OCS Study
BOEM 2021-036

New York Bight Fish, Fisheries, and Sand Features: Literature and Data Synthesis and Knowledge Gaps

Volume 0: Front Matter

US Department of the Interior
Bureau of Ocean Energy Management
Headquarters (Sterling, VA)

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June 2021

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Prepared under BOEM Agreement # M20AC00003
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Study collaboration and funding were provided by the US Department of the Interior, Bureau of Ocean Energy Management (BOEM), Environmental Studies Program, Washington, DC, under Agreement Number M20AC00003. This report has been technically reviewed by BOEM, and it has been approved for publication. The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the opinions or policies of the US Government, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

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CITATION

Grothues TM, Hunter EJ, Iwicki CM, Taghon GL, Borsetti S. 2021. Data synthesis of NY Bight fish, fisheries, and sand features; volume 0: front matter. Sterling (VA): US Department of the Interior, Bureau of Ocean Energy Management. OCS Study BOEM 2021-036. 6 p.

ABOUT THE COVER

Contents of a trawl aboard the commercial trawler *FV Viking II* during a study on bycatch along a shoreface sand ridge off Little Egg Inlet, New Jersey. Clearnose Skate, Windowpane Flounder, clams, Channeled Whelk, and Atlantic Horseshoe Crab represent resources that utilize sand habitat in this area.

ACKNOWLEDGMENTS

Phil Politis and Paul Kostovick manage and provided access to the NEFSC trawl surveys. Kevin Hassell, Lindy Barry, Jeffrey Brust, and Joe Ciminio, and Gregory Kinks of the New Jersey Department of Environmental Protection, Bureau of Marine Fisheries manage and provided access to the clam and Ocean Stock Assessment survey data. Thomas Ertle, Miranda Rosen, and Margaret Shaw helped extract data from literature to provide the guild classifications and trophic crosswalk tables.

Contents

List of Abbreviations and Acronyms

BOEM	Bureau of Ocean Energy Management
EFH	Essential Fish Habitat
MAB	Mid-Atlantic Bight
MARCO	Mid-Atlantic Regional Council on the Ocean
MMIS	Marine Minerals Information System
MSA	Magnuson-Stevens Fishery Conservation and Management Act
NEFSC	Northeast Fisheries Science Center
NJDEP	New Jersey Department of Environmental Protection
NYB	New York Bight
OCS	Outer Continental Shelf

1 Executive Summary

1.1 Background

The Bureau of Ocean Energy Management (BOEM) is receiving increased interest in outer continental shelf (OCS) sand resources for shore protection, beach and wetland restoration, and construction projects. Worldwide, sand and mineral aggregates are the second most exploited natural resource behind water, and expected demand far outpaces supply (United Nations Environmental Programme 2015). Sand includes aggregates of differing chemical composition, shape, grain size, roundness, and sorting.

Sand is an important habitat for many benthic organisms. Sand is indirectly linked to epibenthic and pelagic organisms through food web dynamics. Sand provides temporary refuge from predators or other adverse conditions, and facilitates ambush predation (Byrnes et al. 2004; Diaz et al. 2003; Diaz et al. 2004; Mahon et al. 1998; Vasslides and Able 2008; Walsh et al. 2006). The seafloor of the Northeast Large Marine Ecosystem is dominated by unconsolidated substrate that is used to some degree by numerous fish and invertebrate species of economic or special ecological value.

In recognition of the importance of specific habitats in the completion of life cycles for fishes and key invertebrates, the habitat of managed fish species is under legal protection by the Magnuson-Stevens Fishery Conservation and Management Act (also referenced as Magnuson-Stevens Act, or MSA, 16 U.S.C. 1801 et seq.). The 1996 amendment to the MSA requires the identification, description, and designation of essential fish habitat (EFH), which is inclusive of managed and commercially important invertebrates. EFH, the "waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity," is identified so that it can be managed and protected from other activities.

