Impacts to Fish Habitat from Anthropogenic Activities: Introduction and Methods

Prepared by the Fisheries Leadership & Sustainability Forum for the Mid-Atlantic Fishery Management Council

I. Introduction

To support the Mid-Atlantic Fishery Management Council's (MAFMC) consideration of habitat impacts from anthropogenic activities, the Fisheries Forum prepared a set of background documents, which aim to:

- Provide a high level understanding of anthropogenic activities identified as priorities by the Oversight Team;
- Describe potential impacts to habitat that may result from these activities; and
- Identify overlap between potential habitat impacts and the habitats important to MAFMC managed species.

This document describes the methods used to develop background documents on the following six activities:

- Liquefied Natural Gas (LNG)
- Wind Energy
- Offshore Oil
- Marine Transport
- Coastal Development
- Fishing

II. Document Contents and Structure

Given the different nature of habitat impacts resulting from fishing activities compared to non-fishing anthropogenic activities, separate approaches were taken in drafting these two different sub-categories of background documents.

Fishing

I. Introduction – explains the purpose and organization of the document, and introduces important habitat concepts used throughout the document.
II. Gear Profiles – provides an overview of each fishing gear configuration, how it's used in the Mid-Atlantic region, and its potential impacts to habitat.
III. Potential Impacts in the MAFMC Context – provides a ranking of gears as low, moderate or high impacts, and explores the relative impact given the proportion of effort each gear represents within a fishery (see "Methods" below).
IV. Discussion – highlights nuances and considerations that influence the extent and severity of habitat impacts from fishing activities.
V. References

Non-Fishing Activities

Background documents for energy development (LNG, wind and oil), marine transport and coastal development are structured according to the following outline:

I. Activity Overview – provides a succinct introduction to the activity, permitting authorities, and the extent to which the activity is or could occur in the Mid-Atlantic region.
II. Habitat Impacts by Habitat Type – describes potential impacts to habitat, organized by habitat type (see "Methods" below).
III. Potential Impacts to MAFMC Managed Stocks – highlights MAFMC stocks and habitat types that may be impacted by each activity. This information is also presented in table format (see "Methods" below).
IV. Indirect Impacts – describes impacts to the survival and productivity of fish stocks and potential interactions with other coastal or marine activities.
V. References

III. Methods

All six background documents synthesize and organize existing information on anthropogenic activities and their potential impacts to important fish habitat. Primary source documents include:

- National Oceanic and Atmospheric Administration (NOAA) Technical Memorandum 209, "Impacts to Marine Fisheries Habitat from Nonfishing Activities in the Northeastern United States"
- New England Fishery Management Council's "Omnibus Essential Fish Habitat Amendment 2 Draft Environmental Impact Statement. Appendix G: Non-Fishing Impacts to Essential Fish Habitat"
- NOAA Technical Memorandum 181 "Characterization of the Fishing Practices and Marine Benthic Ecosystems of the Northeast U.S. Shelf, and an Evaluation of the Potential Effects of Fishing on Essential Fish Habitat"

Experts involved in fisheries management, habitat conservation and the essential fish habitat (EFH) consultation process also provided valuable insights. A complete list of references and sources is included with each background document.

The following methods were used to aggregate and synthesize information from multiple sources and draw insights about potential impacts to habitat.

Fishing

Expert judgment

In addition to several technical and peer-reviewed resources, information was also drawn from sources that leverage expert judgment. To distinguish between these different informational resources, footnotes are used to identify the source of specific insights.

Heat map of habitat impacts

To provide a visual comparison of habitat impacts across gear types, fishing gears were assigned a ranking of low (green), moderate (yellow) or high (orange). These rankings are a qualitative simplification of the information summarized in each gear profile, which is rooted in expert judgment, peer-reviewed published research, observational studies, and gray literature. Rankings reflect relative potentials for habitat impacts, recognizing that the actual impacts to habitat are a function of how, when and where the gear is used.

Effort-based indexing

Gear types used within each fishery are assigned a relative effort categorization, using landings estimates generated by MAFMC staff and NOAA Fisheries trip report logbook data:

- Majority – gears accounting for greater than 50% of landings
- Minority – gears accounting for less than 50% of landings
- Minimal – gears accounting for less than 5% of landings

Fishing gears responsible for minimal landings in a fishery are assigned a lower habitat impact ranking, reflecting a lower potential for habitat impacts.

Non-Fishing Activities

Habitat categorization

The potential for intersections between habitat impacts and habitats important for Mid-Atlantic stocks is assessed using a simplified set of habitat types and attributes. This allows for direct comparisons between MAFMC's EFH and habitat areas of particular concern (HAPC) descriptions, and habitat descriptions in reference documents. These attributes include distance from shore, depth in the water column, and substrate type.

Distance from shore: Three categories are used to describe habitat in terms of distance from shore. While estuaries are subset of nearshore habitat, this specific habitat type is included to recognize the importance of estuarine environments and their susceptibility to impacts. Nearshore and offshore are not strictly defined in terms of specific distance from shore but are general categorizations used for this specific purpose.

- Estuarine – includes habitats such as estuaries, intertidal flats, submerged and exposed vegetative zones, etc.
- Nearshore – includes habitats close to shore, including inshore, coastal, and state waters, etc.
- Offshore – includes habitats far from shore, including outer continental shelf, federal waters, etc.

Water column: Three categories are used to describe different habitat types relative to their distribution within the water column.

- Pelagic – includes the upper water column, mid-water column or entire water column. This designation is inclusive of pelagic habitats not specifically referenced as demersal or benthic. This designation is also inclusive of nearshore and offshore habitats, though is less relevant for estuarine environments.
- Demersal – specific to the lower water column. The use of demersal waters is implicit for habitats that expand the entire water column, and is an added distinction for habitat in the lower portion of the water column.
- Benthic – includes general and specific bottom habitats, the delineation of which is expanded through the third set of categorizations below.

<u>Benthic substrate/structure</u>: Benthic habitats are further categorized based upon the type of substrate or structure present.

- Submerged aquatic vegetation (SAV) – includes submerged vegetation such as eelgrass etc.
- Structured – includes a range of natural or manmade structured habitat such as rock, boulder piles, shell, oyster reefs, etc.
- Soft – includes soft substrates such as sand, silt, clay, mud, etc.

MAFMC EFH and HAPC table

EFH and HAPC for each species and life stage are “tagged” according the nine habitat types described above, based on information described or clearly implied by text descriptions from MAFMC and NOAA Fisheries source documents. These tags are not mutually exclusive; EFH for a single species may include habitat types in each category. This approach documents all habitat attributes identified as EFH or HAPC, intentionally allowing for overlap and avoiding distinction in the relative amounts of each habitat type used by each species or life stage.

Visualizing EFH and HAPC designations in this table (below) reinforces that Mid-Atlantic species have a strong association with nearshore habitats, and some or all life stages occur throughout state and federal waters. Additionally, many managed species are estuarine-dependent for several life stages. While only a few species are specifically benthic dwelling, there is a strong connection between MAFMC stocks and the demersal and benthic environment.

Potential for adverse impacts

Impacts to each habitat type are drawn from the source documents and summarized in Section II of each background document. Each habitat type is the characterized as having: a) potential for adverse impacts; b) low potential for adverse impacts; or c) no potential for adverse impacts, for each specific activity. These characterizations are identified through color-coding in the table within each background document. Overlaps between the habitat types potentially impacted and habitat types identified as EFH or HAPC for each species and life stage are identified.

Assumptions
The methods described above purposefully simplify and generalize habitat types and the relationship between these activities and MAFMC species for the purpose of identifying potential overlap. Given that these activities were explored from a hypothetical perspective (rather than with respect to a specific project proposal), an inclusive rather than exclusive approach was taken. Several of the activities explored are not occurring in the Mid-Atlantic region at this time. Thus all potential configurations of each activity are explored to provide the Oversight Team with an understanding of the full suite of impacts that may potentially result from this development.

	Distribution			**Water Column**			**Benthic Substrate/Structure**		
	Estuary	Nearshore (state waters)	Offshore	Pelagic (upper/mid/ entire column)	Demersal (lower water column)	Benthic (seafloor substrate)	SAV	Structured (e.g. shell, manmade)	Soft (sand, silt)
MAFMC Species									
Atlantic Mackerel									
Eggs	x	x	x	x					
Larvae	x	x	x	x					
Juveniles	x	x	x	x					
Adults	x	x	x	x					
Black Sea Bass									
Eggs	x	x	x	x					
Larvae	x	x	x	x	x	x		x	
Juveniles	x	x	x		x	x	x	x	x
Adults	x	x	x		x	x		x	x
Atlantic Bluefish									
Eggs		x	x	x					
Larvae		x	x	x					
Juveniles	x	x	x	x					
Adults	x	x	x	x					
Butterfish									
Eggs	x	x	x	x					
Larvae	x	x	x	x					
Juveniles	x	x	x	x					
Adults	x	x	x	x					
Shortfin Squid (*Illex*)									
Eggs			x	x					
Pre-Recruits			x	x					
Recruits		x	x	x					
Longfin Squid (*Loligo*)									
Eggs	x	x	x		x	x	x	x	x
Pre-Recruits	x	x	x	x					
Recruits	x	x	x	x	x	x	x	x	x
Ocean Quahogs									
Juveniles		x	x			x			x
Adults		x	x			x			x
Scup									
Eggs	x	x							
Larvae	x	x							
Juveniles	x	x	x		x	x	x	x	x
Adults	x	x	x		x	x			
Spiny Dogfish									
Juveniles		x	x	x	x				
Sub-Adults		x	x	x	x				
Adults		x	x	x	x				
Summer Flounder									
Eggs		x	x	x					
Larvae	x	x	x	x					
Juveniles	x	x	x		x	x	x		x
Adults	x	x	x		x	x	x		x
HAPC	x						x		
Atlantic Surfclams									
Juveniles		x	x			x			x
Adults		x	x			x			x
Golden Tilefish									
Eggs			x	x					
Larvae			x	x					
Juveniles			x		x	x		x	x
Adults			x		x	x		x	x
HAPC			x			x		x	x

Habitat Table References

Atlantic Bluefish

MAFMC. 1999. "Amendment 1 to the Bluefish Fishery Management Plan." Dover, DE. 408 p. + append.

Shepherd, G. and D. Packer. 2006. "Essential Fish Habitat Source Document: Bluefish, *Pomatomus saltatrix*, Life History and Habitat Characteristics." NOAA Technical Memorandum, NMFS-NE-198.

Atlantic Mackerel

MAFMC. 2011. "Amendment 11 to the Atlantic Mackerel, Squid, and Butterfish Fishery Management Plan." Dover, DE. 559 p. + append.

Studholme A. et al. 1999. "Essential Fish Habitat Source Document: Atlantic Mackerel, *Scomber scombrus*, Life History and Habitat Characteristics." NOAA Technical Memorandum, NMFS NE 141; 35 p.

Atlantic Surfclams

Cargnelli, L. et al. 1999a. "Essential Fish Habitat Source Document: Atlantic Surfclam, *Spisula solidissima*, Life History and Habitat Characteristics." NOAA Technical Memorandum, NMFS-NE-142.

MAFMC. 2003. "Amendment 13 to the Atlantic Surfclam and Ocean Quahog Fishery Management Plan." Dover, DE. 344 p. + append.

Black Sea Bass

Drohan, A., J. Manderson, and D. Packer. 2007. "Essential Fish Habitat Source Document: Black Sea Bass, *Centropristis striata*, Life History and Habitat Characteristics, 2nd Edition." NOAA Technical Memorandum, NMFS NE 200; 68 p.

MAFMC. 2002. "Amendment 13 to the Summer Flounder, Scup, and Black Sea Bass Fishery Management Plan." Dover, DE. 552 p. + append.

Steimle, F. et al. 1999. "Essential Fish Habitat Source Document: Black Sea Bass, *Centropristis striata*, Life History and Habitat Characteristics." NOAA Technical Memorandum, NMFS NE 143; 42 p.

Butterfish

Cross, J. et al. 1999. "Essential Fish Habitat Source Document: Butterfish, *Peprilus triacanthus*, Life History and Habitat Characteristics." NOAA Technical Memorandum, NMFS NE 145; 42 p.

MAFMC. 2011. "Amendment 11 to the Atlantic Mackerel, Squid, and Butterfish Fishery Management Plan." Dover, DE. 559 p. + append.

Golden Tilefish
MAFMC. 2009. "Amendment 1 to the Tilefish Fishery Management Plan." Dover, DE. 496 p. + append.

Steimle, F. et al. 1999. "Essential Fish Habitat Source Document: Tilefish, *Lopholatilus chamaeleonticeps*, Life History and Habitat Characteristics." NOAA Technical Memorandum, NMFS-NE-152.

Longfin Squid (*Loligo*)
Cargnelli, L. et al. 1999. "Essential Fish Habitat Source Document: Longfin Inshore Squid, *Loligo pealeii*, Life History and Habitat Characteristics." NOAA Technical Memorandum, NMFS NE 146; 27 p.

Jacobson, L. 2005. "Essential Fish Habitat Source Document: Longfin Inshore Squid, *Loligo pealeii*, Life History and Habitat Characteristics, 2nd Edition." NOAA Technical Memorandum, NMFS NE 193; 42 p.

MAFMC. 2011. "Amendment 11 to the Atlantic Mackerel, Squid, and Butterfish Fishery Management Plan." Dover, DE. 559 p. + append.

Ocean Quahogs
Cargnelli, L. et al. 1999b. "Essential Fish Habitat Source Document: Ocean Quahog, *Arctica islandica*, Life History and Habitat Characteristics." NOAA Technical Memorandum, NMFS-NE-148.

MAFMC. 2003. "Amendment 13 to the Atlantic Surfclam and Ocean Quahog Fishery Management Plan." Dover, DE. 344 p. + append.

Scup
MAFMC. 2002. "Amendment 13 to the Summer Flounder, Scup, and Black Sea Bass Fishery Management Plan." Dover, DE. 552 p. + append.

Steimle, F. et al. 1999. "Essential Fish Habitat Source Document: Scup, *Stenotomus chrysops*, Life History and Habitat Characteristics." NOAA Technical Memorandum, NMFS-NE-149.

Shortfin Squid (*Illex*)
Cargnelli, L., S. Griesbach, and C. Zetlin. 1999. "Essential Fish Habitat Source Document: Northern Shortfin Squid, *Illex illecebrosus*, Life History and Habitat Characteristics." NOAA Technical Memorandum, NMFS NE 147; 21 p.

Hendrickson, L. and E. Holmes. 2004. "Essential Fish Habitat Source Document: Northern Shortfin Squid, *Illex illecebrosus*, Life History and Habitat Characteristics, 2nd Edition." NOAA Technical Memorandum, NMFS NE 191; 36 p.

MAFMC. 2011. “Amendment 11 to the Atlantic Mackerel, Squid, and Butterfish Fishery Management Plan.” Dover, DE. 559 p. + append.

Spiny Dogfish

MAFMC. 2014. “Amendment 3 to the Spiny Dogfish Fishery Management Plan.” Dover, DE. 106 p. + append.

Stehlik, L. 2007. “Essential Fish Habitat Source Document: Spiny Dogfish, *Squalus acanthias*, Life History and Habitat Characteristics.” NOAA Technical Memorandum, NMFS-NE-203.

Summer Flounder

MAFMC. 2002. “Amendment 13 to the Summer Flounder, Scup, and Black Sea Bass Fishery Management Plan.” Dover, DE. 552 p. + append.

Packer, D. et al. 1999. “Essential Fish Habitat Source Document: Summer Flounder, *Paralichthys dentatus*, Life History and Habitat Characteristics.” NOAA Technical Memorandum, NMFS-NE-151.

Offshore Wind Energy
Anthropogenic Activity Background Document

I. Activity Overview

Offshore wind projects leverage strong, steady winds over the ocean to rotate turbine blades, driving attached generators to create electricity. Turbines can be mounted on fixed piles or floating devices, and the resulting structures can stand several hundred feet above the surface of the water. Each turbine, whether fixed or floating, must be connected to an electric service platform that collects and relays the electricity to shore, and serves as a base for maintenance activities. Together, the collection of wind turbines and a service platform form a "wind farm," which can consist of just a few or many dozen turbines with a very large project footprint. Specialized, high voltage cables are used to transmit the generated electricity from the service platform to an onshore substation that connects to the existing power grid. While generally termed "offshore wind energy," projects can be sited in both nearshore and offshore waters. The U.S. Department of the Interior's Bureau of Ocean Energy Management (BOEM) leases areas to be considered for siting wind energy projects, and the U.S. Army Corps of Engineers (Corps) permits offshore wind projects in state waters. The U.S. Coast Guard oversees lighting and traffic patterns at wind farms to reduce potential navigation hazards.

Construction and Operation

There are several considerations that inform siting of offshore wind farms including wind speed, size of turbines, distance from shore, and depth of water. Larger turbines are more efficient at harnessing energy at a given wind speed; however, they require larger, sturdier piles to support their span. Floating turbines, which employ turbines mounted on floating devices and anchored to the seafloor with cables, can allow wind farms to be sited further from shore and in deep water. However, given current technological limitations with floating turbines and driving piles in deep water, wind farms are most likely to be comprised of fixed turbines and sited in shallow waters less than one-hundred and fifty feet deep.

To construct fixed turbines, construction barges equipped with percussive or gravity hammers drive piles up to 100 feet into the seabed in mostly sandy habitats. Crushed rock or concrete mattresses are placed on the seafloor at the base of the piles to stabilize them against the forces of waves, high winds and ice floes, and to prevent currents from scouring sediment. Cranes onboard the barges are used to mount turbines and a service platform onto the piles. The piles, turbines, and electric service platforms are all assembled onshore and moved to the project site on construction barges for installation.

Electricity Transmission

To collect and distribute the electricity generated at a wind farm, a network of expensive transmission cables must be laid to connect each turbine to the service platform, and the service platform to an onshore power substation. The cables are laid in trenches on the seafloor that are excavated by jetting, trenching, or plowing tools and then buried to protect them from damage or disturbance. The amount of cable required to network a wind farm is related to the spacing between turbines, distance from shore, and the number and type of seafloor obstacles that the cables must be routed around or through. In instances where re-routing cables is impractical, they may be placed on the substrate and buried with concrete mattresses; explosives can also be used to remove benthic obstacles, though this is less common. Throughout the life cycle of a wind farm, transmission cables must occasionally be unearthed and inspected for damage and eventually removed during decommissioning.

Activity in the Mid-Atlantic Region

The Mid-Atlantic region is densely populated with extensive development along the shoreline. High energy demand and lack of space for onshore coastal wind farms make it an attractive area to develop offshore wind projects. While there are currently no operational wind farms in Mid-Atlantic waters, BOEM has worked with states and stakeholders to identify offshore leasing areas for wind development under a program called “Smart from the Start.” Under this program, National Oceanic and Atmospheric Administration (NOAA) Fisheries Habitat Conservation Division staff are actively involved in the pre-consultation phase to help identify potential concerns and impacts to Essential Fish Habitat (EFH) and Habitat Areas of Particular Concern (HAPC). These insights can prompt states and BOEM to modify the areas identified for potential wind energy development. Offshore wind energy sites have been identified off of Virginia, Maryland, New Jersey, Delaware, and New York, and there are several proposals to develop wind farms in both nearshore and offshore waters. Given technological limitations and the abundance of shallow sandy areas suitable for installing fixed turbines, there are currently no proposals for building floating turbines in the Mid-Atlantic.

