# Introduction

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## 1.1. A CALL FOR SPATIAL PLANNING OFFSHORE OF NEW YORK

New York depends on healthy coastal and marine ecosystems for its thriving economy and vibrant communities. These ecosystems support critical habitats for wildlife and a growing number of significant and often competing ocean uses and activities, such as fishing, commercial transportation, recreational boating and energy production. Planners, policy makers and resource managers are being challenged to sustainably balance ocean uses and environmental conservation in a finite space and with limited information. Solutions to these challenges are complicated by emerging industries, climate change, and a growing coastal population with shifting needs.

*Image 1.1. Offshore wind farm.*
*Photo credit: A. Meskens (Wikimedia Commons)*

New York is addressing competition and evolving threats to coastal and marine resources and services by compiling spatial information and applying ecosystem-based management to spatial planning. In 2006, the New York Oceans and Great Lakes Ecosystem Conservation Act created the New York Oceans and Great Lakes Ecosystem Conservation Council and charged the New York Department of State (DOS) with developing amendments to its federally-approved Coastal Management Program to better manage human activities that impact coastal and marine ecosystems.

The Coastal Management Program within DOS has broad authority to guide human uses and can use the consistency determination process, outlined in the Coastal Zone Management Act of 1972 (Public Law 92-583, 16 U.S.C. 1451-1456), to affect decisions made in both federal and state waters. Ultimately amendments will be integrated into state and federal permitting processes related to siting ocean uses and regional ocean planning programs. A state with an approved Coastal Management Program has the authority to approve or deny a proposed federal action if it may affect the state's coastal resources.

DOS is taking a phased approach for developing amendments by focusing on the most pressing issues first. New York's first amendment will apply to the Atlantic waters off New York out to the continental shelf and will focus on guiding decisions for new clean, renewable energy production and transmission, while addressing conflicts with other human activities and protecting critical habitats. Future amendments will include Long Island Sound and the Great Lakes.

New York has joined a growing number of states and federal agencies thinking about offshore spatial planning. For instance, Massachusetts and Rhode Island have recently completed ocean management plans, and New Jersey, Oregon and California are in the process of developing plans or collecting information necessary for planning purposes. In addition to state-level planning initiatives, multi-state partnerships and the federal government are undertaking spatial planning and have adopted a regional approach. The regional approach was chosen to allow for the variability of economic, environmental, and social aspects among different areas, provide an ecosystem-based perspective, and match existing regional governance structures.

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In 2009, the governors of New York, New Jersey, Delaware, Maryland and Virginia committed to a comprehensive regional approach to address challenges faced in the ocean waters of the Mid-Atlantic, and created the Mid-Atlantic Regional Council on the Ocean (MARCO). The council has since developed action teams to protect critical habitats, improve water quality, support sustainable development of renewable energy, prepare for climate change, and build capacity for effective spatial planning in the region. Many of the data and analytical approaches used in this report will likely be useful to the entire mid-Atlantic region.

The MARCO initiative fits in well with the first ever National Ocean Policy signed by President Obama in 2010 (Executive Order 13547, 2010). The policy seeks to improve stewardship of the oceans, coasts, and Great Lakes by way of: adopting ecosystem-based management; obtaining, advancing, using, and sharing the best science and data; promoting efficiency and collaboration; and strengthening regional efforts. The order established the National Ocean Council to guide implementation of the policy, and identified nine national priority objectives, one of which is to implement coastal and marine spatial planning (CMSP). The Council outlined a flexible framework for spatial planning that is regional in scope, developed cooperatively among federal, state, tribal, and local authorities, and includes substantial stakeholder, scientific, and public input (NOC, 2012).

*According to U.S. Executive Order 13547, CMSP is a "comprehensive, adaptive, integrated, ecosystem-based, and transparent spatial planning process, based on sound science, for analyzing current and anticipated uses….[CMSP] identifies areas most suitable for various types or classes of activities in order to reduce conflicts among uses, reduce environmental impacts, facilitate compatible uses, and preserve critical ecosystem services to meet economic, environmental, security, and social objectives."*