Sand resource extraction, or dredging, removes sand substrate and infauna, produces turbidity plumes, and changes bathymetric contours (Pickens et al. 2020). Contours and texture (i.e., bottom roughness) influence topographic steering, including upwelling (Michel et al. 2013; Pickens et al. 2020; Wenger et al. 2017). When sand is extracted, damage to the community that depends on it is expected through removal or screening of infauna, exposure to hypoxic sediment horizons and thinning of the oxygenated sediment layer suitable as habitat, resorting of sediment sizes appropriate for different infauna, burial of epibenthic fauna and fish eggs from sediment plumes, clogging of fish gills, behavioral response such as movement, and the consequent depletion of infaunal prey and their trophic transfer to fishes (Nairn et al. 2004; Pickens et al. 2020; United States Army Corps of Engineers 2015). However, similar to the case for natural disturbances, such communities should be expected to recover. These disturbances occur within a background of diurnal and seasonal photoperiod and production cycles, upwelling, seasonal and advective temperature changes, storms, disease and predation dynamics, migrations, and successional community dynamics that introduce natural variability in the system. Sand resource extraction may emulate aspects of other anthropogenic disturbances such as bottom trawling or clam suction harvest or scallop dredging (Sullivan et al. 2003). Disturbance, or more generally perturbation, is an important ecological structuring mechanism. It is particularly important as a driver of diversity through interruption of community succession by the suppression of otherwise dominant species (Grassle and Sanders 1973; Hardin 1960). This data synthesis focuses on a contextual view of spatial and temporal dynamics as perturbations that influence fish and macro invertebrate production and distribution in the New York Bight (NYB).

1.2 Scope of the Report

For this study, the NYB is a region geographically defined on the west and north by the bowed US coastline and to the east and south as a line drawn between Block Island, RI, and Cape Henlopen, DE. The apex of this study area is the entrance to the Hudson River Estuary, the relict channel of which continues as the submarine Hudson Shelf Valley with important influence on the regional benthic structure and circulation, and therefore on composition of fish and invertebrate communities and on fisheries. Within this, the study area extends from the 3-mile Federal jurisdiction line to the 50-m bathymetric contour. Due to technological constraints, sand extraction normally occurs in depths of 30 m (98 ft) or less. The seaward extent of the current study provides a buffer should technology advance dredging into deeper waters. This depth corresponds to an offshore distance of about 16.7 km (9 nm) but varies greatly with latitude. Select data collected in adjacent State waters were also reviewed for comparison.

1.3 Key Findings

Volume 1: Literature Synthesis and Gap Analysis

We reviewed 640 reports, theses, and peer-reviewed science publications to extract patterns of sand habitat use as well as recreational and commercial fisher use of sand features in or relevant to the NYB. About half of these were specific to the NYB or the larger Mid-Atlantic Bight (MAB) in which it is nested, while additional studies contributed to understanding life history and habitat function in general and for species with a greater range.

A unifying theme for the literature synthesis was how the extent and duration of perturbation, or the environmental variation experienced by fishes and invertebrates of the region over their life history, compared to that imparted by dredging. For this reason, the literature review included papers on oceanography, geology, ocean acidification, climate change, disease, and storms.

Important patterns that emerged were as follows:

- The NYB is highly seasonal in its temperature, hydrographic, and productivity characterization.
- Habitat use by fishes reflects these dynamics with seasonal occupancy of migrants from nearby (on-offshore) and other regions (Gulf of Maine, Southeastern US Continental Shelf, oceanic).
- The character of benthic habitat varies north and south of the Hudson Shelf Valley bisecting the NYB, mostly as a function of bathymetric relief.
- Adult and nursery habitat for many of the species that use the NYB is segregated through migration, seasonality, estuarine, or oceanic-dependent life stages. Nursery habitat for others is temporally and or dynamically defined by hydrography. Nursery segregation, especially for estuarine-dependent species, may isolate young-of-year from short-term dredging impacts.
- The seasonal overturn that owes to mechanisms of migration and recruitment after pelagic larval drift for bony fishes and some invertebrates from other regions means that the overall fish population should be resilient to short-term (< 1 year) disturbance, but also that disturbances elsewhere may add to cumulative effects in the NYB, and that disturbances in the NYB may influence other regions.
- There are many sharks, rays, and skates among the fish resources of the NYB. These do not have pelagic larval stages but are live born or hatch from benthic egg capsules. Movement after parturition may still segregate nursery and adult habitat.
- In line with the migratory response to seasonal temperature and production, and the expanse of soft sediments, a predominance of trophic ecology and life history adaptations reflects common use of unconsolidated habitat rather than reef-residence. Common forms include planktivorous