II. Habitat Impacts from Offshore Wind by Habitat Type

Development of offshore wind farms has the potential to impact all marine habitat types. Impacts from construction activities are likely to be temporary, while impacts from operation and transmission may occur over longer timeframes. Specific impacts to habitat types are described below, organized by distribution and depth.

Distribution (Nearshore (Including Estuarine)/Offshore)

a) Nearshore

Each construction and transmission-related activity associated with developing wind farms has the potential to impact nearshore habitats. The percussive or gravity hammers used to drive piles into the seabed can directly damage benthic habitats by crushing, removing, converting, or suspending substrates. These hammers vibrate and emit sound waves, which can travel great distances and alter fish and marine mammal behavior, damage hearing and communication organs, and decrease survival near the project site (see Indirect Impacts). Placing crushed rock or concrete mattresses at the base of piles can also directly destroy, convert, or bury substrates. These scour-preventing defenses, along with the vertical structure of the piles themselves, can introduce artificial habitat and also alter species behavior (see Indirect Impacts). Construction barges used to install piles, turbines, service platforms, and transmission cables may drag their anchors along the seafloor, which can directly destroy or damage benthic habitats and suspend sediment. Strong cables and anchors placed on the seafloor to keep floating piles in place could also cause similar benthic habitat impacts.

Regardless of where wind farms are sited, cables connecting service platforms to onshore substations must pass through nearshore habitats. After trenches are excavated, cables are positioned and laid inside the trenches by construction barges and covered with the displaced sediment. These activities can directly destroy, damage, bury, or convert benthic substrate. The resulting suspended sediments can increase sedimentation, siltation and turbidity. When cables are unearthed for inspection and eventual decommissioning, these impacts may occur again. Electricity-bearing transmission cables also create electromagnetic fields around cables, which can alter species behavior (see Indirect Impacts).

Estuarine

In addition to the impacts described above, piles in confined water bodies like estuaries can disrupt tidal patterns and alter the flow of currents, sediments, and nutrients. This disruption can impact the distribution of eggs, larvae, and juveniles of many species that rely on these areas as nurseries. These impacts vary with the size, number and configuration of piles. Laying cables in shallow estuaries can disrupt littoral sediment and freshwater inflow, cause faster draining at low tide, and increase saltwater intrusion at high tide; these changes can lead to net loss of salt-intolerant plants and organic matter and cause soil erosion and siltation. In addition, these activities can resuspend contaminated sediments, which cannot easily disperse in shallow waters and may alter the behavior and survival of eggs, larvae, and juvenile fish and shellfish.

b) Offshore

For wind projects sited in offshore waters, the construction and transmission-related impacts described above can also be expected in offshore habitats. As fixed deepwater pile and floating turbine technologies continue to evolve, wind farms may increasingly be sited in deeper offshore waters.

Depth (Pelagic/Demersal/Benthic)

a) Pelagic

Spilled chemicals such as lubricants have the potential to reduce water quality and increase toxicity throughout the water column. Reduced water quality can lead to direct mortality and have sublethal effects on fish and other species by altering behaviors such as feeding, growth, migration, and reproduction. The physical presence of piles and turbines may also impact species behavior throughout the water column (see Indirect Impacts).

b) Demersal

Construction of wind farms and laying transmission cables can suspend sediments, including contaminated sediments, which increases turbidity and causes sedimentation in demersal waters. Suspended particles and contaminants may temporarily degrade the habitability of surrounding waters, decrease long-term survival, and alter the behavior of demersal species.

c) Benthic
Benthic habitats will likely be subject to the most damaging impacts from the construction and operation of wind farms. Installing piles and laying networks of transmission cables can destroy, damage, convert, and disturb all benthic habitat types. The anchors of construction barges and floating turbines may also cause similar impacts by sliding along the seafloor. A considerable amount of cable is required to connect turbines to service platforms and platforms to onshore substations, resulting in a large footprint on benthic impact. The presence of piles themselves are likely to cause currents to speed up as they move around them, leading to scouring of sediment around their bases. Scour unearths and removes benthic sediment in plumes, leaving holes on the seafloor that can alter community dynamics through habitat and species removal. Resuspended contaminated sediments eventually settle to the seafloor and can persist over long timeframes, degrading the habitability of benthic substrates and exposing organisms that live on or feed near the seafloor to toxins. In addition, the presence of transmission cables in benthic substrates can alter or inhibit benthic species' migrations, especially for invertebrates living in sediments.

Benthic Substrate (Submerged Aquatic Vegetation/Structured/Soft)

a) Submerged Aquatic Vegetation
In addition to the general benthic impacts described above, sedimentation, siltation and turbidity from construction activities can bury submerged aquatic vegetation (SAV) with fine particles and decrease sunlight penetration, which results in decreased productivity of SAV habitats. SAV is particularly sensitive to reduced water quality from pollutants and resuspended contaminated sediments, which can poison existing SAV and prevent future growth in the surrounding substrate. If cables are sited through SAV, these habitats could be directly destroyed by excavation and burial, and contribute to increased turbidity and sedimentation.

b) Structured
Offshore wind farms are unlikely to be sited on structured habitats such as gravel, shell beds, or cobble; however, destruction and damage from excavation and cable burial may result if transmission cables need to be routed through these habitats. Where cables are unable to be buried to standard depths, concrete mattresses may be used to cover cables passing through hard bottom habitats, resulting in similar impacts. In some cases, explosives may be used to permanently remove large hard bottom obstacles. The force of explosives can directly destroy and permanently remove hard structured habitat, alter nearby habitats, and increase sedimentation and turbidity as the result of suspended sediments. Structured habitats may also be crushed, removed or disturbed by driving piles in adjacent habitats or dragging construction barge anchors.

c) Soft
Soft bottom habitats such as sand, silt, and clay are particularly vulnerable to sediment impacts due to the small, relatively light particles that typify them. Construction activities near the seafloor may create small disturbances that can remove sediment altogether or cause plumes of sediment to be resuspended, leading to sedimentation and burial of existing benthic habitat.

Trenching and burying transmission cables can alter habitat complexity and quality by removing or exposing sediment, smoothing out existing seafloor depressions, and creating new contours through the effects of scour.

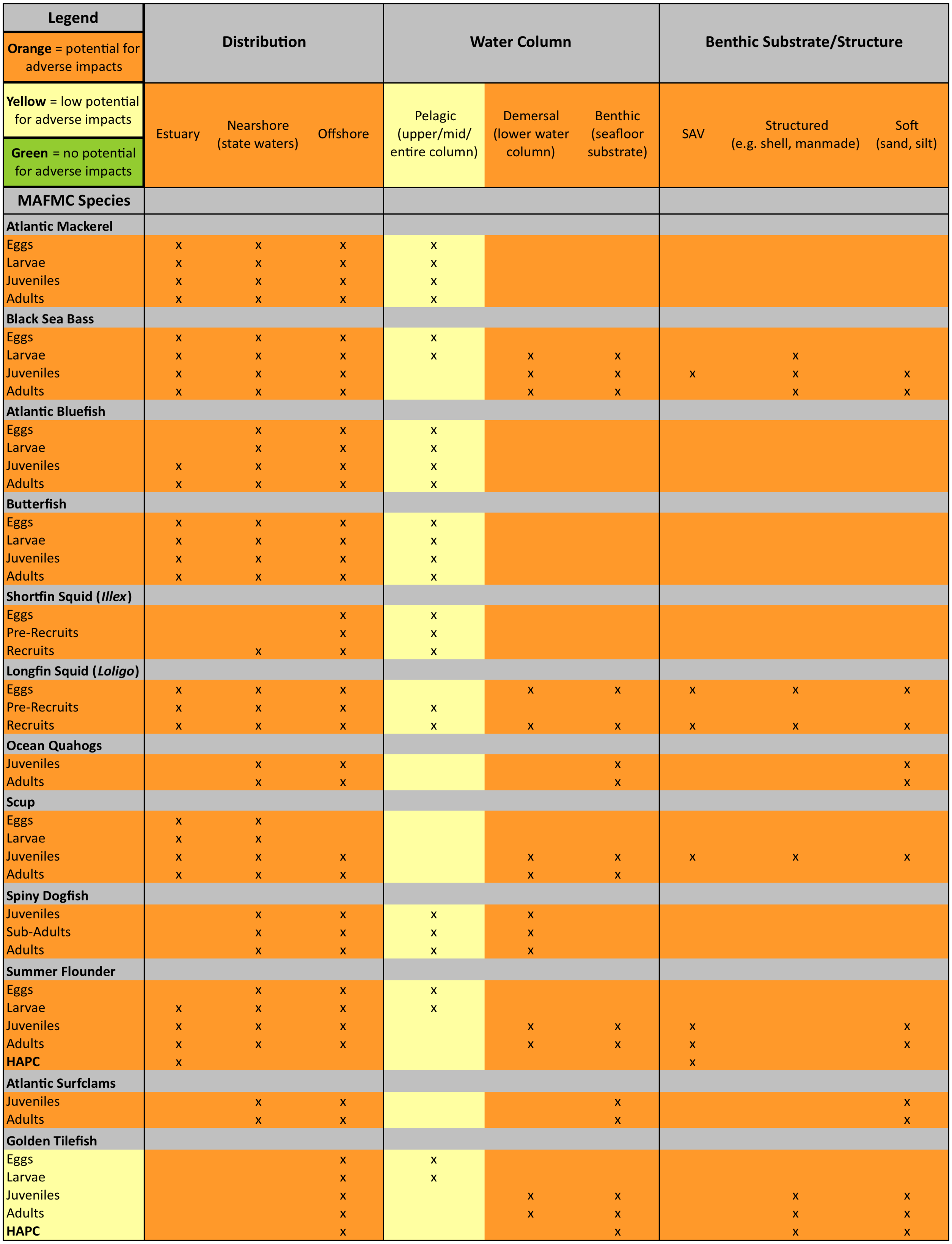
III. Potential Impacts of Offshore Wind to MAFMC Managed Stocks

Considering the full potential of wind farm configurations and siting options, all habitats utilized by Mid-Atlantic Fishery Management Council (MAFMC) species could potentially be impacted to some extent by offshore wind development. Given technological limitations and the structure of current proposals, offshore wind developments in the near term are likely to be sited close to shore and utilize fixed turbine technology. Thus, impacts from construction and transmission activities will occur in nearshore, shallow water, and will be mostly benthic or demersal in nature. Offshore wind development activities are most likely to occur in soft bottom habitat given the ease of construction in this substrate. SAV and estuarine habitats are particularly vulnerable to transmission-related construction, and may incur significant impacts if activities occur in those areas. If wind farms are sited in deeper offshore water in the future, the impacts described above will likely extend to benthic and demersal habitats offshore.

The following table lists the habitat types designated as EFH and HAPC for the different life stages of MAFMC managed stocks (see *Impacts to Fish Habitat from Anthropogenic Activities: Introduction and Methods)*. Cells highlighted in orange indicate an overlay between the habitat type used and the potential for the habitat type to be adversely impacted by offshore wind activities; cells highlighted in yellow indicate a lower potential for adverse impacts.

MAFMC species that depend on nearshore, benthic habitats during at least one life stage have the most potential to be impacted by wind development projects. In the Mid-Atlantic, soft, sandy substrate is the dominant benthic habitat type. Given that wind farms tend to be sited in soft substrates, there are very large areas of the Mid-Atlantic region where wind development could potentially take place. Of the six species that utilize nearshore, benthic habitat, soft bottom substrate is an essential habitat for at least one life stage. The overlap between potential areas of development and the common use of soft bottom habitat may increase the likelihood of impacts to some of these species. With their strong dependence on soft bottom substrates, ocean quahogs and Atlantic surfclams may be particularly vulnerable to impacts from offshore wind development. If transmission cables are routed through estuarine habitats, additional species may be impacted considering the sensitivity and importance of that habitat to early life stages of many stocks. Golden tilefish are the only MAFMC managed species not likely to be impacted directly by wind development activities due to their reliance on very deep, offshore habitats.

Visual Overlay of Potential Impacts from Offshore Wind and MAFMC Species' EFH/HAPC



Legend **Orange** = potential for adverse impacts	**Distribution**			**Water Column**			**Benthic Substrate/Structure**		
Yellow = low potential for adverse impacts **Green** = no potential for adverse impacts	Estuary	Nearshore (state waters)	Offshore	Pelagic (upper/mid/ entire column)	Demersal (lower water column)	Benthic (seafloor substrate)	SAV	Structured (e.g. shell, manmade)	Soft (sand, silt)
MAFMC Species									
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Eggs	x	x	x	x					
Larvae	x	x	x	x					
Juveniles	x	x	x	x					
Adults	x	x	x	x					
Black Sea Bass									
Eggs	x	x	x	x					
Larvae	x	x	x	x	x	x		x	
Juveniles	x	x	x		x	x	x	x	x
Adults	x	x	x		x	x		x	x
Atlantic Bluefish									
Eggs		x	x	x					
Larvae		x	x	x					
Juveniles	x	x	x	x					
Adults	x	x	x	x					
Butterfish									
Eggs	x	x	x	x					
Larvae	x	x	x	x					
Juveniles	x	x	x	x					
Adults	x	x	x	x					
Shortfin Squid (*Illex*)									
Eggs			x	x					
Pre-Recruits			x	x					
Recruits		x	x	x					
Longfin Squid (*Loligo*)									
Eggs	x	x	x		x	x	x	x	x
Pre-Recruits	x	x	x	x					
Recruits	x	x	x	x	x	x	x	x	x
Ocean Quahogs									
Juveniles		x	x			x			x
Adults		x	x			x			x
Scup									
Eggs	x	x							
Larvae	x	x							
Juveniles	x	x	x		x	x	x	x	x
Adults	x	x	x		x	x			
Spiny Dogfish									
Juveniles		x	x	x	x				
Sub-Adults		x	x	x	x				
Adults		x	x	x	x				
Summer Flounder									
Eggs		x	x	x					
Larvae	x	x	x	x					
Juveniles	x	x	x		x	x	x		x
Adults	x	x	x		x	x	x		x
HAPC	x						x		
Atlantic Surfclams									
Juveniles		x	x			x			x
Adults		x	x			x			x
Golden Tilefish									
Eggs			x	x					
Larvae			x	x					
Juveniles			x		x	x		x	x
Adults			x		x	x		x	x
HAPC			x			x		x	x

IV. Indirect Impacts

In addition to the habitat impacts described above, offshore wind development may result in indirect impacts, such as potentially excluding fishing vessels and shifting fishing effort away from wind farms, introducing potential hazards to navigation, and increasing mortality of seabirds through collisions with turbines. Offshore wind may also have impacts on the survival and productivity of marine species over various timeframes. Construction activities may cause temporary, site-specific impacts on fish and marine mammal species, depending on the specific number and configuration of turbines and transmission cables. Other impacts from operation and transmission activities are likely to occur over the life of a wind farm, such as:

a) Underwater Sound

Pile driving hammers emit harmful sound waves that create concussive forces and cause pressure changes that can temporarily or permanently damage hearing organs and cause disorientation. These sounds can alter feeding and migration behaviors and reduce hearing, communication and echolocation effectiveness in marine mammals and fish. Persistent sound from spinning turbines over the lifespan of a wind farm can also deter or attract some species. For example, salmon and cod are capable of detecting sound generated by operating wind turbines from several miles away, which could lead to long-term avoidance of those areas.

b) Electromagnetic Fields

Transmission cables bearing high-voltage electricity loads create electromagnetic fields around them. Electromagnetic fields can be detected by anadromous and elasmobranch species such as salmon and sharks, and may potentially alter their distribution, behavior, feeding and migration, potentially changing community dynamics near wind farms.

c) Artificial Habitat Creation

Piles, scour preventing structures, and floating turbines can create artificial habitat or act as Fish Aggregating Devices (FADs) throughout the water column. The introduction of new habitat may be beneficial to fish species, though it is not known if they increase local fish production or simply act as an aggregation point for existing fish. The attraction or avoidance caused by offshore wind infrastructure may also alter predator-prey relationships, disrupt species dominance, and modify local mortality rates by supplying ambush sites for predators and refuge for prey. The presence of this infrastructure can also impede migratory pathways for many species of marine mammals, fish, and invertebrates over a portion of the ocean.

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Offshore Oil
Anthropogenic Activity Background Document

I. Activity Overview

Offshore oil development is a multi-phase process that includes exploration, construction, extraction, transmission, and decommissioning over the lifetime of a project. Oil exploration begins with conducting surveys and completing exploratory drilling to locate oil reserves trapped in subsea sediments on the continental shelf. Once surveys are completed and oil is located, specialized drilling vessels and equipment are used to drill through sediments below the seafloor to release and extract the target crude oil and associated liquid hydrocarbons from undersea reservoirs. A platform and associated production infrastructure, collectively called a "rig," is then installed on the surface of the ocean by barges to replace the drilling infrastructure. The platform houses the crew, machinery, and facilities used to pump the crude oil to the surface through pipes for separation, cleaning, and storage. Once separated from other materials, crude oil is pumped onshore to refinery or distribution facilities through pipelines buried on the seafloor. After wells stop producing oil, the rigs and pipelines are decommissioned and removed piece by piece for onshore disposal. Some decommissioned rigs can be used as artificial reef habitat under "rigs to reefs" programs administered by coastal states. The U.S. Department of the Interior's Bureau of Ocean Energy Management (BOEM) utilizes a five-year planning framework to identify potential drilling sites. BOEM then implements a multi-stage parcel leasing and environmental review process that regulates oil exploration and production activities in designated areas on the continental shelf.

The development and extraction of offshore oil is complex. This document is organized around activity subsections to facilitate an exploration of the habitat impacts associated with each phase of this process, and identify the risks and unintended consequences of oil development. The four subsections include: 1) surveying and exploration, 2) drilling, construction and extraction, 3) decommissioning; and 4) oil spills.

1. <u>Surveying and Exploration</u>

Producers use seismic and acoustic surveying equipment such as air guns towed behind vessels to locate oil reserves by refracting sound waves off of the seafloor. Remote sensing technologies that use underwater imaging can also help producers locate subsurface fractures in rock that may contain oil reserves. These survey techniques may require placing sensors on the seafloor to provide additional geological information on sediment composition and density before drilling begins. These activities have the potential to impact marine species and habitats with underwater sound and direct contact with the seafloor.

2. <u>Drilling, Construction and Extraction</u>

a) Exploratory and Production Drilling

Once surveys are completed, specialized drilling equipment is used to drill exploratory wells and sediment cores to determine the specific composition of the hydrocarbons under the seafloor. Special drill ships, semi-submersible vessels, or "jackup rigs," can all be used to drill wells over

10,000 feet deep. Jackup rigs are the most commonly used drilling vessels and must be towed by barges or tugboats to a drill site. These rigs use extendable legs that rest on the seafloor to prop the rig up above the surface of the ocean. To begin drilling, vessels lower slender sections of steel pipe with an attached drill bit, called a "drill string," through their hulls until the drill bit contacts the seafloor. A drilling collar allows the rig to drill at all angles from the vessel through a process known as directional drilling; this technology allows a single drill rig to tap several lateral reserves, and can avoid the need to drill through sensitive habitats.