## 1.2. DATA TO SUPPORT OFFSHORE SPATIAL PLANNING

New York requires accurate, accessible and integrated ecological and human use data in order to base spatial planning on sound science. Whenever possible, these data are needed at spatial and temporal scales that are in line with management decisions, and need to provide continuous information over the whole management domain. With these requirements in mind, over the past year New York has compiled diverse ecological and human use datasets, including: biogeographic data from The Nature Conservancy's Northwest Atlantic Marine EcoRegional Assessment (NAMERA); distributions of marine fishes, marine mammals and sea turtles from Stone Environmental Inc., the University of Rhode Island, the New England Aquarium, and the National Marine Fisheries Services' Northeast Fisheries Science Center; infrastructure data, chiefly from the NOAA electronic navigation charts; jurisdictional information downloaded from the Multi-purpose Marine Cadastre (MMC), a tool developed in collaboration between NOAA Coastal Services Center (CSC) and DOI's Bureau of Ocean Energy Management (BOEM – formerly the Bureau of Ocean Energy Management, Regulation and Enforcement, BOEMRE), and; offshore human use information collected through participatory geographic information system workshops developed and carried out in partnership between the New York State Coastal Management Program and CSC.

This report supplements other datasets and reports compiled by OMAFRA's Great Lakes Program (OGLP), and provides data identified by OGLP as a priority to satisfy the needs of a Coastal Management Program amendment in the Atlantic. Specifically, this report examines the spatial distribution of: seabirds, bathymetry, surficial sediments, deep sea corals, and dynamic oceanographic habitats. We developed new geospatial synthesis products with the objective of providing:

- The most accurate and up-to-date information available,
- Continuous information over the management domain and at the finest spatial scale raw data would support,
- Estimates of synthesis product reliability (certainty) and assessments of data quality,
- Data products in digital formats that allow easy integration with other datasets in a geographic information system, and
- Maps, assessments and interpretations that are easily understood and used by coastal managers to support spatial management decisions.

All data and assessments in this report represent a synthesis of existing information rather than a new data collection effort. Given the short time frame over which management decisions frequently need to be made and omnipresent budget constraints, this approach of interest to be one other coastal zone managers.

## 1.3. AN ANALYTICAL APPROACH USEFUL TO SPATIAL PLANNING

The ocean area offshore of New York has a significant amount of raw data, ranging from sediment samples to bird observations to ocean temperature profiles. But many of these datasets are spatially and temporally limited or exist only as scattered points. As such, they are difficult to use for spatial planning, especially when decisions must be made in locations that are in-between surveys, have few surveys, have widely varying measurements or require a regional context. Where possible, we overcame these challenges by using a spatial analytical approach which applied statistical modeling to generalize from scattered sets of data points to regional maps of important patterns and processes.

Not all data can support this type of spatial analytical approach, especially datasets with few observations and/or with unknown sampling effort. For instance, predictive coral and sponge distribution models could not be developed in this report (Chapter 5) due to these data limitations. In this case, the goal was not to make spatial predictions, but rather to compile the most up-to-date observations and develop maps providing the best available information to make management decisions.

In the remaining chapters, datasets for bathymetry (Chapter 2), surficial sediments (Chapter 3), dynamic oceanographic habitats (Chapter 4), and seabirds (Chapter 6) included sufficient information to develop reliable spatial models. In-depth discussions of the statistical methods used to convert observation point data into continuous surfaces are available in corresponding chapters. A generalized representation of the approach using actual data (common loon sightings) is presented in Figure 1.1.

The spatial analytical approach follows Cressie (1993) and Hengl et al. (2007), where the variables of interest are modeled as a linear combination of components representing a deterministic mean trend, a spatially structured random process, and non-spatially structured error. The deterministic mean trend is estimated using a suitable broad spatial-scale function (generalized linear model for seabirds, or a smoothing function for bathymetry and surficial sediments) and the spatially structured random process and error term are estimated by geostatistical analysis of the residuals. There is no loss of information in this approach since the residuals contain all of the information removed from the trend surface.

The result is a spatially-explicit distribution of predicted outcomes, whether the outcomes are of abundance or the likelihood of occurrence. This predicted distribution of outcomes has two uses. First, the average taken from of the distribution can be mapped and used to represent the most likely outcome for a given location. Second, the distribution provides an estimate of certainty for the mapped outcome. That is, the mapped prediction for an area with a narrow distribution (outcomes are similar) has greater certainty, than the prediction for an area with a wide distribution (outcomes are dissimilar). Knowledge of a prediction’s certainty is a useful measure in spatial planning, because it allows planners to use the best available data to make decisions with an understanding of limitations on generalizations that can be made from the available data. We use the terms reliability, certainty and uncertainty throughout this report.

