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.

<u>1. Dredging and Disposal</u>

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).

<u>2. Sand Mining and Beach Nourishment</u>

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.

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

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).

<u>Benthic Substrate (Submerged Aquatic Vegetation/Structured/Soft)</u>

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 **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 Coastal Infill 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

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.

V. References

1. Personal Communication with Susan-Marie Stedman, Office of Habitat Conservation Division, NOAA Fisheries. 1/8/2015.
2. Personal Communication with Janine Harris, Office of Habitat Conservation Division, NOAA Fisheries. 1/14/2015.
3. Personal Communication with David O'Brian, NMFS Virginia Field Office, NOAA Fisheries. 1/29/2015.
4. Personal Communication with Karen Greene, NMFS Habitat Conservation Division, James J. Howard Marine Sciences Laboratory, NOAA Fisheries. 03/30/2015.
5. National Oceanic and Atmospheric Administration. 2008. "Impacts to Marine Fisheries Habitat from Nonfishing Activities in the Northeastern United States." NOAA Technical Memorandum NMFS-NE-209. 339p.
6. New England Fishery Management Council. 2014. "Omnibus Essential Fish Habitat Amendment 2 Draft Environmental Impact Statement. Appendix G: Non-Fishing Impacts to Essential Fish Habitat." 168p. <http://www.nefmc.org/library/omnibus-habitat-amendment-2>.
7. Atlantic States Marine Fisheries Commission. 2013. "Harbor Deepening: Potential Habitat and Natural Resource Issues." 12p.
8. Greene, K. November 2002. "Beach Nourishment: A Review of the Biological and Physical Impacts." Atlantic States Marine Fisheries Commission (ASMFC) Habitat Management Series #7. 179p. Web: <http://www.asmfc.org/uploads/file/beachNourishment.pdf>. Accessed 3/31/2015.
9. South Atlantic Fishery Management Council. March 2003. "Policies for the Protection and Restoration of Essential Fish Habitats from Beach Dredging and Filling and Large-Scale Coastal Engineering." 7p. Web: <http://www.safmc.net/habitat-ecosystem/pdf/BeachPolicy.pdf>. Accessed 4/4/2015.
10. California Sea Grant Extension Program. 2015. "Beach Nourishment." Web: < http://ca-sgep.ucsd.edu/focus-areas/healthy-coastal-marine-ecosystems/explore-beach-ecosystems/beach-nourishment>. Accessed 4/2/2015.
11. Burlas, M., Ray. G. L. & Clarke, D. (2001). "The New York District's Biological Monitoring Program for the Atlantic Coast of New Jersey, Asbury Park to Manasquan Section Beach Erosion Control Project. Final Report". U.S. Army Engineer District, New York and U.S. Army Engineer Research and Development Center, Waterways Experiment Station. Web:<http://www.nan.usace.army.mil/Missions/CivilWorks/ProjectsinNewJersey/SandyHooktoBarnegatInlet/BiologicalMonitoringProgram.aspx>. Accessed 4/1/2015.
12. Byrnes, M. et al. 2000. "Assessing Potential Environmental Impacts of Offshore Sand and Gravel Mining." Final Report to the Commonwealth of Massachusetts, Executive Office of Environmental Affairs. Coastal Zone Management, 43 pp. Web: <http://www.appliedcoastal.com/pdf/99-07_rpt.pdf>. Accessed March 23, 2015.
13. Byrnes, M. et al. 2000. "Environmental Survey of Potential Sand Resource Sites: Offshore New Jersey." U.S. Department of the Interior, Minerals Management Service, International Activities and Marine Minerals Division (INTERMAR), Herndon, VA. OCS Report MMS 2000-052, Volume I: Main Text 380 pp. + Volume II: Appendices 291 pp.