Steel pipe casings are placed around the drill string to protect it from damage and leaks during operation. As the drill bit rotates and bores into sediments, lubricating and cooling fluids known as "drilling muds" circulate through the casings to keep the drill bit functioning properly in the borehole. Drilling muds can be water-based, oil-based, or entirely synthetic and may incorporate chemicals such as hydrocarbons. As the drilling depth increases, metal casings are placed just below the seafloor and filled with concrete to help stabilize the borehole. These casings also keep unwanted natural gas, hydrocarbons, and hot, saline, metal-filled seawater mixtures called "produced waters" trapped in subsea sediments from flowing through the casings back to the surface. The drilling muds, crushed rock cuttings created during drilling, and produced waters are pumped to the surface for cleaning and then re-circulated back to the drill bit in a continuous cycle. Eventually, these drilling fluids and cuttings must be cleaned and discarded. The U.S. Environmental Protection Agency (EPA) regulates the discharge of these materials from casings in a process known as "shunting." Under Clean Water Act regulations, the EPA typically requires producers to clean and dispose of the slurry of fluids and cuttings onshore, or to pump them back into subsea sediments to avoid dispersion in the water column and prevent the release of toxins that may occur if discarded at the surface platform. Occasionally, drilling gear may contact natural fractures or create new ones in rock formations. These events, called "frac-outs," can potentially release drilling muds, produced waters, and hydrocarbons from subsea reservoirs, which can reduce water quality and introduce toxins into surrounding waters.

After drilling is completed, another casing pipe incorporating several pressure release valves is lowered down into the well to allow the oil to flow to the surface platform. The drill string is then retrieved by the jackup rig and disassembled for future use. A large metal "blowout preventer" is installed on the casing just below the surface platform to control natural pressure releases that may occur during normal operations. In the event of large, uncontrollable pressure releases called "blowouts," rams on the blowout preventer can sever the pipe casing shut to prevent large-scale oil releases and explosions.

b) Platform and Pipeline Installation

After the drill rig retrieves the drill string, the rig is towed away by barges and replaced with a production platform. While there are many designs for semi-submersible and floating platforms, most platforms are attached to the seafloor by steel-coated piles and anchored cable systems. Production platforms can be quite large to provide space for maintenance machinery, oil-processing equipment, living quarters for a small permanent crew, and other resources. They are built onshore as modules and barged to the site; this modular structure also allows for easy disassembly at the end of the project's lifespan.

Pipelines must be installed to connect the platform to onshore infrastructure, including refineries and distribution networks. The pipes can measure up to five feet in diameter and must be buried at least three feet below the seafloor or covered with three feet of rock when sited in water less than 200 feet deep. Where pipelines approach nearshore navigation corridors, they must be buried at least ten feet deep according to U.S. Army Corps of Engineers (Corps) permitting regulations. Installing pipes from the project site to shore can potentially have a very large footprint on the seafloor, and cause significant benthic impacts depending on the installation methods used.

Trench excavation methods for burying pipelines include mechanical plowing, pressurized hydraulic jetting, and dredging techniques. Where hard-bottom substrates obstruct pipeline pathways, explosives may be used to clear a path, which can cause significant damage to benthic habitats. Once laid on the seafloor, pipes are flushed with pressurized liquids that may contain biocides and other chemicals to test for leaks and durability in a process known as hydrostatic pressure testing. The construction vessels and excavation equipment required to lay pipelines can necessitate construction corridors up to a half-mile wide. During the consultation process, National Oceanic and Atmospheric Administration (NOAA) Fisheries Habitat Conservation Division staff provide input on pipeline siting, excavation, and installation methods to avoid impacts to sensitive benthic habitats resulting from these activities.

c) Operations

Once pipelines are in place, production begins when a series of small explosive charges are set off at the base of the well to allow oil to flow to the surface platform. The platform separates target crude oil from other compounds like natural gas and seawater, and then transfers oil into pipelines to be transported to shore for distribution. To support ongoing oil production, supply vessels routinely ferry crew and supplies back and forth from shore. Over the decades-long lifespan of a rig, chemicals and debris from operation, maintenance, and repair activities can be released into surrounding waters. This can impact water quality and result in the accumulation of toxins such as hydrocarbons in substrates.

3. Decommissioning

BOEM requires that within five years of ceasing production, rigs and all associated infrastructure be removed and the site be restored to pre-project conditions. This breakdown and cleanup process uses large construction barges and cranes to plug the well with cement and collect piles and rig components for onshore disposal under EPA rules. Abrasive cutting tools and explosives can be used to remove piles, pipes and the structure of the well at least fifteen feet below the seafloor. The tanks, platform processing equipment, and pipelines must all be flushed to remove oil and chemical residue, and all rig structure must be cleaned of any growth. After decommissioning is complete, pipelines may be left in place as long as they will not interfere with navigation or fishing operations in the future.

Decommissioned rigs may be disassembled, salvaged, and disposed of onshore. Rigs may be sunk in place, or a portion of the rig structure may be severed to leave 85 feet of clearance for vessels. Explosives may be used to sever rig legs from the seafloor when abrasive or other mechanical means are not feasible. Once all project-related structure is removed, producers employ bottom trawls to remove any debris lost overboard during operations. Surveys and diver or Remotely Operated Vehicle (ROV) verification are required to ensure proper cleaning and removal of any hazards to navigation. Through “rigs to reefs” partnership programs, some of the rig structures such as rig legs and piles may be used to create artificial habitat for fish and other species. Most rigs decommissioned for this purpose are moved to designated artificial reefing sites in state waters, though rig operators and owners may also work with state and other partners to leave rigs at the project site.

4. Oil Spills

Oil spills have the potential to severely impact all habitat types and species across ecosystems. Oil can be accidentally leaked or spilled during any stage of exploration, construction, production, shipping, or decommissioning activities. Spills can range in volume from small operational discharges of produced waters to major disasters such as the *Deepwater Horizon* blowout that spilled millions of barrels of crude oil into the Gulf of Mexico. Crude oil and its associated hydrocarbons can move great distances after a spill, reduce water and habitat quality across all depths and distances from shore, and may be toxic to all living organisms that come in contact with it. While unlikely, large spills have the potential to cause the most widespread and lasting impacts on habitat from oil development activities (see Oil Spill Appendix).

Activity in the Mid-Atlantic Region

Under BOEM’s five-year planning and leasing framework, no offshore oil exploration or development is planned in the Mid-Atlantic region through 2017. However, with its large population centers, existing infrastructure for shipping, processing, and refining crude oil, and political movement to expand domestic production, oil development is likely in the region’s future. The Mid-Atlantic Regional Planning Board coordinates energy-leasing activities in the region along with the U.S. Department of Interior and states, and may recommend sites for leasing during the 2017-2022 planning cycle.

II. Habitat Impacts of Oil Development by Habitat Type

While the activity is generally known as “offshore” oil development, it can occur in both nearshore and offshore waters and impact all habitat types. Impacts from drilling, pipeline-associated activities, and decommissioning are generally localized and primarily impact benthic substrates. However, given the scope of activities and phases involved, the ability to extract and pipe oil far from shore, and the long duration of operations, offshore oil development may result in a very large footprint of impact. The total footprint of impact is related to the different temporal and spatial natures of each phase of offshore oil development and extraction. For example, surveying may occur for a short time over a large area, while drilling and extraction may extend over a long period of time over a small area. While rare, oil spills have the greatest potential to cause significant impacts across all habitat types and impacts may persist over long timeframes (see Oil Spill Appendix). The following analysis considers all potential habitat impacts of offshore oil development and does not assess the likelihood of oil development in state and federal waters.

Distribution (Nearshore (Including Estuarine)/Offshore)

a) Nearshore

All habitat types in nearshore waters have the potential to be impacted by oil development. Construction and drilling activities such as driving piles with vibrating or percussive hammers, anchoring platforms, and extending the legs of jackup rigs all have the potential to crush, bury, or disturb benthic habitats in nearshore waters. Construction barges and drilling vessels may sweep anchors and cables along the seafloor across wide areas and cause similar impacts, though to a lesser extent. Excavating and burying pipelines can remove and convert nearshore habitats. Even when platforms are sited far offshore, pipelines must still be routed through nearshore areas. Explosives may be used to permanently remove hard substrates in the path of pipelines, and can cause significant damage to benthic habitats. In nearshore, shallow waters, pipeline-associated activities can exacerbate shoreline erosion, cause steep cliffs of sediment called escarpments to form, and increase sedimentation, altering nearshore communities (see Indirect Impacts). Shunting produced waters, drilling muds, and cuttings on the seafloor can also result in the accumulation and alteration of benthic substrates. All of these activities may increase sedimentation and turbidity, and may resuspend contaminated sediments and toxins that can reduce water quality and impact species that rely on nearshore habitats.

Rig decommissioning activities can cause impacts by disturbing the habitats near rigs, platforms, and pipelines. Moving and sinking rigs to serve as artificial habitat can alter benthic habitat and impact species behavior (see Indirect Impacts). In the event of a spill, waves, wind, currents, and tidal action tend to transport and accumulate spilled oil nearshore. These forces drive oil into interstitial spaces between sediment on beaches and tidal areas, which can cause significant water quality impacts and expose coastal vegetation and the many life stages of species that rely on these areas for habitat to toxins. Over the long term, oil accumulation may decrease coastal vegetation and habitability of sediments in shallow, nearshore waters (see Oil Spill Appendix).

Estuarine

Trenching for pipelines in estuarine habitat can cause marshes to drain more rapidly during low tides or periods of low precipitation, and interrupt freshwater and littoral sediment inflow. Altering these processes can allow increased saltwater intrusion in low salinity areas at high tides, killing saltwater-intolerant plants and submerged aquatic vegetation (SAV). These activities may also cause soil erosion, sedimentation, and increased turbidity. Resuspended contaminated sediments cannot disperse in estuaries due to their tidal influence and low water volumes. The presence of pipelines in estuaries may disrupt current flow, lead to adjacent scour and erosion, and cause escarpments to form on coastal dunes or marshes. These alterations can lead to mortality and reduced productivity of coastal vegetation and fragmentation of coastal wetlands.

If oil exploration activities occur nearshore, shunting produced waters and drilling muds near estuaries has the potential to reduce water quality through the introduction of toxins and disruption of salinity gradients, which can reduce habitat suitability for eggs, larvae, and juvenile fish and shellfish. Given the enclosed nature of estuaries, spilled oil can accumulate and persist over long timeframes, which can cause SAV die-offs and long term exposure of resident organisms to toxins. During cleanup activities, trampling and cutting salt marshes can have long-lasting impacts on estuarine habitat productivity.

b) Offshore
Oil development projects sited far from shore can result in the same impacts associated with drilling, platform construction, laying pipelines, and decommissioning as described above. The further from shore a project is sited, the more pipeline must be laid in offshore benthic habitats. Wind and currents can transport spilled oil far offshore after a spill, potentially reducing offshore water quality and impacting marine communities over a large area of the ocean (see Indirect Impacts).

<u>Depth (Pelagic/Demersal/Benthic)</u>

a) Pelagic
Under some circumstances, drilling muds and produced waters can be shunted at the surface near the production platform rather than in sediments below the seafloor. This can reduce pelagic water quality by releasing toxins and increasing the dispersion area of contaminated materials throughout the water column. Chemicals (e.g. biocides) that leach from piles and other in-water structures may also reduce pelagic water quality and introduce toxins. Conducting seismic and acoustic surveys, drilling, driving piles, using explosives, and decommissioning activities emit sound waves that can travel long distances in pelagic waters and cause direct mortality or behavioral changes in marine species (see Indirect Impacts).

b) Demersal
Drilling, construction, and decommissioning activities near the seafloor can disturb and resuspend sediments, causing increased turbidity and sedimentation in demersal waters. Shunted fluids, cuttings, and suspended contaminated sediments near the seafloor may reduce water quality by releasing metals, pesticides, chemicals, and other toxins such as hydrocarbons into surrounding waters, altering habitat suitability and potentially causing lethal and sublethal impacts on demersal and benthic organisms (see Indirect Impacts).

c) Benthic
Drilling, construction, pipeline installation, and decommissioning activities physically contact the seafloor and can directly destroy benthic habitats. Drilling, driving piles, and excavating trenches for pipelines can crush, remove, bury, or convert benthic habitats and suspend sediments. The suspension of sediments can increase turbidity, which causes sedimentation,

alters existing substrates, and can expose new substrates with different chemical and physical properties. Suspended contaminated sediments eventually accumulate on the seafloor, reducing benthic habitat quality and potentially impacting organisms that live or feed there (see Indirect Impacts). The legs of rigs and piles may also disrupt currents and cause scour, which removes and exposes benthic sediments, alters habitat complexity, and can change species behavior (see Indirect Impacts). Excavating sediments to lay and bury pipelines can reduce benthic habitat suitability and complexity by altering seafloor contours and smoothing depressions and mounds; these activities can have a large footprint of benthic impact. When buried improperly, in nearshore substrates, or adjacent to undersea cliffs, pipelines have the potential to cause scour and may lead to formation of escarpments, leading to erosion and long-term sedimentation.

During decommissioning, barge anchors, explosives, and mechanical cutting tools can also directly destroy, remove, alter or suspend unconsolidated benthic sediments. Trawling the project area after decommissioning may damage or alter benthic substrates, and impact benthic species survival and behavior (see Indirect Impacts). In the event of a spill, oil and its associated hydrocarbons stick to sediments suspended in the water column, causing them to sink and eventually settle to the seafloor through the process known as adsorption. As a result, oil accumulates in benthic sediments, introducing toxins and reducing the suitability of substrate for growth of aquatic vegetation and causing lethal and sublethal impacts to organisms feeding or living on the seafloor (see Indirect Impacts).

Benthic Substrate (Submerged Aquatic Vegetation/Structured/Soft)

a) Submerged Aquatic Vegetation

Depending on project siting, construction and pipeline-associated activities can disturb the seafloor, erode and suspend sediments and contaminants, and cause scour, which increases turbidity and sedimentation. The resulting turbidity can bury or smother SAV, cause siltation, and reduce sunlight penetration, which decreases survival and productivity of SAV habitats and can exacerbate shoreline erosion. Suspended contaminated sediments may resettle on benthic substrates where SAV grows, reducing habitat quality and potential growth in the future. SAV is particularly at risk to impacts from exposure to toxins in oil. In the event of a spill, oil tends to accumulate in shallow, nearshore waters where SAV grows, and can cause die-offs or permanently impair growth if the spill occurs during spring growing seasons (see Oil Spill Appendix).

b) Structured

It is unlikely that drilling and rig construction activities will occur in areas with structured habitats such as shell beds, gravel, or other hard-bottom substrates. If projects are sited in or near these areas in the future, benthic impacts can be expected as described above. Structured habitats, however, may be subject to significant impacts from the use of explosives to remove hard bottom barriers in the path of pipelines and from barge anchors sliding on the seafloor. These activities can permanently remove and alter structured habitat and reduce sources of habitat complexity such as boulder or cobble mounds.

c) Soft

Construction and decommissioning activities are likely to occur on soft-bottom substrates like mud, clay, and silt, which are susceptible to disturbance and resuspension. These processes can remove, convert, bury, or expose substrates and increase turbidity, causing sedimentation and siltation. Turbidity can pose additional problems during an oil spill. Oil adsorption is particularly likely on suspended clay due to its physical and chemical properties, which can expose benthic organisms contacting or feeding in these soft substrates to toxins and cause contamination over decades (see Indirect Impacts).

III. Potential Impacts of Offshore Oil to MAFMC Managed Stocks

Considering all potential configurations and siting options for hypothetical offshore oil developments in the Mid-Atlantic, each habitat used by Mid-Atlantic Fishery Management Council (MAFMC) species could be impacted to some extent. Given the necessity of laying pipelines to connect rigs with onshore infrastructure, nearshore habitats will be impacted regardless of where rigs are sited. Impacts from construction, extraction, and decommissioning activities are most likely benthic or demersal in nature. SAV and estuarine habitats are particularly vulnerable to these impacts, and may incur significant impacts if pipelines are laid in these areas. Oil spills have the potential to severely impact all habitats across timescales of decades.

The following table lists the habitat types designated as Essential Fish Habitat (EFH) and Habitat Areas of Particular Concern (HAPC) for the different life stages of MAFMC managed species (see *Impacts to Fish Habitat from Anthropogenic Activities: Introduction and Methods*). Cells highlighted in orange indicate an overlay between the habitat used and the potential for the habitat type to be adversely impacted by offshore oil activities; cells highlighted in yellow indicate a lower potential for adverse impacts.

If oil exploration and development projects are permitted in the Mid-Atlantic region, federally managed species that depend on nearshore, benthic habitats during at least one life stage have the most potential to be impacted. Should pipelines be routed through sensitive estuarine habitats, additional species may be impacted due to their importance to early life stages of many stocks. Golden tilefish eggs and larvae and shortfin squid (*Illex*) eggs and pre-recruits are the only MAFMC managed species not likely to be impacted directly by offshore oil development activities and regular operations due to their reliance on offshore, pelagic habitats. However, in the event of an oil spill, every life stage of each MAFMC species has the potential to be significantly impacted through direct mortality, reductions in water quality, and disruption of food chains and ecological functions by exposure to toxins (see Oil Spill Appendix).