The applied spatial predictive methods involve a number of statistical assumptions, and it is important to note that the accuracy of model predictions and estimates of certainty depend to varying degrees on these assumptions being met. A complete discourse on all statistical assumptions is beyond the scope of this report (for detailed discussions see the methodological citations in each of the individual analytical chapters of this report), but several general assumptions are:

- *Spatial patterns and sampling effort are constant over the analyzed timeframe*

To compile sufficient data to make predictions we integrated data over several years. This approach provides information on the long-term average state of the system, but ignores long-term trends or cycles.

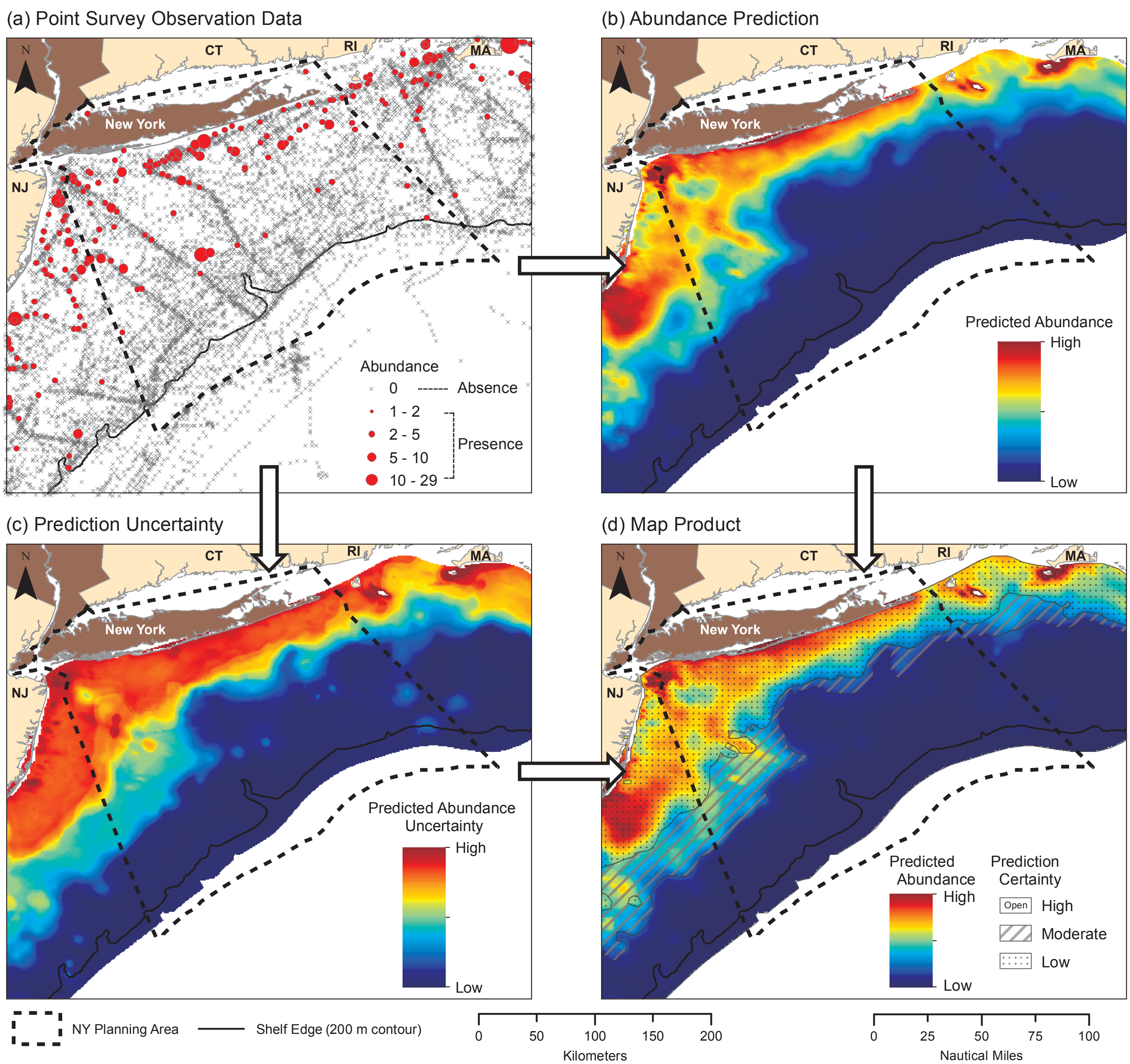


*Figure 1.1: These four panels show the general analytical approach used in this report to develop continuous distribution maps, assess certainty, and make easily understood products from typical survey data. This example uses data from the Manomet Bird Observatory Seabird and Cetacean Assessment Program database. Panel A shows common loon sightings distributed across the study area. A clear spatial pattern is difficult to discern, since sampling effort is irregular and observed presences are dispersed among observed absences. This is a typical ecological pattern since seabirds move around, detection is not perfect and sampling effort is irregular. Panel B shows the continuous output from a predictive model which has linked observations of the common loon to environmental predictors such as sea surface temperature, depth and oceanographic productivity. The model displays the average likelihood of observing a common loon given these environmental linkages and fills in gaps where survey data is missing. Panel C displays the uncertainty related to the predictive model, where areas of most uncertainty indicate the greatest range in possible predicted outcomes. Model uncertainty is commonly greatest where the resource of interest is most variable or where few data are available. Panel D shows a map where certainty (the inverse of uncertainty) is draped over predicted relative abundance. This type of map was requested by coastal resource managers in OGLP, because it was easy to understand and use for spatial management decisions.*

- *Resources and species are precisely detected and measured*

  Species or resources are seldom perfectly detectable, meaning corresponding occurrence and abundance estimates will be biased compared to true abundance and occurrence values. When sampling effort is known and heterogeneous, values can be standardized by effort to allow relative comparisons, but difficulties still arise in assessing areas where little sampling effort was devoted.

- *There exists a constant relationship between sampling effort, relative indices of occurrence and abundance, and true values of occurrence and abundance*

  Not only are species and resources unlikely to be perfectly detectable, the relationship between relative indices of occurrence and abundance and the true values of occurrence and abundance could vary in time and space, depending on differences in observers, weather conditions, animal behavior, etc. Such variation introduces an unaccounted for source of measurement error into data, and it is not possible to correct for all such sources of variation.