Web: <http://www.appliedcoastal.com/pdf/98-05_NJ/MMS_2000-052_report.pdf>. March 23. 2015.
14. Delaware Sea Grant. 2009. "Coastal Processes FAQ." Web: <http://www.deseagrant.org/outreach-extension/coastal-processes-faq-there-difference-between-jetty-and-groin>. Last updated on 11/27/2009. Accessed 3/24/2015.
15. Federal Facilities Environmental Stewardship & Compliance Assistance Center. 2013. "Dredging Operations." Web: https://www.fedcenter.gov/assistance/facilitytour/construction/dredging/>. Last updated 8/19/2013. Accessed 3/14/2015.
16. Giannico, G. and J. Souder. 2004. "The Effects of Tide Gates on Estuarine Habitats and Migratory Fish." Oregon State University. 12 p. Web: <http://www.oregon.gov/oweb/monitor/docs/mr_effectsoftidegates.pdf>. Accessed 3/14/15.
17. U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA) Ocean & Coastal Resource Management. 2010. "Erosion Control Structures." Web:<http://coastalmanagement.noaa.gov/initiatives/shoreline_ppr_eros_control.html>. Last updated 4/16/2010. Accessed 3/24/2015.
18. NOAA. Greene, K. ed. 2014. "Protecting Offshore Habitats While Rebuilding New Jersey Beaches." Web: <http://www.greateratlantic.fisheries.noaa.gov/stories/2014/protectingoffshorehabitats.html>. Accessed March 23, 2015.
19. NOAA and U.S. ACoE. November 2014. "Natural and Structural Measures for Shoreline Stabilization." 4p. Web: <http://coast.noaa.gov/digitalcoast/publications/living-shorelines>. Accessed 3/14/2015.
20. Normandeau Associates, Inc. 2014. "Understanding the Habitat Value and Function of Shoal/Ridge/Trough Complexes to Fish and Fisheries on the Atlantic and Gulf of Mexico Outer Continental Shelf." Draft Literature Synthesis for the U.S. Dept. of the Interior, Bureau of Ocean Energy Management. Contract #M12PS00031. 116 pp. Web: <http://www.boem.gov/Final-Draft-Report/>. Accessed March 23, 2015.
21. Speybroeck *et al.* 2006. "Beach Nourishment: An Ecologically Sound Coastal Defence Alternative? A review." *Aquatic Conservation: Marine and Freshwater Ecosystems* 16: 419-435. Web: < http://www.academia.edu/4319951/Beach_nourishment_an_ecologically_sound_coastal_defence_alternative_A_review>. Accessed 4/2/2015.
22. U.S. ACoE Engineer Research and Development Center. Guilfoyle, M. Fischer, R., Pashley, D. and Lott, C. eds. November 2007. "Summary of Second Regional Workshop on Dredging, Beach Nourishment, and Birds on the North Atlantic Coast." October 25-27, 2005, Long Island, NY. ERDC/EL TR-07-26. Web:< http://www.researchgate.net/publication/228827338_Summary_of_Second_Regional_Workshop_on_Dredging_Beach_Nourishment_and_Bids_on_the_North_Atlantic_Coast>. Accessed 4/2/2015.

23. U.S. ACoE and the Port of West Sacramento. 2011. “Draft Supplemental Environmental Impact Statement/Subsequent Environmental Impact Report for the Sacramento River Deep Water Ship Channel.” 289p.
24. United States Department of the Interior, Bureau of Ocean Energy Management (BOEM). 2015. “Marine Minerals Program Fact Sheet.” Web: <http://www.boem.gov/MMP-General-Fact-Sheet/>. Last updated January 2015. Accessed March 23, 2015.
25. BOEM. 2015. “Marine Minerals Program.” Web: <http://www.boem.gov/Marine-Minerals-Program/>. Accessed March 23, 2015.
26. United States Environmental Protection Agency (EPA) and U.S. Army Corps of Engineers (ACoE). 2004. "Evaluating Environmental Effects of Dredged Material Management Alternatives: A Technical Framework." EPA842-B-92-008, USEPA/USACE, Washington D.C.
27. U.S. EPA. 2010. “Types of Dredging.” Web: <http://www.epa.gov/region02/water/dredge/types.htm>. Last updated 10/10/2010. Accessed 3/14/2015.
28. U.S. EPA. 2012. “Assessment and Remediation of Contaminated Sediments (ARCS) Program.” Web: <http://www.epa.gov/greatlakes/arcs/EPA-905-B94-003/B94-003.ch4.html>. Last updated 6/6/2012. Accessed 3/14/2015.
29. U.S. EPA. 2013. “Coastal Wetlands Initiative: Mid-Atlantic Review.” Prepared by the Eastern Research Group, Inc. under contract EP-C-09-020. 44p. Web: <http://water.epa.gov/type/wetlands/upload/mid-atlantic-review.pdf>. Last updated 8/12/13. Accessed 4/1/15.
30. U.S. EPA. 2015. “Section 404 Permitting.” Web: <http://water.epa.gov/lawsregs/guidance/cwa/dredgdis/>. Last updated 3/14/2015. Accessed 3/17/2015.

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.