Visual Overlay of Potential Impacts from Offshore Oil and MAFMC Species' EFH/HAPC

Legend	**Distribution**			**Water Column**			**Benthic Substrate/Structure**		
Orange = potential for adverse impacts									
Yellow = low potential for adverse impacts **Green** = no potential for adverse impacts	Estuary	Nearshore (state waters)	Offshore	Pelagic (upper/mid/ entire column)	Demersal (lower water column)	Benthic (seafloor substrate)	SAV	Structured (e.g. shell, manmade)	Soft (sand, silt)
MAFMC Species									
Atlantic Mackerel									
Eggs	x	x	x	x					
Larvae	x	x	x	x					
Juveniles	x	x	x	x					
Adults	x	x	x	x					
Black Sea Bass									
Eggs	x	x	x	x					
Larvae	x	x	x	x	x	x		x	
Juveniles	x	x	x		x	x	x	x	x
Adults	x	x	x		x	x		x	x
Atlantic Bluefish									
Eggs		x	x	x					
Larvae		x	x	x					
Juveniles	x	x	x	x					
Adults	x	x	x	x					
Butterfish									
Eggs	x	x	x	x					
Larvae	x	x	x	x					
Juveniles	x	x	x	x					
Adults	x	x	x	x					
Shortfin Squid (*Illex*)									
Eggs			x	x					
Pre-Recruits			x	x					
Recruits		x	x	x					
Longfin Squid (*Loligo*)									
Eggs	x	x	x		x	x	x	x	x
Pre-Recruits	x	x	x	x					
Recruits	x	x	x	x	x	x	x	x	x
Ocean Quahogs									
Juveniles		x	x			x			x
Adults		x	x			x			x
Scup									
Eggs	x	x							
Larvae	x	x							
Juveniles	x	x	x		x	x	x	x	x
Adults	x	x	x		x	x			
Spiny Dogfish									
Juveniles		x	x	x	x				
Sub-Adults		x	x	x	x				
Adults		x	x	x	x				
Summer Flounder									
Eggs		x	x	x					
Larvae	x	x	x	x					
Juveniles	x	x	x		x	x	x		x
Adults	x	x	x		x	x	x		x
HAPC	x						x		
Atlantic Surfclams									
Juveniles		x	x			x			x
Adults		x	x			x			x
Golden Tilefish									
Eggs			x	x					
Larvae			x	x					
Juveniles			x		x	x		x	x
Adults			x		x	x		x	x
HAPC			x			x		x	x

IV. Indirect Impacts

In addition to the habitat impacts described above, exploration, drilling, construction, extraction, and transport activities associated with oil development may cause indirect and non-habitat impacts to the marine environment. While some impacts such as reduced water quality are likely temporary and occur mostly near rigs, impacts from oil spills can be widespread and last for decades. Oil development can cause significant impacts to species, such as complex changes to species behavior and responses to altered environments.

a) Underwater Sound

Air guns used in acoustic surveys, drilling wells, driving piles, and utilizing explosives to remove hard substrates can emit harmful sound waves and result in sudden changes in pressure. These sound and pressure changes can cause direct mortality, damage hearing and communication organs, and alter behaviors such as swimming, migration, and foraging in marine mammals and fish. Sound impacts are exacerbated among species that have swim bladders and those that are attracted to rigs. Sound waves can also travel great distances in water, and may reduce the communication and navigation effectiveness of marine mammals far from the source of the sound. Timing windows that restrict survey and construction activities may be implemented to mitigate these impacts.

b) Water Quality

Water quality can be impacted by discharging drilling muds and produced waters, releasing debris, waste, fuel and lubricants from production platforms and associated vessels, and leaching chemicals from in-water structures. Contaminants can disperse over wide areas up to 1,000 meters away from discharge sites and eventually accumulate in substrates and the tissue of marine species. This can cause direct mortality as well as physiological and behavioral changes in fish and invertebrates.

c) Species Behavior and Fitness

Oil development activities can impact species productivity and fitness through sedimentation, turbidity, and siltation. These mechanisms may suffocate and bury eggs with fine sediments, reduce growth and survival of fish and shellfish, disrupt migration and spawning effectiveness, impact physiological processes, and alter species behavior through attraction or avoidance. Activities associated with trenching and burying pipelines may reduce habitat complexity through smoothing, removing depressions and irregularities, and filling areas with sediment. These activities can also displace burrowing organisms, alter benthic species migrations, and disrupt community dynamics by changing available substrates.

d) Decommissioning and Artificial Habitat

The presence of underwater rig structures can have positive and negative impacts on marine species. Rigs and their associated infrastructure can introduce new structured habitat and create artificial reefs. While this may contribute to productivity, it can alter avoidance or attraction behaviors, provide ambush sites for predators and refuge structure for prey, and disrupt community dynamics by changing species dominance in an area. In addition, this infrastructure may impede and disrupt migratory pathways and alter behaviors such as feeding in marine mammals, fish, and invertebrates.

Each decommissioning option can destroy existing artificial habitat throughout the water column through destruction, removal, and alteration. Cleaning and trawling activities directly remove debris near project sites that may have become de facto artificial habitat during the lifespan of the rig. Decommissioning can also create new artificial habitat in rigs to reefs program areas that may be beneficial to some species over long timeframes; research is needed to understand if these projects increase local fish production or simply aggregate existing fish from nearby areas.

e) Spills

While unlikely, oil spills have the most potential of any aspect of offshore oil development to significantly impact MAFMC habitats and species. Oil may be spilled during any stage of the drilling and extraction process, such as during “frac-outs,” blowouts or spills during shipping and may have significant, long-term impacts. Oil is highly toxic, carcinogenic, and mutagenic and is likely to cause lethal and sublethal impacts such as reduced fitness and physiological and behavioral changes in all species that come in contact with it such as seabirds, marine mammals, fish, invertebrates, and others (see Oil Spill Appendix).

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VI. Oil Spill Appendix

This appendix is intended to build on and capture additional insights from our research to help the MAFMC understand the specific mechanisms and threats to habitats and species that may result from oil spills. It supplements the basic habitat impacts description in the "Oil Spills" section of the document, explains sources of impacts, and puts boundaries on the wide range and severity of potential mechanisms and impacts a spill can have on the marine environment.

Sources

Oil leaks and spills can occur at any stage of the offshore oil development process. Spilled oil can enter marine waters after shipping accidents and collisions, pipeline leaks or ruptures, severe storm events, and blowouts at wells. While large blowouts and catastrophic shipping accidents have the potential to spill large volumes of oil, these events are rare. Over 90% of spilled oil by volume enters marine waters from small, daily operational discharges of produced waters, drilling muds, leaks in pipelines or tankers, and natural pressure releases at wells.

Spill Mechanics

Crude and refined oil is composed of many kinds of hydrocarbons with different chemical and physical properties that can be toxic to marine organisms, depending upon the pathway, severity, and duration of exposure. After a spill or leak, oil floats along the surface of the ocean and can be transported great distances by the forces of wind, waves, currents, and tides. Sunlight can multiply the toxicity of some light hydrocarbon compounds and increase their uptake into living organisms near the ocean's surface, such as plankton. This enhanced toxicity can disrupt ecosystem dynamics by directly impacting plankton at the base of the food chain.

Some oil compounds become more soluble in seawater over time through the degrading forces of waves and wind, and can become suspended and partially dissolve throughout the water column. As these water-oil globules dissolve, a portion of hydrocarbons are broken down by microbes, while the rest introduce toxins and reduce water quality that can impact the entire pelagic community. Wave and wind action over time also increase adsorption of oil onto suspended sediments in the surrounding water, causing it to sink and eventually settle on benthic substrates, contaminating them over decades. The more suspended sediments are present in the water column after a spill, the more oil can be transported to the seafloor and held on benthic sediments. Heavier hydrocarbon components of oil tend to sink more quickly and are lipophilic: they are readily incorporated into the fatty tissues of organisms feeding on and contacting the seafloor.

Water Quality Impacts

Oil and its associated hydrocarbons build up in benthic sediments and can reduce the suitability of habitat for organisms living or feeding near the seafloor, including living habitat (e.g. SAV). Contaminated sediments may also cause direct mortality and sublethal impacts such as reduced fitness in fish and invertebrates that come in contact with them, especially at early life stages.

Species Impacts

Exposure to hydrocarbons can have significant impacts on species ranging from direct mortality to disruption of physiology, metabolism, and feeding and reproduction behaviors. Oil components can be mutagenic, carcinogenic, or both to many species even at low levels of exposure. The wide range of likely sublethal impacts to species from exposure to toxins in hydrocarbons can include, but are not limited to: deformities in eggs and larvae, abnormalities such as altered organ development, diseases of the liver and spleen, altered skin pigmentation, impaired feeding, growth, reproductive efficiency, and recruitment, altered blood and hormone chemistry, increased susceptibility to diseases and infections, and altered behaviors such as lowered return rates of migratory species to spawning grounds and avoidance of areas. In addition, the lipophilic properties of hydrocarbon compounds can cause sublethal impacts such as altered fitness, physiology, and behavior in species and their predators.

Oil can impact all species that come in contact with it, especially seabirds, marine mammals, and fish because it sticks to feathers, skin, and scales easily, is very difficult to remove, and disrupts basic life functions such as respiration and feeding. Early life stages of species that are frequently found in estuaries and sheltered inshore waters are at especially high risk of incurring impacts from exposure to toxins in oil because it cannot disperse easily in enclosed areas. Generally, eggs and larvae are more susceptible to impacts from exposure to oil toxins than juveniles and adults. Eggs, larvae, and other plankton are generally vulnerable to oil impacts because they are often found in high concentrations, cannot actively relocate to avoid oiled areas, and oil absorbs quickly into their small bodies. Impacts to these life stages and plankton can disrupt the prey base of an ecosystem and flow up the food chain to alter pelagic communities and ecosystem dynamics beyond the area directly affected by oiling.

Cleanup Impacts

Impacts to habitats and species can be exacerbated by oil removal and cleanup activities. Oil can be removed from marine waters through burning or skimming activities on the ocean’s surface, dispersal with chemicals, scrubbing sediments using sorbents, direct removal by trenching, and natural degradation by microbes. Each of these options can have significant impacts on species and habitats. While the specific impacts of burning oil from the surface are unclear, chemical dispersants are known to reduce water quality and introduce toxins into living habitats such as SAV. They can cause similar impacts to species as oil itself, such as direct mortality, reduced fitness, survival, egg fertilization, and other sublethal impacts over long timeframes. Spill cleanup activities can suspend contaminated sediments and exacerbate the adsorption of oil and chemical dispersants, transporting more oil to benthic substrates where it is harder to remove. Spill cleanup activity in coastal areas can lead to trampling and cutting of salt marshes and nearshore vegetation, which can severely damage these habitats and lead to die-offs, sedimentation, and reduced productivity. Lastly, vessels involved in cleanup activities can discharge, spill, leak, or spread bilge water, collected hydrocarbons, and dispersants that increase organisms’ exposure to toxins and reduce water quality on a small scale.

Marine Transport
Anthropogenic Activity Background Document

I. Activity Overview

To facilitate the use of marine waters for transport, fishing and recreation, coastal infrastructure is necessary to dock, receive and launch vessels and their associated goods and/or services. Ports and marinas are constructed and maintained along with nearshore shipping channels and harbors to facilitate access. The physical structures vary greatly in size and scale, from backyard docks used to launch personal vessels, to marinas that house many small boats or yachts, to commercial port facilities that accommodate large passenger and cargo vessels and facilitate the loading, unloading and storage of cargo. Similarly, harbors and shipping channels range in depth and breadth to accommodate the associated vessel traffic. Marine transport development activities will continue to grow in the future to keep up with the expansion of global trade and shipping needs.

Construction and Maintenance of Ports and Marinas

Depending on the size and function of the port or marina, the physical infrastructure may be affixed to the shore or seafloor, or float on the surface of the water. Larger structures are often constructed by driving piles into the seafloor to support the raised infrastructure. Over-water, floating structures, such as piers, barges, booms, rafts and mooring buoys have less direct contact with the seafloor, but may still contact benthic habitat through installed guide piles, anchors, and chains.

Port facilities, and to a lesser extent marinas, have often been constructed by filling wetlands or shallow water habitat to create upland areas for associated infrastructure. Bulkheads or seawalls can be constructed to contain the fill, provide a straight upland edge for wharf structures, and a platform for equipment operations and material transfer. In some cases, underwater explosives may be used in the construction of marine transport and hardening structures. The construction of associated onshore facilities, such as cargo handling and storage space, fueling areas, washing and repair facilities, and boat storage may also replace shoreline habitat with impervious surfaces. Marinas, mostly used for recreational boating, are smaller than ports and require less upland infrastructure. Once in place, ports and marinas require periodic maintenance that may involve applying sealants, removing algal buildup, and repairing damaged or weathered structures. The scale of the construction and maintenance activities depends on the size and types of vessels that are expected to use the port or marina.

In addition to ports and marinas, infrastructure is commonly constructed on private property to facilitate access and use of marine and coastal waterways, such as backyard docks and small vessel moorings. These projects have a smaller total footprint and fewer impacts to marine habitat than the commercial activates described above. However, the size and number of these small projects in a given area could potentially result in significant cumulative impacts that degrade coastal habitats.

Dredging of Harbors and Shipping Channels

Dredging is a major component of marine transport activities. To facilitate the construction of ports and marinas, nearshore areas may need to be dredged to create harbors that serve as turning basins, anchorages and berthing docks for different sizes and types of vessels. The dredging of sediments from intertidal and subtidal habitats is often necessary to create shipping channels that facilitate vessel traffic into and out of ports and marinas. Harbors and shipping channels also require routine dredging or “maintenance” dredging to remove accumulated sediments and maintain established depth and width profiles. Maintenance dredging occurs frequently, but “improvement” dredging, which creates new shipping channels or expands the operating profiles of existing channels, has increased along with the demand to accommodate larger capacity commercial cargo vessels.

Dredging uses hydraulic or mechanical equipment; the type of equipment used depends on the characteristics of the sediments to be removed and the type of sediment disposal required. Hydraulic dredging removes a slurry of water and sediment, which is pumped through a pipeline onto a barge or a hopper bin for off-site disposal, or directly to a confined disposal site onshore. Mechanical dredging uses a clamshell dredge, which is suspended from a crane, to grab and deposit the sediments onto a barge for transport. Depending on the chemical and biological profile of the sediments, the dredged material can be placed in confined disposal facilities, open-water disposal sites, or be used for secondary uses. Dredged materials can be repurposed to support a number of beneficial activities, such as restoring sensitive habitats and stabilizing eroded shorelines. The impacts to the environment from a navigational dredging project can have cumulative effects on benthic communities and are proportional to the location and scale of the activities, length of time it takes to complete the project, frequency of maintenance dredging, and resilience of the benthic habitat and associated communities.

Activity in the Mid-Atlantic Region

Marine transport infrastructure is well developed in the Mid-Atlantic region, and thus the majority of proposed marine transport projects are for maintenance dredging. As the Panama Canal expansion is underway, ports will need deeper shipping channels to accommodate larger vessels, improve efficiency, remain competitive, and expand or protect their market share. Projects for deepening and widening of existing ports are larger in scope than maintenance dredging. Port deepening projects have occurred or are underway in New York Harbor, the Delaware River, Baltimore, and Norfolk. National Oceanic and Atmospheric Administration (NOAA) Fisheries Habitat Conservation Division staff are involved during the consultation process for permitting marine transport activities. All types of marine transport projects go through a federal permitting process led by the U.S. Army Corps of Engineers (Corps), who has permitting authority for navigational improvements and construction in navigable waters and oversees dredged material placement. In addition to NOAA Fisheries Habitat Conservation Division staff, the Corps consults with other federal agencies such as the U.S. Environmental Protection Agency and the U.S. Fish and Wildlife Service as needed for project proposals. The permitting process can be quite complex depending on the size of the projects and the engagement of local governments and port authorities.

II. Habitat Impacts from Marine Transport by Habitat Type

Marine transport activities occur solely in nearshore waters, though they may impact a number of different habitat types. The severity of impact is proportional to the size and duration of construction, maintenance or dredging project. Of all the marine transport activities, dredging and filling are likely to cause the most significant impacts to marine habitat. While filling aquatic habitat with sediment is currently a less common practice, fill may be proposed to expand a port's upland area to gain additional storage space. Potential habitat impacts from marine transport activities are described below, organized by distribution and depth of habitat types.

Distribution (Nearshore (Including Estuarine)/Offshore)

a) Nearshore

The construction and maintenance activities that facilitate marine transport all occur in the nearshore environment, thus habitat impacts will be concentrated in the coastal zone. The construction, expansion and maintenance of ports and marinas and associated activities such as dredging, filling and shoreline hardening can result in direct habitat destruction and conversion, altered habitat function, increased sedimentation, and decreased water quality. Dredging in particular can result in disruptions to physical and biochemical habitat properties and reduce the suitability of benthic habitat. The scale and severity of habitat impacts depends on the size, type and configuration of the port or marina, the size and frequency of vessel traffic, the type of habitat on which they are sited, and the timing and frequency of dredging.

The construction and expansion of ports and marinas can result in direct habitat destruction or damage as a result of placing hardened support structures in the water, such as piles or concrete docks. Anchors and guide piles associated with floating structures may also damage nearshore benthic habitat, though to a lesser degree. Filling nearshore habitat to create uplands for port and marina facilities and hardening of adjacent shorelines with erosion control structures such as bulkheads, seawalls or jetties can also result in direct habitat loss, particularly of nearshore benthic habitats. Construction activities may resuspend sediments, including contaminated sediments, increase turbidity, and reduce localized water quality. If underwater explosives are used to construct bulkheads, seawalls and concrete docks, habitat destruction and suspension of sediments can be amplified. Explosives can also impact the survival and behavior of fish (see Indirect Impacts).

Once in place, marine transport infrastructure may continue to impact nearshore habitats. The presence of ports and marinas over the surface of the water can change light regimes of the habitats below, impacting primary production and the behavior of fish species (see Indirect Impacts). In-water structures and shoreline hardening structures can change tidal and current patterns, which may alter longshore sediment transport processes, nearshore beach building processes, and nearshore organism assemblages and their associated food webs. The presence of these structures in the water column can also create new habitat for sessile organisms and alter the surrounding benthic substrate (see Indirect Impacts).

Marine transport infrastructure and associated activities may have significant impacts on water quality. Contaminants such as oil, fuel, chemicals (e.g. paint and solvents), and metals (e.g. mercury and lead) can be released directly into the water during construction and maintenance activities and through incidental spills. Wooden piles and treated concrete can also leach chemicals into the water column and expose organisms to toxins (see Indirect Impacts). As a result of decreased tidal and current flows from in-water structures, contaminants may become trapped in nearshore waters and sediments, thus concentrating toxins, and creating areas of low dissolved oxygen and algal blooms (see Indirect Impacts). Shoreline hardening structures and associated shoreside development that often accompanies marine transport projects can increase the footprint of impervious surfaces and lead to more stormwater runoff. An increase in runoff can exacerbate water quality degradation through increasing suspended sediments and introducing land-based contaminants such as petroleum hydrocarbons, metals, pesticides and fertilizers into coastal waters.

The construction, expansion and maintenance of harbors and shipping channels can have significant and long-term impacts on the nearshore environment, particularly where frequent maintenance dredging is required. Both mechanical and hydraulic dredging may directly destroy, convert and disturb habitat, particularly in nearshore and estuarine areas. Through removing and displacing benthic substrates, sediments are suspended in the water, which can result in increased sedimentation, turbidity and resuspension of contaminants into the water column. Dredging may also alter the physical and biochemical properties of benthic habitat through changing depth profiles and current circulation patterns.

Estuarine

Marine transport activities can be particularly detrimental in estuarine areas. Direct habitat destruction and conversion from construction, maintenance, dredging and shoreline filling and hardening can eliminate critical intertidal and wetland habitats and the ecological functions they provide to many life stages of marine organisms. Impacts associated with sedimentation, siltation, turbidity and stormwater runoff can decrease the productivity of estuarine habitats and exacerbate water quality impacts.

b) Offshore

The habitat impacts from marine transport activities are concentrated in the nearshore environment, and are not expected to result in any impacts to offshore habitat.