In addition to the assumptions inherent in modeling techniques, maps and assessments are a reflection of data quality and we assume that the data quality is suitable for spatial modeling and are representative of the ecosystem's true state. The key challenges of using existing data are that it was collected for a specific purpose, which may not be congruent with spatial analysis, and by definition it was collected in the past. It is important to understand potential limitations inherent to each dataset, and in each chapter we have identified and assessed key data quality issues.

We understand that statistical and data quality assumptions may not be completely met, thus model validation is an important part of the modeling approach. Validation is usually done by cross-validation, a process in which some data are left out of model fitting and model predictions are tested against those data. Model predictions can also be tested against high-precision "ground-truth" datasets where such datasets are available. We use both methods to validate predictions and maps in this report.

## 1.4. DESCRIPTION OF THE STUDY AREA

This report focuses on a study area in ocean waters off the coast of New York. The area covers a portion of the Mid-Atlantic Bight and much of the area characterized as the New York Bight. The study boundaries extend from the southern shores of Long Island to the edge of the continental shelf and from Nantucket Shoals to the shores of New Jersey (Figure 1.2). Both state and federal waters are included.

The study area covers a "spatial planning area" chosen by the OGLP in which they will focus their planning efforts, as well as ocean waters immediately adjacent to the planning area. The spatial planning area includes New York's territorial sea and Federal waters where natural phenomena and human activities can affect services and resources within the territorial sea.

The majority of the study area is characterized by a broad continental shelf approximately 150-200 km wide. At its outer edge, the shelf meets the continental slope, an area 40-60 km wide with very steep slopes and that extend to depths greater than 2 km. The most prominent topographic features in the study are the Hudson shelf valley, which crosses the entire shelf, and several shelf edge incisions made by submarine canyons. These topographic features alter the broad-scale hydrography of the region, are important to cross-shelf water movement and provide important benthic habitats which differ from the surrounding seascape (Cooper, 1987; Steimle et al., 1999).

The seafloor on the shelf is composed of mostly sand which grades to silt and clay in deeper areas (Poppe et al., 2005). The relatively homogenous seafloor has sporadic relic sand and gravel ridges; exposed sandstone and bedrock, dumping sites, dredge disposal sites and artificial reefs (i.e., shipwrecks, lost cargo, submerged pipelines). Bottom sediments play critical roles as habitats for benthic organisms such as demersal fish, clams and corals, and in storage and processing of settling organic matter.