and raptorial pelagic species, flatfishes, rays, skates, and others capable of burrowing, those with subterminal mouths and chemosensitive feelers or barbels for probing sediment.
- Climate change is affecting this region faster than other oceanographic provinces, resulting in mostly poleward and offshore shifts in fish population centers and margins.
- Powerful storms are common to the Mid-Atlantic Bight. Most studies of storm effects on fish come from estuaries, where they show either rejuvenation or detrimental effects from pollution flushing.
- Storms and fishing gear regularly disturb the upper layers of sediment in the NYB.
- Richer and more abundant fish assemblages are associated with the shoreward flanks of a shoreface sand ridge than the seaward side or off-ridge areas. Shoreface sand ridges steer currents.
- The NYB is extensively used by fishers, but some of the most valuable harvests comes from seaward (e.g., Atlantic Sea Scallop) or shoreward (e.g., Blue Crab) of the study area. Summer Flounder, Striped Bass, and Black Sea Bass are important exceptions that leverage other expenditures as part of a recreational experience beyond the market price of the meat.

Important knowledge gaps were identified:

- There is a need to better understand the mechanisms by which individuals of a species interact with their sand habitat to compete with other species or otherwise force the delineation of realized niches. This informs a central bioenergetics understanding of ecology and provides predictability to how trophic reorganization and recruitment is shaped by disturbances.
- An understanding of scale effects, i.e., how size, spacing, and relative concentration of habitat features within a mosaic relates to the bioenergetics and therefore distribution of important species, is likewise useful to predicting how disturbances reshape trophic organization and recruitment.
- Direct observations of fish and invertebrate reactions (positive or negative) to dredging is needed to understand the potential for acute injury, mortality, or feeding opportunities that result from dredging activity.

Volume 2: Data Synthesis and Analysis

Volume 2 is organized around tasks of 1) data inventory; 2) data parsing and serving; 3) examination of latent trends in habitat and fish, scallop, and clam distribution; 4) examination of canonical trends, i.e., fish distribution correlated with spatial and temporal habitat trends and their relative explanatory power as perturbations; 5) autecological trends for important species; 6) analysis of fishing data in the study area; 7) a predator/prey crosstab; and 8) general conclusions.

Data were gathered from sources at Rutgers University, BOEM, Mid-Atlantic Regional Council on the Ocean (MARCO), Marine Minerals Information System (MMIS), New Jersey Department of Environmental Protection (NJDEP), and National Marine Fisheries Service. Much of the data is gathered on an ERDDAP server (https://nybsand.marine.rutgers.edu/erddap/index.html) hosted by Rutgers.

There are 30 data sets served through the project ERDDAP, including some that are already posted on other servers. Additional data available through MARCO—which itself mirrors the BOEM Marine Cadastre (https://marinecadastre.gov/)—and the National Centers for Environmental Information server (https://www.ncei.noaa.gov/) could be useful to assessments of sand features as fish habitat but are not mirrored on the ERDDAP.

Two standardized trawl surveys, the Northeast Fisheries Science Center (NEFSC) trawl survey ("NEFSC survey") and the NJDEP Bureau of Marine Fisheries Ocean Stock Assessment survey ("State survey") have a history in the study area. Only the NEFSC survey covers the entire area, and it is the basis for much of the analysis in this report. The State survey provides important context and is treated briefly. Clam dredge surveys and scallop imaging surveys were also treated. The spatial constraints of the Federal survey, which extended beyond the bounds of the study area, as provided as two ESRI shapefiles, one bounded at the 30-m isobath and the other at the 50-m isobaths. Temporal constraint of the surveys was set at one decade (2010–2019, n =733 samples for the NEFSC survey) based on change-point analysis and other factors such as survey method consistency. Following latent analysis, trawl survey data was aligned with environmental (factor) data collected coincident with survey or from other layer data, such as sediment size and modeled sholas, and analyzed for canonical trends.