Depth (Pelagic/Demersal/Benthic)

a) Pelagic

In-water structures such as piles may reduce water quality by impacting water circulation and leaching biocides and other chemicals. Large over water structures can cause pelagic shading, which affects fish behavior. Vertical structures may introduce habitat for new shellfish communities to develop (see Indirect Impacts). Though these impacts span the water column, they are likely to be concentrated in nearshore, pelagic waters.

b) Demersal

Construction and maintenance activities associated with marine transport, particularly dredging, can suspend sediments in the water column. The resulting sedimentation, siltation and turbidity can cause temporary physical and behavioral impacts to benthic species. The resuspension of contaminated sediments can also degrade benthic habitats and decrease the fitness of benthic organisms (see Indirect Impacts). If required, the use of underwater explosives may exacerbate the spatial extent and duration of these sediment impacts.

c) Benthic

The construction of ports, marinas and shoreline hardening structures can result in direct loss and conversion of benthic habitat. The placement of in-water structures such as piles, concrete docks, bulkheads, jetties and breakwaters can alter tidal and current patterns, thus impacting the distribution and flow of benthic sediments. These structures can hinder natural sediment transport, cause scour of surrounding sediment, or increase the suspension and resettlement of sediment. Benthic organisms may be buried or exposed as a result of these changes in sediment flows. Shellfish communities that settle on introduced structures such as piles can create shell deposits on the surrounding seafloor, changing the composition of the benthic substrate and shifting the benthic community structure to species associated with shell habitat.

Dredging can have significant detrimental impacts to benthic habitat, though the extent of damage depends on the type of benthic substrate, the frequency and scale of disturbance, and the ability of the affected habitat and associated species to recover. Through the physical removal and destruction of benthic substrate, dredging is likely to result in decreased biomass and species diversity (see Indirect Impacts). Dredging of shipping channels can change the physical contours and depth profile of the seafloor. Deepening channels can reduce light penetration and lower water temperatures, which may influence biochemical processes and reduce productivity. When channels become significantly deeper than surrounding areas, natural mixing can decrease, resulting in anoxic or hypoxic water conditions. Altered circulation patterns around dredging projects may change sediment composition from sand or shell substrate to fine particles. This shift may increase the suspension of sediments, reduce the viability of shellfish beds and aquatic vegetation, and negatively impact the survival of species during critical life stages (see Indirect Impacts).

Marine transport activities, particularly dredging of shipping channels, can suspend sediment in the water column. Reductions in pervious surfaces around marinas and ports can also increase stormwater runoff and the direct flow of silt and sediment into adjacent waterways. The resulting increase in sedimentation and siltation can bury benthic organisms, decrease the productivity of submerged vegetation and plankton, and change the structure and/or complexity of benthic habitat. Contaminants in suspended sediments and stormwater runoff can be toxic to benthic organisms and degrade the habitability of nearby areas (see Indirect Impacts).

Benthic Substrate (Submerged Aquatic Vegetation/Structured/Soft)

a) Submerged Aquatic Vegetation

Marine transport activities may directly replace submerged aquatic vegetation (SAV) habitat with hardened structures, or deepen areas to depths that have insufficient light to support SAV, resulting in a loss of the critical ecological functions this habitat provides. In addition to directly burying SAV beds, increased sedimentation, siltation and turbidity that result from construction and dredging can decrease primary productivity through reduced light penetration and reduce dissolved oxygen levels. The placement of structures over the water can also alter light regimes by casting shadows. Shading impacts are greatest directly below structures, but reductions in primary productivity can extend to nearby areas as shadows change from the presence and movement of vessels and docks. Development of shoreside infrastructure associated with marine transport may also increase stormwater runoff, exacerbating sedimentation and siltation impacts and causing eutrophication of SAV beds through nutrient loading.

b) Structured

Structured habitat is less likely to be impacted by marine transport activities since the majority of these activities are taking place in established ports or shipping channels, where structured habitat is not found. Marine transport activities in shipping channels may however affect nearby structured habitat by increased sedimentation burying or converting structured habitat as particles settle.

c) Soft

Marine transport activities, especially dredging, can cause damage to soft bottom habitats through the direct removal and relocation of sediment. Dredging in intertidal mud and sand flats can result in a loss of critical ecological function. Dredging may also change the flow of soft substrate, and alter the contours of soft benthic habitat. Altered circulation patterns may change the nature of soft bottom habitat from coarse sand to finer particle sediments, which can affect benthic community composition. Finer, more organic particles are also more likely to bind with contaminants than coarse particles, which can leader to greater accumulation in sediments (see Indirect Impacts).

III. Potential Impacts of Marine Transport to MAFMC Managed Stocks

Depending on the scale, duration, location and specific activities involved, nearly all habitat types used by Mid-Atlantic Fishery Management Council (MAFMC) stocks have the potential to be impacted to some degree from marine transport projects. Given that most current projects are for maintenance dredging of ports and shipping channels, benthic habitats in nearshore or estuarine areas are most likely to be impacted. Marine transport activities occur strictly nearshore, and thus no impacts are expected to offshore habitats. Impacts to the pelagic environment are likely less destructive than those to benthic and demersal habitats due to the distribution of dredging impacts.

The following table lists the habitat types designated as Essential Fish Habitat (EFH) and Habitat Areas of Particular Concern (HAPC) for the different life stages of MAFMC managed stocks (see *Impacts to Fish Habitat from Anthropogenic Activities: Introduction and Methods*). Cells highlighted in orange indicate an overlay between the habitat type used and the potential for the habitat type to be adversely impacted by marine transport activities; cells highlighted in yellow indicate a lower potential for adverse impacts; cells highlighted in green are unlikely to be impacted.

Given the intersection of where marine transport activities occur and the dependence of MAFMC stocks on the nearshore environment, many MAFMC managed species may potentially be impacted. Benthic habitats used by some or all life stages of black sea bass, longfin squid (*Loligo*), ocean quahogs, scup, summer flounder, and Atlantic surfclams are more likely to be exposed to impacts from marine transport activities, especially dredging. Pelagic habitats, which are important for Atlantic mackerel, Atlantic bluefish, butterfish, and shortfin squid (*Illex*) recruits, are less likely to be impacted by marine transport activities. If marine transport activities take place in estuarine or SAV habitats, the impacts could be severe; they are important for the majority of MAFMC species and are designated as HAPC for summer flounder. Shortfin squid (*Illex*) (eggs and pre-recruits) and golden tilefish (all life stages) are the only MAFMC stocks that are not linked to the nearshore environment and do not have the potential to be impacted by these activities.

Visual Overlay of Potential Impacts from Marine Transport and MAFMC Species’ EFH/HAPC

Legend	**Distribution**			**Water Column**			**Benthic Substrate/Structure**		
Orange = potential for adverse impacts **Yellow** = low potential for adverse impacts **Green** = no potential for adverse impacts	Estuary	Nearshore (state waters)	Offshore	Pelagic (upper/mid/ entire column)	Demersal (lower water column)	Benthic (seafloor substrate)	SAV	Structured (e.g. shell, manmade)	Soft (sand, silt)
MAFMC Species									
Atlantic Mackerel									
Eggs	x	x	x	x					
Larvae	x	x	x	x					
Juveniles	x	x	x	x					
Adults	x	x	x	x					
Black Sea Bass									
Eggs	x	x	x	x					
Larvae	x	x	x	x	x	x		x	
Juveniles	x	x	x		x	x	x	x	x
Adults	x	x	x		x	x		x	x
Atlantic Bluefish									
Eggs		x	x	x					
Larvae		x	x	x					
Juveniles	x	x	x	x					
Adults	x	x	x	x					
Butterfish									
Eggs	x	x	x	x					
Larvae	x	x	x	x					
Juveniles	x	x	x	x					
Adults	x	x	x	x					
Shortfin Squid (*Illex*)									
Eggs			x	x					
Pre-Recruits			x	x					
Recruits		x	x	x					
Longfin Squid (*Loligo*)									
Eggs	x	x	x		x	x	x	x	x
Pre-Recruits	x	x	x	x					
Recruits	x	x	x	x	x	x	x	x	x
Ocean Quahogs									
Juveniles		x	x			x			x
Adults		x	x			x			x
Scup									
Eggs	x	x							
Larvae	x	x							
Juveniles	x	x	x		x	x	x	x	x
Adults	x	x	x		x	x			
Spiny Dogfish									
Juveniles		x	x	x	x				
Sub-Adults		x	x	x	x				
Adults		x	x	x	x				
Summer Flounder									
Eggs		x	x	x					
Larvae	x	x	x	x					
Juveniles	x	x	x		x	x	x		x
Adults	x	x	x		x	x	x		x
HAPC	x						x		
Atlantic Surfclams									
Juveniles		x	x			x			x
Adults		x	x			x			x
Golden Tilefish									
Eggs			x	x					
Larvae			x	x					
Juveniles			x		x	x		x	x
Adults			x		x	x		x	x
HAPC			x			x		x	x

IV. Indirect Impacts

In addition to the habitat impacts described above, activities associated with marine transport can have impacts on the survival and productivity of marine species.

a) Contaminants

The release of contaminants during port and marina construction and maintenance activities, suspension of contaminated sediments from dredging, increased stormwater runoff from impervious surfaces, and leaching from chemically treated wood piles and docks can expose marine species to toxins. Organisms can suffer from tissue damage, changes in hormone regulation, and disturbances to cellular and immune function if exposed to toxins. Chronic exposure to contaminants can cause bioaccumulation in fish species and relay impacts through food webs. Contaminants commonly released during port and marina activities include oil, fuel, chemicals (e.g. paint, detergents, and solvents), and metals (e.g. copper, zinc, arsenic, mercury, lead, nickel, and cadmium).

b) Benthic Community Structure

Changes in habitat caused by marine transport activities can alter the distribution of invertebrates and fish, expose or bury sessile organisms, and change predator-prey interactions. Changes in water quality and primary productivity can also alter plant and animal assemblages and shift nearshore food webs. Dredging can alter the physical and chemical properties of habitat, including sediment composition, and disrupt communities of native species. This may cause a shift in the types of benthic organisms that re-colonize dredged areas and could provide opportunities for invasive species to spread. In-water structures such as shoreline hardening structures, vertical piles, and docks may create artificial habitat for sessile organisms or cause shading underwater, which can alter nearby community structure and local productivity.

c) Survival and Productivity

Marine transport activities can impact the survival and productivity of marine species at the individual and stock level. Dredging activities are particularly harmful to marine species and can result in large reductions in benthic species diversity, the total number of individuals, and overall biomass. Eggs and larvae can be entrained and harmed in dredging equipment. Turbidity, sedimentation and siltation can reduce primary productivity and dissolved oxygen levels, thus reducing food availability and creating anoxic conditions. High levels of suspended sediment can also hinder the respiration of fish and invertebrates, diminish the effectiveness of sight feeders, and reduce the growth and survival of filter feeders. Light regimes changed by over-water structures may inhibit feeding, schooling and migratory behaviors that are driven by visual cues. Changes in sedimentation and current patterns can also have population level impacts by inhibiting the dispersal, settlement and recruitment of eggs and larvae, burying eggs, and impacting juvenile predation rates. If underwater explosives are used to construct port or marina infrastructure, the shock wave can directly impact fish behavior.

d) Invasive Species

Marine transport activities can introduce invasive species through the exchange of ballast water from large commercial vessels, and the presence of fouling organisms on vessel hulls. Invasive species can alter nearshore habitats and threaten the survival and productivity of native marine species.

V. References

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Liquefied Natural Gas
Anthropogenic Activity Background Document

I. Activity Overview

Liquefied Natural Gas (LNG) is super-cooled methane gas, converted into liquid form. In this energy-dense state, LNG takes up significantly less space than gaseous methane, providing for more efficient transport over long distances. The process for transporting LNG requires specialized facilities to convert methane between gaseous and liquid states and connect to distribution pathways, large ships to move the liquefied gas, and large ports to accommodate these vessels.

Shipping

LNG is shipped between facilities in very large double-hulled cryogenic tanker ships, which may be received in shoreside or offshore ports. For shoreside ports, maintenance dredging is often required to maintain the depth and width of shipping channels and port facilities to accommodate the draft of these vessels. Offshore ports are generally sited in deepwater and do not require dredging.

Infrastructure

Specialized LNG facilities are necessary to support the import and export of LNG, which can be located onshore or offshore. Both configurations require shoreside infrastructure to support distribution. Onshore plants are sited in close proximity to the ports receiving the transport vessels, and transfer LNG to the plant for regasification. The construction of onshore LNG plants and associated upland facilities and pipelines can involve a number of coastal development activities, such as dredging, filling, and shoreline stabilization. The U.S. Department of the Interior's Federal Energy Resources Commission (FERC) permits the development of LNG facilities onshore; additional state and federal permits may also be required.

LNG can also be received at offshore facilities constructed on offshore platforms. The construction of offshore receiving ports includes the installation and maintenance of a receiving facility and pipelines to either transport LNG to shoreside facilities and distribution networks, or connect to existing pipelines. The U.S. Coast Guard and the U.S. Department of Transportation's Maritime Administration (MARAD) share joint responsibility for permitting offshore import/export facilities also known as deepwater ports pursuant to the Deepwater Port Act of 1974, as amended by the Maritime transportation Security Act of 2002.

Within LNG facilities, specialized equipment is necessary to conduct the liquefaction and regasification processes. Currently, all plants in the Mid-Atlantic region are configured to regasify imported LNG. Regasification can be conducted by closed-cycle and open-cycle processes. Closed-cycle facilities rely on a mixture of water and chemicals to warm and gasify the super-cooled LNG and to cool machinery within the facility; open-cycle facilities rely on the intake of large amounts of seawater to perform these functions. LNG received offshore is regasified onboard a specialized vessel, and transferred in submerged buoys that connect the vessel to the offshore facility; gaseous methane is then piped to shore and connected to onshore distribution pipelines.

Activity in the Mid-Atlantic Region

LNG is an important, marketable product that supplies fuel for heating in the Northeast. All existing onshore LNG facilities in the Mid-Atlantic are closed-loop import facilities, though a few combined import and export facility configurations are currently proposed for construction. At this time, all transport vessels dock in existing nearshore ports. With its large population centers and increasing demand for energy for heating, the region will continue to import LNG in the near future as a result of the increasing availability of relatively cheap natural gas reserves around the world. In addition, increasing domestic production of natural gas may prompt the construction and re-configuration of facilities to export LNG in the future. Recently, FERC authorized construction and operation of a facility on the Chesapeake Bay to liquefy and export LNG from the Marcellus shale formation in the Northeast, and authorized another existing facility at Calvert Point in the Chesapeake Bay to export LNG.

National Oceanic and Atmospheric Administration (NOAA) Fisheries Habitat Conservation Division staff are actively engaged in the consultation process with federal partners before and during permitting of LNG activities. In addition to providing comments through Essential Fish Habitat (EFH) and Endangered Species Act consultations, and the National Environmental Protection Act (NEPA) process undertaken by FERC and the U.S Coast Guard, NOAA Fisheries also engages early to suggest alterations to the siting and design of potential LNG developments to minimize habitat impacts.

II. Habitat Impacts from LNG by Habitat Type

LNG activities can potentially impact all habitat types, though most impacts are believed to be site-specific. Impacts to marine habitat are described below, organized by distribution and depth of habitat types.

Distribution (Nearshore (Including Estuarine)/Offshore)

a) Nearshore

The construction of onshore plants and associated upland infrastructure can lead to habitat destruction and conversion through dredging and filling shoreline habitat, installation of structures such as piles and foundations, and shoreline stabilization and hardening. Changes in runoff, sedimentation and siltation can also occur as a result of changes to hydrology from impervious surfaces, structures, and changes to intakes and outfalls. Once operational, LNG facilitates may impact habitat, water quality and species behavior through the discharge of seawater, debris and contaminants. Open-cycle LNG plants located in nearshore, confined water bodies can disrupt hydrology and ecosystem function through changes in salinity and temperature resulting from the intake and discharge of large volumes of water. These facilities can also impinge and entrain fish eggs and larvae and impact species survival, behavior and physiology (see Indirect Impacts). Closed-cycle systems also intake and discharge water, but to a lesser degree.

Vessels used to transport LNG between onshore facilities may necessitate dredging to establish and maintain shipping channels. The ballast water exchange of these vessels may have similar impingement and entrainment effects and impact water quality through the release of contaminants into the nearshore environment, and may introduce invasive species (see Indirect Impacts).

The use of offshore receiving facilities can have additional impacts on the nearshore environment. The construction of pipelines linking to onshore LNG plants can lead to habitat destruction and conversion, suspension of sediments including contaminated sediments, and alteration of sediment movement and water flows around pipes. Construction and maintenance barges may also impact habitat through anchoring, use of seawater for cooling and ballast, and expelling debris. Biocides like copper and aluminum compounds are used to coat pipeline surfaces to prevent the growth of marine organisms. These compounds can leach into surrounding waters and accumulate in substrates, potentially exposing organisms living or feeding on the bottom to toxins (see Indirect Impacts).

Estuarine

In addition to the impacts listed above, LNG plant construction and operation can impact estuarine habitats by damaging emergent vegetation and wetland habitat like eelgrass and microalgae beds as a result of dredging, siltation and changes in hydrology and temperature. Shoreline hardening and installation of stabilization structures for onshore facilities can also have direct impacts on vegetation, mudflats, salt marshes and other nursery areas critical to certain species and life stages.

b) Offshore

Where LNG is received offshore, the construction of offshore ports can result in habitat conversion or destruction and suspension of sediment as a result of driving piles or other means of attaching the ports to the seafloor. The use of construction and maintenance barges, and installation and maintenance of pipelines, may also impact offshore benthic habitat as described below.

Depth (Pelagic/Demersal/Benthic)

a) Pelagic

Pelagic environments may be impacted by LNG activities through the exchange of ballast water and noise impacts from construction, operation and maintenance activities (see Indirect Impacts). In shallow pelagic waters, sedimentation and runoff may reduce water quality. Impingement and entrainment of fish eggs and larvae may also occur with closed-cycle processing (see Indirect Impacts).

b) Demersal

Nearshore and offshore demersal environments can be impacted by the suspension and resuspension of sediments caused by dredging, construction of facilities and pipelines, laying cables, and moving vessels in confined areas. The resulting increase in turbidity can result in temporary physical impacts to demersal species and changes in light penetrability. Toxicity impacts from resuspension of contaminated sediment and leaching of biocides from coated pipelines may also occur.

c) Benthic
In addition to construction and maintenance activities associated with offshore ports, the large scale dredging of shipping channels to accommodate LNG vessels can also have permanent and temporary impacts. Impacts from dredging result from the direct removal of substrate, relocation of substrate through plowing, trenching and side casting, and disposition of dredged materials. These activities can result in direct loss of habitat, conversion of substrate and habitat types, and changes in bathymetry and sedimentation. These impacts may result in a net decrease of habitat availability and changes in the distribution of species for all or some life stages, including spawning locations for species with substrate---specific spawning behaviors.

Benthic Substrate (Submerged Aquatic Vegetation/Structured/Soft)

a) Submerged Aquatic Vegetation
In addition to direct impacts from construction, shoreline hardening and dredging, submerged aquatic vegetation (SAV) may also be indirectly impacted by changes in sedimentation, siltation, water quality, and hydrology.

b) Structured
While the extent of construction, dredging and pipeline installation occurring in structured habitat (hard bottom, shell and manmade substrate) may be less than that in soft bottom substrates, these activities can damage and convert structured habitats, which typically take longer to recover than soft substrates.

c) Soft
The construction of offshore ports and pipelines, and dredging of shipping channels are most likely to occur in soft bottom habitat such as sand and silt. In addition to direct habitat impacts from these activities, soft bottom habitats may also be exposed to changes in substrate type, bathymetry, and sediment location and flows.

