZM); some datasets were analyzed for the first time through that project and subsequently used by CZM (e.g., aquaculture).

USES
The final map was not used in a regulatory context, but many of the intermediate spatial products resulting from this exercise have been used by MA CZM (e.g., aquaculture layer). Additionally, this project provided a number of recommendations and lessons-learned for future assessments of cumulative impacts.

DATA

SPATIAL PRODUCTS

TIER I

TIER II

AREAS

HEALTH

IMPACT

CUMULATIVE

TRADEOFFS

EXTENT

MA

TNC NORTHEAST CUMULATIVE IMPACTS

Jenn Greene and Mark Anderson, TNC

This effort by The Nature Conservancy is intended to support the efforts of the Northeast Regional Planning Body by producing tools and data that connect state marine spatial planning processes to the regional scale. Specifically, the goals were to map the spatial extent and intensity of five human uses (commercial fishing, recreational fishing, shipping, dredging and energy development); evaluate the effects of each of these on a variety of marine habitats; estimate the degree of impact each is having on each habitat; and map the distribution of the impacts both individually and cumulatively.

DATA COLLECTION
New data collection is not a goal of this effort.

TEMPORAL EXTENT
This effort uses existing data from the late 1960s - ~2007.

TREATMENT OF DATA
The overall concept of this effort is to utilize the seabed impact weighting scheme developed for the New England Fisheries Management Council's Swept-Area-Seabed-Impact (SASI) model (see page 49) and the vulnerability scores from the NCEAS/SeaPlan Massachusetts Cumulative Impacts study (see page 50) and the Ecological Marine Units and Seabed Forms developed for the NAMERA in order to estimate cumulative impacts in the Northeast region. This effort focused on a smaller number of potential impacts (five) than previous efforts. In addition, this project improves upon the Massachusetts Cumulative Impacts study by widening the study area to the whole region. Furthermore, this project developed an approach to integrate the NAMERA, SASI and NCEAS/SeaPlan benthic habitat models and determined a method to integrate these three disparate models to be used in their analysis.

SPATIAL PRODUCTS
Several human use spatial data product were developed and are now available on the Northeast Ocean Data Portal. Maps indicating estimated degree of vulnerability of specific habitat types to each of the five human uses.

USES
Intended to inform compatibility decisions and studies; to help inform sustainable use planning; to advance knowledge in the region regarding habitat vulnerability.

DATA

SPATIAL PRODUCTS

TIER I

TIER II

AREAS

HEALTH

IMPACT

CUMULATIVE

TRADEOFFS

EXTENT

NE

EPA – DPSIR/BCG

Giancarlo Cicchetti, US EPA

The Biological Condition Gradient (BCG) framework is a bioassessment framework originally developed for stream ecosystems that is now being developed and applied in estuaries and coral reefs. BCG is a conceptual but science-based framework that links human/environmental stressors to trends in marine resources. It is nested within the broader Driver-Pressure-State-Impact-Response (DPSIR) framework that connects human needs and actions (Drivers and Responses) to biological and environmental change.

DATA COLLECTION
New data collection is typically not a component of these efforts.

TEMPORAL EXTENT
Biological condition, and change in condition, is measured and tracked with respect to a reference point, usually a less disturbed state or time period in the past. Reference points can be defined by scientists or by consensus between scientists, managers and other stakeholders. The concept of the reference point provides the opportunity to involve historical or even prehistorical perspectives, allowing better communication of the extent of changes over time.

TREATMENT OF DATA
Quantitative thresholds in stressors can be developed using this approach if data are available. For each biological resource or metric (e.g., structure, abundance, function, connectivity), reference points are determined based on stressor-response relationships, historical data, or expert judgment. Major strengths of this method are its ability to provide a historical perspective, an integrated cumulative impact approach, and visual communication tools to assist with assessment and management.

SPATIAL PRODUCTS
Maps that show current status and/or trends over time would be important parts of this framework, but are not explicit outputs. Typical outputs are habitat-specific or whole ecosystem measures of system integrity (non-spatial index values or scores).

USES
Maine DEP for streams; Connecticut DEEP for streams, Pennsylvania DEP for streams, Tampa Bay Estuary Program; Narragansett Bay in progress, Guanica Bay (Puerto Rico) coral reefs in progress.

DATA

SPATIAL PRODUCTS

TIER I

TIER II

AREAS

HEALTH

IMPACT

CUMULATIVE

TRADEOFFS

EXTENT

NE & NE+

OCEAN HEALTH INDEX

Ben Halpern, Julia Lowndes and Courtney Scarborough, University of California Santa Barbara, NCEAS

The Ocean Health Index (OHI) is an integrated (ecosystem and human) measure of ocean health. The index is an average of individual scores for ten ocean health goals that address the biological, physical, economic and social integrity of the ocean.
www.oceanhealthindex.org

DATA COLLECTION
OHI requires input data that address the following goals: Natural products, food provisioning, artisanal fishing opportunities, carbon storage, coastal protection, tourism and recreation, livelihoods and economies, sense of place, biodiversity, clean waters. NROC has many datasets that can address all or most of the necessary categories, but they may require interpretation/analysis steps first. Inputs will most often be existing Tier I and Tier II spatial products. Potential challenges for a Northeast regional OHI include developing a relevant goal framework, such as reworking the concept of artisanal fishing opportunities; incorporating Working Waterfronts; defining and characterizing "resilience".