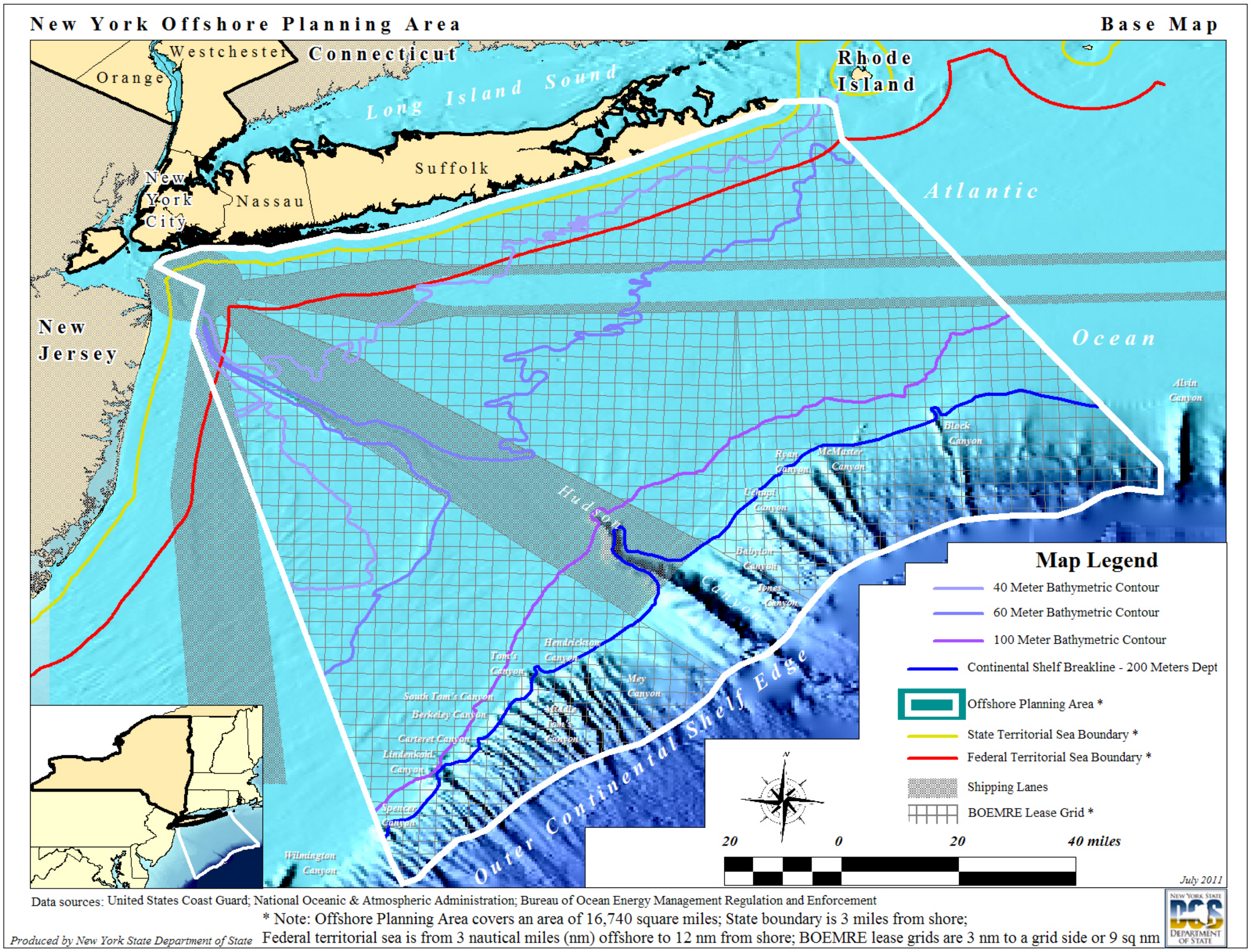


*Figure 1.2: A map of the study area used in this report. Map produced by New York State Department of State. Note that, effective October 1, 2001, the Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE) was renamed to the Bureau of Ocean Energy Management (BOEM).*

The hydrography of the study area is characterized by a strong seasonal cycle, considerable freshwater input from rivers, storm dominated sediment transport and interactions among large distinct water masses which extend across the Northwest Atlantic (Townsend et al., 2006). These hydrographic characteristics, along with characteristics of the seafloor and geomorphological setting produce patterns across multiple spatial and temporal scales in resources (e.g., fish, sand, renewable energy) and ecosystem services (e.g., coastal protection, tourism and transportation).

## 1.5. REFERENCES

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