III. Potential Impacts of LNG to MAFMC Managed Stocks

Depending on the configuration, location, and scale of LNG activities, all Mid---Atlantic Fishery Management Council (MAFMC) managed stocks have the potential to be impacted to some degree. Given the existing configuration of LNG activity in the region, the majority of impacts are expected to occur close to shore, and result from onshore infrastructure construction and operation, and shipping channel/port dredging. Thus, nearshore, estuarine, demersal and benthic habitats (particularly SAV and soft bottoms) are most likely to be harmed or disrupted. Offshore, pelagic and structured benthic habitats are less likely to be impacted, unless offshore receiving facilities are considered in the Mid---Atlantic. The use of offshore receiving ports would also increase impacts to nearshore and benthic habitats from the construction and maintenance of pipelines used to transport LNG from offshore terminals to onshore facilities.

The following table lists the habitat types designated as EFH and Habitat Areas of Particular Concern (HAPC) for the different life stages of MAFMC managed stocks *(*see *Impacts to Fish Habitat from Anthropogenic Activities: Introduction and Methods)*. Cells highlighted in orange indicate an overlay between the habitat type used and the potential for the habitat type to be adversely impacted by LNG activities; cells highlighted in yellow indicate a lower potential for impacts. Aside from specific life stages of shortfin squid (*Illex*) squid and golden tilefish, there is overlap between habitat use and potential impacts for all species and life stages from LNG development. Areas designated as HAPC for summer flounder may be particularly vulnerable to impacts from LNG development.

Visual Overlay of Potential Impacts from LNG Activities and MAFMC Species' EFH/HAPC

Legend 🟧 **Orange** = potential for adverse impacts 🟨 **Yellow** = low potential for adverse impacts 🟩 **Green** = no potential for adverse impacts	**Distribution**			**Water Column**			**Benthic Substrate/Structure**		
	🟧 Estuary	🟧 Nearshore (state waters)	🟨 Offshore	🟨 Pelagic (upper/mid/ entire column)	🟧 Demersal (lower water column)	🟧 Benthic (seafloor substrate)	🟧 SAV	🟨 Structured (e.g. shell, manmade)	🟧 Soft (sand, silt)
MAFMC Species									
Atlantic Mackerel									
Eggs	x	x	x	x					
Larvae	x	x	x	x					
Juveniles	x	x	x	x					
Adults	x	x	x	x					
Black Sea Bass									
Eggs	x	x	x	x					
Larvae	x	x	x	x	x	x		x	
Juveniles	x	x	x		x	x	x	x	x
Adults	x	x	x		x	x		x	x
Atlantic Bluefish									
Eggs		x	x	x					
Larvae		x	x	x					
Juveniles	x	x	x	x					
Adults	x	x	x	x					
Butterfish									
Eggs	x	x	x	x					
Larvae	x	x	x	x					
Juveniles	x	x	x	x					
Adults	x	x	x	x					
Shortfin Squid (*Illex*)									
🟨 Eggs			x	x					
🟨 Pre-Recruits			x	x					
Recruits		x	x	x					
Longfin Squid (*Loligo*)									
Eggs	x	x	x		x	x	x	x	x
Pre-Recruits	x	x	x	x					
Recruits	x	x	x	x	x	x	x	x	x
Ocean Quahogs									
Juveniles		x	x			x			x
Adults		x	x			x			x
Scup									
Eggs	x	x							
Larvae	x	x							
Juveniles	x	x	x		x	x	x	x	x
Adults	x	x	x		x	x			
Spiny Dogfish									
Juveniles		x	x	x	x				
Sub-Adults		x	x	x	x				
Adults		x	x	x	x				
Summer Flounder									
Eggs		x	x	x					
Larvae	x	x	x	x					
Juveniles	x	x	x		x	x	x		x
Adults	x	x	x		x	x	x		x
HAPC	x						x		
Atlantic Surfclams									
Juveniles		x	x			x			x
Adults		x	x			x			x
Golden Tilefish									
🟨 Eggs			x	x					
🟨 Larvae			x	x					
Juveniles			x		x	x		x	x
Adults			x		x	x		x	x
HAPC			x			x		x	x

IV. Indirect Impacts

In its liquid state, methane can be highly explosive when it comes in contact with water. As a result, the U.S. Coast Guard may utilize exclusion zones to ensure LNG port safety. These exclusion zones could displace fishing effort to other areas and increase congestion of shipping traffic around these zones. In addition to the habitat impacts described above, activities associated with LNG can also have impacts on the survival and productivity of marine species:

a) Noise

Construction, operation and shipping activities associated with LNG can cause underwater noise, vibrations and changes in pressure, which can damage marine life and disrupt behavior, such as avoidance of areas with loud or persistent noise. Larvae and juvenile fish are most susceptible to underwater noise impacts, particularly where it occurs in estuaries. Marine mammals may also be impacted through damage to hearing organs, disruptions in communication and echolocation, and changes in behavior and migration patterns.

b) Impingement and Entrainment

Open---cycle LNG facilities utilize seawater for warming and cooling, and can entrain (capture) and impinge (press against intake screens) marine species, including fish eggs, larvae and juveniles, as well as phyto--- and zoo---plankton. Closed---cycle facilities use small volumes of seawater to start and stop the regasification process, thus the impacts are less significant. Offshore ports used for regasification and vessels used in transporting LNG also intake and expel seawater, which can result in similar impacts. Impingement and entrainment associated with LNG activities has been linked to high mortality with eggs and larvae of several species in New England waters.

c) Impacts to Species Survivability

LNG facilities may disrupt the temperature, salinity, and quality of surrounding waters, which can reduce the fitness of marine organisms by altering respiration, metabolism, reproduction, growth, and behavior. Benthic and demersal species may also be exposed to toxins from biocides used to coat LNG pipelines that become resuspended in demersal waters; exposure to biocides such as copper at low concentrations has been shown to impact the survival of herring eggs and larvae. In the event of a spill or leak, LNG may be introduced into the surrounding waters, potentially exposing marine organisms to hydrocarbons. In such cases, acute impacts to marine organisms can be reasonably expected, though there is limited information available on these impacts.

d) Invasive Species

Ballast water exchange occurring during the loading and offloading of LNG from tankers in inshore and offshore facilities can introduce non---native and invasive species. Invasive species pose a large threat to fisheries, habitat, and community structure and dynamics. Invasive species can lower the fitness of organisms, reduce genetic diversity, and introduce exotic diseases.

V. References

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Coastal Development
Anthropogenic Activity Background Document

I. Activity Overview

Coastal development encompasses a broad suite of activities that alter nearshore environments to accommodate a variety of human uses. These activities may be conducted to support trade and transport, such as dredging of shipping channels. They can also involve the expansion of shoreside infrastructure or residential and commercial development, such as filling wetlands and other nearshore habitats with fill materials such as crushed rock, sand, or soil, and grading to prepare and stabilize a site prior to construction. Other coastal development activities aim to buffer eroding shorelines and adjacent property through hardening with seawalls and jetties, or protect low-lying areas by constructing flood control structures. While the actual purpose of each particular activity may vary, coastal development activities generally involve removing or altering existing habitat and/or introducing new structures. These functional similarities result in similar impacts to habitat, and thus a number of activities are discussed within this document. To help illustrate the range of coastal development activities, four general categories are described below: 1) dredging and disposal, 2) sand mining and beach nourishment, 3) coastal infill, and 4) shoreline protection.

1. Dredging and Disposal

Dredging generally involves removing sediment from one area and moving it to another location. Dredging may be done to prepare an area for construction, but is most frequently conducted to support navigation. Navigational dredging occurs regularly in nearshore and estuarine waters to establish and maintain harbors, ports, marinas, and shipping channels to accommodate the ever-growing size of transport vessels. Once sediments are dredged from the seafloor, they are disposed of at confined disposal facilities, open-water sites, or used for secondary activities such as fill for construction activities, landfill cover, beach nourishment or habitat restoration. The extent of dredging and disposal activities depends on the amount of navigational dredging required to accommodate vessels that use or may use the harbor, port, or marina. Additionally, manmade residential lagoon communities require dredging to maintain access to individual homeowners docks. While individual dredging projects can be relatively small and localized, the combined footprint of dredging projects can be quite large: several hundred million cubic yards of sediment is dredged from navigation channels and ports annually to maintain and improve our nation’s navigation system.

Navigational dredging is conducted to maintain or improve marine transport channels. Improvement dredging removes previously undisturbed sediments to create new navigation channels or increase the width, depth, and scope of channels. Maintenance dredging is more common, and is used to maintain the established profiles of existing channels by removing deposited sediments that accumulate over time. Both can be conducted using hydraulic or mechanical equipment, depending on the characteristics of the sediments and the type of disposal required. Hydraulic dredging, which is typically used for larger maintenance dredging projects, uses a hopper dredge or cutterhead pipeline dredge to remove loosely compacted materials from the seafloor by drawing the sediment through a pipeline onto a barge, hopper bin, or directly to another area. Mechanical dredging uses a clamshell or dipper dredge suspended from a crane to grab loose or hard, compacted materials off the seafloor and deposit the sediments onto a barge for transport. This technique is often used for smaller projects in confined areas, such as preparing a small site for construction. In addition to these two dredging methods, specialized equipment may also be used to remove storm debris from navigable waterways.

Once materials are dredged, they are transported to designated disposal areas by barges or pipelines. Depending on the grain size and contamination level of the dredged material, it can be disposed of in confined disposal facilities located on dry land or less commonly in open water sites. The selection of a disposal option balances environmental considerations, technical feasibility, and cost. Contaminated sediments must be treated, mixed with other materials, and disposed of in confined facilities. Non-contaminated sediments can be disposed at open-water sites and designated areas on the continental shelf that have historically been used for this purpose. Dredged materials may also be repurposed for secondary uses, such as creating or restoring wetlands, stabilizing eroding shorelines, or to serve as agricultural fertilizer, landfill cover, or construction materials (see Wetland and Estuarine Alteration Appendix).

2. Sand Mining and Beach Nourishment

Sand Mining

Sand mining uses hydraulic dredging techniques to collect sand deposits from the ocean floor. Mined sand is used for beach nourishment, pre-construction fill, as an ingredient in construction material such as concrete, and to protect sensitive habitats, such as nesting areas for sea turtles and birds. The vast majority of sand mined in U.S. waters is used to nourish eroded beaches. This activity often occurs on targeted sandy shoals and/or ridges in shallow nearshore waters, especially in navigation channels and existing mine sites historically used for this purpose. Dredging barges use hydraulic pressurized jets to fluidize sediments and draw them up a hose, like a vacuum, into large hoppers on their decks. The collected sand is then barged directly to shore or transported in pipelines.

Beach Nourishment

Beaches are dynamic interfaces of land and sea that provide recreation and tourism in coastal cities. To counter erosion and natural migration of sand, beach nourishment uses mined sand to replenish and provide protection to beaches and property from flood damage, storm surge, sea level rise, and other erosive forces. Sand that matches the grain size and properties of target beaches is dredged from specific mine sites on the seafloor, and is either placed directly on beaches or on offshore shoals for natural transport onto beaches by waves and currents. Typically, hydraulic dredging barges pump sand directly onto beach faces through flexible pipelines held on the seafloor by a pipe sled. Once ashore, bulldozers spread the sand to attain the desired slope and gradient and to create dunes on target beaches to protect coastal properties. The size of a nourishment project depends on the size of the beach, and can range from a few acres to hundreds of acres requiring over one million cubic yards of sediment.

Acceptable sand is sourced as close to shore as possible to reduce transportation and operation costs; therefore, beach nourishment activities mostly occur in shallow nearshore waters.

Beach nourishment is considered a “soft” shoreline armoring approach that protects beaches and landward property and provides larger, wider areas for increased recreation and tourism opportunities. This shoreline protection approach is generally less intensive and damaging to habitats and organisms than “hard” armoring techniques, such as installing seawalls. While intended to reduce erosion on dynamic coastlines, nourishment may actually exacerbate erosion if the grain size and composition of the nourishing sediments do not match those of the target beach. As a result, most nourished beaches must be nourished every few years or on a routine basis, locking the site into an ongoing, expensive cycle and exposing habitats to recurrent and cumulative impacts. Through state-federal cost sharing arrangements, the U.S. Army Corps of Engineers (Corps) commits to supporting and maintaining projects over 50-year timeframes.

3. Coastal Infill

Coastal development activities frequently require filling wetlands or shallow water habitat to create upland areas for residential and commercial development, and any associated infrastructure. However, most projects in the Mid-Atlantic are relatively small-scale and expand on current development, such as filling for utility lines, residential housing, roads, or commercial development. Before undertaking a new coastal development project, pre-construction preparation and stabilization work at the project site is often required, which may include repairing existing infrastructure such as docks and marinas, and employing shoreline hardening techniques. Typically, nearshore or estuarine areas are filled with hard substrates, shorelines may be graded to facilitate construction activities, or structures such as rebar or piles are installed to provide foundational support for coastal construction projects. For example, dredging out intertidal areas to clear sediment and riparian debris or filling portions of wetlands with layers of dirt and crushed rock may be necessary before road, dike, or bridge construction may begin in a coastal area. Hard structures such as concrete mattresses may also be installed to create a strong foundation before construction can begin. Shoreline hardening structures, such as bulkheads or seawalls, can also be constructed to contain fill and provide a straight upland edge for waterfront structures. These activities may all cause impacts to habitat and are considered a necessary component of many coastal development activities.

4. Shoreline Protection

Shoreline protection involves installing a variety of hardened structures at the land-sea interface to stabilize dynamic shorelines, prevent erosion, and provide buffers to protect shoreside property from flooding. Different structures serve different purposes, and can incorporate hard, structural stabilization components including concrete, wood and rock, soft components such as sediments and natural vegetation, or both. These armoring structures generally alter erosion and sediment deposition patterns, break waves or dissipate their energy, and reduce storm surge flood levels. The range of shoreline protection structures includes employing large “hard” structures such as seawalls and bulkheads, jetties, groins, or breakwaters, as well as “soft” structures such as sand, shellfish beds, and coastal vegetation (see Living Shorelines Appendix). Shoreline protection structures can also include flood control structures such as dikes, floodgates, and tide gates. Although shoreline protection structures destroy nearshore habitat, these structures can also create habitat for some species of fish and invertebrates.

Structural “hard” techniques are best suited for environments with large waves, a large fetch (the cross shore distance along open water over which wind blows to generate waves), steep slope and an open coast. Hardening structures such as bulkheads and seawalls, jetties and groins, revetments, and breakwaters are used to reduce wave, tide, and wind energy and erosion on shorelines. These structures can range in size from smaller bulkheads to protect personal property to larger projects such as seawalls that can be over 10 miles long. Construction of these structures typically involves large excavators, dump trucks, or barges to transport and install the hardening materials (stone, riprap, and wood).

Bulkheads, seawalls, and revetments are hard, vertical structures placed parallel to the shoreline that retain sediments and intercept wave energy. Bulkheads are usually made of wood, steel sheet piles, or concrete and are smaller than seawalls, which are typically concrete. These structures are designed to withstand the full force of waves and prevent storm surge flooding. Construction of both structures can require driving support piles or rebar into the seafloor and possibly dredging intertidal areas to clear out sediment and riparian debris. Revetments are made of layered rock or rock-like materials (i.e. riprap) placed over the seaward-facing slope of a shoreline. They are designed to break waves more gradually than bulkheads or seawalls and hold land and sediments behind the rocks in place.

Jetties and groins are structures designed to prevent beach erosion and break waves. They run perpendicular to the beach and extend out into the water, trapping sand on the updrift side and causing a loss of sediment on the downdrift side of the structure. Groins are smaller structures designed to stabilize sandy beaches, while jetties are larger structures built around tidal inlets to stabilize their location. Both jetties and groins are typically made of rock or concrete rubble, logs, or metal sheet piles placed on the seafloor near the beach or inlet.

In contrast, breakwaters are built in shallow water, parallel to the shoreline to break waves and reduce shoreline erosion. Breakwaters encourage sediment accretion behind the structure and also provide some storm surge flood level reduction. They can be constructed with poured concrete, wood, or rocks, and may be attached to the seafloor or shore. Living reefs, such as oysters or mussel beds, can also be incorporated into breakwaters in low wave energy environments. These “soft” shoreline protection approaches known as “living shorelines” retain some natural characteristics of existing nearshore habitat, and may incorporate native vegetation or sand to reduce coastal erosion (see Living Shorelines Appendix).

Selecting an erosion control strategy is site-dependent, and the best approach depends on existing conditions of the site, including the wave energy, bathymetry, fetch, composition of the adjacent shoreline, and purpose of the structure. Resiliency, effectiveness, and affordability also help determine an appropriate shoreline protection approach. Ironically, these structures can cause further erosion by starving downcurrent areas of sediment, increasing scour adjacent to hardening structures, and preventing natural migration of habitat. For example, coastal wetlands and beaches naturally migrate landward in response to sea level rise, but may be constrained by shoreline hardening activities.

Flood control structures are used predominantly in estuaries and constructed in low-lying, enclosed areas to direct water away from flood prone areas or prevent tidal and storm surge from flooding upland areas. Dikes are elevated earthen or concrete embankments constructed along tidally influenced channels in estuaries. Tide gates and floodgates are typically made of metal or wood and are mounted on dikes in front of a waterway to prevent upstream flooding of estuarine waters. Both types of flood control structures are adjustable and usually left open to avoid interfering with existing flows or species' migrations. Floodgates are larger than tide gates and they are usually closed before and during storms. Tide gates are typically used on smaller bodies of water and can be set to allow a certain amount of tidal flow or one-way movement of water out of an estuary. Ditches, or dug out canals, can also be used to divert water flow away from low-lying, flood prone areas. To achieve the desired flood protection, several structures are often used in combination.

Permitting

In general, the Corps plays the lead role in permitting the suite of coastal development activities discussed above, especially where dredging and filling are involved or activities take place near navigable waterways. The Corps typically works in coordination with the coastal state in which the activity is undertaken since many states have their own special rules governing development in wetlands and beach nourishment. Permitting for dredging requires additional coordination: the Corps permits dredging and disposal activities, while the U.S. Environmental Protection Agency (EPA) provides oversight and authorization for determining suitability of dredged sediments for specific disposal options. Together, they consult with the National Oceanic and Atmospheric Administration (NOAA) Fisheries Habitat Conservation Division staff and the U.S. Fish and Wildlife Service on siting dredging and disposal activities and any actions that involve the placement of structures or fill in navigable waterways. Construction or maintenance of shoreline and flood control structures requires specialized permits from the Corps and associated state. Large projects with the potential for significant impacts are permitted individually, while general permits are commonly used for projects with minimal adverse impacts. For sand mining and beach nourishment, the U.S. Department of the Interior's Bureau of Ocean Energy Management (BOEM) is tasked with setting and implementing regulations to oversee sand mining in federal waters, and utilizes a comprehensive sand source evaluation program in partnership with states.