Faunal assemblages were examined by principle components analysis. Seasonality explained much of the latent variation, with a depth/offshore gradient also evident. An initial Spring trawl survey data set represented 92 species, and the initial Fall trawl survey data represented 167 species. The union of the two sets represented 183 species. There were 76 species common to both surveys. There were 16 species unique to the Spring survey and 91 species unique to the Fall survey. Data sets were further reduced to include only managed species, ecologically important forage species, and a few indicator species that were both common and had special adaptations to demersal habitat. Species differentiating Spring samples (Little Skate, Atlantic Herring, Spiny Dogfish, Winter Skate, Alewife, Blueback Herring, Winter Flounder, Red Hake, Silver Hake) were predominantly MAB or Northern origin guild species. Consistent with the patterns in richness and unique species described in Section 3.3.3 in Volume 2, there were more species differentiating Fall samples (Longfin Squid, Butterfish, Scup, Smooth Dogfish, Black Sea Bass, Striped Sea Robin, Clearnose Skate, Northern Puffer, Weakfish, Atlantic Croaker, Spot, Northern Kingfish, and others). These included members of Northern, Southern, MAB, Broad, and unknown origin guilds. Samples that overlapped were characterized by having relatively few fauna in general, so that the non-migratory Atlantic Sea Scallop, Gulf Stream Flounder, and Fourspot Flounder with MAB or Northern guild-affiliation were the strongest representatives. American Lobster showed no trend, and Striped Bass, Northern Sand Lance, Smallmouth Flounder, Goosefish, Atlantic Mackerel, and Spotted Hake had relatively weak gradients in relative abundance. *Etropus* sp. flounders, Horseshoe Crab, and Windowpane did not trend strongly with season, but also were not abundant in the samples that were similar among seasons. This may be interpreted as spatial segregation.

After separation into seasonal data sets, canonical trends explained 11% of the total variation for both Spring and Fall data independently. Of this, hydrographic factors, followed by depth, explained most of the trends in species relative abundance overturn, but proximity to shoals and grain size were significant in explaining approximately 12% and 4% (respectively) of canonical variance in Spring and 11% and 10% (respectively) for canonical variance in Fall. The distribution of Little Skate and Winter Flounder in Spring were most closely fit with the presence of target shoal features, while other species were significantly associated with flats. In Fall, Striped Anchovy, Round Herring, and Rough Scad—all planktivorous species—were most closely associated with shoals. Southern Kingfish, Weakfish, Bullnose Ray, Atlantic Croaker, and Atlantic Horseshoe Cab used habitat around shoals but also used habitat elsewhere, while samples near shoals but in deeper, cooler, and more stratified water tended to consist predominantly of Butterfish, American Lobster, and Atlantic Herring. The deepest samples from cooler stratified water were represented especially by Atlantic Sea Scallop, Goosefish, Haddock, Ocean Pout, Spiny Dogfish, and Gulfstream Flounder. Species characterizing samples typified by a modal environment or broadly distributed during Fall comprised largely of Windowpane, Atlantic Mackerel, Winter Skate, Round Scad, Summer Flounder, Smooth Dogfish, Northern Sand Lance, and Bluefish.

We interpret this as indicative of highly mobile fauna using a landscape over which resources of microhabitat features are widely spread. Mechanistic links of association with shoals, such as bathymetric steering of currents that concentrate prey for pelagic nekton, such as forage species, need further study.

Biomass within the study area is concentrated on the inside of the continental shelf and especially near the Delaware Bay and Long Island Sound outlets. The southern concentration coincides with a concentration of BOEM-identified sand resources. Species richness was also greater closer to shore and peaked with the 30-m isobath, especially near the Hudson River Shelf valley at the apex of the study area.

Ocean Quahog and Atlantic Surfclam were centered in the study area, but distribution of Atlantic Sea Scallop and its fishery are strongly skewed with a mode deeper than the 50-m limit of the study area. The distribution of Atlantic Surfclam is shifting to deeper waters and thus from State into Federal jurisdiction, due to warming water.

Total commercial landings of seafood from bottom tending gear (trap and pot, trawl, dredge, purse seine, and gillnet) from eight statistical areas within the NYB totaled between $40 and 73 million between 2010 and 2019, with an overall declining trend following pounds of landings (approximately 43 and 87 million pounds). Landed mass was due mostly to Atlantic Sea Scallop from outside the study area (but inside the representative statistical area), Atlantic Herring, Atlantic Mackerel, Atlantic Menhaden, and Longfin Squid, all of which are predominantly planktivores or small (larval) fish consumers. Revenue, however, was mostly from Atlantic Sea Scallop and Summer Flounder, and occasionally Atlantic Mackerel, Scup, or Longfin Squid.

Recreational fishing was concentrated especially inside the 30-m contour, with hotspots reflecting those of biomass and richness. Both commercial and recreational fishing captains in New Jersey identified "Lumps" (shoreface sand ridges) as prime fishing grounds for a variety of species, especially Summer Flounder and Bluefish.

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