TEMPORAL EXTENT
Flexible. Reference points (baselines) need to be established.

TREATMENT OF DATA
After baselines are established for each category, current status, trends, pressures (stressors), and measures of resilience must be characterized for each category. NCEAS is currently building a tool so that users can add and update data to support the model, thereby reducing capacity needs after the initial assessment

SPATIAL PRODUCTS
The output is a score (1-100) of "health". The scores are not calculated per-pixel, so this is not a fine-scale spatially explicit index. A single OHI score could be calculated for the Northeast region, or for each NROC state and tracked through time. OHI can be used to consider future scenarios.

USES
There are multiple examples of OHI – global, California Current LME and Brazil. So far, none have been used in a regulatory context. A proposal to develop an OHI for the Northeast region has been submitted and a decision is in progress.

$ 5. TRADEOFFS

A variety of ecosystem services modeling tools exist to support decision-making in marine systems. These are a group of dynamic, spatially explicit simulation models of the natural-human coupled marine ecosystem that are used to understand ecosystem services tradeoffs under alternative management strategies.

These tools provide a methodology for using existing knowledge to model the spatial and temporal dimensions of ecosystem services. Ecosystem service modeling tools allow users to explore alternative management decisions and assess the costs/benefits of those decisions to ecosystem services (i.e., "ecosystem service tradeoffs"). Tools can also help users identify decisions that are optimal across sectors (i.e., ecosystem, human uses). Scenarios can then be tested against the data to validate/invalidate our understanding of the system. The various modeling tools are characterized by distinct methodologies and each is associated with different advantages and limitations. All are spatially explicit.

There are two main processes that these models explore— 1) How the ecosystem affects human use (i.e., ecosystem services and valuation) and the converse 2) How human use affects the ecosystem (i.e., cumulative impacts).

The outputs from these tools can typically be expressed in biophysical terms (e.g., biomass lost or gained) economic terms (e.g., dollars lost or gained), social terms (e.g., stakeholder satisfaction or dissatisfaction) or all of the above.

TRADEOFFS

Les Kaufman and Irit Altman, Boston University

These are a group of models of the natural-human coupled marine ecosystem including the Multiscale Integrated Model of Ecosystem Services (MIMES, Altman et al. 2014), the Massachusetts Ecosystem Service Tradeoff Analysis (ESTA, White et al. 2012), and Marine InVEST. InVEST models have generally higher data needs, but can be easily run by non-experts. ESTA provides an important example of how to optimize human use decisions across multiple ecosystem services. MIMES is a highly flexible approach that focuses on the spatial and temporal dimensions of a system. One of the main goals of MIMES is to understand long-term sustainability of multiple ecosystem services in association with alternative human use decisions.

DATA COLLECTION

Existing biological, environmental, and human-use data are integrated from many sources for these approaches. Often, existing data needs to be re-scaled or pre-processed prior to inclusion in ecosystem service models.

TEMPORAL EXTENT

These approaches do not prescribe a certain temporal extent of input data in order to run, but can incorporate long records of historical data. These models project into the future and provide information about how the coupled natural-human system would change over time under the "status quo" or in response to a potential human-use decision (forecasting).

TREATMENT OF DATA

Input data are primarily spatial in nature (maps or data points tied to locations). For MIMES and ESTA there is no prescribed treatment of the input data for the model to run, however InVEST models often require a specific set of data inputs to run the model. Data may be reinterpreted in order to better address key management questions in the study area. For example, fish and other species may be summarized by food web group (benthic feeder, forage species, predator). Existing datasets may be interpolated or re-sampled so that they each have matching grid sizes. Data may be reclassified, or averaged by season. Human use data may be grouped into categories (conservation, commercial fishing, energy).

SPATIAL PRODUCTS

Spatial products include maps of ecosystem service values and ecological impacts under different management scenarios.

USES

None of these tools are currently in use in the Northeast region. MIMES has been tested in several other study areas around the world, with case studies in Massachusetts for the MA OMP, Albamarle-Pamlica watershed in North Carolina, and Cambodia's Lake Tonle Sap. The ESTA approach was also developed and tested as part of the MA OMP. Several input data layers that were developed for these case studies have been useful to the MA OMP process as stand-alone spatial information. Marine InVEST also has many successful case studies for informing spatial planning, permitting and multi-stakeholder planning in places including Hawaii, Indonesia, Colombia, and Vancouver Island. A case study in the Northeast region had been previously planned but not yet executed.

DATA

SPATIAL PRODUCTS

TIER I

TIER II

AREAS

HEALTH

IMPACT

CUMULATIVE

TRADEOFFS $

EXTENT

NE & NE+