Activity in the Mid-Atlantic Region

The Mid-Atlantic is a densely populated region, and the demand for coastal development activities will continue to grow to keep pace with increasing inland development. These activities do not occur in isolation, but can comprise different aspects of a larger coastal development activity and occur simultaneously along the coastline. In addition, the effects of climate change, such as sea level rise and the potential for more frequent and intense storms, will likely increase utilization of the full suite of shoreline protection techniques in the Mid-Atlantic region. For example, a higher demand for shoreline protection structures has been seen following the event known as "Superstorm Sandy." With the expansion of existing infrastructure and construction of new shoreline protection structures, there is a corresponding increase in the need for filling nearshore areas. As property owners, cities, and states repair damaged hardening structures in the wake of the storm, they are generally trying to incorporate living shorelines and shoreline vegetation to buffer storm effects in the future (see Living Shorelines Appendix).

While beach nourishment has been common along the Atlantic coast since the 1960s, proposals for siting new sand mine sites offshore have been steadily increasing to keep up with the frequency and intensity of powerful eroding storms. Most Mid-Atlantic states have existing beach nourishment policies in place to regulate sand mining locations and operations. NOAA Fisheries Habitat Conservation Division staff are working with the Corps to help replenish eroded areas hard hit by Superstorm Sandy through beach nourishment, though suitable nearshore mine sites are becoming depleted. The Corps, BOEM, and states are looking to expand sand mining activities to offshore sand banks and shoals in deeper federal waters on the outer continental shelf.

As the Panama Canal continues to expand to allow passage for larger capacity vessels, U.S. ports will need deeper shipping channels to accommodate larger vessels. As a result, there are a number of improvement dredging projects in the Mid-Atlantic region that are intended to deepen and widen existing ports and shipping channels. Major port deepening projects have occurred or are underway in New York Harbor, the Delaware River, in Baltimore, and in Norfolk. While maintenance dredging occurs more frequently, expansion dredging projects at existing ports are larger in scope and may cause more widespread and significant impacts to habitat. Most of the resulting dredged material is disposed of on land or in nearshore waters, though there are offshore open ocean disposal sites off the coasts of Virginia and New Jersey.

II. Habitat Impacts from Coastal Development by Habitat Type

Coastal development activities occur almost exclusively in nearshore waters and may impact a number of different habitat types. Nearshore benthic habitats are especially likely to incur impacts given that all activities involve taking natural habitat out of the environment (e.g. dredging and sand mining) or placing something in or on natural habitat (e.g. shoreline protection structures). Different coastal development activities have different footprints, spanning small coastal infill projects on personal property to miles of beach nourishment. While the scale of projects varies greatly, coastal development activities may alter important coastal processes, reduce habitat complexity and cause fragmentation, thus reducing the productivity and suitability of habitats. The severity of specific impacts that result from these activities are proportional to the scale and location of the activities and the resilience of the impacted habitat and its associated communities. Compared to other anthropogenic activities such as energy development, coastal development activities are widespread and frequent across the Mid-Atlantic shoreline and may have significant cumulative impacts.

Distribution (Nearshore (Including Estuarine)/Offshore)

a) Nearshore

Coastal development activities may directly destroy, convert and disturb habitat, particularly in nearshore and estuarine areas. Many of the coastal development activities involve constructing a physical barrier in the habitat, including shoreline hardening structures or coastal infill, which can alter the flow of currents, sediments and nutrients. These impacts will ultimately reduce the complexity and functionality of habitat. For example, the suite of coastal activities, especially shoreline hardening and coastal infill, can remove high diversity shoreline vegetation and woody debris, which play an important ecological role. Additionally, these barriers can cause fragmentation of valuable shallow coastal habitats, such as salt marshes, and inhibit the natural migration of these habitats landward in response to sea level rise.

Coastal development activities can impact benthic habitats by altering seafloor topography. These activities can also change the hydrological flows from the shore to the ocean and also within the nearshore waters. Activities that decrease shoreline vegetation and increase impervious surfaces from coastal construction can increase the flow of sediments and nutrients into the nearshore environment, which can result in eutrophication and decreased dissolved oxygen (see Indirect Impacts). Additionally, in-water structures and fill can change tidal and current patterns, which may alter longshore sediment transport processes, nearshore beach building processes, and nearshore organism assemblages and associated food webs. The presence of these structures in the water column can also create new habitat for sessile organisms and alter surrounding benthic substrate (see Indirect Impacts)**.**

Coastal development activities can reduce localized water quality. Removing and displacing substrates can resuspend sediments in the water, resulting in increased turbidity and sedimentation, burial of nearshore substrates, and resuspension of contaminants into the water column. Many of these activities, especially the disposal of dredged material and beach nourishment, can create sediment plumes, which can reduce sunlight penetration and impact nearshore primary productivity. Treated wood and concrete, used to construct nearshore infrastructure and shoreline hardening structures, can leach chemicals into the water column and expose organisms to toxins (see Indirect Impacts). Coastal infrastructure and shoreline hardening structures can also increase the footprint of impervious surfaces and increase stormwater runoff. This can exacerbate water quality degradation through increasing suspended sediments and introducing land-based contaminants such as petroleum hydrocarbons, metals, pesticides and fertilizers into coastal waters, creating algal blooms and areas of low dissolved oxygen. Additionally, as a result of decreased tidal and current flows from the presence of in-water structures, these contaminants may become trapped in nearshore waters and sediments, thus concentrating toxins (see Indirect Impacts).

Estuarine

Coastal development activities can be particularly detrimental in estuarine areas. As previously mentioned, the majority of activities occur in nearshore, estuarine habitat, and some activities occur exclusively in these habitats, including installation of flood control structures and disposal of dredged material used for estuarine habitat restoration projects. Direct habitat destruction and conversion from these activities can eliminate critical shallow water and wetland habitats and the valuable ecological functions they provide to many life stages of marine organisms. Impacts associated with increased sedimentation, siltation, turbidity and stormwater runoff can decrease the productivity of estuarine habitats and exacerbate water quality impacts. Many of these activities construct barriers in estuarine habitats that reduce the natural water flushing and cause shading, which can alter temperature regimes, increase salinity, reduce dissolved oxygen levels, and concentrate contaminants (see Wetland and Estuarine Alteration Appendix).

b) Offshore

The habitat impacts from coastal development activities are concentrated in the nearshore environment, and any impacts to offshore habitats are likely to be minimal. However, if dredged material is disposed of in offshore open ocean disposal sites, or if sand mining sites are located offshore, impacts from substrate removal, burial, turbidity, and settling of particles can be expected in the offshore environment.

Depth (Pelagic/Demersal/Benthic)

a) Pelagic

Coastal development activities, including dredging and disposal of dredged material, filling, and constructing in-water structures may reduce water quality by impeding water circulation and increasing sedimentation and turbidity. Large over-water structures can cause shading throughout the water column, which may impact the behavior of fish and other species. Structures may leach biocides and other chemicals into the water column. Constructing in-water structures introduces habitat for new shellfish communities to develop (see Indirect Impacts). Though these impacts span the water column, they are likely to be concentrated in nearshore waters.

b) Demersal

Coastal development activities, particularly dredging, disposal, and beach nourishment can suspend sediments in the water column. Dredging may also result in entrainment of dermersal and benthic organisms, larvae, and eggs (see Indirect Impacts). The resuspension of contaminated sediments can degrade benthic habitats and decrease water quality. The resulting turbidity, sedimentation and siltation can cause temporary physical and behavioral impacts to demersal species, such as decreasing the fitness of organisms contacting or feeding on the seafloor or causing avoidance (see Indirect Impacts).

c) Benthic

Coastal development activities can result in direct loss and conversion of benthic habitat through the physical removal or destruction of substrates. Benthic habitat can also be disturbed by temporary construction activities such as using equipment that can compress, scrape or smooth the seafloor. Conversion of benthic habitat may occur as suspended sediments settle over substrate, new substrate is exposed from dredging or construction activities, or in-water structures introduce new vertical habitat for shellfish, which can change surrounding substrate composition. These activities may also alter benthic habitat by filling depressions, reducing gradients of shoals and ridges, and compressing sediments, which can destroy important mound and burrow habitats for organisms. Benthic habitat loss and conversion can result in decreased biomass and species diversity (see Indirect Impacts).

Some activities, especially dredging and sand mining, can change the physical contours and depth profile of the seafloor. Altered circulation patterns around dredging projects may change sediment composition from sand or shell-dominated substrate to fine particles. This shift may increase the suspension of sediments, reduce the viability of shellfish beds and aquatic vegetation, and negatively impact the survival of species during critical life stages (see Indirect Impacts). Additionally, the disposal of dredged materials and placement of in-water structures and fill can alter tidal and current patterns, thus impacting the distribution and flow of benthic sediments. These structures can hinder natural sediment transport, cause scour of surrounding sediment, or increase the suspension and resettlement of sediment. Benthic organisms may be buried or exposed as a result of these changes.

Coastal development activities, particularly dredging, disposal and beach nourishment can suspend sediment in the water column and impact water quality. Coastal development construction activities may cause reductions in pervious surfaces around onshore infrastructure, increasing stormwater runoff and direct flow of silt and sediment into adjacent waterways. The resulting increase in sedimentation and siltation can bury benthic organisms, decrease the productivity of plankton and submerged vegetation, and change the structure of benthic habitat. Contaminants in suspended sediments and stormwater runoff may expose benthic organisms to toxins and degrade the habitability of nearby areas (see Indirect Impacts).

Benthic Substrate (Submerged Aquatic Vegetation/Structured/Soft)

a) Submerged Aquatic Vegetation

Coastal development activities may directly replace submerged aquatic vegetation (SAV) habitat with fill or hardened structures. Some activities can also deepen areas to depths that reduce sufficient light to support SAV, resulting in a loss of the critical ecological functions this habitat provides (see Wetland and Estuarine Alteration Appendix). In general, these activities are not likely to occur directly on SAV beds, but the temporal nature of SAV make it difficult to map and therefore it is vulnerable to unintended impacts from nearby activities. Shoreline hardening structures or fill can fragment SAV beds, impede natural migration necessary to survive sea level rise, and alter the flow of sediments and nutrients needed for vegetation growth. The placement of structures over the water can also alter light regimes by casting shadows and shading, thus reducing primary productivity of these habitats. Similarly, increased sedimentation, siltation and turbidity that result from coastal development activities can directly bury SAV beds, decrease primary productivity through reduced light penetration, and reduce dissolved oxygen levels. Development of shoreside infrastructure may also increase stormwater runoff, exacerbating sedimentation and siltation impacts, increasing contaminant levels and causing eutrophication of SAV beds through nutrient loading.

b) Structured

Structured habitat is less likely to be directly impacted by coastal development activities than other substrates, since the majority of these activities take place in areas where structured habitat is not found. Coastal development activities may, however, affect nearby structured habitat by increased sedimentation, which may bury or disturb structured habitat as particles settle.

c) Soft

Coastal development activities are likely to occur in soft bottom habitats, and are likely to cause impacts through the direct removal and/or relocation of sediment. Dredging and filling activities in intertidal mud and sand flats can result in a loss of critical ecological function. Activities may also change the flow of soft sediments and alter the contours of soft benthic habitat. Altered circulation patterns may change the nature of soft bottom habitat from coarse sand to fine particle sediments, which can affect benthic community composition. Fine organic particles are also more likely to bind with contaminants than coarse particles, which can lead to greater accumulation in sediments and expose species to toxins (see Indirect Impacts).

Activity-Specific Habitat Impacts

Dredging and Disposal

Dredging and disposal generally occurs nearshore, though there are some offshore sites used for disposal and sand mining. In these instances, similar impacts expected to occur in nearshore habitats are also likely to occur offshore. The direct disruption and conversion of substrates may fill depressions or smooth the seafloor, remove vertical topography, and decrease suitability of substrates for burrowing organisms (see Indirect Impacts). Through removal and placement of sediment, these activities can change benthic contours and increase turbidity throughout the water column near dredging sites, during transportation (especially with mechanical dredges), and at the disposal sites. As a result, substrate composition in or near dredging or disposal sites may be altered as surface textures and grain size may not match with the surrounding substrate.

Dredging and disposal can also disrupt currents and sediment transport, and may temporarily cause scour and sediment plumes to form up to thousands of feet downcurrent of project sites. The deepening of channels during dredging may also reduce water quality by reducing temperature, oxygen, and sunlight penetration in these areas, and potentially lead to poor mixing, which can result in hypoxic or anoxic conditions. Dredging in certain areas may not only increase water depth, but also potentially wave heights, leading to more shoreline erosion. In addition, these activities can resuspend nutrients and sediments, including contaminated sediments, and cause eutrophication.

Sand Mining and Beach Nourishment

In addition to the general impacts discussed above resulting from dredging and disposal of dredged material, sand mining in particular may change the characteristics of soft substrates. By burying adjacent habitats through sedimentation and siltation, uncovering new sediments, and leaving behind substrates with lower sand and higher silt content and poorly-sorted particles, these habitats can be altered for a long time. If sand mining sites continue to expand into offshore waters in the future, offshore sand shoals known as “relic shoals,” which are static and do not receive new sediments from the nearshore sediment transport system, may be permanently removed. These shoals can act as important migratory markers, feeding, and spawning locations for various species and fishing grounds (see Indirect Impacts).

Beach nourishment can add soft sediments to the nearshore sediment transport system with different properties than the existing substrates, which may increase erosion and turbidity adjacent to and downcurrent from target beaches. Increased turbidity on target beaches is usually temporary, but if mud, silt, and clay are accidentally introduced onto target beaches with the sand, the increase in turbidity and reduction in habitat suitability in the intertidal zone can persist and impact species behavior.

Coastal Infill and Shoreline Protection

These activities exclusively take place in nearshore, estuarine and intertidal areas, and generally replace soft sediments with hard structures, which can fragment and alter habitat function. By placing structures in the path of currents, tides, and mixing zones of fresh and saltwater, these activities alter sediment and nutrient flows, causing accretion, scour, and exacerbating erosion, which may cause subsidence of nearby marsh and wetland habitats (see Wetland and Estuarine Alteration Appendix). In addition, these fill-associated structures can inhibit longshore sediment transport and beach formation, alter dune size, and impede nearshore benthic habitat migration. Flood control structures such as dikes, floodgates, and tide gates are placed exclusively in estuaries and may also disrupt currents, sediment, and nutrient flow and create barriers to species migrations (see Wetland and Estuarine Alteration Appendix).

III. Potential Impacts of Coastal Development to MAFMC Managed Stocks

Depending on the scale, duration, location and specific coastal development activities involved, all habitat types have the potential to be impacted to some degree. Coastal development activities occur almost exclusively nearshore, and thus impacts are likely to be concentrated along the land-sea interface and in waters close to shore. Given that most projects involve the removal of sediments (e.g., dredging and sand mining) or the placement of sediments or structures (e.g., coastal infill and shoreline hardening), benthic habitats within nearshore or estuarine areas will be most significantly impacted. Impacts to offshore and pelagic environments are both less likely, and potentially less severe.

The following tables list the habitat types designated as Essential Fish Habitat (EFH) and Habitat Areas of Particular Concern (HAPC) for the different life stages of Mid-Atlantic Fishery Management Council (MAFMC) managed stocks (see *Impacts to Fish Habitat from Anthropogenic Activities: Introduction and Methods*). Cells highlighted in orange indicate an overlay between the habitat type used and the potential for the habitat type to be adversely impacted by coastal development activities; cells highlighted in yellow indicate a lower potential for adverse impacts; cells highlighted in green are unlikely to be impacted.

To illustrate the similarities and differences in how coastal development activities may impact important fish habitat, a table has been created for each of the four general categories: dredging and disposal, sand mining and beach nourishment, coastal infill, and shoreline hardening. For all four activities, nearshore and estuarine environments may be subject to impacts. While shoreline hardening and coastal infill occur exclusively nearshore, the disposal of dredged material and sand mining may occur offshore, and thus offshore habitat may be exposed to impacts. Impacts to pelagic waters from all four activities are likely to be temporary and less significant than impacts to demersal or benthic habitats. Among benthic habitats, soft substrates and SAV habitats are more likely to be impacted than structured habitats.

Given the intersection of where most coastal development activities occur and the general dependence of MAFMC stocks on nearshore habitats, almost all MAFMC managed species may potentially be impacted. Where coastal development activities take place in estuarine habitats, such as installing flood control structures, the impacts could be severe. Estuaries are important for the majority of MAFMC species and are designated as Habitat Areas of Particular Concern (HAPC) for summer flounder (see Wetland and Estuarine Alteration Appendix). Benthic habitats important for some or all life stages of black sea bass, longfin squid (*Loligo*), ocean quahogs, scup, summer flounder, and Atlantic surfclams are more likely to be exposed to impacts from coastal development activities, especially dredging and disposal, sand mining and beach nourishment. Pelagic habitats, such as those used by Atlantic mackerel, Atlantic bluefish, spiny dogfish, and butterfish may have less exposure to impacts. Golden tilefish (all life stages) are the only MAFMC stock not linked to the nearshore environment; due to the deep nature of their offshore habitat, they are not likely to be impacted by these activities. Shortfin squid (*Illex*) eggs and pre-recruits are unlikely to be impacted by coastal infill and shoreline protection activities due to their reliance on offshore pelagic habitats; however, they may be impacted if dredged material is disposed of offshore, and are more likely to be impacted during sand mining on offshore shoals. Sand mining may also remove or alter sand ridges and/or shoals that are particularly important for both juvenile and adult Atlantic surfclams and ocean quahogs, and may be important migratory markers and feeding areas for Atlantic bluefish, scup, and summer flounder.

Visual Overlay of Potential Impacts from Dredging and Disposal and MAFMC Species' EFH/HAPC

Legend	**Distribution**			**Water Column**			**Benthic Substrate/Structure**		
Orange = potential for adverse impacts **Yellow** = low potential for adverse impacts **Green** = no potential for adverse impacts	Estuary	Nearshore (state waters)	Offshore	Pelagic (upper/mid/ entire column)	Demersal (lower water column)	Benthic (seafloor substrate)	SAV	Structured (e.g. shell, manmade)	Soft (sand, silt)
MAFMC Species									
Atlantic Mackerel									
Eggs	x	x	x	x					
Larvae	x	x	x	x					
Juveniles	x	x	x	x					
Adults	x	x	x	x					
Black Sea Bass									
Eggs	x	x	x	x					
Larvae	x	x	x	x	x	x		x	
Juveniles	x	x	x		x	x	x	x	x
Adults	x	x	x		x	x		x	x
Atlantic Bluefish									
Eggs		x	x	x					
Larvae		x	x	x					
Juveniles	x	x	x	x					
Adults	x	x	x	x					
Butterfish									
Eggs	x	x	x	x					
Larvae	x	x	x	x					
Juveniles	x	x	x	x					
Adults	x	x	x	x					
Shortfin Squid (*Illex*)									
Eggs			x	x					
Pre-Recruits			x	x					
Recruits		x	x	x					
Longfin Squid (*Loligo*)									
Eggs	x	x	x		x	x	x	x	x
Pre-Recruits	x	x	x	x					
Recruits	x	x	x	x	x	x	x	x	x
Ocean Quahogs									
Juveniles		x	x			x			x
Adults		x	x			x			x
Scup									
Eggs	x	x							
Larvae	x	x							
Juveniles	x	x	x		x	x	x	x	x
Adults	x	x	x		x	x			
Spiny Dogfish									
Juveniles		x	x	x	x				
Sub-Adults		x	x	x	x				
Adults		x	x	x	x				
Summer Flounder									
Eggs		x	x	x					
Larvae	x	x	x	x					
Juveniles	x	x	x		x	x	x		x
Adults	x	x	x		x	x	x		x
HAPC	x						x		
Atlantic Surfclams									
Juveniles		x	x			x			x
Adults		x	x			x			x
Golden Tilefish									
Eggs			x	x					
Larvae			x	x					
Juveniles			x		x	x		x	x
Adults			x		x	x		x	x
HAPC			x			x		x	x

Visual Overlay of Potential Impacts from Sand Mining/Beach Nourishment and MAFMC Species' EFH/HAPC

Legend	**Distribution**			**Water Column**			**Benthic Substrate/Structure**		
Orange = potential for adverse impacts									
Yellow = low potential for adverse impacts	Estuary	Nearshore (state waters)	Offshore	Pelagic (upper/mid/ entire column)	Demersal (lower water column)	Benthic (seafloor substrate)	SAV	Structured (e.g. shell, manmade)	Soft (sand, silt)
Green = no potential for adverse impacts									
MAFMC Species									
Atlantic Mackerel									
Eggs	x	x	x	x					
Larvae	x	x	x	x					
Juveniles	x	x	x	x					
Adults	x	x	x	x					
Black Sea Bass									
Eggs	x	x	x	x					
Larvae	x	x	x	x	x	x		x	
Juveniles	x	x	x		x	x	x	x	x
Adults	x	x	x		x	x		x	x
Atlantic Bluefish									
Eggs		x	x	x					
Larvae		x	x	x					
Juveniles	x	x	x	x					
Adults	x	x	x	x					
Butterfish									
Eggs	x	x	x	x					
Larvae	x	x	x	x					
Juveniles	x	x	x	x					
Adults	x	x	x	x					
Shortfin Squid (*Illex*)									
Eggs			x	x					
Pre-Recruits			x	x					
Recruits		x	x	x					
Longfin Squid (*Loligo*)									
Eggs	x	x	x		x	x	x	x	x
Pre-Recruits	x	x	x	x					
Recruits	x	x	x	x	x	x	x	x	x
Ocean Quahogs									
Juveniles		x	x			x			x
Adults		x	x			x			x
Scup									
Eggs	x	x							
Larvae	x	x							
Juveniles	x	x	x		x	x	x	x	x
Adults	x	x	x		x	x			
Spiny Dogfish									
Juveniles		x	x	x	x				
Sub-Adults		x	x	x	x				
Adults		x	x	x	x				
Summer Flounder									
Eggs		x	x	x					
Larvae	x	x	x	x					
Juveniles	x	x	x		x	x	x		x
Adults	x	x	x		x	x	x		x
HAPC	x						x		
Atlantic Surfclams									
Juveniles		x	x			x			x
Adults		x	x			x			x
Golden Tilefish									
Eggs			x	x					
Larvae			x	x					
Juveniles			x		x	x		x	x
Adults			x		x	x		x	x
HAPC			x			x		x	x

Visual Overlay of Potential Impacts from Coastal Infill and MAFMC Species’ EFH/HAPC

Legend	Distribution			Water Column			Benthic Substrate/Structure		
🟧 **Orange** = potential for adverse impacts 🟨 **Yellow** = low potential for adverse impacts 🟩 **Green** = no potential for adverse impacts	🟧 Estuary	🟧 Nearshore (state waters)	🟩 Offshore	🟨 Pelagic (upper/mid/ entire column)	🟧 Demersal (lower water column)	🟧 Benthic (seafloor substrate)	🟧 SAV	🟨 Structured (e.g. shell, manmade)	🟧 Soft (sand, silt)
MAFMC Species									
Atlantic Mackerel									
Eggs	x	x	x	x					
Larvae	x	x	x	x					
Juveniles	x	x	x	x					
Adults	x	x	x	x					
Black Sea Bass									
Eggs	x	x	x	x					
Larvae	x	x	x	x	x	x		x	
Juveniles	x	x	x		x	x	x	x	x
Adults	x	x	x		x	x		x	x
Atlantic Bluefish									
Eggs		x	x	x					
Larvae		x	x	x					
Juveniles	x	x	x	x					
Adults	x	x	x	x					
Butterfish									
Eggs	x	x	x	x					
Larvae	x	x	x	x					
Juveniles	x	x	x	x					
Adults	x	x	x	x					
Shortfin Squid (*Illex*)									
🟩 Eggs			x	x					
🟩 Pre-Recruits			x	x					
Recruits		x	x	x					
Longfin Squid (*Loligo*)									
Eggs	x	x	x		x	x	x	x	x
Pre-Recruits	x	x	x	x					
Recruits	x	x	x	x	x	x	x	x	x
Ocean Quahogs									
Juveniles		x	x			x			x
Adults		x	x			x			x
Scup									
Eggs	x	x							
Larvae	x	x							
Juveniles	x	x	x		x	x	x	x	x
Adults	x	x	x		x	x			
Spiny Dogfish									
Juveniles		x	x	x	x				
Sub-Adults		x	x	x	x				
Adults		x	x	x	x				
Summer Flounder									
Eggs		x	x	x					
Larvae	x	x	x	x					
Juveniles	x	x	x		x	x	x		x
Adults	x	x	x		x	x	x		x
HAPC	x						x		
Atlantic Surfclams									
Juveniles		x	x			x			x
Adults		x	x			x			x
Golden Tilefish									
🟩 Eggs			x	x					
🟩 Larvae			x	x					
🟩 Juveniles			x		x	x		x	x
🟩 Adults			x		x	x		x	x
🟩 **HAPC**			x			x		x	x

Visual Overlay of Potential Impacts from Shoreline Protection and MAFMC Species' EFH/HAPC

Legend

Orange = potential for adverse impacts

Yellow = low potential for adverse impacts

Green = no potential for adverse impacts

MAFMC Species	**Distribution**			**Water Column**			**Benthic Substrate/Structure**		
	Estuary	Nearshore (state waters)	Offshore	Pelagic (upper/mid/ entire column)	Demersal (lower water column)	Benthic (seafloor substrate)	SAV	Structured (e.g. shell, manmade)	Soft (sand, silt)
Atlantic Mackerel									
Eggs	x	x	x	x					
Larvae	x	x	x	x					
Juveniles	x	x	x	x					
Adults	x	x	x	x					
Black Sea Bass									
Eggs	x	x	x	x					
Larvae	x	x	x	x	x	x		x	
Juveniles	x	x	x		x	x	x	x	x
Adults	x	x	x		x	x		x	x
Atlantic Bluefish									
Eggs		x	x	x					
Larvae		x	x	x					
Juveniles	x	x	x	x					
Adults	x	x	x	x					
Butterfish									
Eggs	x	x	x	x					
Larvae	x	x	x	x					
Juveniles	x	x	x	x					
Adults	x	x	x	x					
Shortfin Squid (*Illex*)									
Eggs			x	x					
Pre-Recruits			x	x					
Recruits		x	x	x					
Longfin Squid (*Loligo*)									
Eggs	x	x	x		x	x	x	x	x
Pre-Recruits	x	x	x	x					
Recruits	x	x	x	x	x	x	x	x	x
Ocean Quahogs									
Juveniles		x	x			x			x
Adults		x	x			x			x
Scup									
Eggs	x	x							
Larvae	x	x							
Juveniles	x	x	x		x	x	x	x	x
Adults	x	x	x		x	x			
Spiny Dogfish									
Juveniles		x	x	x	x				
Sub-Adults		x	x	x	x				
Adults		x	x	x	x				
Summer Flounder									
Eggs		x	x	x					
Larvae	x	x	x	x					
Juveniles	x	x	x		x	x	x		x
Adults	x	x	x		x	x	x		x
HAPC	x						x		
Atlantic Surfclams									
Juveniles		x	x			x			x
Adults		x	x			x			x
Golden Tilefish									
Eggs			x	x					
Larvae			x	x					
Juveniles			x		x	x		x	x
Adults			x		x	x		x	x
HAPC			x			x		x	x

IV. Indirect Impacts

In addition to the habitat impacts described above, coastal development activities can have impacts on the survival, productivity, community structure and behaviors of marine species.

a) Survival and Productivity

Coastal development activities can impact species at both the individual and stock level. Dredging and disposal activities may be particularly harmful to species by causing removal, burial, and entrainment, which can cause direct mortality to species, especially at early life stages. These activities also increase turbidity, sedimentation and siltation, which can reduce the development and survival of eggs and larvae, hinder respiration and metabolism, and inhibit light penetration through the water column, reducing primary productivity. Suspended sediments may bury and smother species, alter growth rates and survival, and cause gill abrasion in fish species. In-water structures may also create barriers that disrupt current flows, which can alter distribution and recruitment of eggs and larvae, and limit the amount of food and nutrients available to organisms.

b) Behavior Changes

Changes in habitat from coastal development activities can remove important nursery, refuge, forage, and spawning areas, which may alter species behavior. Sand mining on targeted offshore sand shoals and/or ridges in particular can remove navigation points that may limit or obstruct species migrations. Increased turbidity and sedimentation can disrupt the foraging patterns and reduce the success of sight- and filter-feeders, alter swimming and spawning behavior, and cause attraction or avoidance at individual and population levels. Dredging and disposal and flood control structures, such as floodgates or tide gates, may also impede passage of diadromous species into and out of upstream areas and may limit spawning by cutting off access to spawning grounds.

c) Water Quality

These activities can introduce contaminants into the water column and resuspend contaminated sediments, which can expose organisms to toxins that may alter species' behavior, physiology, and survival. In-water structures can leach chemicals including metals into surrounding waters, and may also resuspend and concentrate existing contaminants by altering currents and reducing flushing. Chronic exposure to contaminants can cause bioaccumulation in species and compound impacts throughout food webs. Channel deepening and alteration can alter temperature regimes and change nutrient flows, which can reduce the dissolved oxygen content of the water and lead to anoxic or hypoxic conditions and decrease primary productivity.

d) Community Structure Shifts

Coastal development activities can directly remove or displace organisms, decreasing the overall abundance, biomass, and diversity of a community. Installing in-water infrastructure such as shoreline hardening structures may alter habitat suitability, and change the distribution of invertebrates, shellfish, and fish, which can lead to changes to predator-prey interactions and food webs. Similarly, removing or disrupting substrates can alter their chemical and physical properties, disrupting species abundance and dominance in an area. Changing hydrological processes, reducing water quality, and removing or altering high-diversity or highly productive areas, such as wetlands, may also disrupt community structure and dynamics. Introducing new structures into nearshore waters may serve beneficial purposes by offering species new habitats to colonize or use as refuge areas. However, original species assemblages may never return to disturbed areas, and the disturbance may provide opportunities for the spread of invasive species. Secondary uses of fill, such as wetland restoration and beach nourishment, may also change communities by altering the suitability and occupancy of restored habitat.

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VI. Wetland and Estuarine Alteration Appendix

This appendix builds on and captures additional insights from our research to help the MAFMC understand the important ecological roles wetland and estuarine habitats play in the marine ecosystem and the threats that coastal development activities in the Mid-Atlantic may pose. It supplements the basic habitat impacts description in the "Estuarine" section of the document by explaining mechanisms of impacts, discussing the ecosystem services these habitats provide, and exploring increasingly common restoration and mitigation activities.

Sources of Impacts

Many of the coastal development activities described above occur in or near estuaries, including coastal infill, installing shoreline protection structures, dredging and disposal of dredged materials, including secondary fill uses such as saltmarsh and wetland restoration. The installation and operation of flood control structures such as floodgates, tide gates, and dikes occur exclusively in these habitats because they lie at the interface of fresh and saltwater. In addition to direct habitat losses resulting from these anthropogenic activities, the Mid-Atlantic also loses portions of these habitats through subsidence and erosion due to unique geological factors. As the coast becomes more crowded in this region, coastal development encroaches on estuaries and wetlands and can cause impacts from various fill-related activities. In fact, many coastal habitats of the Mid-Atlantic region have already incurred cumulative impacts of overlapping coastal development activities, urbanization, sediment contamination and the significant loss of wetlands over time.

Loss of Ecosystem Services

Estuaries and wetlands provide several important ecosystem services, including buffering storm surges and floods, filtering surrounding waters, and protecting shallow, highly productive waters. These habitats act as natural vegetative coastal barriers that absorb storm surge and provide storage capacity to reduce flooding. As conduits from rivers to the ocean, these habitats also help to maintain salinity, temperature, oxygenation, and stratification of brackish waters to maximize primary productivity in some areas, and facilitate transport and mixing of littoral sediments, nutrients, and freshwater in others. In addition, vegetation in estuaries and wetlands supports water quality by filtering out contaminants, excess nutrients, turbidity, and toxins from groundwater, stormwater, and riverine sources. Most importantly, these habitats support high primary productivity and provide important nursery, feeding, and spawning habitat for many species of invertebrates, fish, and seabirds.

Activities such as filling in or near these habitats can reduce these important ecosystem functions through direct habitat destruction, reduction of habitat complexity and fragmentation. Many of these activities construct barriers in estuarine habitats that reduce natural tidal flushing, which can increase salinity, reduce dissolved oxygen levels, and concentrate contaminants. Installation of structures can also alter temperature regimes in estuaries and wetlands by causing a loss of vegetation, which can increase water temperatures. Conversely, these structures may also shade the water column, lowering adjacent water temperatures and reducing habitat suitability. Alteration of estuaries or wetlands has the potential to release and resuspend contaminated sediments, which can disrupt nutrient availability for SAV and coastal vegetation and reduce overall ecosystem productivity. If these habitats are replaced with impervious surfaces, erosion and runoff may increase, resulting in decreased water quality and increased turbidity and sedimentation.

Importance to MAFMC species

Estuaries and wetlands are particularly important to MAFMC stocks; seven of the twelve species depend on estuaries as EFH for at least one life stage, and estuaries comprise a portion of HAPC for summer flounder. In addition, many other species such as invertebrates, anadromous fish (including forage species such as herring), shellfish, and seabirds also rely on estuaries and wetlands as important habitat and contribute to the total productivity of regional fisheries.

Wetland Mitigation and Restoration

The cultural attitude has shifted in Mid-Atlantic following Superstorm Sandy as residents have realized the important ecological functions that estuaries and wetlands provide; there are no longer many large wetland alteration or filling projects in the region. Instead, smaller projects with relatively small footprints of impact are more common, mostly for road, bridge, and home development and are sited to avoid impacts to these sensitive habitats. Although these projects are relatively small, their combined impacts decrease the habitat's overall functionality. Where impacts are unavoidable, NOAA Fisheries Habitat Conservation Division staff and the Corps usually require compensatory mitigation to ensure that there is no net loss of wetlands. Mitigation may be "in-kind" meaning that the same habitat type impacted is restored or created in another location; mitigation may also restore a different habitat type than is impacted if it provides greater function and value. Mitigated or restored wetlands do not have the same ecological function as naturally occurring wetlands. As a result, compensatory mitigation ratios are usually greater than 2:1. The specific ration for each project is informed by a number of factors, such as the specific habitat loss, mitigation methods and likelihood of success.

Secondary Uses of Dredged Materials

To support wetland and estuarine mitigation and restoration projects, dredged materials from coastal development activities may be used for secondary purposes, such as creating beneficial habitat or restoring or enhancing existing habitats. Examples of these approaches include increasing the height of eroded saltmarsh or wetland areas by adding sediment to subsiding areas to counteract the effects of sea level rise. By strategically placing layers of dredged material to bring degraded substrates to the intertidal level or constructing wave barriers, vegetation can be allowed to re-grow and restore damaged areas and stabilize eroding shorelines. The Mid-Atlantic region is considering using these restoration techniques, but is proceeding with caution to avoid unintended adverse effects to existing marsh habitat. Dredged material can foster accretion of sediments and lead to the development and growth of intertidal flats, native coastal vegetation and SAV beds, and shellfish reefs over time, which can further support the productivity and ecological functions of these areas.

VII. Living Shorelines Appendix

This appendix is intended to capture insights gleaned from our research to help the MAFMC understand the range of "living" shoreline protection techniques and their advantages in terms of less severe or lasting impacts to habitats compared with "hard" alternatives such as seawalls, breakwaters, and jetties.

Range of Living Shoreline Alternatives

"Living shorelines" encompass a range of shoreline protection and stabilization techniques and structures that can leverage natural vegetation along with other "soft" stabilization elements such as sand. They may also include "hard" engineered shoreline structures such as rockpiles or breakwaters, or utilize hybrid approaches that leverage aspects of both soft and hard structures. Living shorelines help to stabilize and reduce erosion along protected shorelines such as estuaries, bays, and sheltered tributaries, while preserving and supplementing aspects of the nearshore habitat's natural appearance and function. Living shorelines can take many forms and come in many sizes, ranging from nourished beaches and vegetated dunes, to engineered shorelines in small bays that incorporate natural marsh habitat and coir fiber logs, rock or oyster shell to help hold existing and planted vegetation in place. Various configurations can also leverage both man-made and natural structures, including engineered rock revetments and sills to protect existing vegetation, living oyster or mussel reefs and rock breakwaters to buffer coastlines and upland areas from small waves, and vegetation edging with erosion control blankets to hold sediment in place near marshes and wetlands.

Applications and Limitations

Living shorelines are not well suited for high-energy wave environments or areas subject to frequent flooding or high storm surge, as these actions are likely to inundate and damage living vegetative buffers. Rather, living shorelines are best suited for coastlines with low to moderate wave energy, smaller waves and fetch, and gently sloping shores. These erosion control and shoreline stabilization alternatives have advantages over traditional "hard" protection and stabilization techniques, and are becoming more popular along the Atlantic coast as a result. The vegetated buffers of living shorelines reduce the volume, contaminant capacity, and turbidity effects of upland runoff, improve water quality in adjacent marine waters, dissipate wave energy effectively without exacerbating erosion like seawalls or bulkheads, and may also create wetland habitat for many species. As natural and planted vegetation is protected over time and becomes established along a living shoreline, it can create important habitat for fish, invertebrates, and seabirds. In the post-Superstorm Sandy Mid-Atlantic region, states and municipalities are becoming more interested in these approaches as affordable and effective shoreline stabilization and erosion control management tools.

Living shorelines have benefits over traditional "hard" shoreline protection methods, but NOAA Fisheries Habitat Conservation Division staff must consider the habitat that exists where the living shoreline is proposed and if developing a living shoreline would be a trade up in habitat value. Areas of existing SAV, shellfish, or hard bottom habitat may not be appropriate for a living shoreline since these natural habitats are considered more valuable habitat.